SERIAL NO. 120

REPORT NO.
TOR-269(4303)-9.
VOL. I

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Reliability Management Handbook

Volume I: Sections 1 Through 6

14 FEBRUARY 1964

Prepared by
ARINC RESEARCH INC.

as directed, revised, and updated by
AEROSPACE RELIABILITY DEPARTMENT

Prepared for COMMANDER SPACE SYSTEMS DIVISION
UNITED STATES AIR FORCE
Inglewood, California

APPLIED MECHANICS DIVISION • AEROSPACE CORPORATION
CONTRACT NO. AF 04(695)-269

Rep[redacted]t. No.
TOR-269(4303)-9- Vol. I
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RELIABILITY MANAGEMENT HANDBOOK

Volume I. Sections 1 through 6.

Prepared by

ARINC RESEARCH INC*

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AEROSPACE RELIABILITY DEPARTMENT

AEROSPACE CORP[redacted]
El Segundo, Calif[redacted]

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COMMANDER SPACE SYSTEMS DIVISION
UNITED STATES AIR FORCE
Inglewood, California

*Aerospace Contract 62-160

This Document Supersedes and Replaces Vol I
of ATN-64(4303)-1, Dated 3 September 1963

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Report No.
TOR-269(4303)-9, Vol I

RELIABILITY MANAGEMENT HANDBOOK

Volume I: Sections 1 through 6

Prepared by

ARINC Research Corporation
as directed, revised, and updated by
Reliability Department
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AEROSPACE CORPORATION
El Segundo, California

Report No.
TOR-269(4303)-9, Vol. I
14 February 1964

FOREWORD

The Reliability Management Handbook is designed to assist Air Force System Program Office (SPO) Reliability Engineers in the performance of their assigned management tasks. This Handbook is intended to serve as an aid in the implementation of MIL-R-27542A (USAF), "Reliability Program for Systems, Subsystems, and Equipment."

It is recognized that certain definitions and statements of philosophy expressed herein may be controversial. However, the Handbook is presented as an expression of current practice in the field of reliability program management. Although the Handbook has been extensively reviewed, it is inevitable that not all of the errors and inconsistencies have been eliminated. In order to make this work available to you within a reasonable time, while it is still meaningful, it is published in its present imperfect form. It is the intention of the Aerospace Corporation to review periodically and update the Handbook as required. This Handbook is constructed so that individual pages or sections may be revised as required. Recommendations for improvement of the Handbook are solicited from users, interested individuals, and organizations.

REVISION INSTRUCTIONS

Changes to this report will be accomplished by transmitting one or more revision pages. Each revised page will be identified by the abbreviation Rev. and a sequential Arabic number, beginning with 1, placed immediately below the report number. The revisions number reflects the total number of revisions to this report issue; it does not indicate the number of revisions to a particular page.

A new title page and Revision Summary sheet will accompany each revision. Revision title pages will carry the revision date below the revision designation.

Revision Summary sheets (see Page ix) should be retained as a permanent part of the particular document issue to serve as a record of all change action. Revision Summary sheets replace previously issued sheets if they include all prior change information; otherwise they are handled as additional pages and numbered accordingly.

REVISION SUMMARY

REV. CODE	REV. DATE	REVISION DETAILS	REVISION ACTION	REV. CCN	REVISION APPROVAL(S)

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1.2.1 Systems Management Concept

The organizational structure of the Air Force is characterized by two distinct categories of management activity:

(1) Functional Management ------ the grouping of responsibilities according to the type of work to be performed, that is, plans, operations, research and development, procurement and production, supply and maintenance, personnel and comptroller.

(2) Systems Management -- the process of organizing and employing functional agencies to accomplish objectives of a clearly defined weapon, support, or command and control system program.

The systems management concept requires establishment of a separate System Program Office (SPO) for each approved system. This office provides a management focal point and central locale where the Air Force functional agencies involved in the preparation and implementation of the particular system program are represented in an integrated organization.

1.2.2 Air Force Reliability Coordinators

A Reliability Coordinator is a person in the System Program Office designated as the central agent for reliability policy, plans, programs, and activities. As prescribed in AFSCR 80-1, Reliability Program for Aerospace, Support, and Command and Control Systems, each SPO will "maintain an adequate staff for monitoring and guidance of the reliability program for the system with which they are concerned." Consistent with the systems approach to the management task, the functions and responsibilities of the SPO Reliability Coordinator can thus be assumed to encompass all matters which contribute to or in any way affect the reliability of the system.

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1. INTRODUCTION

1.1 Importance of Reliability in Military Programs

The field of reliability engineering has grown in the last decade from a limited study of electron tube failures to an engineering discipline of considerable stature. What was formerly a highly specialized area of consideration is today a formal and systematic branch of technology. Numerous factors have contributed to the tremendous growth of the reliability field. But, paramount among them is the insistence by the military that contractors actively practice the principles and techniques of reliability engineering.

The achievement of desired results in a reliability program is closely related to a customer's acceptance of a given degree of risk in respect to end-product performance. Time and resources expended will determine this degree of risk. It follows, then, that one of the initial and major challenges which confront a procuring activity is the determination of expenditures to be allotted to a program. The importance of this challenge -- as it affects ultimate product capability -- demands that reliability be considered as a system parameter and that this parameter be designated as the specific responsibility of some person(s) within the organizational structure for systems management. In Air Force systems management, the responsibility would logically be assigned to the System Program Office (SPO) Reliability Coordinator.

Accordingly, with the recognition of the proper consideration of reliability as a vital factor in the planning, design, development and testing of complex military systems, it is important to provide suitable guides to management concerning the scope and application of reliability engineering concepts and techniques in systems engineering. A description of the system engineering process is presented in Section 1.5 including an explanation of the role of reliability engineering. This Reliability Management Handbook has been prepared to increase the understanding of System Program Office personnel with systems reliability considerations and how they interface with other systems characteristics, such as performance, maintainability, operability, effectiveness, availability, safety, supportability, procurability, producibility and cost.

1.2 Air Force Organization for Reliability Management

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1.3 Purpose and Content of Reliability Management Handbook

This handbook has been compiled to serve as a guide to SPO Reliability Coordinators in the performance of their assigned management tasks. In accordance with this objective, the handbook is oriented toward:

(1) Defining the over-all task of reliability management by dividing it into specific functions.

(2) Categorizing existing Air Force policies and responsibility assignments in respect to these management functions.

(3) Suggesting procedures for implementing the functions.

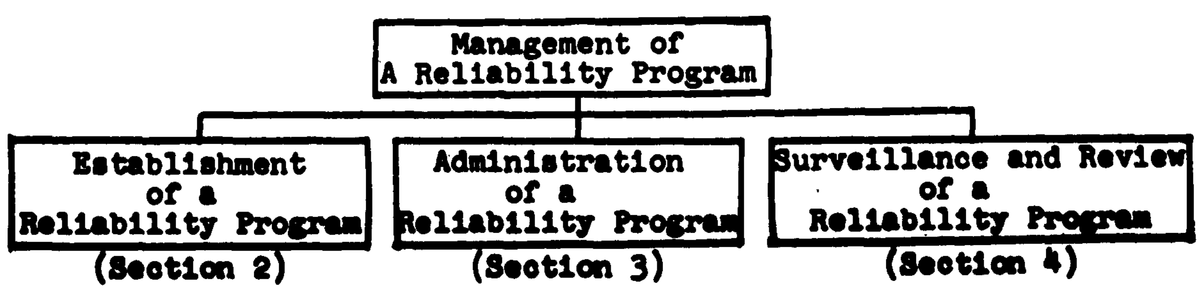
(4) Serving as an aid in the implementation of MIL-R-27542A (USAF), "Reliability Program for Systems, Subsystems, and Equipment."

The guidance information contained herein is not a substitute for sound management practice or managerial ability (these factors have no substitute). Rather, it is intended to contribute to the positive approach necessare for the achievement of the objectives which govern a reliability program. It augments the training, experience, and judgment of the SPO Reliability Coordinators.

Sections 2, 3, and 4 of the handbook are organized to reflect the three major functions which evolve from the reliability management task, as illustrated in Figure 1-1:

FIGURE 1-1

MAJOR FUNCTIONS WITHIN
OVER-ALL RELIABILITY MANAGEMENT TASK



Within the appropriate section, the functions of program establishment, administration, and surveillance and review are further subdivided into detailed management activities. Definitions, pertinent policy and responsibility statements from Air Force directives, suggested implementation procedures and techniques, and listings of additional reference reading are included in these activity discussions.

Sections 2, 3, and 4 are primarily concerned with answers to the question, "How does the SPO Reliability Coordinator manage a reliability program?" Answers to the question, "What does he manage?", are provided by Appendix A, Elements of a Reliability Program. This appendix defines, describes, and discusses the disciplines and activities which cumulatively constitute a contractor's reliability program as required by MIL-R-27542A.

1.4 Guides for Utilizing Handbook Material

The scope of material presented in Sections 2, 3, and 4 and the appendices of the handbook is intentionally broad in order to provide as comprehensive coverage of the reliability management task as possible. The following general comments and guidance discussions are included to suggest effective ways of extracting and applying this wide range of information:

(1) Reliability Management Functions and Activities -- The discussions in Sections 2, 3, and 4 are based on a descriptive outline or breakdown of the over-all task of reliability management (this outline is apparent from the table of contents for these sections). Specific attempts have been made to highlight the major management functions and activities which confront the System Program Offices and SPO Reliability Coordinators. Hence, such topics as "Preparation of Statement of Reliability Requirements" and "Evaluation of Proposals" have been selected as subjects for discussion.

(2) Air Force Reliability Documents -- Several forms of documentation relating to reliability have been issued by all command levels within the Air Force. These documents represent a prime source of authority and direction for work performed by SPO Reliability Coordinators. Three significant regulations have been singled out for special consideration within this handbook:

   (a) Air Force Regulation No. 80-5, Reliability Program for Systems, Subsystems, and Equipments, 4 June 1962.

   (b) Air Force Systems Command Regulation No. 80-1, Reliability Program for Aerospace, Support, and Command and Control Systems, 14 Dec. 1962.

   (c) Air Force Ballistics Systems Division Regulation No. 80-5, Reliability Program Management, 28 Dec. 1962.

   Appendix B presents the entire contents of the above listed regulations in tabular form, arranged by similar subject categories.

(3) Additional Reading Materials -- Several published references have been listed throughout the handbook to inform the SPO Reliability Coordinators of the availability of additional treatments of the subjects covered. The following publications are also pointed out as general information sources of significant interest to those in the reliability management field:

   (a) Proceedings of the Annual National Symposium sponsored by the IRE Professional Group on Reliability and Quality Control.

   (b) Published papers of the Military-Industry Missile and Space Reliability Symposium sponsored by the Office of the Director of Defense Research and Engineering.

(4) Reliability Management Procedures -- Where possible, specific procedures are suggested for implementing reliability management activities. For example, in discussing the subject of evaluation of contractor status reports, a check list of sixteen items (see Table 3-2) has been presented as a model with specific application. Procedural examples presented in this handbook are not intended to convey that stereotyped methods exist for accomplishing the given tasks. Rather they are intended to suggest approaches and to encourage the individual SPO Reliability Coordinators to develop techniques on the basis of their own sets of program needs and objectives.

(5) Reliability Management Policies and Responsibilities -- A major responsibility of any Air Force manager is to carry out the directives established by higher authority. Hence, it is felt that prevailing policy statements and responsibility assignments constitute a major frame of reference for the performance of reliability management functions. In this handbook, each major topic of discussion is prefaced by a tabular presentation of appropriate policy and responsibility statements.

(6) Relation of Reliability to Other System Parameters -- In utilizing the material contained in this handbook, the reader should understand that "reliability" is but one of the major elements which contribute to the performance capability of a system. Other important system parameters

include maintainability, availability, and design adequacy. All of these parameters are interrelated in the broader concept termed "system effectiveness." Appendix F has been included to depict the relationships between reliability and other system attributes and to define the terms of interest which are normally used in describing these relationships.

(7) Aids to Location of Subject Material -- There are certain characteristics of this handbook which are specially intended to assist the user in locating material relating to a particular subject. These include the subject matter index (at end of handbook), the table of contents, the MIL-R-27542A cross-reference chart (page 1-9, following, and page A-2 of Appendix A), and parenthetical references to other appropriate paragraphs throughout the text.

MIL-R-27542A CROSS-REFERENCE CHART

The material presented in Appendix A has been based, to the extent possible, on the philosophy and specifications expressed in MIL-R-27542A, Reliability Program for Systems, Subsystems, and Equipment, dated 21 May 1963 (however, it is not limited in that respect). The extent of this correlation has been depicted by the table shown on the following page. A ● indicates applicability of sections in Appendix A to specific paragraphs in MIL-R-27542A. The table has been included herein to guide the Reliability Coordinator in the use of the Appendix A material.

Subject Matter Covered in MIL-R-27542A, dtd. 21 May 1963	Par. No.	A.1.1 Statistical Methods Research	A.1.2 Materials Research	A.1.3 Environmental Research	A.1.4 Failure Rate Data Research	A.1.5 Physics of Failure Research	A.1.6 Applications Research	A.2.1 Formal Reliability Training	A.2.2 Motivational Reliability Training	A.3.1 Reliability Prediction	A.3.2 Reliability Apportionment	A.3.3 Parts Program	A.3.4 Developmental Testing	A.3.5 Failure Reporting, Anal. and Corrective Action	A.3.6 Environmental Studies	A.3.7 Documentation Generation
Reliability Program	3.1															
Numerical Requirements	3.2.1	●								●						
Mathematical Models	3.2.2	●								●	●					
Reliability Requirement Studies	3.2.3	●								●	●	●	●		●	
Proposed Reliability Program Plan	3.3.1															
Reliability Organization	3.3.2															
Management and Control	3.3.3															
Program Review	3.4															
Test Requirements for Development Qualification and Acceptance	3.5.1		●	●	●	●						●	●	●	●	●
Furnished Equipment	3.5.2									●						
Parts Reliability	3.5.3				●	●						●		●	●	
Critical Items	3.5.4		●	●	●									●		
Supplier and Subcontractor Reliability Programs	3.5.5															
Reliability Indoctrination and Training	3.5.6							●	●							
Human Engineering	3.5.7											●	●	●		
Statistical Methods	3.5.8	●					●									
Effects of Storage, Shelf-Life, Packaging, Trans., Handl. and Maint.	3.5.9											●	●	●		
Design Review	3.5.10															
Manufacturing Control and Standards	3.5.11															●
Failure Data Collection, Analysis, and Corrective Action	3.5.12													●		
Reliability Demonstration	3.5.13															
Periodic and Final Reports	3.5.14															
Assurance Provisions	4															

Subject Matter Covered in MIL-R-27542A, dtd. 21 May 1963	Par. No.	A.3.8 Supplier Selection and Control	A.4.1 Document Review	A.4.2 Design Review	A.4.3 Qualification and Acceptance Tests	A.4.4 Reliability Demonstration	A.4.5 Inspection for Compliance to Documentation	A.4.6 Measurement of Achieved Reliability	A.5.1 Contracting	A.5.2 Programming	A.5.3 Status and Progress Reporting	A.5.4 Monitoring	A.5.5 Management Controls	A.5.6 Program Documentation	A.6.1 Instructions to Customer Personnel	A.6.2 User Tests and Product Evaluations
Reliability Program	3.1									●				●		
Numerical Requirements	3.2.1								●							
Mathematical Models	3.2.2															
Reliability Requirement Studies	3.2.3	●														
Proposed Reliability Program Plan	3.3.1					●				●			●	●		
Reliability Organization	3.3.2									●			●			
Management and Control	3.3.3									●		●	●	●		
Program Review	3.4											●				
Test Requirements for Development Qualification and Acceptance	3.5.1				●			●								
Furnished Equipment	3.5.2															
Parts Reliability	3.5.3															
Critical Items	3.5.4															
Supplier and Subcontractor Reliability Programs	3.5.5	●							●							
Reliability Indoctrination and Training	3.5.6															
Human Engineering	3.5.7			●												
Statistical Methods	3.5.8															
Effects of Storage, Shelf-Life, Packaging, Trans., Handl. and Maint.	3.5.9			●												
Design Review	3.5.10		●	●												
Manufacturing Control and Standards	3.5.11			●												
Failure Data Collection, Analysis, and Corrective Action	3.5.12							●			●				●	●
Reliability Demonstration	3.5.13					●										
Periodic and Final Reports	3.5.14										●					
Assurance Provisions	4		●	●	●	●	●	●								

1.5 The System Engineering Process

Rapid advancement of technology in recent years has made possible the design and development of increasingly complex military systems. Dependability of weapons to accomplish their role in the destruction of an enemy's capability to overrun and destroy the homeland has always been the goal of military equipment engineers. Simple weapons systems such as the bow and arrow, the rifle, and the cannon could be invented, produced, and tested by a few craftsmen under the personal direction and supervision of an individual engineer or master craftsman. They could be easily tested before their mass duplication in order to prove their reliability under operational and environmental conditions such as were to be faced on prospective battlefields. Through World War II, the airplane and its manually operated machine guns and bomb sights could be designed, developed and tested by specialists groups, still largely under the personal direction and surveillance of a chief engineer. The weapons system was then integrated and their operational worth demonstrated by flight test engineerng crews. The normal development cycle took such a weapons system progressively and serially through experimental, prototype and production models. The requirement to demonstrate the reliability of new weapon systems has, therefore, always existed. A tactical advantage has always been gained by the combat force which possessed the operationally dependable weapons. Until about 1950, this quality could be most easily and directly achieved by individual engineers and small groups of ordnance specialists. It was inherent in their engineering process.

With the advent of scientific and technological breakthroughs which increased the effective speed, range, accuracy and destructive power of weapons systems, the need arose for reliability engineering as a specialty. The reasons that it has become a specialty rather than a simple quality that an inventor or engineer seeks in designing, developing and proving out a new weapon are several:

a. No one individual is any longer capable of possessing sufficient knowledge covering all of the scientific and technical fields which are employed in order to solely make the necessary technical judgments required to develop an effective and dependable military system.

b. To integrate the efforts of the large number of varied technical specialists in designing and developing components for incorporation into a system requires a well-defined process and a communication system to produce a total system design.

c. The time period permitted for developing and deploying new complex military systems is necessarily compressed for strategic reasons.

d. Cost of developing and procuring a new system has multiplied manifold, reducing the national capability to support parallel competing systems development in order to insure a desired capability.

Because of these considerations, there has been an emerging awareness of the need for and the importance of a discipline which will bring about an integration of specialists' efforts to achieve desired system outputs. Groups of specialists, therefore, have emerged as adjuncts to the design, development and testing programs for complex military systems. Each in their own way has attempted to supply an information processing method and technique for identifying and interrelating the various qualitative and quantitative aspects of systems development. Each specialist group has found it necessary to make such an attempt in order to properly achieve its desired quality or characteristic in a system's output. These engineering specialist groups have been concerned with achieving such things as: reliability; maintainability; operability; supportability; invulnerability; safety; producibility; procurability; and, other "ilities." These groups of specialists which emphasize the system design approach may be identified in organizations under such terms as: Reliability; Maintainability; Facilities; Ground Support; Safety; Human Engineering; System Integration and Testing; Functional and Task Analysis; Cost Analysis; and, others. All such groups have the same characteristic of not being specifically tied to the engineering of a particular kind of equipment.

The experience of each of these specialty groups in trying to furnish the requirements and to be the forcing function upon the equipment oriented engineering groups for designing end items on an integrated systems basis has been frustrating; and, their goals for attaining desired levels of systems effectiveness have fallen far short of being realized. However, their efforts and their insistent promotion of the systems viewpoint, along with accumulated experience gained in the operational deployment of complex weapons systems, have forced responsible systems management personnel to realize that a system must be designed and tested as a complete entity.

The word "System," therefore, has come through actual practice to include: prime mission equipment; the facilities required to operate and maintain the system; the selection and training of specialist personnel; software; the operational and maintenance procedures; instrumentation and data reduction for test and evaluation; special activation and acceptance programs; and, logistics support programs for spares and depot maintenance.

All parts of a system must have a common unified purpose: to contribute to the production of a single set of optimum outputs from given input(s) with respect to some appropriate measure of effectiveness. Increasing recognition of this fundamental requirement by responsible systems management personnel, is leading to the promulgation of policy directives from the Office of the Secretary of Defense; Regulations and Directives from Headquarters USAF; Regulations and Manuals from Air Force Systems Command; and, revision of Specifications and Exhibits at Systems Divisions and Systems Programs Office. These will serve to implement and contract for a complete systems engineering effort in the study, design, development and testing of an aerospace weapon, support or space system. The term "Systems Engineering" has been accepted and is being used to encompass and/or replace such terms as: systems thinking, systems approach, systems synthesis, systems analysis, functional analysis, task analysis, system definition, system concept and, team development method.

System engineering is fundamentally concerned with deriving a coherent system design to achieve stated objectives. The system engineering process logically considers and evaluates each of the innumerable military, technical and economic variables identified by the system engineers. Choices of methods of system operation and the system elements is a highly involved process, for a change in one system variable will affect many other system variables, rarely in a linear fashion. The generation of a well-balanced system design requires that each major system decision be based upon the proper consideration of other system variables such as cost, facilities, personnel requirements, procedural data requirements, testing and logistics. Further, it requires a balancing among the considerations leading to incorpoation of design characteristics which will produce reliability, maintainability, operability, safety, and supportability. To achieve desired system performance effectiveness and dependability requires the closest coordination amongst system engineers and implies a design team of select specialists skilled in system engineering. This team has the responsibility of translating military operational or advanced developmental requirements into a feasible, economical system. This team responsibility will not be satisfied until system tests/demonstrations have proven the adequacy of the production end-item specifications, personnel selection and training data, facilities and procedural data.

Each of the members of this system engineering team will have a different and probably unique educational and technical experience background. They must represent or be thoroughly knowledgeable concerning each technical specialty to be employed in planning, designing, developing and testing a given system. No two systems are ever alike in their development requirements. However, the process for arriving at logical system decisions is identical, regardless of system purpose, size or complexity. Regardless of their particular technical specialty, therefore, system engineers must be trained and given experience in system engineering, and be devoted to arriving at the best system design, considering all of the requirements and constraints to be met.

Reliability engineering and reliability engineers play an important and unique role in this system engineering process.

First, some reliability engineers must become qualified systems engineers and participate in the system engineering team effort in arriving at the system design.

Second, all reliability engineers must be fully informed and skilled in the application of reliability engineering methods and techniques in executing the detailed design, development and testing of equipment end-items. The reliability engineers must be famaliar with the facilities and environmental controls, the operations and maintenance procedures, including personnel performance, and the systems testing and deployment of these end-items. This background will enable the reliability engineer to participate in the systems engineering activity.

Third, some reliability engineers will be highly specialized and skilled in the application and development of methods and techniques to be employed by other reliability engineers. These applied research activities will contribute to the analysis and evaluation processes for obtaining, deriving, reducing, and evaluating assumed or obtained equipment and system performance data for the purpose of making judgments about the probable dependability of the system for successfully achieving its performance objectives.

In this connection, the achievement of desired results by a system from the viewpoint of reliability considerations, must be related to a customer's acceptance of a given degree of risk in respect to its end-product performance. Time and resources (both material and human) expended will establish this degree of risk. It follows, then, that one of the initial and major challenges which confront a procuring activity, such as the Office of the Secretary of Defense, and its agent the Air Force Systems Command, is the determination of the expenditures to be allocated to a program. In helping to arrive at a system design, therefore, the reliability engineer functioning in the role of a systems engineer must objectively accept this requirement and contribute his findings as "best judgments," and to honestly state the most probable outcomes of incorporating given design characteristics. It is for the lack of this skill which can be applied by a well-qualified reliability engineer, trained and experienced in the system engineering process, that has led in the past to costly overruns and schedule slippages on some systems, or where degraded capability has been accepted in order to achieve some performance value out of an expensive and tactically important system. Because of complexity and costs, war plans have been made dependent upon a specified system performance capability becoming available for a given time period. For the lack of proper and accurate reliability considerations, at the right time and in the proper context during system engineering, the national security can be seriously, and perhaps fatally jeopardized. It is for this most urgent reason, and the examples of failures in effective systems engineering in the past, that system management is currently concerned with achieving the objectives described in this handbook as one of the important attributes and contributions to effective systems engineering.

2. ESTABLISHMENT OF A RELIABILITY PROGRAM

Establishment of an effective reliability program is a task which is essential to the ultimate achievement of desired system reliability in a contracted program. It is a task which places major responsibilities upon the customer as well as the contractor.

The customer must lay the basic foundation which will assure eventual accomplishment of a design by equipment manufacturers. He must formulate an adequate and realistic statement of reliability requirements for the system (2.1); he must select the most qualified contractor (or contractors) for fulfilling these requirements (2.2); and he must specify and evaluate the reliability activities (reliability program plan) to be implemented by the contractor (2.3).

Frequent occasions have arisen in which the efforts of a contractor to achieve desired reliability in a system have proven to be inadequate. In analyzing the cause of the inadequacy, reference must invariably be made to the initial statement of reliability requirements provided by the customer. Common complaints registered by contractors or their representatives have included the following:

(1) Program requirements as contractually stated were lacking in sufficient detail, ambiguous, or not applicable to the specific product in question.

(2) Overlapping, inconsistent, or conflicting requirements were created by a complex contract structure incorporating several different specifications, standards, and other obligatory statements.

(3) The program requirements were unnecessarily demanding.

(4) Requirements which altered the scope of work were imposed on the contractor subsequent to contract negotiation.

(5) Requirements were imposed on the contractor on an unofficial basis, that is, without stipulation in the contract.

Such problems can never be entirely eliminated from programs which are complex in scope and requirements. They can be minimized, however, through conscientious and detailed attention to the disciplines and tasks necessary to establishment of an effective reliability program.

Section 2 of this handbook provides guidance to SPO Reliability Coordinators in determining a deliberate and definitive course of action relative to establishment of a reliability program. The functions and responsibilities described in this section are those which are properly the responsibility of a SPO Reliability Coordinator (whether he performs the tasks himself or directs the performance of others). They encompass a time period which may be considered to extend from the first decision of the customer to recognize reliability as a factor of interest in a system program to the official approval of a contractor's reliability program plan by the procuring activity (usually at some time immediately following the negotiation of a contract).

2.1 Formulation of Reliability Requirements

There are two basic approaches which can be utilized in formulating reliability requirements for a contracted program:

(1) Prescribing reliability requirements in detail not only for the system but also for components, materials, and processes so that all elements of work and levels of effort in the program are controlled as much as possible. This method is used to provide added assurance to the customer that end items delivered after acceptance of the product will continue to meet requirements, since controls are imposed on all aspects of product production (e.g., quality of materials and components must be continuously tested and/or inspected).

(2) Prescribing reliability requirements only for the end product. This process allows a minimum of customer interference and provides the contractor complete freedom in determining and implementing the methods to be used in achieving the reliability requirements. Determination of reliability achievement is accomplished through a demonstration program conducted on the customer's behalf.

In formulating the reliability requirements for a specific program, usually a compromise set of requirements will evolve, including some detail requirements as well as end-product requirements. The extent to which detail requirements are specified will also depend on parameters other than reliability, such as the time scale and cost of the program.

The formulation of program reliability requirements is, hypothetically, independent of and preliminary to the selection of a contractor. Activity to establish such requirements commences at the time of decision to incorporate reliability into a program and continues until the program requirements are stated in documentary form. This documentary form is usually a contractual "Statement of Work," although in certain cases it may be an exhibit, a specification, or a standard. In any event, it represents the cumulative statement of the customer-imposed requirements that must be considered by prospective contractors in submitting bids for performing work.

Principal sources of directives which dictate Air Force policy in respect to requirements formulation are:

(1) Air Force Regulation 80-5 (AFR 80-5), 4 June 1962

(2) Air Force Systems Command Regulation 80-1, 14 Dec. 1962 (AFSCR 80-1)

(3) Air Force Ballistic Systems Division Regulation 80-5 (AFBSDR 80-5), 28 Dec. 1962

All of these specify that reliability is a factor that must be considered during program planning stages and must embrace both quantitative and qualitative aspects. Further, they vest direct responsibility for formulation of reliability requirements in the System Program Office (SPO), and thus in the SPO Reliability Coordinator.

In the discussion of 2.1, the task of reliability requirements formulation is subdivided into three areas of consideration:

(1) Selection of quantitative requirements (i.e., the numerical statement of required reliability).

(2) Selection of qualitative requirements (i.e., the elements of work to be implemented in a reliability program).

(3) Statement of contract requirements.

These subtasks are interrelated in many respects, but each also has specific needs and requires specific considerations and documentation.

Tasks (1) and (2) above suggest the performance of analytical studies, consideration of trade-offs, and formulation of decisions which are intended to identify, describe, or otherwise depict the objectives and requirements of the reliability program for a defined system. After these tasks have been essentially completed, it is then the primary concern of the SPO Reliability Coordinator to document the program requirements in a statement form to be used by the procuring activity in selecting a contractor to perform the work.

2.1.1 Selection of Quantitative Reliability Requirements

2.1.1.1 Definition

Reliability is a system parameter in that it is controllable and can be measured under specific conditions of operation. This concept of quantitative reliability is recognized within existing Air Force philosophy and is manifest in directives from all command levels. Such directives stipulate that quantitative reliability requirements be considered during the conceptual phases of planned programs.

The activity discussed in 2.1.1 is defined as that effort which relates to the determinations, decisions, and stipulations instrumental to selection of quantitative reliability requirements. This activity commences at the time of program identification and continues until a statement of quantitative requirements is defined.

2.1.1.2 Air Force Policy

Air Force policy which relates to selection of quantitative reliability requirements is summarized in Table 2-1.

2.1.1.3 Responsibilities for Quantitative Requirements Selection

The responsibilities of System Program Offices (and thus SPO Reliability Coordinators) and other associated levels of authority relating to selection of quantitative requirements are summarized in Table 2-2.

TABLE 2-1

SUMMARY OF AIR FORCE POLICY
RELATING TO SELECTION OF QUANTITATIVE RELIABILITY REQUIREMENTS

Air Force Document	Statement of Policy	Par. No.
AFR 80-5 4 June 1962	(1) During the conceptual and acquisition phases, systems will be analyzed, and a reliability program established for each. Each program will include a minimum acceptable reliability level as well as a reliability goal, with intermediate quantitative values required to measure progression. Where sufficient sampling permits, a stated minimum acceptable confidence level should be included for each probability value.	4.a.(3)
	(2) Reprocured spares and parts will be procured to definitive reliability requirements.	4.a.(4)
	(3) Specifications, exhibits, work statements, product descriptions, and contracts for systems and associated materiel, including GFE for inventory, will include specific minimum acceptable reliability requirements as one of the major engineering factors. Individual parts specifications will include current failure rate level and up to four discrete graduated levels representing state of the art advancements. The total number of levels will be governed by systems requirements.	4.b
	(4) System contracts will include a requirement for a comprehensive contractor reliability program, including quantitative requirements.	4.c
AFSCR 80-1 14 Dec. 1962	(1) Proposed system package plans (PSPP's), system package programs (SPP's), and development plans (DP's) will contain a narrative statement delineating the desired reliability characteristics. However, comprehensive reliability programs for feasibility studies, exploratory development, and advanced development categories are not desired.	4.b
	(2) Quantitative reliability requirements will be developed from stated objectives and stated in specific numerical terms in the appropriate contractual documents and systems specifications and will include the definition of satisfactory operation, including operating time or cycles, environmental conditions, and where practicable, the confidence levels to which the specified probabilities will be demonstrated.	4.c
	(3) Quantitative reliability figures will be stipulated for the reliability goal, the minimum acceptable reliability requirements and the achieved reliability at such specified intermediate points as necessary to measure progress.	4.d
AFBSDR 80-5 28 Dec. 1962	(1) Quantitative requirements and provisions for demonstration will be incorporated into future contracts and into existing contracts as appropriate.	5.d

TABLE 2-2

SUMMARY OF RESPONSIBILITIES

RELATING TO SELECTION

OF QUANTITATIVE RELIABILITY REQUIREMENTS

Air Force Document	Level to Which Assigned	Statement of Responsibility	Par. No.
AFR 80-5 4 June 1962	Hq, USAF	(1) Insure that specific operational requirements and system documentation include numerical reliability requirements and adequate provisions for reliability programs.	5.b
	AFSC	(1) Establish objectives for system analysis and quantitative reliability requirements for use in the conceptual phase.	6.b
		(2) Incorporate quantitative reliability requirements and provisions for demonstrating reliability in all specifications, exhibits, product descriptions, work statements and contractual clauses to be referred to or included in contracts for systems and associated material.	6.c
AFSCR 80-1 14 Dec. 1962	AFSC Divisions and Centers	(1) Develop and incorporate quantitative reliability requirements in PSPP's, SPP's, DP's*, and other programming documents that may be applied to individual systems.	6.a
	System Project Offices (SPO's)	(1) Establish with the collaboration of the operating command and technical assistance from the development division realistic quantitative reliability requirements for the system.	7.b
AFBSDR 80-5 28 Dec. 1962	SE/TD Contractors	(1) Establish numerical reliability requirements for each contractor.	6.c

*PSPP = Proposed System Package Plan
SPP = System Package Program
DP = Development Plan

2.1.1.4 Implementation of Quantitative Requirements Selection

The following steps represent the basic procedure for selecting a quantitative reliability requirement for a defined system:

(1) Determine, to the extent possible, the mission of the system.

(2) Determine the need for establishing a quantitative requirement.

(3) Determine the form in which the quantitative requirement can best be stated (e.g., mean time between failures, probability of survival, etc.).

(4) Determine the number and nature of the requirements to be stated (e.g., possible utilization of a higher reliability goal in addition to minimum acceptable and intermediate values).

(5) Perform trade-off analyses between reliability and other parameters (e.g., system cost, weight and space limitations, etc.).

(6) Determine the requirements for reliability demonstration.

(7) Determine statistical confidence levels to be associated with the quantitative requirements.

(8) Perform an estimate of attainable reliability.

(9) Prepare a formal statement of the quantitative reliability requirement for the system.

The above listing generally represents the sequence in which the procedural steps should occur, but deviations to this order will not necessarily prevent successful accomplishment of the task.

The separate steps in selecting a quantitative requirement are discussed in detail in following sections.

2.1.1.4.1 Description of System Mission

Numerical reliability is associated with the concept of system mission (see Appendix F). Hence, in determining a quantitative reliability requirement for a system, the system's mission must first be defined and understood. Although the full details of the mission may not be established until a later time, some information should nevertheless be available at the time when quantitative reliability is initially considered.

The specific mission characteristics which should be defined in order to develop a realistic reliability requirement include:

(1) The function to be performed by the system (or its subsystems or major components).

(2) The intended operating conditions and/or environment.

(3) The duration of the mission.

(4) The feasibility of repair of the system before, during, and after the mission.

(5) The intended useful life of the system, either in time or number of missions to be performed.

Regardless of the time at which these characteristics are considered, the information available on them can be expected to vary in degree of accuracy and completeness. However, they should be defined to the extent possible with such information.

Various formal and informal documents will exist prior to any contract award which can provide assistance in describing the system's mission. Typical types of documents (the document titles may vary from program to program) which will normally be available include:

(1) Specific Operational Requirement (SOR) -- This document states a need for a capability, outlines a system or major component for achieving it, and gives reasons for the requirement.

(2) Advanced Development Objective (ADO) -- This document outlines an experimental system or major component which is not yet assured as to military usefulness, technical feasibility, and financial acceptability.

(3) Proposed System Package Plan (PSPP) -- This document identifies the responsibilities, tasks, resources, and time phasing of the major actions of each Air Force organization participating in a system program.

In addition, the conceptual phase of a program will be characterized by a series of correspondence, reports, or descriptive statements which will contribute to overall knowledge of the mission requirements.

2.1.1.4.2 Need for Establishing Quantitative Reliability Requirement

The need for establishing quantitative reliability requirements is generally applicable to Air Force research and development for systems, subsystems, and equipment (see Table 2-1). There are few situations when a decision should be made to negate formulation of quantitative requirements. In the event, however, that such a decision is deemed in the best interests of the Air Force, it must be fully justified, and the ultimate decision will warrant action by high levels of authority.

2.1.1.4.3 Form of Expressing Quantitative Requirements

There are several forms in which numerical reliability requirements can be expressed. Table 2-3 lists and defines the more common forms, and gives certain guidelines to assist in determining which form of expression is appropriate to a particular selection. There is no general restriction in Air Force policy which dictates the specific manner in which the quantitative reliability requirement for a system is to be expressed (although BSDR 70-16, Contractual Reliability Requirements, dated 28 December 1962, prescribes the use of "probability of mission success" and/or "mean time between failures").

TABLE 2-3

FORMS OF EXPRESSION FOR NUMERICAL RELIABILITY
AND GUIDELINES FOR SELECTING FORMS
TO BE USED IN STATING QUANTITATIVE RELIABILITY REQUIREMENTS

Form of Expression	Definition
Mean time to failure	The average or mean life of an irreparable item (expressed in hours or cycles)
Mean time before failure (or between failures)	The limit of the ratio of operating time to the number of failures, as the number of failures approaches infinity (expressed in hours or cycles)
Reliability of equipment	The probability that an item will satisfactorily perform a given function for a definite period of time under specified conditions (expressed as a percentage or a decimal fraction of 1)
Probability of mission success	The probability that a given item will satisfactorily perform a stated mission (expressed as a percentage or a decimal fraction of 1)
Failure rate	The number of failures per unit of operating time (usually expressed as the per cent of item failures during a 1000-hour interval)

Guidelines for Selecting Form of Expression to be Used

(1) A statement of numerical reliability in terms of "mean time" implies a known or assumed distribution of failure times. For example, in electronic equipment, failures are usually assumed to occur at a random rate.

(2) A statement of "mean time," when accompanied by information concerning the distribution of failure times, can be easily converted to a probability statement.

(3) "Mean time to failure" is generally used only in conjunction with an irreparable item.

(4) "Probability of mission success" is generally used for one-shot items for which the mission is known and success can be defined. Its use is not restricted to such situations, however.

(5) "Failure rate" is most often associated with simple levels of consideration (e.g., parts).

(6) "Mean time before failure" is the reciprocal of "failure rate" when the failure rate is constant.

(7) "Probability" can be associated with either a given time (or number of cycles) or a defined mission, whichever represents the most adequate description of system requirements.

2.1.1.4.4 Number and Nature of Quantitative Requirements

The ultimate objective of this task is to determine whether primary and/or sole emphasis will be placed on the formulation of:

(1) A single numerical reliability requirement (usually called "minimum acceptable value"), or

(2) A series of discrete graduated levels of numerical reliability as based on anticipated advancement of the state of the art or planned progress (usually called the "idealized reliability growth curve" and depicted as shown in Figure 2-1).

The later method (2) of establishing numerical requirements is stipulated within AFR 80-5 and AFSCR 80-1 (see Table 2-1). When the growth curve is used to describe numerical requirements, the point or points on the curve that are to be accompanied by reliability demonstration should be identified.

2.1.1.4.5 Relationship of Reliability to Other System Parameters ("Trade-Offs")

The development of quantitative reliability requirements for a system requires consideration of restricting relationships between reliability and other system parameters. The principal system parameters which affect reliability are shown in Figure 2-2 and discussed in following sections.

FIGURE 2-1

EXAMPLE OF "IDEALIZED" RELIABILITY GROWTH CURVE

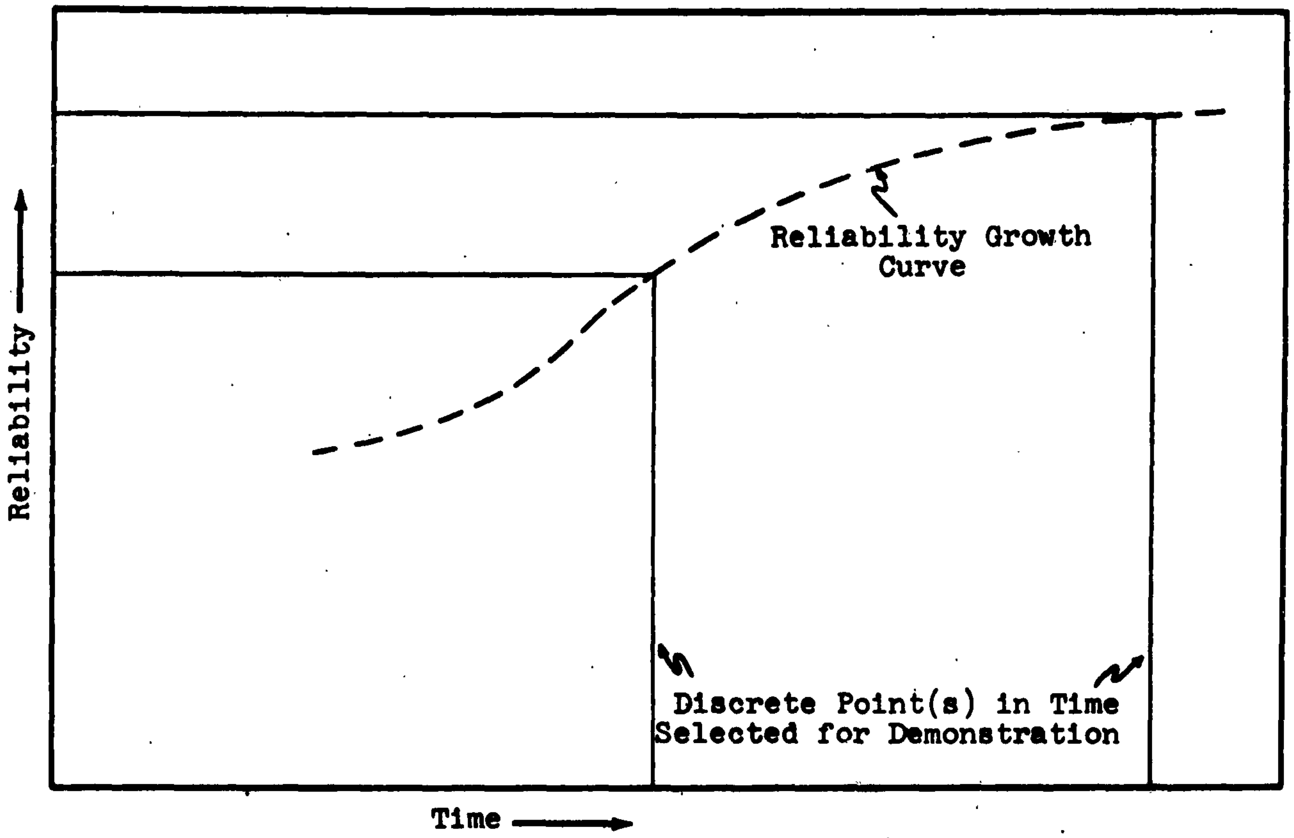
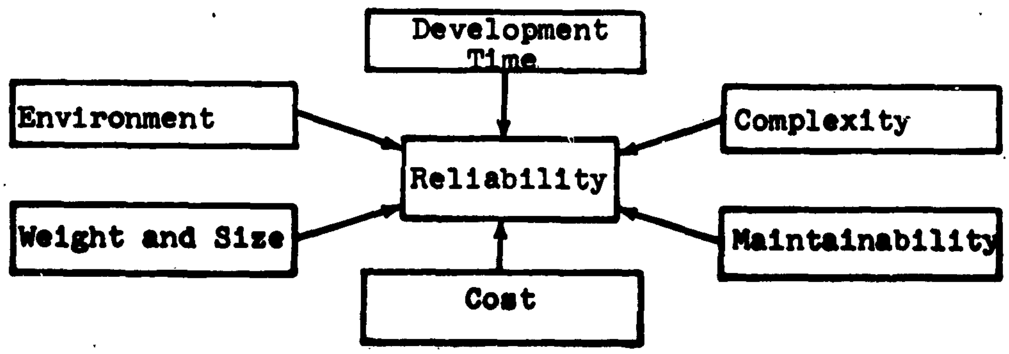


FIGURE 2-2

SYSTEM PARAMETERS WHICH AFFECT SYSTEM RELIABILITY



2.1.1.4.5.1 Development Time

Since the relationship of development time to reliability is difficult to assess quantitatively, the assumption is often made that development time does not affect reliability. However, there is qualitative evidence that drastic shortening of development schedules adversely affects system reliability.

Figure 2-3 shows that a gradual increase in reliability occurs as a program progresses from the feasibility stage to the production stage. This reliability growth results from:

(1) Redesign of immature or weak components.

(2) Elimination of part misapplications.

(3) Improvement of part and system quality.

(4) Elimination of interfaces, cabling, and other system type problems which reduce reliability.

(5) Elimination or improvement of poor reliability items discovered through demonstration and environmental tests.

(6) Improvement of manufacturing and inspection procedures.

Shortening or compression of development schedules does not allow for the natural progression of the above factors and is therefore likely to involve compromises with respect to reliability.

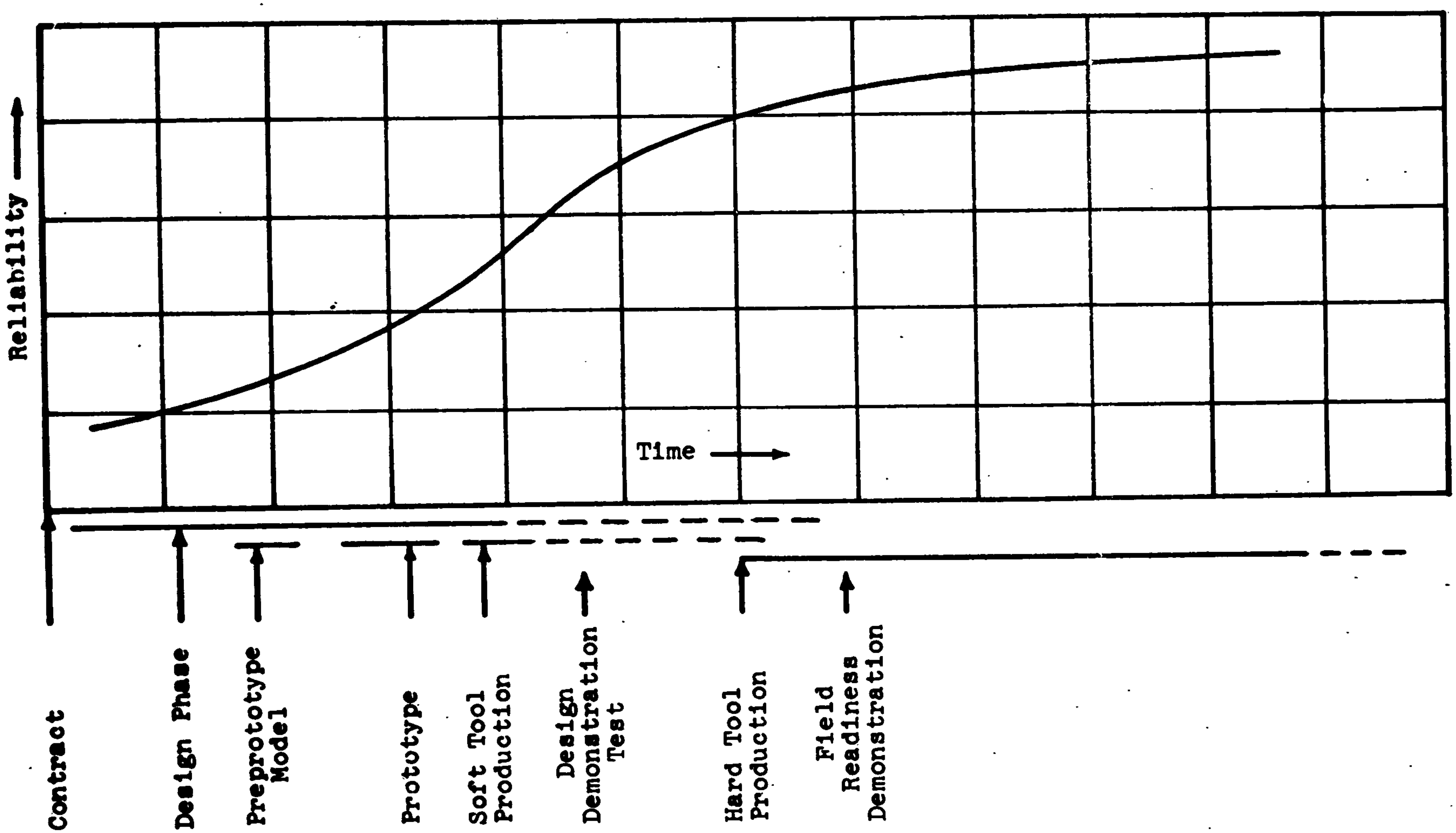
If schedules must be established which do not permit completion of desired reliability activity, measures must be taken to compensate for the decrease in reliability. These measures may include more careful maintenance, protection from environment, special instructions to the user, or increase in production quantities.

2.1.1.4.5.2 Complexity

As the complexity of an equipment increases, its reliability decreases; further, the reliability decrease is more rapid then the complexity increase (see Figure 2-10 in 2.1.1.4.8).

FIGURE 2-3

RELATIONSHIP BETWEEN RELIABILITY AND DEVELOPMENT TIME



2.1.1.4.5.3 Availability

Availability is the probability that a system (subsystem, equipment, device, etc.) will be operable at a desired instant of time when used under specified conditions. This probability statement is concerned with an instant or point in time rather than a duration or a given interval; this is the significant difference between availability and reliability. Also, the term "availability" is concerned with whether the system is available to operate at a given instant regardless of whether it is actually in operation. Thus, if the system is in a good state of repair, it makes no difference whether it is "turned on" or "turned off," provided that sufficient "warm up" time can be planned prior to initiating a mission.

Availability can be estimated from the ratio

$$A = \theta / (\theta + \phi),$$

where θ = system MTBF.

and ϕ = system mean "down time."

This is an estimator rather than a definition. It is a rigorous definition only if the exact values of θ and ϕ can be found.

2.1.1.4.5.4 Maintainability

Maintainability is the probability that, when maintenance action is initiated under stated conditions, a failed system will be restored to operable condition within a specified total down time.

Maintainability, by this definition, is synonymous with the usual meaning of the word "repairability" or reparability." The time duration of interest in this definition must, itself, be precisely described. In some usages of the term "maintainability," only that time duration which a repair operation is actively being carried out is considered; and administrative time and logistic time are omitted. However, inclusion or omission of these additional periods of time may be left to the desires or needs of the moment, provided the conditions are clearly stated.

Estimation of maintainability is essentially identical to estimation of reliability. To assess maintainability of an existing system, one must observe the length of time each maintenance action requires; from such data a maintainability function may be generated by non-parametric means, or parameters may be estimated if a distribution has been assumed. To predict maintainability, one must define certain ground rules and assumptions upon which to base derivation of a mathematical model of the maintainability function of the system. Into this model may be inserted data derived from past experience with maintenance of similar systems; this constitutes a prediction of maintainability.

The relationship between reliability and maintainability must be discussed in terms of availability (see Figure 2-4). The graph shows that, for a given value of availability, a decrease in reliability (expressed as a decrease in mean-time-between-failures) can be traded-off by a corresponding increase in maintainability (expressed as a decrease in mean-time-to-repair). Conversely, if reliability can be increased, requirements for maintainability can be relaxed while maintaining the same availability.

Figure 2-5 illustrates the trade-off discussed in the preceding paragraph. If point O in the figure represents the status of a design with respect to reliability and maintainability, an improvement in reliability can have one of several effects: maintainability can be improved (a), kept constant (b), or reduced (c), depending on how repair times are affected by the design change. Thus, reliability changes in the conceptual design phase must be carefully evaluated as to their effect on maintainability and availability.

MIL-M-26512C (USAF), "Maintainability Program Requirements for Aerospace Systems and Equipment" establishes maintainability program requirements and policies. Included is a detailed procedure for prediction, testing and demonstration of availability and maintainability.

FIGURE 2-4

RELATIONSHIP BETWEEN RELIABILITY (EXPRESSED IN TERMS OF MTBF), MAINTAINABILITY (EXPRESSED IN TERMS OF MTTR), AND AVAILABILITY

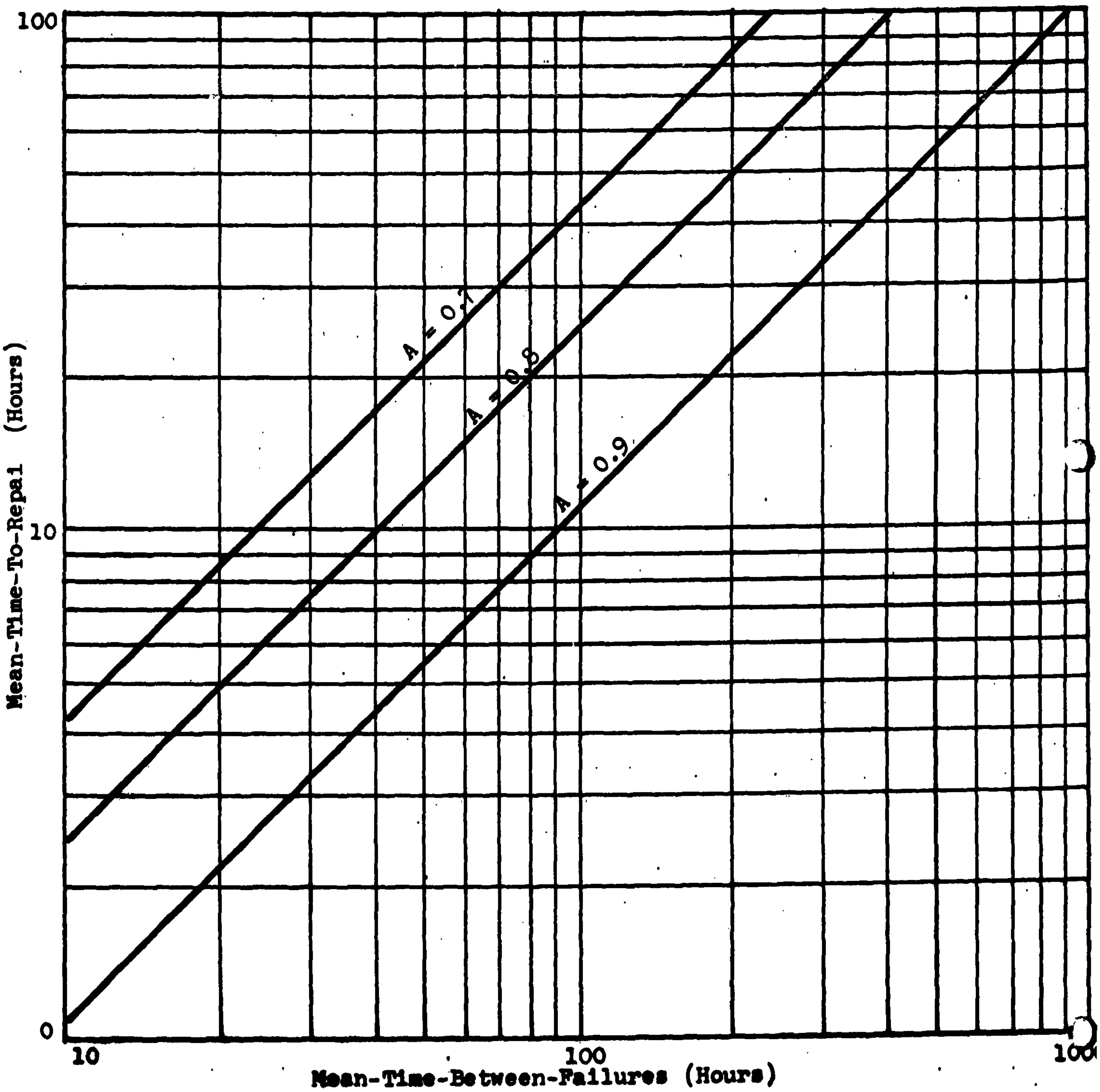
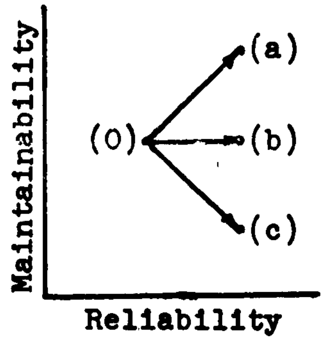


FIGURE 2-5

RELIABILITY/MAINTAINABILITY TRADE-OFF



2.1.1.4.5.5 Cost

Figure 2-6 shows the characteristic relationship between system cost and reliability: as system reliability increases, operational costs decrease but development costs increase. The total cost of a system program is the summation of development and operational costs, and the most efficient program cost/reliability relationship is represented by the lowest point on the cost summation curve in Figure 2-6. This trade-off effectively illustrates that when reliability is related to cost, both procurement and maintenance costs must be considered.

When costs are strictly limited on a program and some reliability activity must be curtailed, such precautions as special instructions to the user and more frequent maintenance activity should be followed to compensate for loss of reliability.

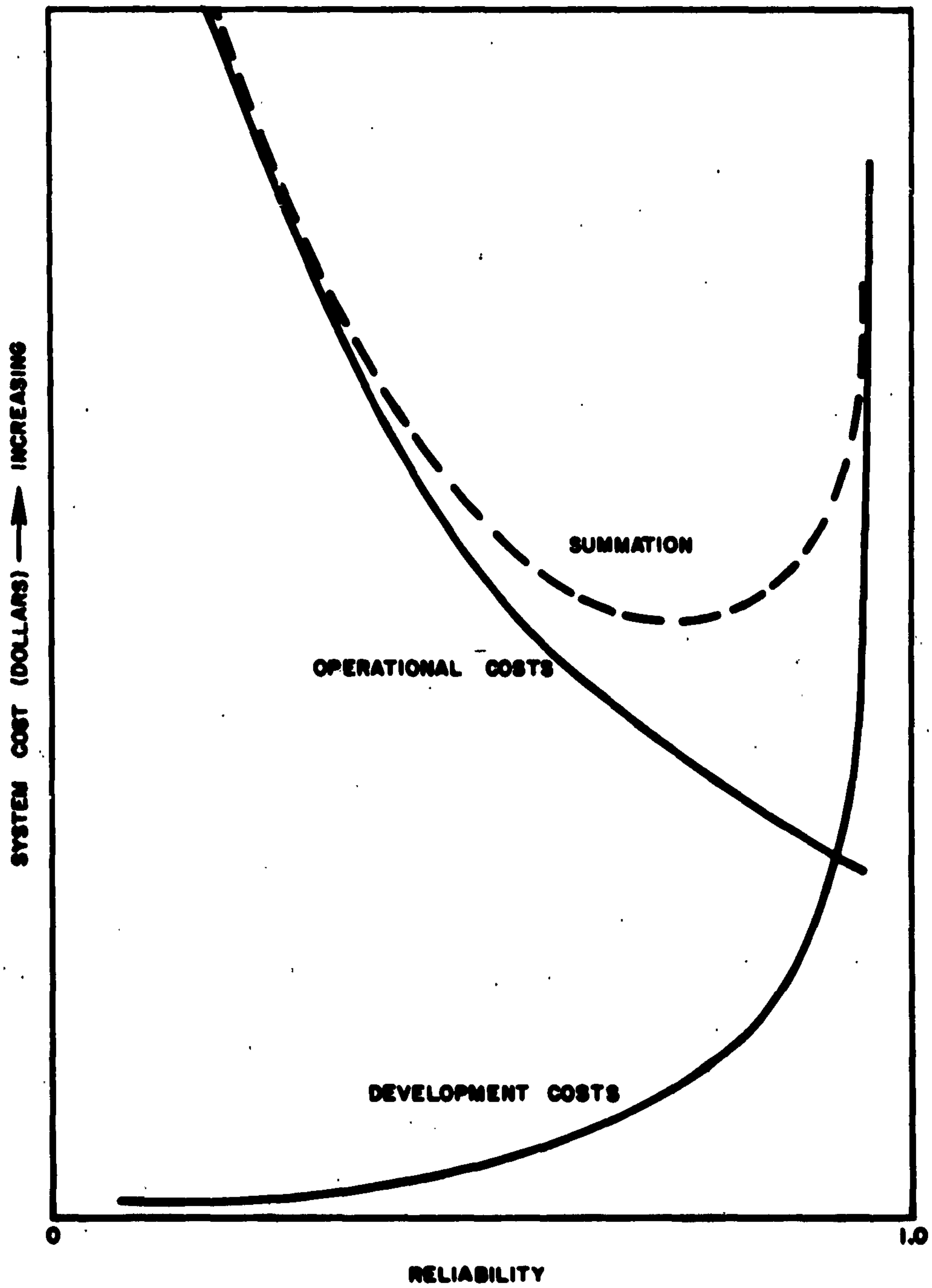
2.1.1.4.5.6 Weight and Size

Weight and size are factors which must often be traded-off with reliability, particularly in airborne and satellite applications.

Size and weight reductions can be made through the use of miniaturized and low-power components, but these changes are not always without adverse effects on reliability. Indiscriminant reductions in size and weight can cause short circuits, incorrect wiring, overheating, overstressing, and increased maintenance.

FIGURE 2-6

RELATIONSHIP BETWEEN RELIABILITY AND SYSTEM COST



NOTE: A KNOWN USEFUL LIFE WAS ASSUMED IN PLOTTING OPERATIONAL COSTS.

On the other hand, when reliability is a paramount consideration, as in safety applications, it can be improved through weight and size increases in the form of redundancy. Figure 2-7 shows that if a unit with a reliability of 0.6 is applied in redundant configurations of 2, 3, 4, --- units, the reliability of the over-all configuration is rapidly increased. Assuming that no weight is required for switching the redundant units, the horizontal scale in the figure can be read in terms of relative weight or size.

2.1.1.4.5. 7 Environment

Although environment may not be strictly considered as a system parameter, it nevertheless has an important effect on reliability. In general, reliability decreases as the severity of environment is increased (see Figure 2-8). Thus, if there is no way to influence the applied environment, the choice of parts and components should be made on the basis of maximum performance in the most severe environment expected to be encountered.

2.1.1.4.6 Requirements for Reliability Demonstration

It is impractical to consider quantitative reliability as a program requirement unless there is a provision for reliability demonstration. A reliability level which is not to be realized through demonstration must be considered a goal, rather than a requirement which is binding on a contractor.

Full details for reliability demonstration will usually not be developed until some time after a contract is awarded. However, during the formulation of reliability requirements, it is desirable to set forth as much information as possible concerning:

(1) The intended time of demonstration, or time at which demonstration will first become feasible.

(2) The extent of demonstration -- whether it is to be a one-time occurrence or a planned series of activities. If the demonstration is planned as a series of progressive steps, these steps should coincide with major program milestones, such as a preproduction demonstration or a service-readiness demonstration.

FIGURE 2-7

RELATIONSHIP BETWEEN RELIABILITY, REDUNDANCY, AND WEIGHT/SIZE

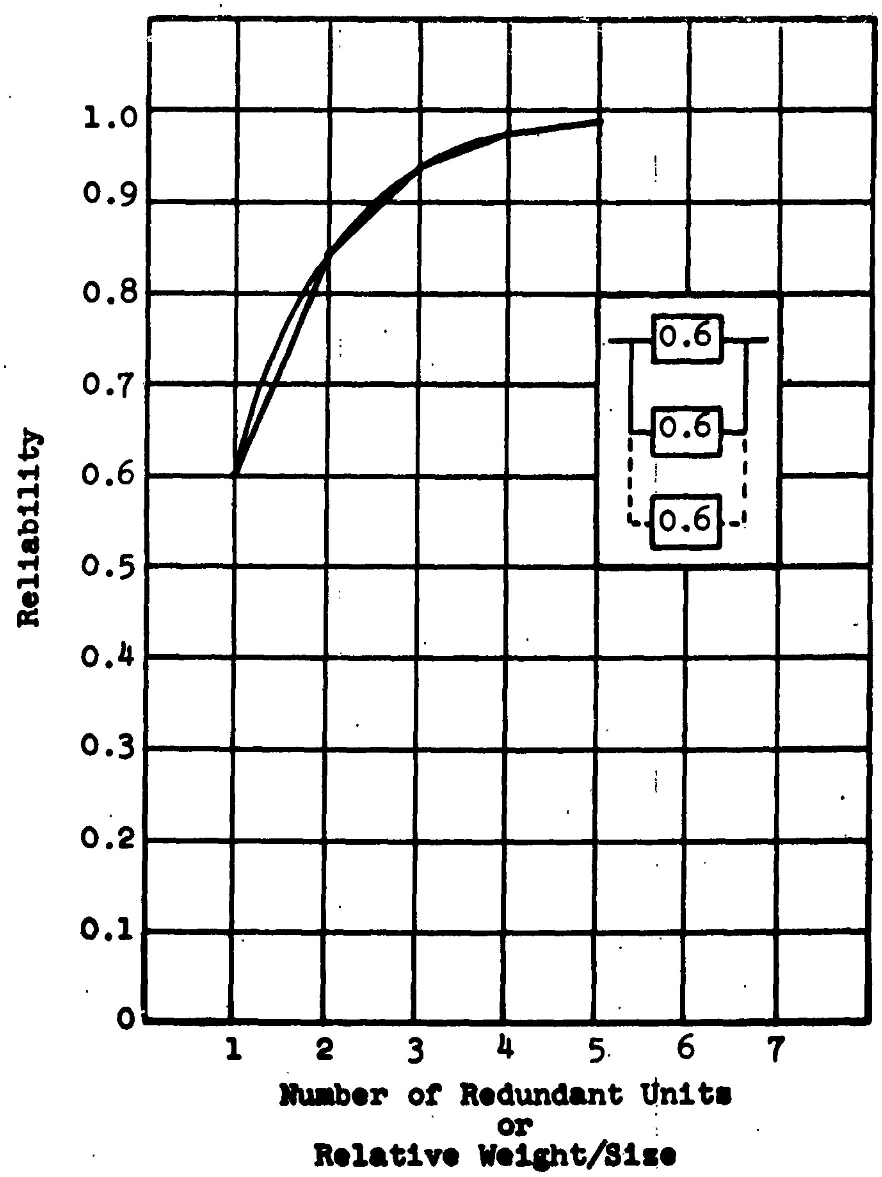
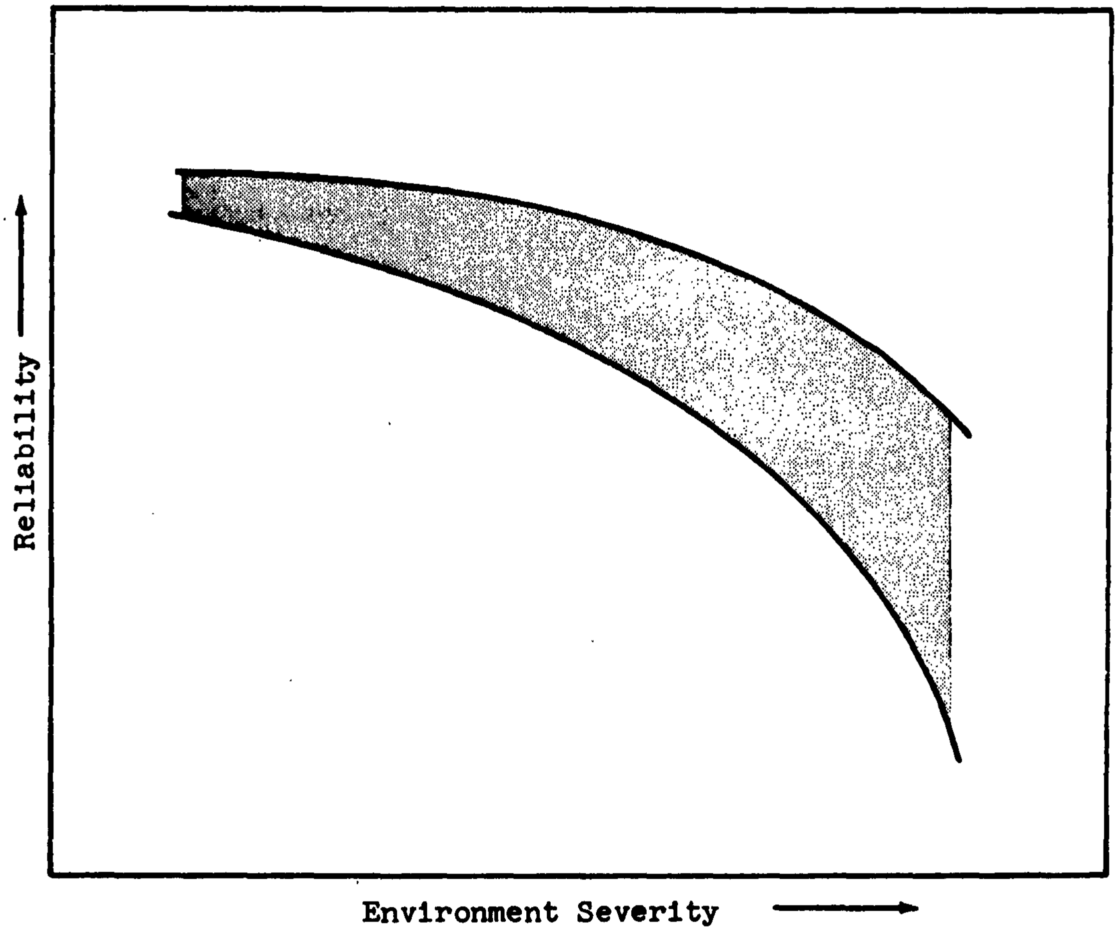


FIGURE 2-8

RELATIONSHIP BETWEEN RELIABILITY AND ENVIRONMENT



2.1.1.4.7 Confidence Levels for Quantitative Requirements

A quantitative statement of required reliability can be formulated for a system without expressing statistical confidence levels. However, as discussed in 2.1.1.4.6, a quantitative reliability requirement is intended to be demonstrated, and for the process of demonstration, it is necessary to indicate a required confidence level (i.e., degree of assurance, expressed as a percentage, that the reliability value measured in the demonstration test is the actual reliability of the system).

Figure 2-9 represents an example of graphically illustrating the quantitative relationship between statistical confidence level, reliability requirement, and parameters of reliability demonstration such as number of failures encountered and required operating time. This example is restricted to the assumption that only one failure is allowed during demonstration. In this figure, reliability is expressed as a probability of mission success, with the number of equivalent missions required for demonstration plotted as a function of required mission reliability. Plots are shown for several assumed levels of desired confidence.

Figure 2-9 is not, of course, of general application and is only to be used if all conditions are met, including the assumption that only one failure is allowed. It has been introduced at this point solely to show that in establishing a quantitative reliability requirement, there must be an accompanying understanding of the implications with respect to reliability demonstration and statistical confidence.

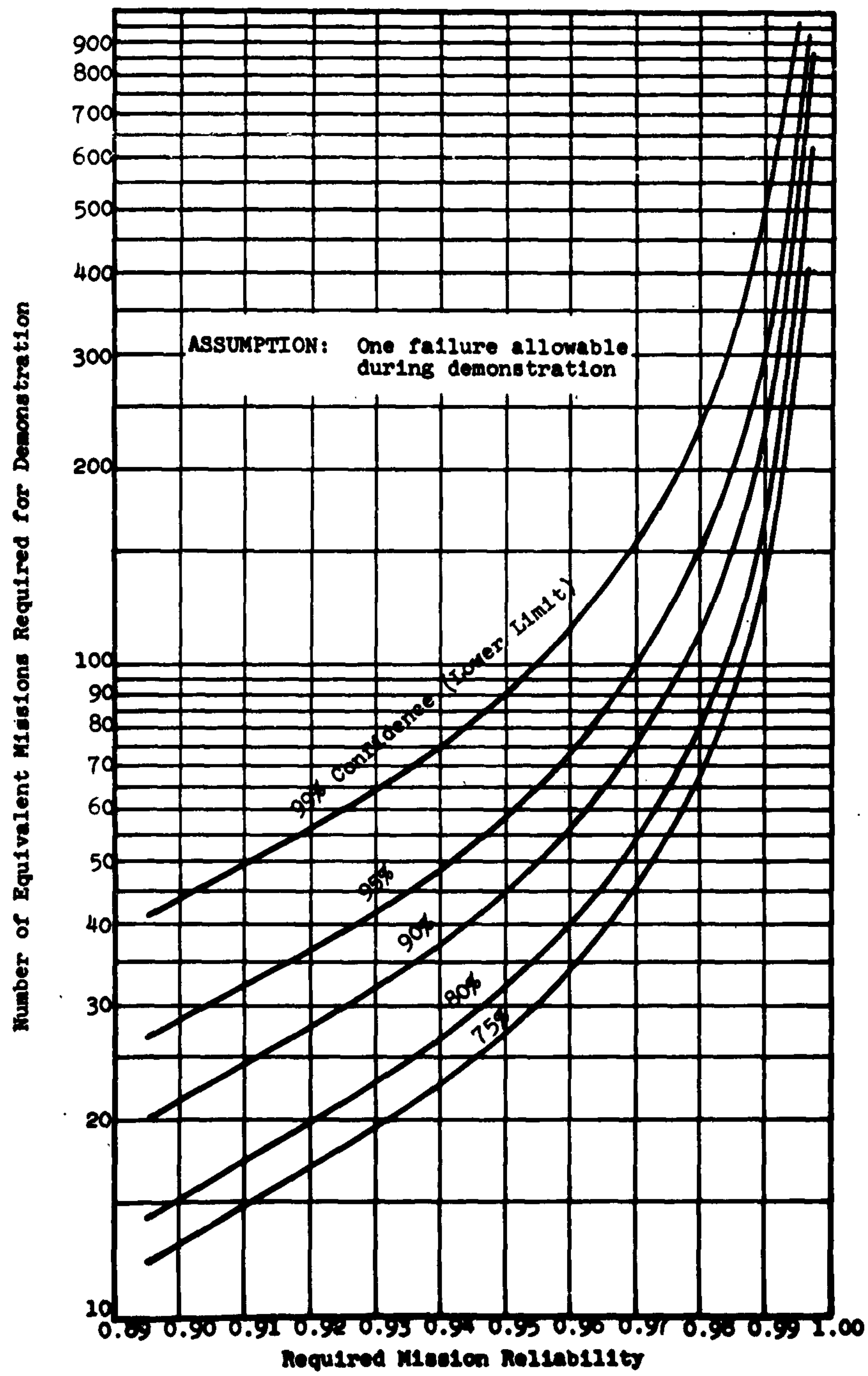
2.1.1.4.8 Estimates of Attainable Reliability

The process of estimating or "predicting" the reliability of a new system is essential to the formulation of a quantitative reliability requirement for the system. In some instances, the reliability prediction technique serves as the sole basis for the initial statement of required reliability. In other instances, where a quantitative requirement has been determined by some other means (such as a definite tactical need or an arbitrary decision as to required operational capability), the prediction technique can be utilized for comparative analysis.

During the conceptual phase of a program, comparatively little data will be available to serve as the basis

FIGURE 2-9

HYPOTHETICAL EXAMPLE OF RELATIONSHIP
BETWEEN RELIABILITY AND DEMONSTRATION PARAMETERS



for estimating attainable reliability. The standard approach to predicting reliability of a new system is, therefore, to investigate past performance of identical or similar systems. The following are three examples of techniques employing this approach:

(1) Figure 2-10, taken from MIL-STD 756A, Reliability Prediction Procedures for Aircraft, Missiles, Satellites, and Electronic Equipment, dated 15 May 1963. This chart is intended to provide a method of prediction based on general considerations of environment and equipment complexity. It was derived through interpretation of observed data for systems operating (prior to 1960) in ground, shipborne, and airborne environments.

(2) Figure 2-11, taken from Aerospace Corporation Report No. ATM-63(3303)-1, Reliability Practices and Problems for Spacecraft and Missile Systems, dated 1 October 1962. The information plotted in this curve was derived from an analysis of mission success associated with the launching of U. S. space vehicles.

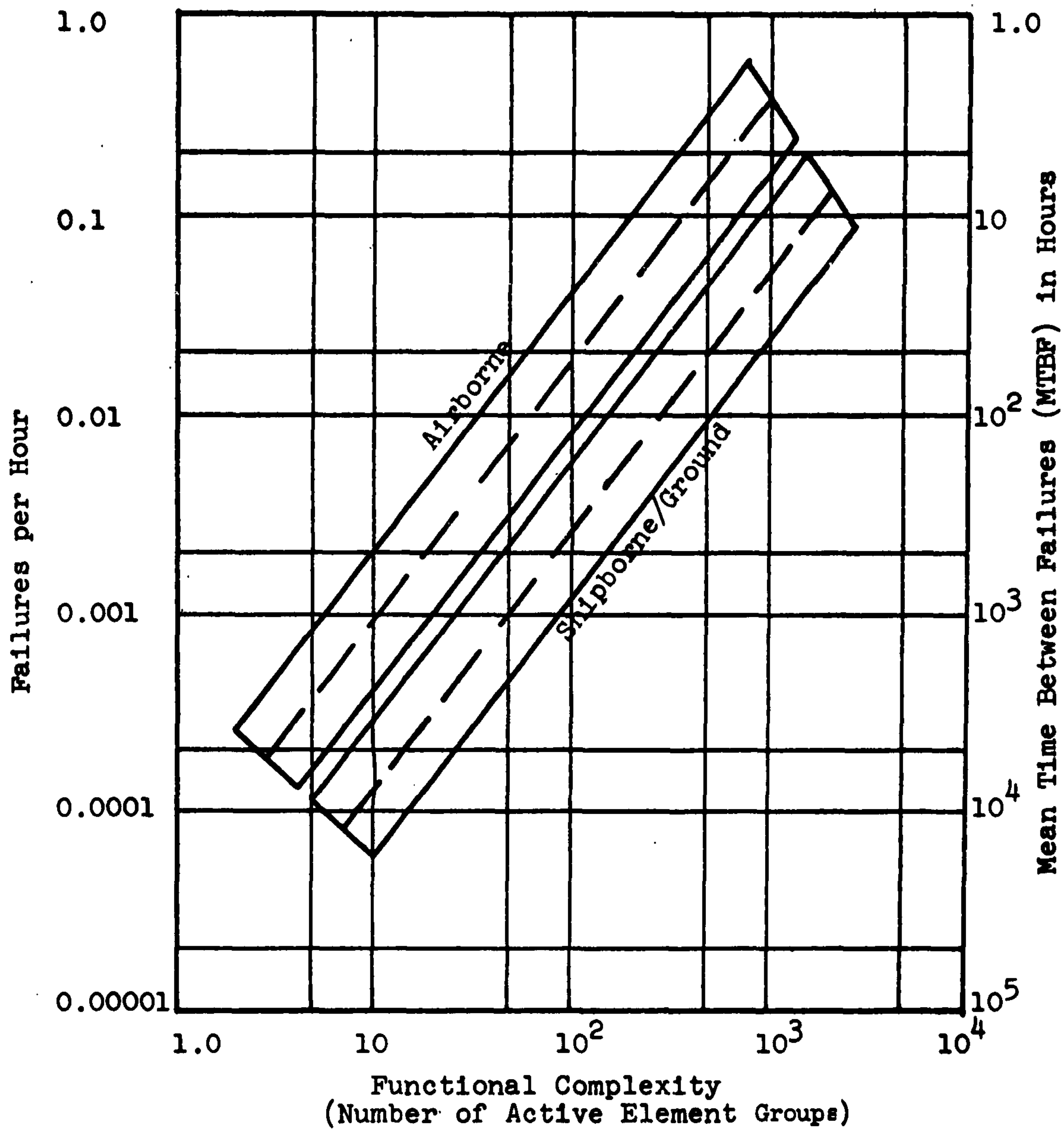
(3) A presentation of observed reliability for certain Air Force ground electronic equipments as a function of equipment complexity (in number of system parts), in an article entitled, "The Measurement and Specification of Product Abilities," by F. A. Cafaro and H. D. Voegtlen, in Industrial Quality Control, March 1962.

These examples are not cited to suggest prediction tools which have general application. Rather, they are mentioned to illustrate that techniques for analyzing and summarizing data from past performance have been and are continuing to be developed. Hence, when formulating a quantitative requirement for a specific new program, it is advisable to exploit available sources in determing the applicability of observed past performance.

Any estimate or prediction of system reliability should, of course, be related to the point in time at which attainment is implied. For example, if the estimate is based upon anticipated advancement of the state-of-the-art, the expression of the estimate should be so qualified.

FIGURE 2-10

FAILURE RATE AND MTBF VERSUS FUNCTIONAL COMPLEXITY FOR ELECTRONIC EQUIPMENT*



Notes: (1) Active element group (AEG) = one electron tube or transistor and associated circuitry (or ten computer diodes and associated circuitry in digital computers)

(2) Reliability estimate obtained from this chart represents band of possible outcomes. Upper limit of band is obtainable with good reliability and design effort.

*Figure taken from MIL-STD 756A.

FIGURE 2-11

TOTAL MISSIONS VERSUS SUCCESSFUL MISSIONS --
U. S. SPACE VEHICLES (INCLUDING BOOSTERS)*

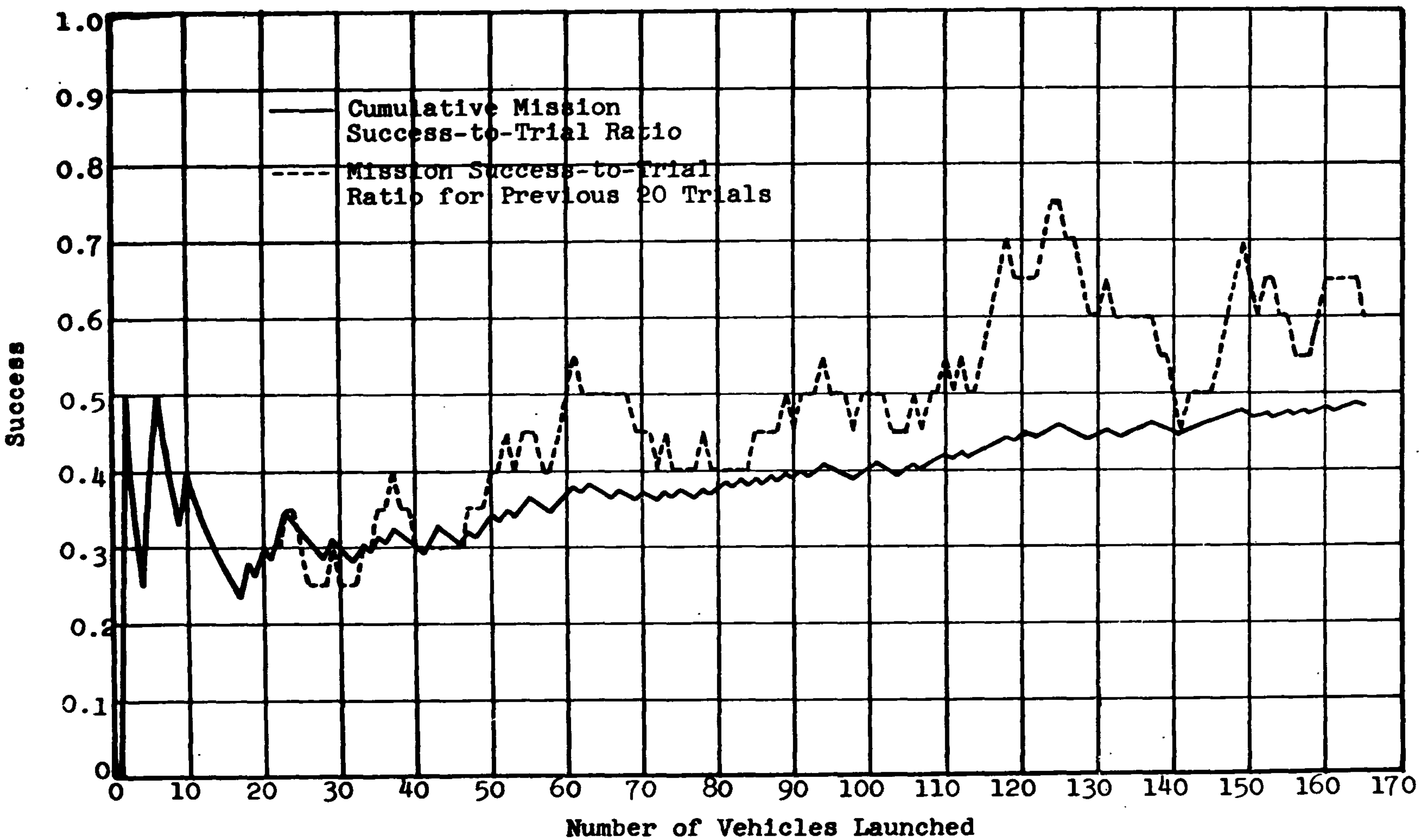


*Figure taken from Aerospace Corporation Report No. ATM 63(3301).

2.1.1.4.9 Statement of Quantitative Requirement

The culmination of the efforts described in 2.1.1.4.1 through 2.1.1.4.8 is a formal statement of quantitative reliability requirements for a particular program. In setting forth this statement, the attempt should be made to express the requirement in a manner suitable for inclusion in a contract.

The actual numerical statement of the reliability requirement will most likely be brief, as typified by the following examples:

Sample Statement (1)

The minimum acceptable reliability requirement for the system is 90% probability of success, demonstrated to a 90 per cent confidence level for the mission profile as defined in (cite reference).

Sample Statement (2)

The minimum acceptable reliability for the system is as follows (constant failure rate assumed):

Configuration	MTBF (hr.)	Confidence Level (%)*
X	500	90
Y	750	90
Z	1000	80

*Demonstration Requirement

Sample Statement (3)

The minimum acceptable reliability requirement for the system is 0.95 for a typical mission with a duration of 4 hours, demonstrated to a 90 per cent confidence level. The typical mission shall be as defined in (cite reference).

Sample Statement (4)

The failure rate for the part shall be no greater than 0.01% per 1000 hours of operation, demonstrated to a 60 per cent confidence level.

The brief numerical statement must, however, be augmented with considerable amplifying information such as assumptions, qualifications, definitions, and stipulations. This information could include any or all of the following items:

(1) Description of mission profile.

(2) Description of environmental conditions.

(3) Statement of type of failure distribution.

(4) Statement of program phase in which reliability demonstration is intended.

(5) Comparison of reliability requirement to known or anticipated state-of-the-art.

(6) Definition of mission success or failure.

(7) Description of equipment to which reliability requirement applies.

(8) Amplification of intended contractual significance of reliability requirement.

(9) In incentive contracts having reliability penalties and premiums, include a statement of minimum acceptable statistical confidence level for demonstration.

2.1.1.5 Problem and Special Considerations Relating to Quantitative Requirements Selection

2.1.1.5.1 Criticalness of Reliability

It is possible to identify some situations in which, based on subjective evaluation, reliability is less critical than are other factors. There are certain systems, for example, in which availability or maintainability are considered to take precedence over reliability. For such systems, management decisions may be appropriate to relax quantitative reliability requirements in order to improve or concentrate emphasis on the other system effectiveness and associated parameters).

The criticalness of reliability is, of course, related to the existing state-of-the-art for reliability achievement. But there are factors other than state-of-the-art which dictate required numerical reliability. For example, the criticalness of the reliability requirement may be increased if the tactical situation demands reliability in excess of that attainable through normal or routine practice. This problem occurred in the Minuteman program, and the necessary increase in capability was taken into consideration in planning the program effort.

2.1.1.5.2 State of Program Maturity

In 2.1.1.4, it was assumed that, in general, the process of selecting reliability requirements occurs early in the conceptual phase of a particular program. This assumption was based on the fact that a quantitative requirement must exist at the time a program is opened to bids. Often, however, the need arises to refine, amplify, or re-state the requirement at a later stage of the program. The guidance principles and procedures set forth in 2.1.1.4 are applicable to requirements initiation or review at any period during the life of a program.

2.1.1.5.3 Interpretation of Reliability Requirements

Different interpretations placed on the significance of a numerical reliability statement by the contractor and the customer are a common source of difficulty in contracted programs. Frequently, a contractor assumes that reliability values are intended to represent desired achievements or goals, while the customer has intended that they represent unequivocal obligations. To avoid such difficulty, the customer must:

(1) Emphasize the obligatory intent in expressing reliability requirements in contracts.

(2) Stipulate reliability requirements that are, in fact, realistic.

(3) Support the requirements by including a requirement for a feasible reliability demonstration program.

2.1.1.5.4 Inclusion of Quantitative Requirements in Incentive Clauses

The selection of quantitative reliability requirements is complicated when they are intended for inclusion in incentive contracts -- and particularly when reliability forms the basis for incentive. In such case, it is necessary to determine a "standard" requirement which can be related to a "standard" fee. In addition, the increase or decrease in fee as a function of the increase or decrease in achieved reliability must be established.

Considerable effort has been advanced to develop reliability incentives, and, based on current policy statements in AFR 80-5, it is apparent that such incentives will be extensively applied in future procurements.

2.1.1.6 Additional References on Quantitative Requirements Selection

Specification and Assurance of Large MTBF's Typical of Spacecraft Electronic Equipments, C. C. Petersen, Military Systems Design, April 1963, pp. 27-33.

Reliability Practices and Problems for Spacecraft and Missile Systems, F. P. Klein, Aerospace Corporation Report No. ATM-63(3303)-1, 1 October 1962.

Quantitative Reliability Requirements, Letter from B. A. Schriever, General, USAF, Commander AFSC, 25 January 1962.

2.1.2 Selection of Qualitative Reliability Requirements

2.1.2.1 Definition

The current approach to military procurement is to combine quantitative requirements (which stipulate measurable characteristics) with requirements which specify in detail the elements of work and level of effort to be implemented in a program. The specification of such qualitative requirements for a reliability program is not intended to limit the initiative of a contractor or relieve him of his responsibility for achieving a particular quantitative reliability requirement. Rather, it is intended to support the contractor's effort by providing adequate direction and enabling a common understanding of the scope, objective, and progressive achievement of the program.

Selection of qualitative reliability requirements, as discussed in 2.1.2, comprises that initial activity which is directed toward outlining , choosing, or developing the elements which will govern the scope of work and level of effort of a planned reliability program. This activity commences during the conceptual phase of the program and continues until adequate information exists to permit preparation of a statement of work or similar contractual instrument.

2.1.2.2 Air Force Policy

Air Force policy which relates to selection of qualitative reliability requirements is summarized in Table 2-4.

2.1.2.3 Responsibilities for Qualitative Requirements Selection

The responsibilities of System Program Offices (and thus SPO Reliability Coordinators) and other associated levels of authority relating to selection of qualitative requirements are summarized in Table 2-5.

TABLE 2-4

SUMMARY OF AIR FORCE POLICY
RELATING TO SELECTION
OF QUALITATIVE RELIABILITY REQUIREMENTS

Air Force Document	Statement of Policy	Par. No.
AFR 80-5 4 June 1962	(1) Inherent reliability is established by the basic design and can be improved only by design changes. The feasible time to implement reliability is during design and early development and testing.	3.b
	(2) Reliability will be stressed during early system studies, source selection, design, development, and production. It is of major consequence during the operational phase of the system, but its adequacy in that phase depends upon the emphasis received during the conceptual and acquisition phases.	4.a.(1)
	(3) During the conceptual and acquisition phases, systems will be analyzed, and a reliability established for each.	4.a.(3)
	(4) System contracts will include a requirement for a comprehensive contractor reliability program.	4.c
AFSCR 80-1 14 Dec. 1962	(1) Proposed system package plans (PSPP's) system package programs (SPP's), and development plans (DP's) will contain a narrative statement delineating the desired reliability characteristics. However, comprehensive reliability programs for feasibility studies, exploratory development, and advanced development categories are not desired. Due consideration shall be given to reliability in the early planning and feasibility study stages, and comprehensive reliability programs are expected for operational development projects.	4.b
	(2) Contracts for aerospace systems, major subsystems, and equipment will include a requirement for a comprehensive and organized contractor reliability program that extends through subcontractor and vendor levels.	4.e
	(3) Specific activities may be identified as reliability effort in order to provide a management tool for guiding and assessing adequacy of effort.	4.g
AFBSDR 80-5 28 Dec. 1962	(1) Specific reliability programs will be established for all ballistics systems or portions thereof having separate Air Force contracts for their development/procurement.	5
	(2) MIL-R-27542 will be incorporated into future Air Force ballistic missile contracts and into existing contracts as appropriate.	5.c

TABLE 2-5

SUMMARY OF RESPONSIBILITIES
RELATING TO SELECTION
OF QUALITATIVE RELIABILITY REQUIREMENTS

Air Force Document	Level to Which Assigned	Statement of Responsibility	Par. No.
AFR 80-5 4 June 1962	AFSC	Establish objectives for system analysis and reliability programs for use in the conceptual phase.	6.b
AFSCR 80-1 14 Dec. 1962	AFSC	Prescribe policies and procedures necessary to assure contractual requirements for reliability in each system, subsystem, or equipment being developed for the Air Force inventory.	5.a.(3)
	AFSC divisions and centers	Establish and man a staff office for reliability and related efforts (per AFSCR 23-30) to insure establishment of uniform policies, procedures, and programs.	6.d
	System project offices (SPO's)	Define, for contractual purposes, an adequate and comprehensive contractor reliability program for weapon and support systems, associate, and government-furnished subsystems.	7.d

2.1.2.4 Implementation of Qualitative Requirements Selection

The process of selecting qualitative reliability requirements for a particular program is characterized by a series of background investigations, trade-offs, decisions, and documentary stipulations. This series can be summarized as follows:

(1) Acquire an understanding of standard Air Force policy and requirements for reliability.

(2) Determine the level of comprehensiveness for the program.

(3) Estimate the degree of technical difficulty in achieving the quantitative requirements of the program.

(4) Determine the availability of resources (e.g., funds) for the program.

(5) Define potential problem areas.

(6) Investigate the applicability of previously developed requirement instruments.

(7) Select a method for outlining the elements of required effort.

(8) Outline the qualitative reliability requirements to the extent possible.

(9) Determine major exceptions to standard Air Force requirements.

(10) Determine the type of contractual instruments to be used.

These procedural items are listed in their general order of accomplishment for a hypothetical situation. Each item is discussed separately in following sections.

2.1.2.4.1 Standard Air Force Policy and Requirements

The initial step in formulating qualitative requirements is to determine the current Air Force regulations (at all levels of authority) and standard specifications which govern reliability programs. The documents listed in Table 2-4, considered either individually or cumulatively, identify areas of interest for which qualitative requirements must be formulated. In addition, a more detailed identification of areas of interest is manifested by MIL-R-27542A, Reliability Program for Systems, Subsystems, and Equipment. Concurrently, it is compulsory that MIL-R-27542A be incorporated in all system, subsystem, and equipment contracts.

SPO Reliability Coordinators should attain a complete understanding of the content of the documents mentioned above (or their successors) since these documents constitute directives for the formulation of reliability requirements.

2.1.2.4.2 Level of Comprehensiveness for Program

There is no precise method for objectively stipulating the level of comprehensiveness which will best serve the interest of a new program. The scope of the program must be initially estimated on a relative basis and subsequently refined through a series of trade-offs. However, as part of the process of selecting qualitative requirements, the SPO Reliability Coordinator should develop a general understanding of the desired level of comprehensiveness and define it, to the extent possible, in descriptive terms. Such action will undoubtedly require coordination with higher management.

Some guidance in determining the scope of new programs is provided by AFSCR 80-1, which states that comprehensive reliability programs are not desired for feasibility, exploratory development, and advanced development studies. However, this statement should not be considered to imply that reliability effort is to be omitted from such studies.

Rather, these are times for thorough analysis of a system's reliability potential.

2.1.2.4.3 Degree of Technical Difficulty in Achieving Quantitative Requirement

It is desirable to relate the quantitative reliability requirement for a system to current and anticipated capabilities for reliability achievement, in order to indicate how much advancement (if any) in the state-of-the-art must be obtained through program efforts. A sincere attempt should be made to objectively assess the degree of difficulty of achieving the requirement -- by comparison with past performance of similar systems, by consideration of the known capabilities of the appropriate segment of industry, or as a last resort, by "expert opinion". Some assessment should be made even if data of desired accuracy are lacking.

2.1.2.4.4 Availability of Resources

To the customer, the program resource of principal interest is the funds available for performing the intended effort. Knowledge of the funds allotted for reliability can provide considerable guidance in determining the qualitative reliability requirements to be applied to a program. The SPO Reliability Coordinator should therefore possess information concerning the allocation of funds to the various interests within the program. (It is not meant to imply that the SPO Reliability Coordinator does not contribute to the process of allocation; rather, it is assumed that he will be continuously active in making the needs of the reliability program known.) (See 3.4.4.1 for further discussion of program funding.)

2.1.2.4.5 Potential Problem Areas

The identification of potential problem areas relative to reliability achievement may, typically, be expected to concern any one of the following:

(1) An identifiable element of the system with known poor reliability.

(2) An identifiable element of the system with unknown capabilities.

(3) A known environmental condition (e.g., high temperature) which is significantly determental to reliability.

(4) A quantitative reliability requirement which is of such magnitude as to cause difficulty in demonstration.

(5) An apparent difficulty in respect to capability for simulating environments.

(6) A complexity factor which suggests the need for extreme parts control.

(7) A design concept which suggests the need for extensive development.

2.1.2.4.6 Applicability of Previously Developed Requirement Instruments

In formulating qualitative requirements for a new program, the SPO Reliability Coordinator may be guided to some extent by requirement documentation (e.g., exhibits, requirements statements, program plans, reports, etc.) previously generated in support of other system programs. In determining the applicability of these documents for purposes of guidance, the following factors should be considered:

(1) Similarity of program scope.

(2) Similarity of equipment.

(3) Similarity of environment.

(4) Similarity of mission.

(5) Similarity of quantitative requirements.

(6) Currency of the document.

(7) Demonstrated effectiveness of the document as a requirement instrument.

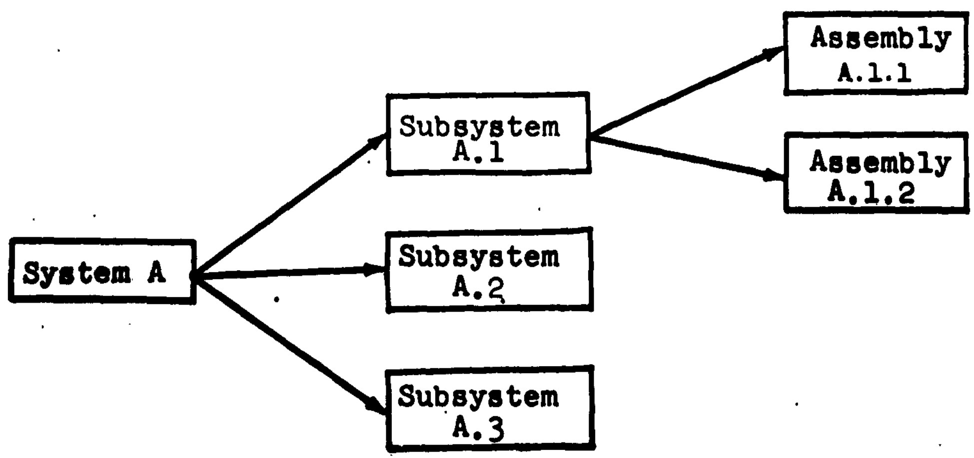
2.1.2.4.7 Methods of Outlining Elements of Required Effort

Several basic approaches can be used to initially outline the elements of required program effort, including the following four methods:

(1) Identification of equipment items -- The reliability program is described in terms of the equipment configuration, as illustrated in Figure 2-12.

FIGURE 2-12

IDENTIFICATION OF EQUIPMENT ITEMS



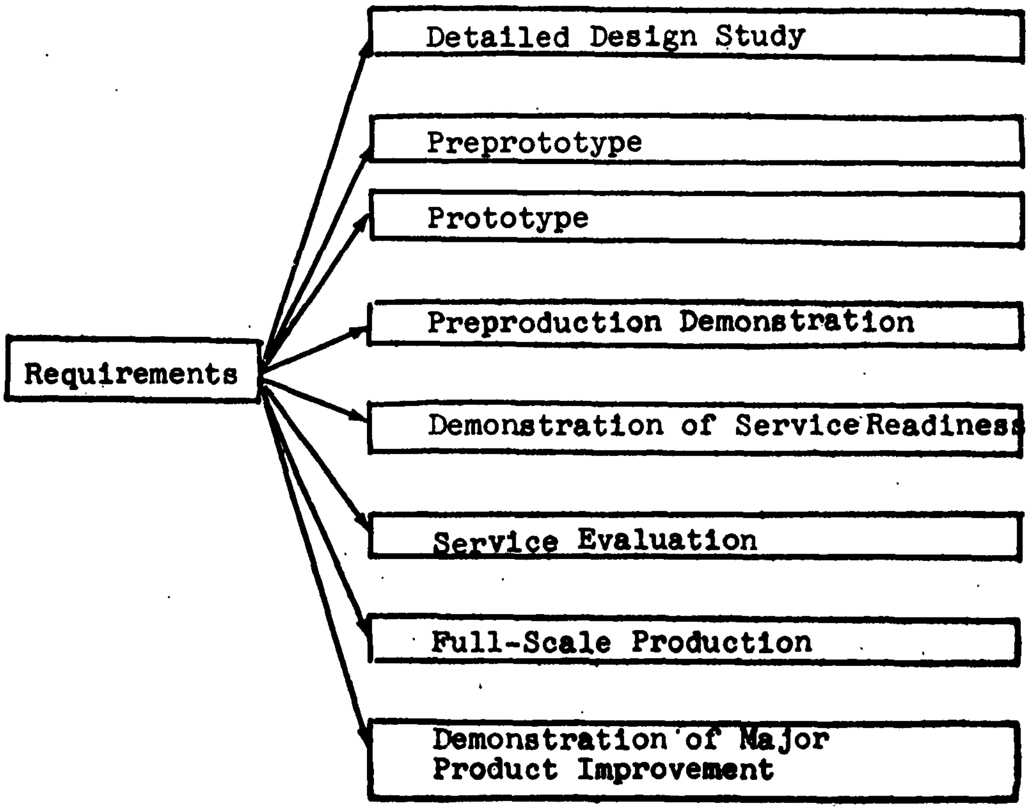
This approach can be used when significantly variable levels of effort will be applicable to the different items within a system. The major disadvantage is the necessary repetition of requirement statements to assure coverage of all items.

(2) Reference to definable time periods within acquisition phase -- The reliability requirements are delineated on the basis of program milestones such as those listed in AFR 80-1 as typical points in the cycle of a program.

Figure 2-13 illustrates the requirements structure when these points are used as the basis for the outline.

FIGURE 2-13

IDENTIFICATION OF TYPICAL PROGRAM MILESTONES

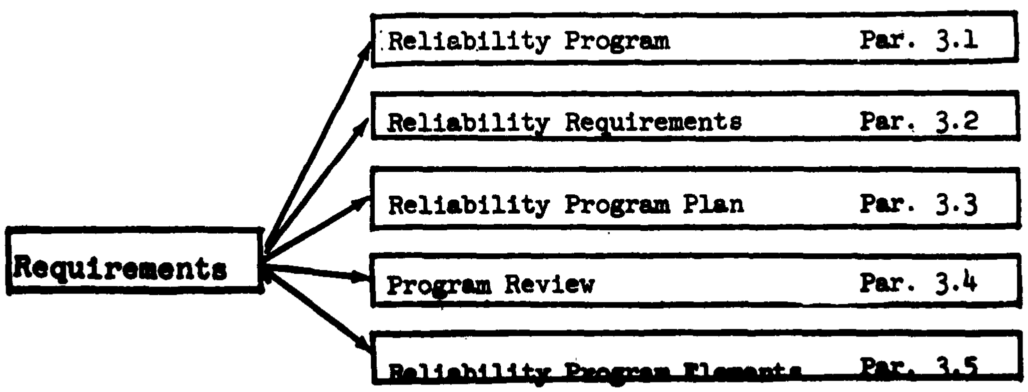


Use of this method will facilitate the task of monitoring fulfillment of requirements, since it essentially provides a time base for requirements. A disadvantage of the approach is the necessary repetitive statement of standard reliability disciplines because of the overlapping of program development phases.

(3) Reference to a prime specification -- Requirements for a program are outlined by reference to the format of a specification which is intended to have prime applicability to the program. For example, if MIL-R-27542A is used, the requirements outline will, in general, have the form illustrated in Figure 2-14.

FIGURE 2-14

OUTLINE OF MAJOR SECTIONS WITHIN MIL-R-27542A



A basic advantage of this method is that it is responsive to a prime source of direction. It should be recognized that the format of a standard specification may require appropriate tailoring to meet the needs of a specific program application. However, it is possible to be responsive to the specification without paralleling its format.

(4) Reference to descriptive areas of technical activity -- This method is exemplified by the approach used in AFBM Exhibit 60-11A, Reliability Specification for WS107A-2, dated 10 October 1960. Figure 2-15 was derived from an outline of the reliability requirements stated in that specification. Each progressive step included in the figure is increasingly descriptive of technical or administrative elements of the over-all requirement. The particular advantage of this method is that it is not only conducive to defining elements of work but is also effective in developing procedures for implementation.

No attempt is made herein to evaluate the applicability of the four methods discussed above. The last method is suggested as representing the most practical approach in new programs. However, all four methods are descriptive of desired areas of coverage and should be reflected to various extents in the final statement of requirements.

2.1.2.4.8 Outline of Reliability Requirements

When a basic approach to outlining qualitative reliability requirements has been selected (2.1.2.4.7), the requirements outline should be developed and described to the extent possible. The knowledge acquired and decisions made in the steps discussed in 2.1.2.4.1 through 2.1.2.4.6 will provide guidance in this process.

The following check list items are typical of those which should be used in developing the detailed outline:

FIGURE 2-15

TYPICAL SEQUENTIAL STEPS
IN DEVELOPMENT OF QUALITATIVE RELIABILITY REQUIREMENTS*

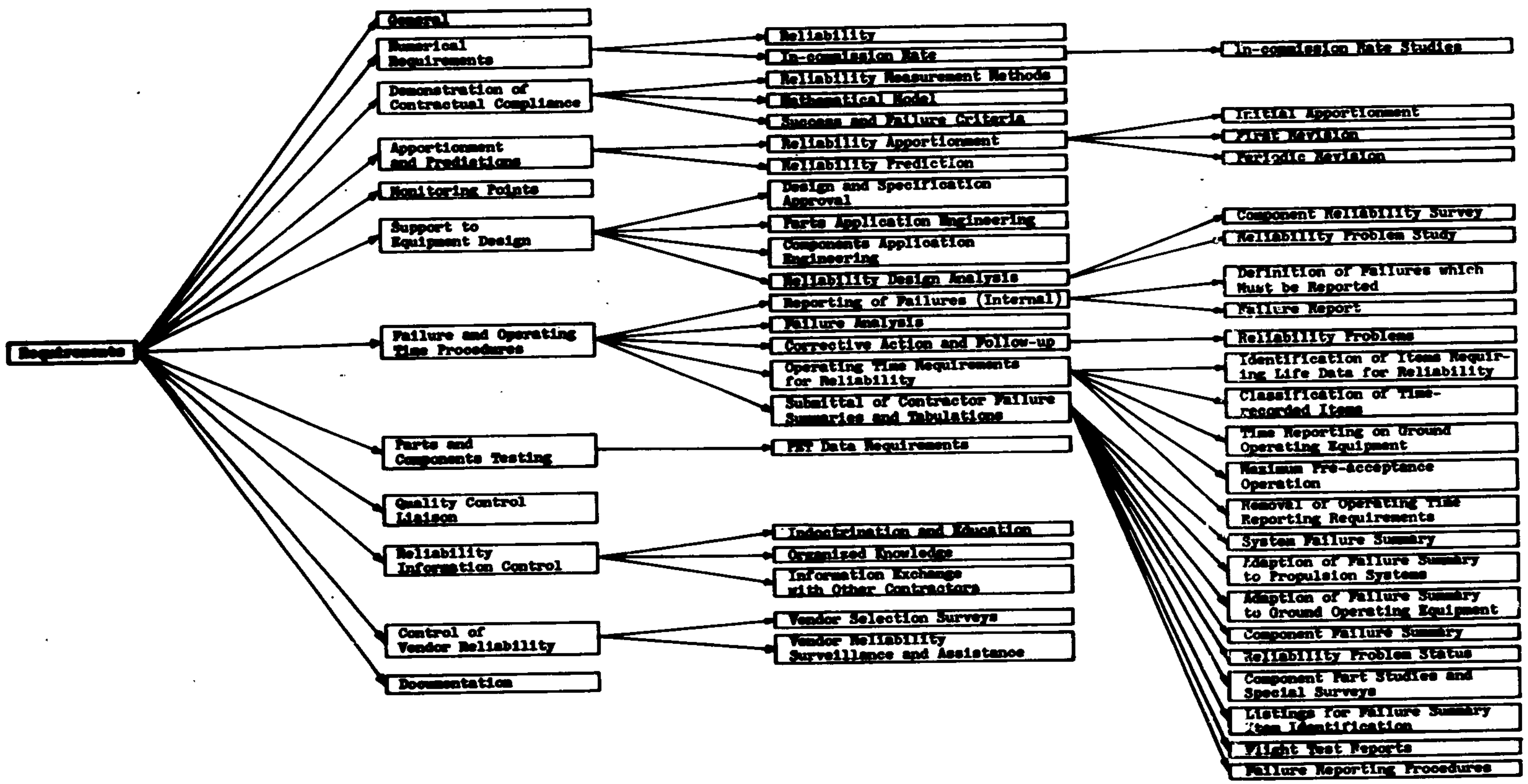


*Figure derived from AFBM Exhibit 60-11A, Reliability Specification for WS 107A-2, dated 10 October 1960.

(1) Is the outline sufficiently responsive, in content, to the governing Air Force specification (e.g., MIL-R-27542A)?

(2) Does it also embrace the policy of other applicable Air Force regulations (e.g., AFR 80-1)?

(3) Does it fully exploit the available areas of reliability technology (see 2.3 and Appendix A)?

(4) Are primary requirement areas (e.g., prediction, failure reporting, demonstration) represented by major segments of the outline?

(5) Is the outline consistent with the desired level of comprehensiveness of the program, available resources for the program, and the degree of difficulty in achieving quantitative requirements?

(6) Does it provide for coverage of potential problem areas?

(7) Does it identify specific research areas (if such have been determined to be necessary)?

As the outline is developed, it is good practice to stipulate requirement statements which correspond to the various segments of the outline. (The process of preparing a final statement of all requirements is discussed in detail in 2.1.3.).

2.1.2.4.9 Exceptions to Standard Requirements

If it is intended that the prime contractual instrument for reliability will be an existing standard specification (e.g., MIL-R-27542A or its successor), each requirement statement within the standard should be evaluated for applicability to the specific program.

2.1.2.4.10 Type of Contractual Instrument(s)

There are several approaches that can be taken to introduce qualitative reliability requirements into a contract for a particular program, including:

(1) Establishing an existing standard (e.g., MIL-R-27542A or its successor) as the sole statement of requirements and noting any exceptions thereto.

(2) Initiating an exhibit (e.g., a document similar to AFBM 60-11A) which will serve as the standard for the program.

(3) Preparing a statement of work which incorporates all statements and references representing reliability requirements.

The title of the ultimate contractual instrument for stating program reliability requirements may vary, but the following are essential factors in planning the contract format:

(1) Reliability should be considered as a distinct discipline within the contract.

(2) If possible, all reliability requirements should be contained by direct statement or reference within one identifiable document.

(3) The statement of requirements should include both numerical reliability requirements with confidence levels (e.g., an achieved probability of mission success) and qualitative requirements which describe the desired elements of work or level of effort.

2.1.2.5 Problems and Special Considerations Relating to Qualitative Requirements Selection

2.1.2.5.1 State of Development of System Concept

At the outset of any new program, there will usually be some relative estimate of the degree of state-of-the-art advancement required to achieve the program objective. Selected qualitative requirements should reflect the advancement required. If the proposed program represents significantly new design concepts, the requirements should emphasize those techniques which are most actively pursued during development (e.g., prediction, apportionment, design review). If the program is primarily a production contract for a large number of items, emphasis should be placed on maintaining quality. If the program includes field or service evaluation, emphasis should be placed upon field failure reporting and resulting analysis.

2.1.2.5.2 Type of Equipment Involved

Qualitative requirements should be tailored to the particular type of equipment involved in the program. For example, a system with an enormous number of electronic parts (e.g., a communications satellite) should be supported by a reliability program which emphasizes part improvement, selection, and control. If the system involves propulsion, special emphasis should be given to the development of prediction techniques for mechanical configuration. Or, if the program involves development of ground equipments, emphasis could be placed on the employment of redundancy (since weight and size are usually less critical in such equipments) or on maintainability concepts.

2.1.2.5.3 Continuity of Requirements Formulation

The formulation of qualitative reliability requirements is a process of continual development: each succeeding step in deriving requirements represents a refinement or amplification of preceding effort. The continuity of the process is hindered when a program plan is prepared without basic reference to contract requirements or contract requirements are prepared without references to governing specifications. In such instances, it becomes difficult to relate and evaluate program documents in respect to higher order of precedence, and the terminology in the documents is often inconsistent. Full reference to controlling documents should be made in all program plans and contracts.

2.1.2.6 Additional References on Qualitative Requirements Selection

(1) General:

Military Management of Missile Quality Control/ Programs, R. W. Smiley, Proceedings, Ninth National Symposium on Reliability and Quality Control, January 1963, pp. 66-68.

Analysis of Reliability Management in Defense Industries, V. J. Bracha, BSD-TDR-62-48, June 1962.

(2) Air Force Regulations, Specifications, Exhibits:

MIL-R-26484A, Reliability Requirements for Development of Electronic Subsystems or Equipment, 18 April 1960.

MIL-R-27542A, Reliability Program for Systems, Subsystems, and Equipment, 21 May 1963.

AFBM Exhibit 60-11A, Reliability Specification for WS107A-2, 10 October 1960 (See Appendix C).

2.1.3 Preparation of Statement of Reliability Requirements

2.1.3.1 Definition

Once the quantitative and qualitative reliability requirements for a program have been determined (see 2.1.1 and 2.1.2), a formal statement of the requirements must be prepared for ultimate incorporation into a contract. The importance of clarity and completeness of this requirements statement is emphasized by several considerations: It represents the initial effort for describing the manner in which reliability tasks are to be accomplished; it represents the document which must be used by bidders in describing their plan and estimating the cost of the work to be performed; and it also represents the standard upon which the bidders will be evaluated.

The activity discussed in 2.1.3 is defined as that effort necessary to amplify, refine, or otherwise adapt the selected reliability requirements so as to express them in a form suitable for inclusion in a procurement contract. This effort commences when an outline of requirements has been formulated and continues until a formal statement which can serve as a contractual instrument has been prepared.

2.1.3.2 Air Force Policy

Air Force policy which relates to preparation of contractual instruments for reliability requirements is summarized in Table 2-6.

2.1.3.3 Responsibilities for Preparation of Requirements Statement

The responsibilities of SPO Reliability Coordinators and other associated levels of authority relating to preparation of contractual instruments for reliability requirements are summarized in Table 2-7.

TABLE 2-6

SUMMARY OF AIR FORCE POLICY
RELATING TO PREPARATION OF CONTRACTUAL INSTRUMENTS
FOR RELIABILITY REQUIREMENTS

Air Force Document	Statement of Policy	Par. No.
AFR 80-5 4 June 1962	(1) Reliability will be stressed during early system studies, source selection, design, development, and production.	4.a.(1)
	(2) During the conceptual and acquisition phases, systems will be analyzed and a reliability program established for each. Program will include a minimum acceptable reliability level as well as a reliability goal, with intermediate quantitative values required to measure progression. Where sufficient sampling permits, a stated minimum acceptable confidence level should be included for each probability value.	4.a.(3)
	(3) Reprocured spares and parts will be procured to definitive reliability requirements.	4.a.(4)
	(4) Specifications, exhibits, work statements, product descriptions, and contracts for systems and associated materiel, including GFE for inventory, will include specific minimum acceptable reliability requirements as one of the major engineering factors.	4.b
	(5) Systems contracts will include a requirement for a comprehensive contractor reliability program, including quantitative requirements and tests for reliability demonstration.	4.c
AFR 80-5 4 June 1962 AFSCR 80-1 14 Dec. 1962	(1) Individual parts specifications will include current failure rate level and up to four discrete graduated levels representing state-of-the-art advancements. The total number of levels will be governed by system requirements.	4.b/ 4.d

TABLE 2-6 (Continued)

SUMMARY OF AIR FORCE POLICY
RELATING TO PREPARATION OF CONTRACTUAL INSTRUMENTS
FOR RELIABILITY REQUIREMENTS

Air Force Document	Statement of Policy	Par. No.
AFSCR 80-1 14 Dec. 1962	(1) Quantitative reliability requirements will be developed from stated objectives and stated in specific numerical terms in the appropriate contractual documents and systems specifications will include the definition of satisfactory operation, including operating time or cycles, environmental conditions, and where practicable, the confidence levels to which specified probabilities will be demonstrated.	4.c
	(2) Quantitative reliability figures will be stipulated for the reliability goal, the minimum acceptable reliability requirement, and the achieved reliability at such specified intermediate points as necessary to measure the progress of the reliability effort.	4.d
	(3) Contracts for aerospace systems, major subsystems, and equipment will include a requirement for a comprehensive and organized contractor reliability program that extends through subcontractor and vendor levels.	4.e
	(4) Integrated test plans to investigate causes, effects, modes of failure, and to demonstrate achieved reliability will be developed and incorporated in contractual documents. Plans will be designed to provide the maximum information and assurance consistent with the state-of-the-art.	4.f
	(5) Specific activities may be identified as reliability effort in order to provide a management tool for guiding and assessing adequacy of effort.	4.g
AFBSDR 80-5 28 Dec. 1962	MIL-R-27542 (or superseding publications) quantitative requirements, and provisions for demonstration will be incorporated into future Air Force ballistic missile contracts and into existing contracts as appropriate.	5.c

TABLE 2-7

SUMMARY OF RESPONSIBILITIES
RELATING TO PREPARATION OF CONTRACTUAL INSTRUMENTS
FOR RELIABILITY REQUIREMENTS

Air Force Document	Level to Which Assigned	Statement of Responsibility	Par. No.
AFR 80-5 4 June 1962	AFSC	(1) Incorporate quantitative reliability requirements and provisions for demonstrating reliability in all specifications, exhibits, product description, work statements and contractual clauses to be referenced to or included in contracts for systems and associated material. These documents will include specific provisions related to procurement, production, and quality control processes necessary to insure achievement of the required reliability.	6.c
		(2) Assume responsibility for system procurement reliability activities, including quality control, production, packaging, transportation, and storage.	6.g
	AFLC	(1) Assume responsibility for logistic support reliability activities as related to procurement, production, packaging, transportation, supply, maintenance, quality control, and materiel management.	7.b
AFSCR 80-1 14 Dec. 1962	AFSC (DCS/Systems)	(1) Prescribe policies and procedures necessary to assure contractual requirements for reliability in each system, subsystem, or equipment being developed for the Air Force inventory.	5.a.(3)
	AFSC (DCS/ Procurement and Materiel)	(1) Prescribe procurement policies for inclusion of reliability requirements in contracts and invoke monetary penalties, unit price decreases, or other considerations deemed equitable if requirements are not met.	5.b.(1)
	System Program Offices (SPO's)	(1) Incorporate reliability requirements, including provisions for demonstrations of reliability in all specifications, exhibits, product descriptions, or other contractual documents to be referenced in contracts for weapon and support systems and associated material (including GFE). Prime contractors will be required to impose adequate requirements on subcontractors and vendors. Contractual documents will include any specific requirements related to the control of manufacturing processes necessary to insure the desired reliability.	7.c
		(2) Define for contractual purposes an adequate and comprehensive contractor reliability program for weapon and support systems, associate and government-furnished subsystems.	7.d
		(3) Incorporate requirements for quantitative data in contractual documents.	7.e
AFBSDR 80-5 28 Dec. 1962	SPO Reliability Coordinators	(1) Assist the OPR for reliability in developing reliability specifications, policies, and procedures in accessing the over-all BSD reliability program effectiveness.	6.b.(5)

2.1.3.4 Implementation of Preparation of Requirements Statement

Two primary considerations govern the preparation of a statement of reliability requirements for a specific program:

(1) The statement should be directly tailored to the needs of the program. -- The most instrumental factor in determining the elements of work to be performed and the necessary level of effort is the numerical reliability requirement. Hence, if the numerical requirement for the system is conceived on the basis of the needs of the program (as should be the case), it should follow that the details of the work required will also be based on those needs.

(2) The requirements should be stated in as much detail as possible. -- In preparing standards which are intended for use in a large number of programs, considerable flexibility must be maintained in setting forth requirements. Hence, when such general standards are applied to particular programs, they must be augmented by requirements statements specifically directed to the needs of the given systems. High Air Force authority has stated: "In the specification of reliability requirements, it is to the advantage of industry for government agencies to be as definitive as possible. It is our objective to continue to eliminate vagueness and generality from reliability requirements."*

Reliability requirements stated in a contract may be subject to later amplification, refinement, or even change. However, anticipation of any such actions subsequent to contract award should not lessen the objective of attaining clarity and completeness in the initial contractual statement of requirements.

*Major General O. J. Ritland, Commander Space Systems Division, U. S. Air Force, in paper entitled, "Specifying Reliability in Military Contracts," presented at Seventh Military-Industry Missile and Space Reliability Symposium, June 1962.

2.1.3.4.1 Format of Requirements Statement

In selecting a documentary format for inclusion of reliability requirements within a contract, the primary considerations are that the requirements be separately identified and be contained within one continuous section of the over-all contract. The descriptive title given to the statement of requirements (e.g., "Work Statement," "Exhibit," etc.) is of less importance and will vary from contract to contract.

2.1.3.4.2 Content of Requirements Statement

The content of the statement of requirements will, of course, vary with each individual system. However, the following outline is a general guide to statement content:

(1) Scope -- A brief statement of the system to which the requirements are applicable, the prime specification (e.g., MIL-R-27542A) to which the requirements are responsive, and any other information pertinent to the coverage intended.

(2) Applicable Documents -- A complete listing of the government (or other documents) which govern the requirements, including designation of the appropriate issues and statement of the order of precedence of the documents.

(3) Requirements -- A complete listing and description of the qualitative and quantitative requirements which have been established for the reliability program.

(4) Definitions -- Brief explanations of the intended meanings of terms unique to the statement of requirements.

2.1.3.4.3 Relation of Requirements Statement to Other Contractual Documents

Most system procurements will require conformance to both a statement of reliability requirements specifically designed for the program and at least one standard specification (e.g., MIL-R-27542A) of more general application. The relationship between these various contractual documents must be clearly established. The specific statement of requirements will most likely stipulate additional tasks as well as interpret certain of the tasks directed by the general specification. Care must be taken that the "additional" tasks and "interpretive" tasks are distinctly recognized, so that the specific program document will not contribute to duplication of effort. If the "additional" tasks are intended to replace similar efforts described in the general specifications, proper exceptions should be noted in the program document.

2.1.3.4.4 Definitiveness of Requirements Statement

In preparing the statement of reliability requirements for a specific program, maximum use should be made of definitive words and phrases. For example, words such as "periodically" or continuously" should be replaced by "monthly," "quarterly," "30 days after contract award," or other time-definitive phrases. When reliability tasks (e.g., prediction, apportionment) are described, the number of times or frequency of performance should be stipulated where possible. General statements must be used in some cases because the precise level of effort or scope of work will not be known at the time contract requirements are prepared. However, their use should be minimized to the extent possible.

The SPO Reliability Coordinator can find some guidance in respect to format, content, definitiveness, and other considerations in preparing a requirements statement for a particular program by comparing the statements provided for other similar programs. Sample reliability work statements are presented in Appendix C to illustrate ways in which reliability requirements can be specified for system programs.

2.1.3.4.5 Further Definition of Requirements Statement by Contractor

It is usually desirable that requirements statement preparation be as complete as possible prior to the actual initiation of contract documentation. In some instances, however, the procuring activity may allow the contractor, as part of his effort, to describe requirements more fully and accurately; however, the tentative plans of the contractor must be stated so that the customer can approve them prior to issuance of the contract. Some negotiation details may be allowed after contract award, but these details should be defined explicitly and documented prior to contract award.

2.1.3.5 Problems and Special Considerations Relating to Preparation of Requirements Statement

2.1.3.5.1 Statement of Demonstration Requirements

Difficulty is frequently experienced in stipulating the requirements for demonstrating achieved reliability, particularly high quantitative reliability requirements such as those normally associated with missile and space programs. For example, a communications satellite with a required mean time to failure of one year would require over 20,000 hours of failure-free operation in order to demonstrate attainment with 90% statistical confidence. Or, a one-shot device with a required probability of survival of 0.90 would require 14 successes out of 15 trials to demonstrate attainment at 90% confidence. When the typical costs associated with test items are considered, it is apparent that the expense of tests to demonstrate achievement of high reliability requirements could assume great proportions.

There are no routine solutions to the problem of lowering the costs of demonstration tests, but there are several considerations which may facilitate accomplishing the purposes of demonstration:

(1) Extend the period of demonstration beyond early hardware delivery dates and stipulate that demonstration be made at the latest possible time when it can be tolerated.

(2) Permit contractors to satisfy reliability requirements by reference to previous tests conducted on their products.

(3) Permit demonstration tests which accept a lower order of confidence.

(4) Permit use of accelerated test methods where practicable.

The preceding discussion is not intended to imply that the objectives of demonstration should be compromised or that insurmountable problems will always be encountered. Rather, it is intended to convey that the subject of demonstration should be actively considered during the requirements formulation phase. In this way, any potential problems which may characterize the program can receive the full benefit of management consideration at the earliest possible time in the program, and maximum time for solution of these problems can be provided.

2.1.3.6 Additional References on Preparation of Requirements Statement

Reliability: Management, Methods and Mathematics, D. K. Lloyd and M. Lipow, Prentice-Hall, 1962, pp. 20-26.

Reliability Principles and Practices, S. R. Calabro, McGraw-Hill, 1962, pp. 239-255.

Reliability Procurement, M. R. Seldon, Industrial Quality Control, Vol. 17, April 1961, pp. 8-9.

Research and Development Reliability, R. H. Meyers et al., Technical Publications Committee, Electronics Division of American Society for Quality Control, 1961.

Reliability Through Adequate Specification, A. R. Park, Fifth National Symposium on Reliability and Quality Control, January 1959, pp. 246-250.

2.2 Selection of Contractor

Air Force directives unequivocally require that quantitative and qualitative reliability commitments be featured in every procurement contract for the development of aerospace items (see Tables 2-1 and 2-4).

Implementation of this basic requirement necessitates important preparatory activities on the part of the System Program Office: First, system reliability requirements must be determined (2.1.1 and 2.1.2) and formally documented (i.e., preparation of a specific contractual work statement as discussed in 2.1.3 and compilation of other documents, such as military specifications, which set forth general requirements). Then, a contractor must be selected who has the necessary capability to achieve the system requirements. System Program Office activities which pertain directly to selection of a contractor are discussed in this section.

In order for adequate contractor evaluation to be performed, the selection activities should begin as early in the program as possible. The major areas of activity (and the sections in which they are discussed) are:

(1) Selection of qualified bidders (2.2.1).

(2) Preparation of the request for proposal (RFP) (2.2.2).

(3) Evaluation of proposals (2.2.3). Not all bidders will respond to the program reliability requirements with equally adequate proposals. Some standard means must therefore be employed to evaluate each proposal for adequacy.

(4) Negotiation of the contract (2.2.4). This seemingly routine activity provides an opportunity for the customer to assure that all of his requirements are covered by contractual obligations upon the contractor.

2.2.1 Selection of Qualified Bidders

2.2.1.1 Definition

The activity of selecting qualified bidders involves an analysis and evaluation process to determine which of the many potential contractors are more likely to fulfill efficiently the reliability and other requirements of a system program.

The potential bidders are evaluated on the basis of past performance and manifest capabilities. Capability to meet reliability requirements is one of several considerations in evaluating bidders, but it is a vital criterion in respect to ultimate program success and should receive equal emphasis with other important contractor qualifications.

2.2.1.2 Air Force Policy

Air Force policy pertaining to reliability considerations in selection of qualified bidders is summarized in Table 2-8.

2.2.1.3 Responsibilities for Selection of Qualified Bidders

The assigned responsibilities of SPO Reliability Coordinators and other associated levels of authority relating to selection of qualified bidders are summarized in Table 2-9. These general SPO responsibilities can, in turn, be interpreted to imply more explicit responsibilities, as follows:

(1) To carry out all Air Force regulations pertaining to reliability assurance.

(2) To stress reliability in the selection of a source for items or services.

(3) To consider a contractor's reliability capability (as manifest in past performance) as a major factor in all source-selection action.

TABLE 2-8

SUMMARY OF AIR FORCE POLICY
RELATING TO RELIABILITY CONSIDERATIONS
IN SELECTION OF BIDDERS

Air Force Document	Statement of Policy	Par. No.
AFR 80-5 4 June 1962	(1) Reliability will be stressed during early system studies, source selection, design, development, and production. Its adequacy depends upon the emphasis received during the conceptual and acquisition phases.	4.a.(1)
	(2) Contractor's reliability capability, considering both past performance and proposed programs, will be a major factor in all source selection action.	4.e

TABLE 2-9

SUMMARY OF RESPONSIBILITIES
RELATING TO RELIABILITY CONSIDERATIONS
IN SELECTION OF BIDDERS

Air Force Document	Level to Which Assigned	Statement of Responsibility	Par. No.
AFR 80-5 4 June 1962	AFSC	(1) Include specific provisions related to procurement, production, and quality control processes necessary to insure achievement of the required reliability.	6.c
		(2) Determine the adequacy of each Air Force contractor's reliability program for achieving and demonstrating Air Force product reliability goals.	6.d
		(3) Assume responsibility for system procurement reliability activities.	6.g
AFSCR 80-1 14 Dec. 1962	AFSC DCS/ Procurement and Materiel	Prescribe procurement policies for inclusion of reliability requirements.	5.b.(1)
AFBSDR 80-5 28 Dec. 1962	SPO Reliability Coordinators	Assume responsibility for all aspects of the system reliability program including all aspects of the contractor's reliability program.	6.b.(3)

(4) To determine the adequacy of each potential contractor's reliability program for achieving Air Force product reliability goals.

(5) To assume responsibility for all reliability procurement activities.

In summary, a SPO Reliability Coordinator is responsible for taking all possible steps to assure that bidders are selected on the basis of their inherent capability to produce a product having the required level of reliability.

2.2.1.4 Implementation of Selection of Qualified Bidders

2.2.1.4.1 Knowledge of Reliability Requirements

By the time selection of bidders becomes a factor of immediate interest in a program, all system reliability requirements should have been established (see 2.1.1, 2.1.2, and 2.1.3). The SPO Reliability Coordinator, because of his contribution to the formulation of these requirements, should be thoroughly familiar with their content and thus understand the scope and level of effort which a contractor must implement to fulfill the requirements.

2.2.1.4.2 Sources of Bidder Information

Potential bidders can be found in Approved Vendor lists and other lists having a similar purpose. In general, such lists are not exhaustive of all contractors capable of performing the desired work. Efforts should therefore be made to determine as many additional potential suppliers as possible for preliminary evaluation. The potential contractor nonchalantly overlooked may be the very one most capable of providing reliable equipment.

2.2.1.4.3 Preliminary Evaluation of Bidders

The gross list of potential bidders should be analyzed for correlation between obvious capabilities and the program needs. Entries having unacceptable correlations should be eliminated.

All potential bidders should be compared on an equal basis in this preliminary analysis. A check list such as that shown in Figure 2-16 or one tailored for the particular program should be used. If a standard bidder evaluation check list is developed and used, it may be adapted to different program requirements by varying the emphasis placed on the items in the list (e.g., "weighting factors" can be applied to guide the evaluator as to the relative importance of specific items).

The check list of Figure 2-16 is designed so that the information necessary to its completion can be obtained by either direct contact or telephone response to the questions listed. It is entirely appropriate to visit the facilities of a potential bidder to survey his facilities and to talk to his personnel. If essential information regarding a potential bidder is lacking, a reasonable effort should be made to obtain it before the entry is eliminated. Every qualified source of materials, equipments, or services is a valuable asset to the Air Force in meeting its rapidly and widely expanding technological needs.

It is not necessary to perform a complete evaluation of the capabilities of potential bidders in order to determine a list of qualified bidders. The effort in this preliminary evaluation is to determine bidders who can perform adequately and who should therefore be given an opportunity to submit proposals for the planned program. Bidders whose technical proposals and reliability program plans are acceptable (see 2.2.3) will be subjected to thorough examination before a contract is let (see 2.2.4).

2.2.1.5 Problems and Special Considerations Relating to Selection of Qualified Bidders

2.2.1.5.2 Inadequate Information on System Reliability Requirements

Lack of knowledge regarding the actual requirements of the system or product may lead to subjectiveness in selection of bidders. The evaluator may place emphasis on certain requirements and arrive at one list of potential bidders, while emphasis on other requirements would result in an entirely different list of perhaps better qualified boddera.

FIGURE 2-16

SAMPLE CHECK LIST FOR DETERMINING QUALIFIED BIDDERS

BIDDER RELIABILITY EVALUATION QUESTIONNAIRE

Company ________	Program ________
Address ________	Considered for ________
________	Date ________
To what corporation officer does the reliability organization report?	President ___ Corporate Vice President ___ Quality Assurance ___ Chief Engineer ___ Engineering Subgroup ___ Quality Control Dept. ___
What are the distinguishable areas of activity shown in the corporation reliability organization chart and how many people staff each group?	Data Collection ___ Data Analysis ___ Physics of Failure ___ Failure Reporting ___ Parts Control ___ Statistical Methods ___ Reliability Test Lab. ___ Environmental Test Lab. ___ Design Review group ___
What is considered to be the most sophisticated project undertaken by the corporation to date?	Less Advanced ___ Equally Advanced ___ More Advanced ___
In what terms were reliability requirements imposed in that project? Values required and attained?	Past Reliability Required ___ Past Reliability Attained ___
Have improved methods or techniques since been learned?	Reliability Growth ___ Yes ___ No
What per cent of the previous project money was devoted to reliability effort?	Per cent ________
What is the total plant employment?	Plant Employment ________ People

Successful selection of bidders and successful conduct of the entire program depend to a large degree upon the accuracy with which the program reliability requirements have been defined. Bidder capabilities should correlate with these requirements. For example, if a system mission is to be five hours in a rather moderate environment, a list of bidders having the capability to develop moderately sophisticated equipment should be compiled. Contractors having far superior capabilities might not be sought in order to save money and/or reserve their capabilities for more demanding work. If the mission duration is to be very long, say seven years, a group of bidders having experience in the development and manufacture of equipment regularly meeting long-life requirements would be selected. Or, if the use environment is to involve severe conditions such as high temperature, a list of bidders having experience in design and production of equipment for operation in such environments would be selected.

2.2.1.5.2 Non-Correlation of Bidder Experience and Program Requirements

Air Force technical requirements necessarily stress or even surpass the state-of-the-art to such a degree that bidders cannot always be found who have sufficient experience in the technology required for a particular program. When experience/requirements correlation is low in all entries for the bidders' list, the procuring activity must determine which bidders have adequate potential for new development along the required lines. In such instances, factors other than specific experience (e.g., available engineering and management talents, special facilities, experience in related fields) should be evaluated.

2.2.2 Preparation of Requests for Proposal (RFP)

2.2.2.1 Definition

The Request for Proposal is the means by which the Air Force communicates its need for a product or service to potential contractors. It must describe the desired product or service in sufficient detail so that bidders can reasonably determine whether they have the interest and capability for meeting the Air Force need. The Request for Proposal is sent to qualified bidders sufficiently in advance of the formal start of a program for the bidders to develop proposals in response and transmit them to the procuring agency's designated office.

The discussion in 2.2.2 is primarily concerned with the responsibilities of the SPO Reliability Coordinator in assuring that reliability requirements are considered in RFP preparation.

2.2.2.2 Air Force Policy

Explicit policy statements governing the preparation of Requests for Proposal (RFP's) are provided by Air Force procurement directives rather than by the directives relating to reliability. The reliability directives do stipulate, however, that all documentation used in procurement for a specific program must reflect the reliability requirements of the program.

2.2.2.3 Responsibilities for Preparation of Request for Proposal

The responsibilities assigned by Air Force directives to SPO Reliability Coordinators and other associated levels of authority regarding the incorporation of reliability requirements in RFP's are given in Table 2-10.

TABLE 2-10

SUMMARY OF RESPONSIBILITIES
RELATING TO RELIABILITY CONSIDERATIONS
IN PREPARATION OF REQUESTS FOR PROPOSAL

Air Force Document	Level to Which Assigned	Statement of Responsibility	Par. No.
AFR 80-5 4 June 1962	AFSC	(1) To incorporate quantitative reliability requirements and provisions for demonstrating reliability in all specifications, exhibits, product descriptions, work statements, and contractual clauses to be referred to or included in contracts for systems and associated materiel. These documents will include specific provisions related to procurement, production, and quality control processes necessary to insure achievement of the required reliability.	6.c
		(2) To assume responsibility for system procurement reliability activities, including quality control, production, packaging, transportation, and storage.	6.g
AFSCR 80-1 14 Dec. 1962	System Project Offices (SPO's)	(1) Incorporate reliability requirements, including provisions for demonstration of reliability in all specifications, exhibits, product descriptions, or other contractual documents to be referenced in contracts for weapon and support systems and associated materiel.	7.c

2.2.2.4 Implementation of Preparation of Request for Proposal

In Air Force procurement of aerospace systems and services, Requests for Proposal are usually sent to a limited list of potential bidders known to be particularly qualified to provide the desired systems or services (see 2.2.1). Specific instructions for the issuance of RFP's are given in ASPR 3-500 and 3-802. Further information is provided by AFBSD Interim Regulation 80-7, Source Selection Board Procedures.

2.2.2.4.1 Content of Request for Proposal

The RFP basic document should contain a complete and specific description of the items or services to be procured, together with applicable requirements for quantities to be delivered, time and place of delivery, method of shipment, methods of preservation and packaging, and technical instruction books and data to be delivered. The type of contract desired (cost plus fixed fee or other) should also be specified.

When RFP's are sent to potential bidders, the basic document will be accompanied by a packet of associated documents such as:

Statement of Work

Technical Specifications

Reliability Specifications

Special Instructions

Each of these documents will, in turn, reference military standards, specifications, exhibits, and directives which are to become integral to the contract. For a specific program, the RFP packets sent to potential bidders must be identical to assure an equal opportunity to each bidder.

2.2.2.4.2 Reliability Requirements in Request for Proposal

The SPO Reliability Coordinator is obligated (see Table 2-10) to assure that system reliability requirements (both quantitative and qualitative) are correctly and completely stated in the appropriate RFP documents. Other reliability considerations to be covered in the RFP include:

(1) Organization and preparation of a reliability program plan. When a bidder submits a proposal, he must also submit, as a separate entity, his plan for implementing reliability activities.

(2) Distinction between the contents of the desired proposal (see 2.2.3) and the desired reliability program plan (see 2.3.2).

(3) Reliability program activities requiring special emphasis.

(4) Format of reports, program plans, and data collection.

(5) Encouragement of contractor initiative in suggesting state-of-the-art advances relating to reliability technology.

2.2.2.4.3 Bidders' Conferences

In the procurement of large or complex systems, it is often advantageous to both the Air Force and industry for the former to hold bidders' conferences. These conferences are attended by representatives from the several contracting firms which are considered to have the capability to produce the desired system. They provide an opportunity for the Air Force to give technical details and other special information relating to the system and for the bidders to ask questions which will assist them in preparing proposals.

Bidders' conferences become almost essential in the procurement of systems and services of a classified nature.

2.2.2.5 Problems and Special Considerations Relating to Preparation of Request for Proposal

2.2.2.5.1 Inaccurate Determination of System Reliability Requirements

Inaccuracy in the determination of the system reliability requirements will, of course, be reflected in the Request for Proposal because that document must describe the qualities of the desired product. If subsequent study indicates that a higher level of reliability is required than that stated in the RFP, it can be implemented in the program only as an increase in the scope of work. If it is determined that original reliability requirements were higher then necessary, the specifications can be relaxed through contract negotiation (see 2.2.4), but such relaxation of requirements will not necessarily result in a monetary saving. Downgrading of specifications can, however, sometimes result in speeding up of schedules.

2.2.2.5.2 Insufficient Information on Potential Bidders

Each procuring activity should take special care to maintain an extensive and accurate list of qualified bidders (see 2.2.1). If insufficient information concerning potential bidders exists when RFP's are to be distributed for a particular program, time which could be saved by going to specific bidders with the desired capability is lost while the procuring activity seeks more information on bidders. Further, RFP's may be sent to the wrong bidders; some bidders who are qualified may be overlooked while other unqualified bidders are solicited.

2.2.2.5.3 Insufficient Time Allowed for Proposal Preparation

RFP's state a specific date on which bidders' proposals are due at the procuring activity's office. If bidders are allowed insufficient proposal preparation time between receipt of the RFP and the due date, they may make hurried judgments concerning the program. While a bidder's commitment is his own responsibility, any misjudgment in the area of reliability may eventually be reflected in failure of the program. Sufficient time should be allowed for each bidder to analyze the system and its requirements thoroughly so that competent and realistic proposals will result.

2.2.3 Evaluation of Proposals

2.2.3.1 Definition

Evaluation of proposals is the process of determining which proposed program (and thus which bidder) is most suited to provide a product or service needed by the Air Force. The evaluation considerations discussed in 2.2.3 are those pertaining primarily to the bidder's proposed over-all approach and his qualifications for meeting reliability requirements associated with the Air Force need.

The bidder's specific reliability program plan, detailing procedures, schedules, and assignments for implementing reliability activities, is to be submitted as a separate entity with his proposal. Because reliability program planning is an activity which extends beyond the proposal state, evaluation of this specific plan is discussed separately in 2.3.2.

2.2.3.2 Air Force Policy

Air Force policy relating to evaluation of reliability considerations in proposals is stated in Table 2-11.

2.2.3.3 Responsibilities for Evaluation of Proposals

As shown in Table 2-12, basic responsibility for obtaining adequate reliability commitments from contractors rests with the SPO Reliability Coordinator. Consequently, he is responsible for analyzing and evaluating the reliability aspects of a bidder's proposal. Implicit to the responsibility for proposal evaluation is knowledge of the type and scope of effort which any contractor would have to put forth to meet the reliability requirements of the program.

TABLE 2-11

SUMMARY OF AIR FORCE POLICY
RELATING TO RELIABILITY CONSIDERATIONS
IN PROPOSAL EVALUATION

Air Force Document	Statement of Policy	Par. No.
AFR 80-5 4 June 1962	(1) Proposals must contain a description of the contractor's reliability program and design strategy in sufficient detail for evaluation and Air Force decision during design selection phases regarding adequacy, kind, and level of effort.	3.g
	(2) Contractor's reliability capability, considering both past performance and proposed programs, will be a major factor in all source selection action.	4.e

TABLE 2-12

SUMMARY OF RESPONSIBILITIES
RELATING TO RELIABILITY CONSIDERATIONS
IN PROPOSAL EVALUATION

Air Force Document	Level to Which Assigned	Statement of Responsibility	Par. No.
AFR 80-5 4 June 1962	AFSC	(1) Insure that quantitative reliability requirements are specified in proposals or bids requested from industry.	6.b
		(2) Evaluate contractor reliability program proposals in all system source selection actions.	6.m
AFBSDR 80-5 28 Dec. 1962	SPO Reliability Coordinators	Evaluate all aspects of the contractor's reliability program and take action as necessary to assure the adequacy of this program	6.b.(3)
	SE/TD Contractors	Review the contractor's reliability program submitted in accordance with MIL-R-27542 or other contractual reliability documents.	6.c.(2)

2.2.3.4 Implementation of Evaluation of Proposals

2.2.3.4.1 Evaluation of Bidders' Reliability Capabilities

There are three major considerations relating to reliability which should be covered in a bidder's proposal and thus evaluated by the SPO Reliability Coordinator:

(1) Analysis of requirements -- The bidder should indicate recognition of and appreciation for the nature of the reliability problems inherent in the program and propose approaches for solution of these problems.

(2) Proposed reliability program -- The bidder should discuss the type and scope of effort he proposes to undertake to meet program reliability requirements. (This discussion of proposed effort is distinct from the separate and more detailed reliability program plan which the bidder must also submit--see 2.3).

(3) Qualifications of bidder -- The bidder should describe his capabilities for implementing an effective reliability effort, including qualified personnel and over-all reliability organization.

Standard check lists and evaluation forms are useful in grading both proposals and bidders in procurement of products and services, but many of those in use (e.g., AFSC 51 and 51A) do not provide for evaluation of reliability capability. Figure 2-17 is a sample questionnaire primarily intended to evaluate this aspect of a bidder's proposal, taking into account the bidder's adequacy in the three areas listed above -- analysis of the reliability problems, elements of proposed reliability program, and qualifications for implementing such a program.

FIGURE 2- 17

SAMPLE QUESTIONNAIRE FOR EVALUATING PROPOSALS

PROPOSAL RELIABILITY EVALUATION QUESTIONNAIRE (Page 1)

Company______________________________ RFP No.____________________

Address______________________________ Date______________________

____

I. ANALYSIS OF RELIABILTTY REQUIREMENTS:

(1) Does the proposal include a preliminary analysis of reliability requirements?

(2) Does the proposal demonstrate correct interpretation of requirements?

(3) Does the proposal set reliability in proper perspective? That is, does the potential contractor show awareness of the relationships between reliability, other system parameters, and the effectiveness of the system?

(4) Does the proposal recognize the implications of the reliability requirements? Does the bidder translate his experience and knowledge into logical conclusions regarding scope of work such that confidence may be reasonably placed in initial estimates of probability of success and cost? As for example:

(a) Will state-of-the-art constraints on part life preclude the achievement of requirements by use of available parts?

(b) Will part improvement be necessary and feasible?

(c) Will redundancy be necessary?

(d) Do significant areas of uncertainty exist which may require special study and influence both confidence and expected cost?

(e) Does the proposal describe the basis on which judgments regarding the above are made?

II. RELIABILITY PROGRAM ELEMENTS:

A. System Analysis

(1) Does the proposed program make adequate provision for analysis of system requirements to better define optimum configuration and equipment design criteria? Will results be available on a timely basis?

(2) Are the influences of environment identified and properly considered?

FIGURE 2-17 (Continued)

SAMPLE QUESTIONNAIRE FOR EVALUATING PROPOSALS

PROPOSAL RELIABILITY EVALUATION QUESTIONNAIRE (Page 2)

Company ______________________ RFP No. ______________

Address ______________________ Date ______________

____

II. RELIABILITY PROGRAM ELEMENTS (Continued):

A. System Analysis (Continued)

(3) Does the proposed program provide for translation of requirements and the results of system analysis into design criteria such as:

(a) Allocation of reliability requirements to equipment or black box level?

(b) Description of relative importance of individual equipment to system function?

(c) Potential trade-offs between reliability and other system parameters to achieve given effectiveness for minimum resource cost?

B. Part Selection and Application

(1) Does the proposal show availability of parts life data as necessary for satisfactory part selection and application (includes derating)?

(2) Does adequate quality control exist to insure acceptable initial and continued part quality? Is vendor surveillance used effectively toward this end?

C. Circuit Tolerance

(1) Does the proposal recognize the need for attention to circuit tolerance to part parameter variations in both the population and time domains?

(2) Does the proposal show knowledge of techniques for assessing the cumulative effects of part parameter variations and for design of circuits of optimum tolerance?

D. Audit and Control

(1) Does the proposed program provide adequate means for audit of progress to include:

(a) Design review?

(b) Reliability prediction and analysis?

(c) Tests as appropriate?

(d) Special studies?

FIGURE 2- 17 (Continued)

SAMPLE QUESTIONNAIRE FOR EVALUATING PROPOSALS

PROPOSAL RELIABILITY EVALUATION QUESTIONNAIRE (Page 3)

Company____________________ RFP No.________________

Address____________________ Date________________

____

II. RELIABILITY PROGRAM ELEMENTS (Continued):

E. Verification

(1) Does the proposal provide an adequate plan for verification of achieved reliability?

(2) Is the operational environment properly accounted for?

III. QUALIFICATIONS OF BIDDER:

A. Qualified Personnel

(1) Does the proposal identify, by qualifications, the personnel to be assigned to the reliability program?

(2) Is the number of personnel, particularly of those to be assigned full time, adequate in the light of the scope of the over-all program?

(3) Is the experience of the personnel adequate?

(4) Does the group represent a good cross-section of qualifications in important areas such as analysis, design, statistical methods, parts, and test methods?

B. Reliability Organization

(1) Is the framework of the bidder's reliability group such that the work of the group will be timely, truly responsive to over-all requirements, sensitive to problem areas, and effective in the formulation of design criteria and the control of design for reliability?

(2) Does the group have adequate stature and authority?

(3) Do means exist for audit of progress?

(4) Do means exist for feed back and exchange of information?

IV. PROPOSAL NON-RESPONSIVE TO:____________________

____

____

V. EXCEPTIONS TAKEN TO:____________________

____

Numerical rating values could be assigned to the various elements of a questionnaire such as that shown in Figure 2-17 if a quantitative assessment of proposals is desired. Weighting factors could also be assigned to the questionnaire sections to indicate the relative importance of various areas of bidder capability to the requirements of a specific program. However, the same numerical rating or weighting basis should be applied to the proposals of all bidders on a particular procurement.

Numerical rating features can be used in bid evaluations for procurements conducted on a "negotiated"* basis but not for procurements conducted on an "advertised"* basis. In "advertised" procurement, vendor evaluation must be solely on the basis of responsive or not responsive to the request for bid.

2.2.3.4.2 Evaluation of Cost

Cost should not be a factor in the initial technical evaluation of proposed reliability programs. Estimated costs for performing a proposed program should therefore be presented in a separable portion of bidders' proposals. After those proposals which offer adequate reliability effort have been determined, the relative cost considerations should be reviewed and evaluated.

2.2.3.5 Problems and Special Considerations Relating to Evaluation of Proposals

2.2.3.5.1 Inadequate Guidance in Request for Proposal

Faulty or inadequate information in an RFP may lead to proposals which do not meet the true need of the procurement. Some contractors may recognize the inadequacies of the RFP, reconstruct the requirements, and submit acceptable proposals. Others, however, may respond with a proposal which answers the inadequate RFP but not the actual requirements of the program.

*AFSCP 80-1, Guide for Evaluaters, 15 August 1962.

If it is intended to apply weighting factors in the evaluation of proposals, the stressing of requirements in the RFP should correspond to the intended weighting basis. This procedure will elicit responses from bidders which are more indicative of their willingness and ability to comply with those requirements which are of particular importance in a program.

2.2.3.6 Additional References on Evaluation of Proposals

Supplier Reliability Assurance Programs, M. H. Saltz, Sixth National Symposium on Reliability and Quality Control, January 1960, pp. 445-448.

AFR 70-15, Procurement Source Selection Procedures, 24 April 1962.

AFSCR 70-3A, Procurement Source Selection Board Procedures, 11 September 1963.

2.2.4 Negotiation of Contracts

2.2.4.1 Definition

Negotiation is the activity in which the customer and a contractor determine and agree upon the exact terms of the contractual relationship under which the contractor will furnish a desired product or service to the Air Force. The accuracy and completeness with which both contractor and customer obligations are stated in a contract have considerable effect on the ultimate success or failure of a program.

Negotiation for Air Force procurement is conducted by a team of Air Force personnel assisted by representatives of SE/TD contractors. The discussion in 2.2.4 is primarily concerned with the responsibilities of the System Program Office, and thus the SPO Reliability Coordinator, in assuring that reliability requirements are adequately covered in system contracts.

2.2.4.2 Air Force Policy

Air Force policy relating to negotiation of the reliability portion of contracts is presented in Table 2-13.

2.2.4.3 Responsibilities for Contract Negotiation

Responsibilities explicitly stated by Air Force directives in regard to incorporation of reliability requirements in contracts are given in Table 2-14.

2.2.4.4 Implementation of Contract Negotiation

2.2.4.4.1 Fundamental Assumptions

At the time negotiation of a contract is to begin,it is assumed that the following background tasks will have been completed by the System Program Office:

TABLE 2-13

SUMMARY OF AIR FORCE POLICY
RELATING TO RELIABILITY CONSIDERATIONS
IN CONTRACT NEGOTIATION

Air Force Document	Statement of Policy	Par. No.
AFR 80-5 4 June 1962	(1) System contracts will include a requirement for a comprehensive contractor reliability program, including quantitative requirements and tests for reliability demonstration.	4.c
	(2) If contract reliability requirements are not met, or if the contractor's reliability effort is decreased, the decision to accept or reject the end item or the revised reliability program will be considered with a view toward monetary penalties, unit price decreases, or other considerations deemed equitable.	4.f
AFSCR 80-1 14 Dec. 1962	New programs will include adequate funds for reliability effort in design proposals and initial program funding. Specific activities may be identified as reliability effort in order to provide a management tool for guiding and assessing adequacy of effort.	4.g
AFBSDR 80-5 28 Dec. 1962	Adequate funds will be made available in the initial program funding for ballistic missile system programs to provide for the implementation of a complete and well balanced reliability program.	5.d

TABLE 2-14

SUMMARY OF RESPONSIBILITIES
RELATING TO RELIABILITY CONSIDERATIONS
IN CONTRACT NEGOTIATION

Air Force Document	Level to Which Assigned	Statement of Responsibility	Par. No.
AFR 80-5 4 June 1962	AFSC	(1) Assume responsibility for system procurement reliability activities, including quality control, production, packaging, transportation, and storage.	6.g
		(2) Establish and fund basic and applied research programs for reliability based on current and future system requirements.	6.j
AFSCR 80-1 14 Dec. 1962	HQ AFSC DCS/Systems	(1) Prescribe policies and procedures necessary to assure contractual requirements for reliability in each system, subsystem, or equipment being developed for the Air Force inventory.	5.a.(3)
	HQ AFSC DCS/ Procurement and Materiel	(1) Prescribe procurement policies for inclusion of reliability requirements in contracts and invoke monetary penalties, unit price decreases, or other considerations deemed equitable if requirements are not met.	5.b.(1)
	System Program Offices (SPO's)	(1) Incorporate reliability requirements, including provisions for demonstration of reliability in all specifications, exhibits, product descriptions, or other contractual documents to be referenced in contracts for weapon and support systems and associated materiel (including government-furnished equipment). Prime contractors will be required to impose adequate requirements on subcontractors and vendors. Contractual documents will include any specific requirements related to the control of manufacturing processes necessary to insure the desired reliability.	7.c
		(2) Incorporate requirements for quantitative data in contractual documents.	7.e

(1) System reliability requirements will have been thoroughly determined in the conceptual phase of the program, and numerical values will have been established for all reliability parameters (see 2.1.1 and 2.1.2).

(2) The major activities in which a contractor will have to engage to fulfill the program reliability requirements will have been determined, and preliminary documents such as a Statement of Work and a Request for Proposal will have been adequately prepared so as to communicate program requirements to bidders (see 2.1.3 and 2.2.2)

(3) Proposals will have been received and evaluated with great care, and the contractor having the highest probability of success will have been selected (see 2.2.3).

2.2.4.4.2 Listing of Weaknesses in Contractor's Program

As a result of thorough evaluations of the contractor's proposal, including his proposed reliability program, a list of items requiring negotiation should have been determined. These items may be the result of ambiguity, omission, error, or misunderstanding on the part of the contractor or of pre-contract changes in required scope of work on the part of the Air Force. They must be clarified in the Statement of Work, the contractor's reliability program plan, and the final contract.

2.2.4.4.3 Presentation of Air Force View

The Air Force should present its view regarding the questionable items in the contractor's proposed program, and allow the contractor to study each item before replying.

2.2.4.4.4 Reply of Contractor

After review of the Air Force comments on his proposed reliability and other program efforts, the contractor may be expected to take one of several actions:

(1) Accept the Air Force view without exception and make necessary adjustments in proposed program.

(2) Accept the Air Force view but propose cost revision because of changes to be made in the program.

(3) Take exception to the Air Force view on technical grounds.

(4) Take exception to the Air Force view on both technical and monetary grounds.

2.2.4.4.5 Areas Not to Be Negotiated

There are some considerations which, by Air Force directive, are not subject to negotiation for a system procurement contract:

(1) Numerical reliability requirements which are acceptable to the Air Force must be a part of the contract.

(2) A reliability program plan which is acceptable to the Air Force as being adequate to meet the system needs must be a part of the contract (see 2.3).

(3) The contractor must establish management procedures which will assure control of those factors in research, development, manufacture, shipment, and storage which will result in the required level of product reliability.

(4) The contract must contain penalty clauses for non-fulfillment of contractual reliability requirements.

2.2.4.4.6 Control of Agenda in Contract Negotiation

Contract negotiation should be done in formal meetings between an Air Force negotiating team and the contractor's delegated representatives. The Air Force should maintain control of these meeting through the following actions:

(1) Assigning a member of the Air Force team as chairman of the meeting so that order and progress can be maintained.

(2) Pre-delivering the list of negotiable points and a proposed meeting agenda to the contractor.

(3) Establishing a schedule for the agenda so that the meeting time will be efficiently used.

2.2.4.5 Problems and Special Considerations Relating to Contract Negotiations

2.2.4.5.1 Level of Contract Negotiation

Different contractors place the responsibility for contract negotiation at various levels within their company structures. The Air Force should endeavor to negotiate a system contract with high officials of the company involved in order to assure management recognition of contractual objectives and obligations. However, in negotiation of the reliability phases of a contract, the Air Force should insist that key personnel of the contractor's reliability organization be present to assure that corporate commitments are in keeping with the actual capabilities of the reliability organization.

2.2.4.5.2 Amount of Negotiation Required

If the Air Force Statement of Work and Request for Proposal were adequately prepared and the contractor's proposal was well received and executed, there may be a few points to negotiate in arriving at a contract.

However, if less than ideal conditions prevail and there are many points to negotiate, the course to be followed will depend upon the criticalness of the factors to be negotiated and the time allowed for negotiation.

If insufficient time is allowed for negotiation, both the Air Force and the contractor are prone to make concessions deleterious to the success of the over-all program and reliability effort. By controlling the agenda, listing the negotiable points, and screening them for relative importance prior to actual negotiation meetings, the Air Force negotiation team chairman should be able to allow sufficient negotiation time and to accomplish his goals in the allowed time.

2.2.4.5.3 Agreement on Program Details

Agreement on general principles involved in a system program should have been reached before the contract negotiation stage is reached, through the activities of selecting qualified bidders and evaluating proposals. Detail requirements for the program are the problems to be dealt with in contract negotiation. In respect to reliability, agreement must be attained on the following points:

(1) What are the requirements to be placed on the reliability program?

(2) How will the reliability program accomplish these requirements?

(3) When will these tasks be completed?

(4) How will fulfillment of requirements be measured?

(5) What is the monetary value of each program activity and phase and what penalties will be evoked for non-fulfillment of requirements?

2.3 Enactment of Reliability Program Plan

A third vital factor in the establishment of a reliability program is the enactment of an effective reliability program plan. The importance of the program plan is emphasized through the realization that:

(1) It serves as the contractor's primary statement of his intended methods for implementing the elements of the reliability program and accomplishing the requirements of the contract.

(2) When approved, it constitutes an official requirement within the over-all system program and thus becomes a vital working document and primary source of information for contractor personnel involved in the reliatility effort.

(3) It serves the SPO Reliability Coordinator and other Air Force representatives as a tool for measuring progress and determining fulfillment of contractual obligations.

Air Force policy relating to enactment of a reliability program plan is summarized in Table 2-15. The assigned responsibilities of SPO Reliability Coordinators and other associated levels of authority are presented in Table 2-16. From the tabulated information, it may be concluded that the prime tasks of the SPO Reliability Coordinator in enacting an effective reliability program plan are to:

(1) Provide the contractor with sufficient direction and guidance to enable him to prepare the plan.

(2) Review and evaluate the contractor's plan.

Ideally, for a particular program, instructions would be given only once, and evaluation for acceptance would also represent a single occurrence. However, the importance of the program plan and the degree of detail with which it should be prepared suggest that it is more practical for enactment of the plan to be accompanied by a period of planned development. This development would involve repeated instruction and evaluation events, starting with the initial contact with prospective contractors and ending with the official customer approval of the program plan.

TABLE 2-15

SUMMARY OF AIR FORCE POLICY
RELATING TO ENACTMENT OF RELIABILITY PROGRAM PLAN

Air Force Document	Statement of Policy	Par. No.
AFR 80-5 4 June 1962	(1) During the conceptual and acquisition phases, systems will be analyzed and a reliability program established for each. Each program will include a minimum acceptable reliability level as well as a reliability goal, with intermediate quantitative values required to measure progression.	4.a.(3)
	(2) System contracts will include a requirement for a comprehensive reliability program, including quantitative requirements and tests for reliability demonstration.	4.c
AFSCR 80-1 14 Dec. 1962	(1) Integrated test plans to investigate causes, effects, and modes of failure, and to demonstrate achieved reliability will be developed and incorporated in contractual documents. Plans will be designed to provide the maximum information and assurance consistent with the state-of-the-art.	4.f

TABLE 2-16

SUMMARY OF RESPONSIBILITIES

RELATING TO ENACTMENT OF RELIABILITY PROGRAM PLAN

Air Force Document	Level to Which Assigned	Statement of Responsibility	Par. No.
AFR 80-5 4 June 1962	AFSC	(1) Incorporate quantitative reliability requirements and provisions for demonstrating reliability in all specifications, exhibits, product descriptions, work statements, and contractual clauses to be referred to or included in contracts for systems and associated materiel.	6.c
		(2) Determine the adequacy of each Air Force contractor's reliability program for achieving and demonstrating Air Force product reliability goals.	6.d
		(3) Evaluate contractor reliability program proposals in all system source selection action.	6.m
AFSCR 80-1 14 Dec. 1962	System Program Offices (SPO's)	(1) Establish the minimum amount of detailed reliability program information required from contractors and supporting Air Force agencies.	9.a
		(2) Define for contractor purposes an adequate and comprehensive contractor reliability program for weapon and support systems, associated material, and government-furnished subsystems.	7.d
AFBSDR 80-5 28 Dec. 1962	SPO Reliability Coordinators	(1) Evaluate all aspects of the contractor's reliability program and take action as necessary to assure the adequacy of this program.	6.b.(3)
	SE/TD Contractors	(1) Be responsible for systems engineering and technical direction of the associate contractor's reliability program, including detailed instructions regarding implementation of contractually referenced reliability documents, to the extent established by the technical directorate concerned.	6.c.(1)
		(2) Review the contractor's reliability program submitted in accordance with MIL-R-27542 or other contractual reliability documents.	6.c.(2)
		(3) Evaluate and assure that data and assumptions used by the contractor are valid prior to preparation of plans for demonstration of achieved reliability.	6.c.(3)

It is entirely possible for the SPO Reliability Coordinator to engage in a sequence of any or all of the following typical actions (listed in chronological order) relating to enactment of the reliability program plan:

(1) Within the Request for Proposal, direct potential bidders to submit a reliability program plan as part of their proposal. (This action is required by MIL-R-27542A.)

(2) Issue supplemental instructions on specific requirements for the plan.

(3) Evaluate bidders' program plans as submitted with their proposals.

(4) Shortly after contract award, conduct a briefing for the selected contractor to clarify and interpret requirements for the reliability program plan and issue additional instructions.

(5) Evaluate the contractor's plan as submitted subsequent to the post-award briefing.

(6) Provide comments indicating necessary contractor actions in order for the plan to be acceptable.

(7) Re-evaluate the contractor's final draft and approve the plan if acceptable. (If the plan is not acceptable, events 6 and 7 should be repeated until acceptance is attained.)

The above procedure may seem to represent an administrative burden on both the SPO Reliability Coordinator and the contractor, but past experience has shown that when comprehensive programs are involved, this degree of customer-contractor coordination is necessary.

The time intervals between instruction and evaluation events are dependent on the circumstances of individual programs. One typical sequence of events which can be used as guidance was set forth in the General Work Specifications for Atlas Standard Space Launch Vehicle Reliability Assurance and Quality Assurance Requirements (Aerospace Corporation Document No. 1923.1347, dated August 1962):

(1) A briefing meeting was scheduled within 15 days after contract start to instruct the contractor as to the requirements of the work statement and their relation to the reliability program plan.

(2) The contractor was required to submit a preliminary draft of his program plan 30 days after the briefing meeting.

(3) The customer (in this case, SSD) was to review the draft with the contractor and submit detailed comments to him within 15 days after receipt of the draft.

(4) The contractor was required to submit a final draft for customer approval within 30 days after receipt of comments on the preliminary draft.

2.3.1 Instructions to Contractor

2.3.1.1 Definition

This activity includes preparation of any statement of work (see 2.1.3), supplemental written instruction, post-award briefing, or other guidance material which is intended to direct the contractor in preparation of his reliability program plan. Such action by the SPO Reliability Coordinator normally commences at the time the RFP is prepared and distributed and continues until shortly after contract award.

2.3.1.2 Air Force Policy

Air Force policy relating to preparation of specifications or instructions for a reliability program plan is covered by the material in Table 2-15 (see 2.3).

2.3.1.3 Responsibilities for Contractor Instructions

The responsibilities of SPO Reliability Coordinators relating to preparation of specifications or instructions for a reliability program plan are indicated in Table 2-16 (see 2.3).

2.3.1.4 Implementation of Contractor Instructions

It would be desirable, of course, if all instructions pertinent to preparation of a reliability program plan could be made available to potential bidders within the RFP. However, the time constraints which normally prevail and the existence of unknown factors vital to a program usually necessitate that the instruction activity be a continuing effort, extending past the proposal phase into an initial period after contract award.

The detailed instructions provided to the selected contractor should represent an interpretation or amplification of original statements appearing within the basic contract document. These instructions should be presented to the contractor as early as practicable, through formal written directives or informal briefings (either presentation method can be equally effective).

The following factors relating to the reliability program plan should be the subject of the special instructions to the contractor:

(1) Schedule for submission of plan -- A precise statement which indicates the number of preliminary submittals and briefings, and the dates for these events and the final submittal.

(2) Format of plan -- A statement of the mechanical requirements for submission of the plan, e.g., size of paper to be used, copies to be bound or unbound, reproducible copy to be submitted, etc.

(3) Outline of plan -- A brief listing of the subjects to be covered in the plan. For example, the major sections could be:

(a) Scope

(b) Applicable documents

(c) Elements of the program

1. Management elements

2. Technical elements

(d) Schedules for the accomplishment of work

(e) Allocations of manpower

(4) Identification of elements of program -- A statement which describes the management and technical elements to be incorporated in the program. An outline of the statement of requirements appearing in the basic contract document may serve this purpose.

(5) Categories of information for each program element -- A statement of the general information desired for each task of the program, including:

(a) Assignment of task responsibility to a specific working group within the contractor's organization.

(b) Procedure to be employed in implementing the task (description or reference to appropriate procedural document).

(c) Schedule for accomplishment of significant events associated with the task (or identification of the times at which future planning decisions will be made).

(6) Instructions related to specific elements of work -- Special instructions related, in general, to procedures and schedules for specific program tasks.

Table 2-17 illustrates the degree of detail with which the SPO Reliability Coordinator should provide guidance or instructions to the contractor. The list of subjects (elements of work) in the table is not exhaustive but does represent major areas of activity common to most programs. Instructions appropriate to a particular program could be tabulated by reviewing the contractual statement of work for the program. These prepared instructions should also be used later as a basis for evaluation of the reliability program plan submitted by the contractor (see 2.3.2).

2.3.1.5 Problems and Special Considerations Relating to Contractor Instructions

2.3.1.5.1 Influence of System Development Phase on Complexity of Program Plan

A reliability program plan will become more complex as the system development progresses. The program plan for the feasibility phase of a system program will be somewhat theoretical in approach and emphasize potential reliability relationships. As the program proceeds to other phases -- such as exploratory, advanced, and, finally, operational development -- reliability requirements will

TABLE 2-17

TYPICAL INSTRUCTIONS TO CONTRACTOR
FOR PREPARING RELIABILITY PROGRAM PLAN

Subject	Instructions Relating to Procedure	Instructions Relating to Schedule
Program Management	(1) Present an organizational chart for the company which illustrates the corporate structure for management and indicate the specific blocks which will maintain responsibilities for implementing tasks under the reliability program.	If re-organization is currently planned, show the point in time at which this re-organization will occur.
	(2) Describe the relationship between any central reliability group and that group which is a part of the organization for this particular program.	
	(3) Indicate the number of personnel (actual and planned) who will staff each working group which will perform work under this reliability program.	Indicate planned growth on a calendar time base.
	(4) Reference or incorporate those top management policy directives which institute reliability provisions on a company-wide basis.	If these directives are currently not in existence, indicate the date by which they will be established.
	(5) Reference or incorporate those program management directives which are specifically generated in support of this program.	If these directives are currently scheduled for future publication, indicate the scheduled date.
Prediction Techniques	(1) Describe the prediction technique(s) to be used in this program and relate these to anticipated information availability. If a standard method(s) exists within the company, incorporate this standard into the program plan.	If a standard manual for performing predictions is to be prepared in support of the program, indicate the scheduled date of publication.
	(2) Indicate the specific manner by which information on predictions will flow between appropriate working groups.	
	(3) Indicate the number and frequency of reliability predictions which will be made in support of the program.	Show the schedule for performing predictions, and give the descriptive titles by which these predictions are identified.
	(4) Indicate the method of submitting the reports of predictions made.	Show the time schedule for submittal of prediction reports.
	(5) Describe the intended method of acquiring failure rate information for use in reliability prediction.	
Document Review	(1) List the categories of documents which will be subjected to review by representatives of the reliability organization.	Indicate the date the document review activity will commence.
	(2) Indicate which of the documents in (1) will be signed-off by reliability personnel.	
	(3) Indicate how reviewers will be considered as qualified to perform the function of document review.	
	(4) Indicate what standards will be used by reviewers in reviewing documents. If a company standard currently exists, incorporate this document into the reliability program plan.	If a standard is to be generated, indicate the intended date of issuance.
	(5) Indicate the manner in which discrepancies noted during document review will be incorporated into the document.	
Design Review	(1) Identify the types of design reviews to be conducted. (e.g., system, subsystem, and component.)	Present a schedule, based on calendar time, which indicates when each of these will be conducted. If sufficient information is not available at time of program plan submittal, indicate schedule information to the extent possible and describe how subsequent scheduling will be developed and submitted to the Air Force.
	(2) Title and define by reference to state of design maturity the design reviews to be made for each system level (e.g., preliminary, detailed, and final).	
	(3) Indicate the personnel who will participate in design reviews.	
	(4) Indicate who will serve as chairmen for design reviews.	
	(5) Indicate manner in which appropriate Air Force personnel will be advised as to forthcoming design reviews.	
	(6) Describe the manner in which necessary preparations for design reviews (e.g., preparation of agenda or designation of location for review) will be accomplished.	
	(7) Incorporate or refer to any check lists which will be used in the conduct of design reviews.	If these check lists are to be prepared at a future date, indicate time of scheduled publication.
	(8) Incorporate or reference any company or program procedural standards which will govern the conduct of design reviews.	If these standards are to be prepared at a future date, indicate time of scheduled publication.
	(9) Describe the manner in which design review proceedings will be recorded and reported.	Indicate time interval between design review conduct and issuance of the design review report.
	(10) Describe the manner in which discrepancies noted during design review meetings will be acted upon.	
Demonstration of Achieved Reliability	(1) Describe the general plan proposed for demonstrating reliability achievement. Indicate how necessary background studies will be approached and what trade-offs will be considered with respect to determining cost, confidence, sample sizes, etc.	If the "general" (or "preliminary") plan for demonstration will be submitted separately from the reliability program plan, indicate the date of submittal.
	(2) Indicate how assumed failure distributions will be validated.	
	(3) Indicate the system level to be considered in demonstration.	
	(4) Describe the intended contents for the detailed or "final" demonstration plan.	Indicate the date of submittal for the detailed or "final" demonstration plan.

become increasingly more specific and applicable to a larger number of proposed system equipments. Consequently, reliability program plan requirements must become more definitive and increase in number and technical level.

Enactment of comprehensive and complex program plans may pose technical knowledge requirements that are difficult for the SPO Reliability Coordinator to satisfy alone. Therefore, consultants in specialized fields (such as those provided by SE/TD contractors) and review and technical writing assistance should be utilized as necessary to assure preparation of complete and satisfactory program plan instructions for system contractors.

2.3.2 Evaluation of Contractor's Program Plan

2.3.2.1 Definition

The contractor's proposed reliability program plan must be evaluated by the SPO Reliability Coordinator to determine its effectiveness as a contractual and management document for assuring the achievement of the desired reliability requirements. The method of performing this evaluation is not specified in Air Force reliability directives, but it may involve determination of a rating (numerical or otherwise) for the program plan based on comparison with a check list or a specification of program plan requirements. The evaluation activity is usually considered to include preparation of a report or comments noting any observed discrepancies.

In evaluating a reliability program plan, the Air Force SPO Reliability Coordinator should make full use of the technical and engineering consulting facilities available within the appropriate system command (i.e. command staffs, Aerospace Corp., etc.)

2.3.2.2 Air Force Policy

Air Force policy relating to evaluation of a contractor's reliability program plan is covered by the material in Table 2-15 (see 2.3).

2.3.2.3 Responsibilities for Program Plan Evaluation

The responsibilities of SPO Reliability Coordinators relating to evaluation of a contractor's reliability program plan are indicated in Table 2-16 (see 2.3).

2.3.2.4 Implementation of Program Plan Evaluation

2.3.2.4.1 Fundamental Bases of Evaluation

In performing an evaluation of a contractor's reliability program plan, there are several fundamental questions to be answered:

(1) Is the document technically sound? Or are there certain areas, activities, or reliability tasks which are technically unsound or require unusual advances in the state-of-the-art?

(2) Are the managerial aspects such that adequate management and administrative control of the program is assured?

(3) Is the program plan designed as a working document?

(4) Does it provide sufficient program coverage and in enough detail so that amendments will be kept to a minimum?

(5) Does it meet or exceed the instructions and directives which were issued to the contractor?

2.3.2.4.2 Performance of Specific Evaluations

In evaluation of a reliability program plan, it is impractical to take a purely qualitative approach and make a single judgment as to the adequacy or inadequacy of the document. Such an approach, while simple to administer, usually does not provide sufficient direction to the contractor for correcting discrepancies. The most advisable procedure is to devote considerable attention to evaluation of preliminary drafts of the program plan which progressively incorporate improvements based on customer recommendations until an acceptable over-all plan is achieved.

The great number of factors to be considered in evaluating a program plan suggests that an objective approach be taken. The evaluation can never be entirely objective, however, since several qualities such as clarity of the plan and understanding of requirements must necessarily be reviewed on a subjective basis.

Table 2-18 illustrates one approach to program plan evaluation -- a tabulation method which enables recording of certain characteristics relative to the plan and notation of judgments made during the evaluation process. The information required for completion of this table is discussed on the basis of column headings as follows:

(1) Subject -- These descriptive titles define the program plan elements which are to be evaluated. They can be listed prior to actual evaluation of the plan, since in most cases they will represent an outline of the contract statement of requirements.

(2) Weighting Factor -- This numerical value represents a decision by the SPO Reliability Coordinator as to the relative importance of the subject requirement. Usually an elaborate weighting factor system is not practical since virtually all requirements are essential to the success of the program. However, there will be certain requirements (such as demonstration or failure reporting) which warrant identification as items of particular significance. Any weighting factors used should be assigned prior to evaluation of a contractor's program plan.

(3) Statement of requirements reference paragraph -- The number of the paragraph within the contract statement of requirements (or document referenced within the contract) which covers the subject requirement should be indicated.

(4) Contractor's program plan reference paragraph -- The purpose of the information in columns (3) and (4) is to provide cross-references between the contract and the contractor's program plan

and thus facilitate evaluation of the responsiveness of the plan to the contract requirements.

(5) Adequacy of responsibility assignment -- A standard requirement for a reliability program plan is the assignment of specific responsibilities within the contractor's organization. Hence, the plan should contain precise statements or tabular presentations which fulfill this requirement. Compliance or non-compliance with the requirement can be recorded in column (5).

(6) Adequacy of procedures -- Possibly the most important characteristic of the program plan is the statement by the contractor as to the manner of fulfilling contract requirements. Hence, the SPO Reliability Coordinator should compare the contractor's statements with those in the contract to determine the adequacy of the contractor's planned procedures. Any special instructions related to a particular element should also be used as a standard in formulating judgment. In general, the contractor's reliability plan should not be confined to a restatement of the contract requirements but should amplify them to the extent that his plan represents a positive course of action.

(7) Adequacy of scheduling -- In the treatment of each program requirement, there will normally be at least one "milestone" or key event. Some requirements, such as prediction or design review, will usually be characterized by several key events. These events should be scheduled within the program plan to the extent possible, and the SPO Reliability Coordinator should judge the adequacy of the scheduling information presented by the contractor.

(8) Itemization of discrepancies -- Columns (5), (6), and (7) involve either positive or negative judgments. If a negative judgment is made, it is advisable to describe the specific discrepancy in column (8). This action permits the SPO Reliability Coordinator to compile a series of comments for the contractor.

(9) Acceptability -- This column should be used as an over-all record of the acceptability of elements within the contractor's reliability program plan.

TABLE 2-18

SUGGESTED FORM FOR EVALUATION OF PROGRAM PLAN

(1) Subject	(2) Weighting Factor	(3) Statement of Req. Ref. Par.	(4) Contractor's Prgm. Plan Ref. Par.	(5) Adequacy of Resp. Assignment	(6) Adequacy of Procedures	(7) Adequacy of Scheduling	(8) Itemization of Discrepancies	(9) Acceptability
Applicable Documents	1	XX	XX	S	S	Not applic.		✓
Program Management	2	XX	XX	S	Unsat.	Not applic.	Relationship between Reliability Mgr. & Design Engineering Mgr. not Shown	
Company Policy Direction	1	XXX	XX	S	S	S		✓
Program Control	2	XXX	XX	S	S	S		✓
Reliability Organization	2	XX	XXX	S	S	Not applic.		✓
Management Control	2	XXX	XXX	S	S	S		✓
Milestone Status	1	XXX	XX	S	S	S		✓
Failure Report Summaries	2	XX	XXX	Unsat.	S	S	Group responsible for Compilation not cited in Plan.	
Design Review	2	XX	XX	S	Unsat.	S	Plan does not indicate intent to issue Design Review reports	
Prediction	2	XX	XX	S	S	S		✓
Apportionment	2	XX	XXX	S	S	S		✓
Design Studies	3	XXX	XXX	S	S	S		✓
Reliability Data Handbook	1	XX	—	—	—	—	Requirement not covered in Plan	
Environmental Criteria	2	XXX	XXX	S	S	Unsat.	Submittal date for environmental Criteria Report not shown	
Vendor Selection	2	XX	XX	S	S	S		✓
Document Submittals	2	X	X	S	S	S		✓
Management Report	2	XX	XX	S	S	S		✓
Status Report	3	XX	XX	S	Unsat.	S	Plan does not state the types of information which will be reported	
Vehicle Logs	1	XX	XXX	S	S	S		✓
Demonstration	3	X	X	S	S	S		✓

Table 2-18 has been filled in as it might appear relative to evaluation of a hypothetical reliability program plan. The subjects listed in column (1) were arbitrarily selected for the purpose of illustration.

When the evaluation of a particular reliability program plan has been completed, the contractor should be advised of the results and of the specific actions he must take to obtain acceptance of the program plan.

2.3.2.5 Problems and Other Special Considerations Relating to Program Plan Evaluation

2.3.2.5.1 Use of Evaluation Results

The results of the evaluation of a proposed program plan can produce benefits which are not necessarily confined to one program. They should be used as the basis for modifying the evaluation procedure, developing better program plans. Further, because a program plan defines a contractor's reliability activities and associated efforts so thoroughly, some relationship should exist between adequacy of a program plan and ultimate reliability achievements. This relationship merits eventual investigation.

2.3.2.5.2 Availability of Specialists

Since a reliability program plan may involve technical items requiring unique areas of knowledge, specialists should be available to assist the SPO Reliability Coordinator in performing the program plan evaluation. The appropriate use of specialists can make the evaluation more accurate. A description of the assistance and services available through the SE/TD contractors is presented in 3.3.2.

2.3.2.5.3 Program Size and Complexity

The evaluator of a program plan should consider the size and complexity of the program when reviewing the plan. The more complex the program, the more carefully the relationships between the various program elements and schedules must be described and documented.

2.3.2.5.4 Bias in Evaluating Program Plan

There is a possibility of unintentional bias during the evaluation of a program plan. This problem can be minimized, however, by the use of more than one evaluator.

2.3.2.5.5 Reevaluation of Program Plans

Proposed program plans will sometimes be reevaluated after additions or modifications have been made. Changed sections or new sections should be evaluated as though originally proposed. The entire program plan should also be reviewed to determine that previously acceptable sections are still satisfactory.

2.3.2.6. Additional References on Evaluation of Contractor's Program Plan

Reliability and Product Assurance, R. L. Landers, Prentice-Hall, 1963, pp. 126-127.

Reliability: Management, Methods, and Mathematics D. K. Lloyd and M. Lipow, Prentice-Hall, 1962 pp. 34-35.

3. ADMINISTRATION OF A RELIABILITY PROGRAM

Once a reliability program has been established (see section 2), the administration of the program, through sound management actions, becomes a major task within the purview of the SPO Reliability Coordinator. Although the activities associated with the terms "management" and "administration" are often broad in scope, administrative duties must not be random but must be founded on an ordered set of directives, policies or procedures. Section 3 is intended to define the tasks encompassed by reliability program administration, with specific reference to the responsibilities of the SPO Reliability Coordinators.

Reliability engineering as an accepted discipline developed rather recently, although the mathematical and statistical methodology required in reliability research had been established for some time. During the 1950's, two types of reliability research began to be emphasized: (1) data collection or fact-finding effort in which the primary objective was the accumulation of failure-rate information through testing programs, and (2) the development of techniques by which the methods of mathematics could be applied in the solution of reliability problems. These types of research are continuing as important elements in reliability engineering, but they have lately been joined by another type of research which had previously received little attention -- the development of methods for reliability management.

The management problem presented by reliability engineering is usually defined in negative terms, with emphasis on the item that fails, the mode of failure, the human errors contributing to failure, and the control actions that must be taken to prevent failure recurrence. Although this description is sound and can be used effectively, there is another more affirmative method of defining the problem: What are the management methods that promote an atmosphere in which maximum product quality can be achieved? By emphasizing prevention rather than correction of trouble, this approach compels reliability management to exercise constructive responsibilities rather than merely remedial actions.

The positive approach to reliability program administration has been emphasized on many occasions by high Air Force authority. For example, in his keynote address before the Seventh Military-Industry Missile and Space Reliability Symposium, General B. A. Schriever stated:

> "We can no longer afford to take the easy view, that reliability is something that just happens. It must be planned for and worked for -- in a careful, organized, and systematic manner. In systems acquisitions today, reliability is more than just a technical problem -- it is a definite responsibility of management."

The emphasis on an organized and systematic approach to program administration is further manifest in existing regulations which have been issued at all levels of Air Force command.

From the Air Force standpoint, the responsibility for reliability management is primarily vested in the SPO Reliability Coordinators. Section 3 discusses the tasks of a Reliability Coordinator as they relate to administration and management of an established reliability program. Hence, it is assumed that a contract has been awarded and that a reliability program plan exists in an approved form. The function of the Reliability Coordinator, then, is to take those actions necessary to cause implementation of the reliability requirements which have been established by the contract and the contractor's program plan. He must assure that adequate customer-contractor communication channels exist for mutual understanding of program requirements and accomplishments (3.1); he must implement efficient control systems or devices for comparing actual and planned progress (3.2); he must provide effective technical direction to insure program progression toward planned objectives (3.3); he must endeavor to obtain sufficient funding and other support required for proper conduct of the program (3.4).

The task of monitoring and evaluation of a reliability program is not considered in Section 3, but rather is subjected to special consideration in section 4.

3.1 Customer-Contractor Communications

Defined as a task, customer-contractor communications encompass all activities by which the two parties interchange opinions, recommendations, decisions, or status information to increase their material knowledge or understanding relative to a particular program.

The employment of effective communication techniques represents a major challenge in the administration of a reliability program. The complexity of the communication problem can be attributed to the following factors which are characteristic of most programs:

(1) The technical tasks to be performed by a contractor are large in number and embrace many areas of consideration.

(2) The procedures associated with the practice of reliability engineering are not routine and therefore require continual interpretation and refinement.

(3) The number of individuals involved in the implementation of the reliability program is large, necessitating extreme measures for coordination of effort.

(4) The reliability program extends over a considerable period of time, necessitating special measures to maintain continuity of effort.

(5) Reliability is only one of many parameters which are vital to over-all system effectiveness (see Appendix F). Hence, continual trade-offs are necessary throughout the duration of the program. For these trade-offs to be made properly, up-to-date information on program progress and potential must be available on a virtually continuous basis.

The following categories of communication activity are significant to the administration of a reliability program:

(1) Periodic status reports (from the contractor to the customer).

(2) Periodic technical meetings (of both contractor and customer representatives).

(3) Contractor data submittals.

(4) Customer-contractor liaison (i.e., informal contract).

(5) Customer internal reports (i.e., reports generated within the Air Force).

(6) Surveys.

These categories are discussed separately in succeeding sections.

3.1.1 Periodic Status Reporting

3.1.1.1 Definition

Periodic status reporting involves the submittal by the contractor of a documented statement of program highlights (e.g., accomplishments, problems encountered, future plans, etc.) to the customer at a specified frequency. The submittal of status reports usually commences with contract award and continues throughout the duration of the contract.

This reporting activity is vital to the administration of a reliability program since, in most programs, it represents the prime method by which the contractor communicates information to the customer.

3.1.1.2 Air Force Policy

There are many policy statements within existing Air Force regulations which imply that periodic status reporting is required in every reliability program. As a typical example, AFR 80-5 states that achievement of reliability is a growth process and that collection of information is fundamental to this process.

3.1.1.3 Responsibilities for Status Reporting

The assigned responsibilities of the System Program Offices (and thus the SPO Reliability Coordinators) and associated groups relating to administration of reliability status reporting for contracted programs are summarized in Table 3-1.

3.1.1.4 Implementation of Status Reporting

The task of administering the contractor-to-customer status reporting activity for a particular program encompasses three distinct areas of endeavor:

(1) Formulating a plan for report submittals.

(2) Evaluating submitted reports for adequacy.

(3) Effectively utilizing reported information.

TABLE 3-1

SUMMARY OF RESPONSIBILITIES
RELATING TO
ADMINISTRATION OF RELIABILITY STATUS REPORTING

Air Force Document	Level to Which Assigned	Statement of Responsibility	Par. No.
AFSCR 80-1 14 Dec. 1962	AFSC Division and Centers	(1) Maintain complete, factual, and timely information regarding the status of reliability programs as well as associated problem areas.	6.f
	System Program Offices (SPO's)	(1) Maintain complete, factual, and timely information regarding the status of reliability estimates and contractor's reliability program as well as associated and program problem areas.	7.h
		(2) Establish the minimum amount of detailed reliability program information from contractor and supporting Air Force agencies. (AFSCR 174-1 states policies to be observed in establishing reporting requirements from AFSC contractors and provides procedures to be followed in obtaining approval for requirements for contractor reports.) Pertinent reliability information will be compiled in periodic reports for the cognizant SPO. The information contained in these reports will be considered by the SPO in all management decisions which can affect the achieved operational reliability of the system. (Stated as a procedure in AFSCR 80-1.)	9.a
AFBSDR 80-5 28 Dec. 1962	SE/TD Contractors	(1) Assure that documents necessary to technical management of the system reliability program are generated, collected, and maintained.	6.c.(4)

3.1.1.4.1 Formulation of Plan for Report Submittals

For maximum effectiveness to be realized from the status reporting activity, both the customer and the contractor must have a clear understanding of reporting specifics. This understanding can be achieved through contractual stipulation of requirements, amplification of the requirements in supplementary formal instructions, and further guidance provided by informal communication.

3.1.1.4.1.1 Contract Reporting Requirements

Usually, only minimum specifications for reporting are stated within the contract instrument. These include:

(1) Title of the report (e.g., Reliability Status /Progress/ Report).

(2) Frequency of submittal (e.g., monthly).

(3) General scope of coverage (e.g., report of progress relative to defined reliability tasks and statement of significant problem areas).

(4) Persons, offices, agencies, etc. to whom the report is to be submitted.

In some cases, the contract will also stipulate compliance with an existing standard or instruction for report submittal (e.g., AFBM Exhibit 58-1). This standard or instruction will normally have general application to all reports under the program and will not specifically refer to the reliability program status reports.

3.1.1.4.1.2 Supplementary Reporting Instructions

In the administration of a particular program, it will be practical and even necessary for the SPO Reliability Coordinator to supplement the contract statement and its associated general instructions for reporting with a specific set of instructions for periodic reliability status reporting (e.g., "Instructions for Submittal of Monthly Reliability Status Reports -- Program XXX"). Typical of the factors which could be included in such instructions are:

(1) Summary of contract requirements which are pertinent to the reliability status report (including general regulations).

(2) Date of month (or other specific time) when the report is to be submitted.

(3) Relationship between the reliability status report and the over-all program status report. It is important to establish whether reliability status will be included as part of the over-all program status report or will be reported separately.

(4) Basic outline for the presentation of the status information. For example, the status report could be divided into discussions for major subsystems or for other defined areas of activity. The basic outline selected should be consistent with the outline of program requirements as established by the contract and/or the contractor's program plan.

(5) A statement of the types of information desired within the report, with a description of each type. Categories of desired information could include quantitative achievements; significant events, regardless of achievement aspects; problem areas; listing of documents generated for the reporting period; management decisions made by the contractor; and future work plans.

(6) Specific forms that must be submitted as part of the status report. These forms may be specially designed on the basis of individual System Program Offices' requirements

(7) Explicit objective statements which are to be included in the report as a matter of routine. Such statements could include the number of each of the following items accomplished during the reporting period: design reviews, visits to subcontractor facilities, classroom hours spent on reliability training, failure reports processed.

(8) Relationship between the periodic reliability status report and other types of submittals associated with the reliability program. The contract and the program plan will usually identify several other distinct submittals, such as prediction reports, failure summaries, and design review reports. It is necessary to indicate whether these specialized reports should be submitted with the status report or separately.

In most situations, it will be desirable to consider the specifics of status reporting shortly after contract award. This timing permits the contractor's program plan as well as any suggestions or opinions he may have relating to report preparation to be taken into consideration when preparing the detailed instructions for reporting. The SPO Reliability Coordinator should also consider his own requirements for submitting internal Air Force reports (see 3.1.5) and make certain that, where appropriate, requirements stipulated by higher authority are passed on to the contractor.

Figure 3-1 illustrates a typical manner of expressing reporting requirements for a program. The material shown was extracted from a Sample Work Statement issued by BSD for guidance to procuring activities.

3.1.1.4.1.3 Informal Communication Relating to Reporting

The preceding discussions have related to establishment of reporting specifics through contract statements and supplementary instructions which are officially issued. In many cases, the effectiveness of status reporting can be further increased by informal communication with the contractor to provide additional guidance and/or request emphasis on areas of immediate interest.

3.1.1.4.2 Evaluation of Reports

Each reliability status report submitted by the contractor should be evaluated by the SPO Reliability Coordinator. The first few reports submitted in a report

FIGURE 3-1

EXAMPLE OF TYPICAL METHOD
OF STATING REPORTING REQUIREMENTS*

13. Reports Submittal

13.1 The following reports shall be submitted as indicated below:

A. Monthly	B. Quarterly
Reliability Estimates	Mathematical Model Estimates
Availability Estimates	Zero Trend Items
Failure Summaries	Problem Areas

13.2 Sample formats for these reports are given in Figures 2 through 7 on the following pages.

13.3 Other special or one-time reports, including those listed below, have no special requirements regarding format.

C.1 Program Review Reports

C.2 Interface Definition Report

C.3 Design Review Packages (on request only)

C.4 Test Review Board Report

*Section 13 from Sample Work Statement issued by BSD.

FIGURE 3-1 (Continued)
EXAMPLE OF TYPICAL METHOD
OF STATING REPORTING REQUIREMENTS*

FIGURE 2

A.1 Reliability Estimates (Furnished by IACC from AC inputs)

System	Requirement Count-Dn Flight/Patrol	Current Status Ct-Dn Flight/Patrol
	Date through	1963
A. Over-all System		
B. Propulsion		
1. 1st Stage		
2. 2nd Stage		
C. Guidance	-/-	-/-
1. Airborne		
2. Ground		
D. Re-Entry Vehicle		
E. Command and Control		
1. TLV		
2. COC		
F. Transporter Launcher		
1. ECU		
2. APU		

FIGURE 3

A.2 Availability Estimates

	Availability	MTTR (Unsched)	MDT (Sched)
A. Over-all System			
B. Propulsion			
C. Guidance		X	X
D. R/V			
E. C and C	X	X	X
1. TLV			
2. COC			
F. T/L			

*Section 13 from Sample Work Statement issued by BSD

FIGURE 3-1 (Continued)

EXAMPLE OF TYPICAL METHOD
OF STATING REPORTING REQUIREMENTS*

FIGURE 4

A.3. COMPILED AND SUBMITTED BY IACC BASED ON A/C INPUTS

Cumulative Number of F/R	Total Number of F/R this Month	Number of F/R by Cause					Number of F/R by Source								Number Submitted for Failure Analysis	Number of F/R by Environment (Discovered during)						
		Hardware	Human Errors	Procedures and Technical Data	Q. C. Rejections	Other	IACC	Propulsion	Guidance	Re-entry	C and C	T/L	Other	Other		Acceptance/Receiving	Qualification Testing	Development Testing	PET Program	Reliability/QA Testing	Assembly/Check-Out	Other

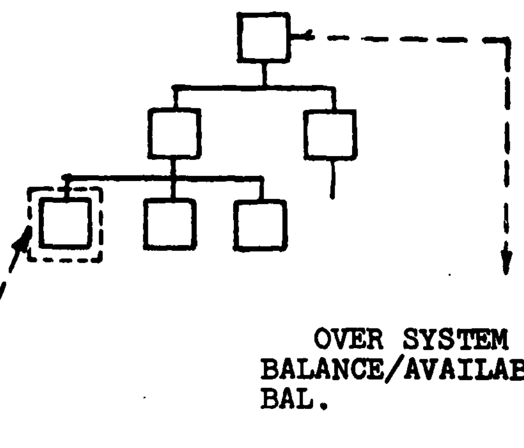
*Section 13 from Sample Work Statement issued by BSD

FIGURE 3-1 (Continued)

EXAMPLE OF TYPICAL METHOD
OF STATING REPORTING REQUIREMENTS*

FIGURE 5

B.1. MATHEMATICAL MODEL



Reliability Balance	: $\pm X(c \pm Dn/Flt)$
Function Number	: 3.2.1
Availability Estimate	: Y%
Validated	: 0 or 1
** Reference Code	: a,k,j,p,w
Design Reviewed	: N/R or 0 or 1

**Reference code: This code allows one to locate on back-up sheets the specific five (5) components (next lowest indenture) which are furthest from their apportioned reliability.

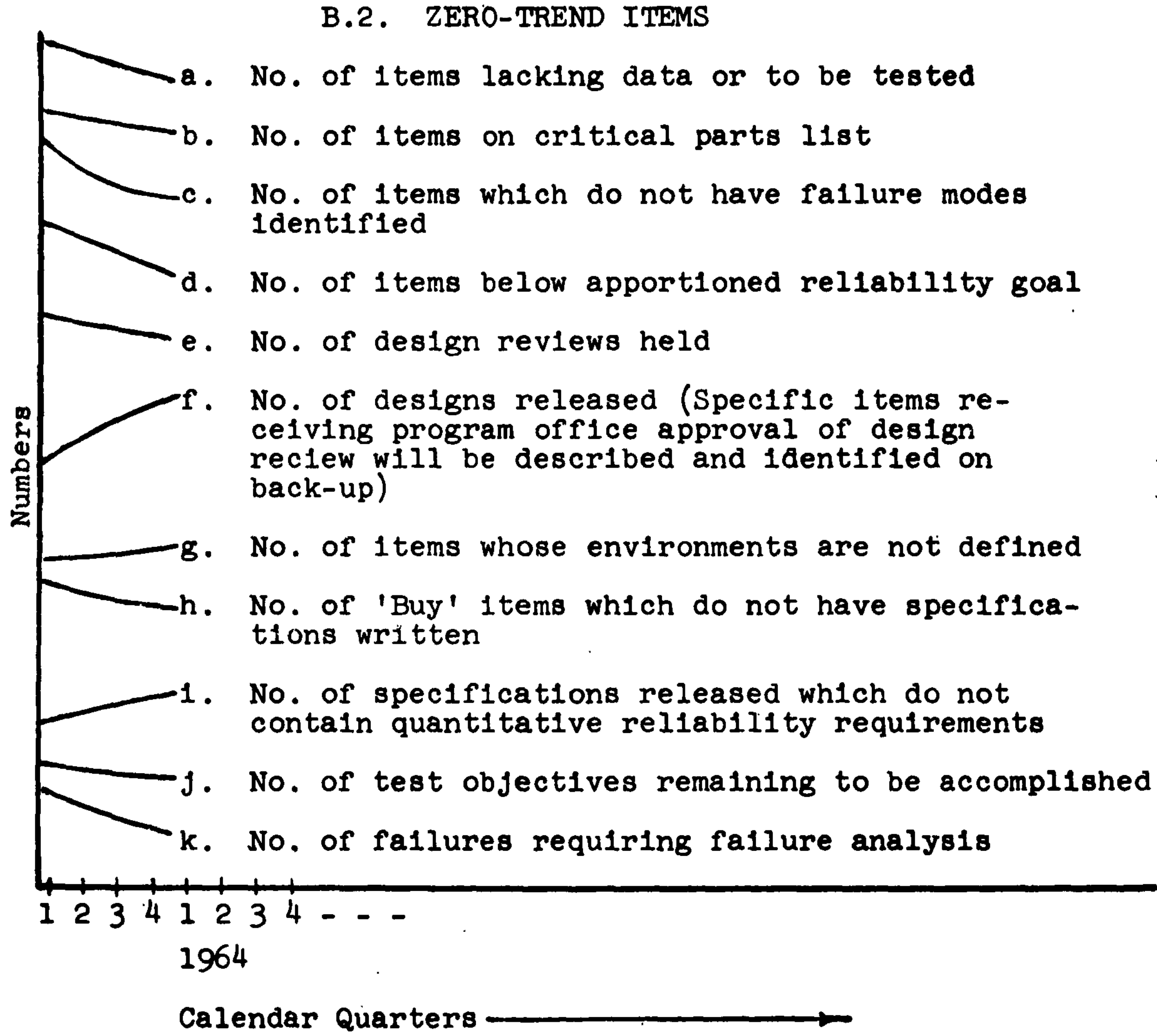
*Section 13 of Sample Work Statement issued by BSD

FIGURE 3-1 (Continued)

EXAMPLE OF TYPICAL METHOD
OF STATING REPORTING REQUIREMENTS*

FIGURE 6

B.2. ZERO-TREND ITEMS



*Section 13 of Sample Work Statement issued by BSD

FIGURE 3-1 (Continued)

EXAMPLE OF TYPICAL METHOD
OF STATING REPORTING REQUIREMENTS*

FIGURE 7

B.3. PROBLEM AREAS

No. of Problems Opened this Qtr	No. of Problems Closed this Qtr	Control Nos. of Problems Open more than 90 days	Control Nos. of Problems Dependent on AF Action
			XXK.20 (Date submitted to SPO)

*Section 13 of Sample Work Statement issued by BSD

should receive particular attention to assure that an understanding exists between the contractor and the customer as to the needs to be fulfilled by the report.

The review and evaluation of status reports may involve a subjective approach relating to the quality of reporting on major elements of the program (the contractor should be advised in advance of the SPO's concept of what constitutes a major element). Or, a more objective approach utilizing pre-established check list items such as those presented in Table 3-2 may be employed.

When the SPO Reliability Coordinator has completed the evaluation of a status report, the results should be communicated to the contractor. Such communication may be a matter of record or on an unofficial basis; however, recording of results is usually more effective in initiating corrective actions by the contractor.

3.1.1.4.3 Utilization of Reported Information

If a sincere effort is made early in a program to assure that the contractor understands and implements the requirements and desired quality of reporting effort, his periodic status reports can serve the SPO Reliability Coordinator in a variety of ways. For maximum value, of course, the reports must have a consistent organization and display continuity with respect to the information reported.

Specific uses which the status reports can serve include:

(1) Providing the major source of information for the SPO Reliability Coordinator's status reports to his higher authority (see 3.1.5).

(2) Providing a listing of action items for discussion at technical direction meetings (see 3.1.2).

(3) Enabling the SPO to initiate proper support activities to solve existing problems.

(4) Assisting SPO judgment as to the adequacy of the contractor's performance.

TABLE 3-2

ITEMS TO BE INCLUDED IN CHECK LIST
FOR EVALUATION OF STATUS REPORTS

(1) Is the report submitted on time?

(2) Is the report signed by the appropriate corporate official?

(3) Does it identify the reporting period?

(4) Is the distribution of the report considered adequate?

(5) Does the report answer questions implied by the preceding one?

(6) Does it identify the questions to be answered in the next report?

(7) Is the report organization consistent with specified format?

(8) Does the report properly identify included references to other documents?

(9) Does the report cover all items scheduled for completion during the reporting period?

(10) Is the information in sufficient detail to enable the required level of understanding?

(11) Is the data consistent with those previously reported?

(12) Is the report in sufficient detail to enable the SPO Reliability Coordinator to compile his own internal reports?

(13) Are all major aspects of the program covered?

(14) Does the report identify significant problem areas?

(15) Does it identify significant events or findings which are truly indicative of quantitative reliability achievement?

(16) Has the contractor complied with supplemental reporting instructions issued?

(5) Providing information for updating charts or other visual displays which may be utilized in the program.

(6) Maintaining a historical record of significant program events.

3.1.1.5 Problems and Special Considerations Relating to Status Reporting

3.1.1.5.1 Relation of Program Size to Reporting Frequency

The magnitude of the contracted program will determine, to a large extent, the frequency with which reports should be submitted. Usually, the optimum frequency for submittal is on a monthly basis, but in programs which do not include comprehensive effort, status reports could be submitted less frequently. It should be noted, however, that MIL-R-27542A requires that status reports are to be submitted at intervals which do not exceed three months.

3.1.1.5.2 Relation of System Development State to Required Status Information

The state of development of the system will be influential in determining the type of reliability status information to be reported. For example, information reported during early design development will emphasize specification and drawing preparation activities, prediction accomplishments, vendor selection, parts improvement programs, training activities, and similar developmental efforts. Later in the program, test results will be more readily available, and failure reporting activities will become more significant. During production phases, more emphasis will be placed upon acceptance techniques and field results.

3.1.1.5.3 Time Consumption in Report Preparation

It is often debated that time consumed in preparing status reports shortens the available time and therefore detracts from a contractor's ability to accomplish technical elements of work. Such an argument usually cannot be justified, but it is possible that the contractor could accomplish the reporting task more efficiently. Emphasis should be placed on establishing a format which facilitates reporting needed information. Tabular presentations, graphs or other illustrations will simplify reporting of data and can be designed for cumulative presentation of information from each reporting period.

3.1.1.5.4 Coordination Between Reporting Procedures and Program Needs

It is usually impractical to enforce a general reporting procedure without specific identification of program needs. The SPO Reliability Coordinator may not, however, be in a position to fully determine these needs early in a program. Hence it is advisable for him to invite suggestions from the contractor in formulating detailed specifications for status reporting.

3.1.1.6 Additional References on Periodic Status Reporting

AFBM Exhibit 58-1, Contractor Report Requirements.

The Computer Reliability Report, I. R. Whiteman, Proceedings, Ninth National Symposium on Reliability and Quality Control, January 1963, pp. 80-83.

Reliability and Product Assurance, R. R. Landers, Prentice-Hall, 1963, pp. 466-468.

Technical Communication, George Harwell, MacMillan, 1960.

3.1.2 Periodic Technical Meetings

3.1.2.1 Definition

Periodic technical meetings comprise those joint meetings of appropriate contractor and customer personnel for the purpose of presenting information or discussing factors significant to a particular reliability program. These meetings provide a vehicle for open treatment of problem areas and creation of a better understanding of mutual needs. (Meetings which are specifically intended for formal review of program progress are discussed in 4.2.)

Conduct of technical meetings in an informal atmosphere is most conducive to beneficial results. However, there are definite procedures which should be considered in implementing this area of activity, including specified schedules and pre-planned agenda for meetings. Technical meetings between contractor and customer representatives should commence shortly after contract award and continue, as needed, throughout the duration of the program.

3.1.2.2 Air Force Policy and Responsibilities for Technical Meetings

Air Force reliability directives do not provide explicit policy statements or responsibility assignments relating to the conduct of technical meetings. However, such meetings are standard practice in the management function for a system program, and SPO Reliability Coordinators have major functions in their conduct, as indicated in the following discussion on implementation

3.1.2.3 Implementation of Technical Meetings

In conducting a series of customer-contractor technical meetings for a particular program, there are three definable tasks which must be implemented:

(1) Pre-planning activities

(2) Conduct of meetings

(3) Reporting of results

3.1.2.3.1 Pre-Planning Activities

The conduct of technical meetings requires the presence of key personnel from both the contractor's and the customer's organizations. In order to minimize expenditure of valuable management time, special attention must be given to the efficient planning of these meetings. Items to be considered include:

(1) Frequency of meetings -- The intervals at which technical meetings should be held can be prescribed within the contract statement of requirements or established shortly after contract award. In past programs, such meetings have been held as frequently as on a monthly basis, but the need for a particular program depends upon the extent of reliability activity involved.

(2) Personnel in attendance -- Because of the joint contractor-customer participation, the technical meetings are an effective means for generating significant decisions relative to the reliability program. Hence, it is desirable that the attending contractor and customer personnel be of appropriate management levels to possess authority for implementing such decisions.

(3) Purpose of meetings -- Technical meetings are usually conducted in addition to, and independent of, periodic status reporting. Therefore, they should preferably not be used to report routine progress but rather to facilitate the identification of significant problem areas and formulate decisions requiring considerable customer-contractor coordination.

3.1.2.3.2 Conduct of Meetings

Universally effective meeting procedures are applicable to the technical meetings associated with reliability programs: a chairman (e.g., the SPO Reliability Coordinator) should be appointed to direct the proceedings, and preplanned agenda should be used.

Undoubtedly, during the course of a technical meeting, problems will be introduced which warrant additional investigation. These problems could be either technical or administrative in scope and represent areas of prime responsibility of either the contractor or the customer. When such problems cannot be resolved at one meeting, they should be identified as "open action" items to be discussed further at some subsequent meeting. The description of an "open action" item, the person responsible for its investigation, and the time of subsequent reporting should be recorded.

3.1.2.3.3 Reporting of Results

Subsequent to the conduct of each technical meeting, the minutes should be published and distributed to all attendees. Such action requires that a secretary be appointed to record the proceedings while they are in progress. The minutes should include the following information:

(1) A summary statement of the topics discussed.

(2) An identification of decisions generated during the meeting.

(3) A listing of "open action" items designated for further investigation.

A file of the technical meeting minutes for a particular program should be maintained by the SPO Reliability Coordinator. This file will serve as a reference for historical information and for future planning relative to program administration.

3.1.2.4 Problems and Special Considerations Relating to Technical Meetings

3.1.2.4.1 Maintenance of Pre-Planned Schedule

It is not uncommon for deviation from a pre-planned meeting schedule to occur as the program progresses, due in most cases to the difficulty of scheduling meeting times and places which are mutually acceptable to all concerned. There is no ready solution to maintaining a consistent schedule of technical meetings, but the situation can be alleviated by:

(1) Emphasizing the importance of technical meetings in the contract statement of requirements.

(2) Pre-planning each meeting by the advance publication of the agenda.

(3) Requiring attendance of key personnel.

(4) Using the meetings as a vehicle for generating program decisions.

(5) Properly publishing and distributing the minutes of meetings.

3.1.2.5 Additional References on Technical Meetings

The Role of the Buyer in Reliability, R. T. Dewey, Proceedings, Ninth National Symposium on Reliability and Quality Control, January 1963.

3.1.3 Contractor Data Submittals

3.1.3.1 Definition

The various data utilized by a contractor to predict reliability, establish reliability requirements, estimate environmental and operational effects, estimate achieved reliability, and demonstrate contract compliance also provide means for the customer to verify and evaluate decisions and performance of the contractor. Specific forms of data presentation are normally prescribed within the contract statement of requirements, with the stipulation that these data be submitted to proper Air Force authority. In most instances involving elements of a reliability program, the proper authority is the SPO Reliability Coordinator.

3.1.3.2 Air Force Policy

Air Force general policy and requirements relating to contractor data submittals are presented in Table 3-3.

3.1.3.3 Responsibilities for Contractor Data Submittals

The assigned responsibilities for System Program Offices and other associated levels of authority relating to contractor data submittals are summarized in Table 3-4. The administrative responsibilities of the SPO Reliability Coordinator are primarily related to the establishment and enforcement of orderly procedures for accomplishment and utilization of these submittals.

3.1.3.4 Implementation of Contractor Data Submittals

Tasks to be implemented by the SPO Reliability Coordinator relative to contractor data submittals are:

(1) Definition of data submittal requirements.

(2) Establishment of procedure for review and evaluation of data submittals.

(3) Continuing administration and control of contractor data submittal activities.

TABLE 3-3

SUMMARY OF AIR FORCE POLICY

RELATIVE TO CONTRACTOR DATA SUBMITTALS

Air Force Document	Statement of Policy	Par. No.
AFR 80-5 4 June 1962	Achieving reliability is a growth process. The collection, analysis, and feedback of information to both the Air Force and industry are fundamental to the control of this process.	3.c
MIL-R-27542A 21 May 1963	Data as referenced or described in the specification under the following paragraph headings shall be submitted by bidders or contractors at such times as required:	
	(1) Reliability Program Plan	3.3
	(2) Program Review	3.4
	(3) Emergency Reporting of Defective Parts	3.5.3.2.c
	(4) Critical Items	3.5.4
	(5) Design Review	3.5.10
	(6) Reliability Considerations for Engineering Changes	3.5.11.5
	(7) Failure Data Collection, Analysis, and Corrective Action	3.5.12
	(8) Reliability Demonstration	3.5.13
	(9) Periodic and Final Reports	3.5.14

TABLE 3-4

SUMMARY OF RESPONSIBILITIES
RELATING TO CONTRACTOR DATA SUBMITTALS

Air Force Document	Level to Which Assigned	Statement of Responsibility	Par. No.
AFR 80-5 4 June 1962	AFSC	(1) Establish procedures for failure data feedback and insure prompt consideration of failure data for incorporation into systems design during research and development and for use in logistic support applications.	6.i
AFSCR 80-1 14 Dec. 1962	AFSC Divisions and Centers	(1) Establish and man a central data office for the collection, evaluation, dissemination of applicable reliability statistics and test results to AFSC divisions and center elements and furnish consultant service in the application of this information to new programs.	6.e
	System Program Offices (SPO's)	(1) Incorporate requirements for quantitative data in contractual documents.	7.e
		(2) Maintain complete, factual, and timely information regarding the status of reliability estimates and contractor reliability program as well as associated and program problem areas.	7.h
AFBSDR 80-5 28 Dec. 1962	SPO Reliability Coordinators	(1) Assume complete and over-all management responsibilities for all aspects of the system reliability program including:	6.b.(3)
		(a) Maintaining a current status of reliability program activities, achievements, and predictions.	6.b.(3)(d)
		(b) Reviewing contractor's and field failure summaries, isolating deficiencies, and assuring that corrective action is taken by the contractor or other responsible agencies.	6.b.(7)
	SE/TD Contractors	(1) Evaluate and assure that data and assumptions used by the contractor are valid prior to preparation of plans for demonstration of achieved reliability.	6.c.(3)
		(2) Accumulate and evaluate reliability data from whatever sources are available.	6.c.(5)
		(3) Process failure and problem summaries as referenced in contractual reliability documents.	6.c.(6)

3.1.3.4.1 Requirements for Data Submittals

Requirements for contractor data submittals should be associated with specific reporting activities in a reliability program and should be as definitive as possible to facilitate control of the quality, content, and schedule of submittals. The requirements should be incorporated in the contractor's reliability program plan or other related documents.

Table 3-5 is a typical check list which could be used by the SPO Reliability Coordinator both in defining data submittal requirements and in monitoring compliance with these requirements. The report and documentation titles listed in the table are representative of those which might be extracted from a specific contractual statement of requirements.

3.1.3.4.2 Review of Data Submittals

Each data submittal should be subjected to a review which considers the following questions:

(1) Are the data pertinent to the specific purpose of the report in which they are submitted and to the conclusions or recommendations in the report?

(2) Are the sources of the data identified?

(3) Are any interpolations or extrapolations made during the use of the data identified as such?

(4) Are the applicable operating and environmental conditions adequately described?

(5) Are valid assumptions made in the use of the data?

(6) Are the data consistent with those contained in previous reports?

(7) Are the data sufficient for Air Force needs?

TABLE 3-5

SAMPLE CHECK LIST
FOR CONTRACTOR DATA SUBMITTALS

Required Reliability Report or Documentation	Information				
	Required Number and Distribution of Report or Document	Required Time After Start of Contract or Date for Submission of Report or Document	Contractor's Organization Responsible for Report or Document	Reliability Coordinator's Source of Assistance in Evaluating Data and Report or Document Contents	Reference Source of Data Requirements for Report or Document
Reliability Program Plan					
Reliability Status Report					
Failure Summary Report					
Environmental Requirements Report					
Part Selection Report					
Product Environmental Test Plan					
Product Evaluation Test Status Report					
Reliability Requirements for Subcontractors					
Reliability Evaluation Test Plan					
Flight Proofing and Qualification Status Report					
Flight Analysis Report					
Detailed Design Study Reliability Analysis					
Preprototype Reliability Analysis					
Prototype Reliability Analysis					
Preproduction Reliability Analysis					
Service Readiness Reliability Analysis					
Product Improvement Reliability Analysis					

(8) For test data:

(a) Are exclusions noted?

(b) Are the operating conditions, time, and environments (real or simulated) identified?

(9) Do graphs, charts, and trade-off curves contain data references sufficient to identify the source?

3.1.3.4.3 Administration and Control of Data Submittals

The continuing administration and control of a contractor's data submittals may encompass the following activities:

(1) Maintenance of a schedule log on all required reports and documentation, and notification of the contractor whenever reports are overdue.

(2) Maintenance of an evaluation log on all reports and documentation, including remarks on data deficiencies, discrepancies, or misapplications.

(3) Checking of each report received from the contractor to determine that the required data are present and satisfactory (see 3.1.3.4.2).

(4) Notification of the contractor as to any discrepancies or deficiencies in the data or their use and required remedial action.

(5) Periodically requesting Air Force Plant Representatives to verify data submitted by the contractor (e.g., in failure summaries), note exclusions and questionable items, and report the results of their investigations. (Air Force management and the contractor should be notified when serious deficiencies exist.)

(6) Informing the contractor within a reasonable time after SPO review or contractor corrective action when data and reports are considered acceptable.

(7) Taking such other actions as may be required, for example:

(a) Generating Air Force reliability studies.

(b) Initiating system or subsystem evaluation by Air Force management.

(c) Initiating action required by SE/TD contractors.

3.1.4 Customer-Contractor Liaison

3.1.4.1 Definition

Liaison can be defined as the informal communicative efforts between the customer and a contractor which are intended to promote better understanding of requirements and coordinate activities of a reliability program. Such efforts include the informal contacts which occur during customer visits to contractor facilities. Liaison activities commence upon contract award and continue throughout the program.

3.1.4.2 Air Force Policy

The policy of the Air Force with respect to liaison activities is summarized in Table 3-6.

TABLE 3-6

SUMMARY OF AIR FORCE POLICY RELATING TO LIAISON ACTIVITIES

Air Force Document	Statement of Policy	Par. No.
AFSCR 80-1 14 Dec. 1962 AFBSDR 80-5 28 Dec. 1962	Procedures for periodic management review and program control will be developed and applied to the management activity at individual systems management level.	4.h/ 5.a
AFSCR 80-1 14 Dec. 1962	The problems resulting from time compression of programs and concurrent activities can be resolved only by exploiting the systems organization to achieve an integrated approach.	3.c

3.1.4.3 Responsibilities for Customer-Contractor Liaison

The responsibilities of SPO Reliability Coordinators and other levels of authority relating to liaison activities are presented in Table 3-7.

3.1.4.4 Implementation of Liaison Activities

Liaison activities which are common practice in the administration of reliability programs fall into two distinct areas:

(1) Visits to contractor facilities.

(2) Coordination with Air Force on-site surveillance agencies (e.g., AFPRO).

3.1.4.4.1 Visits to Contractor Facilities

The practice of visiting a contractor's facility offers obvious advantages to the SPO Reliability Coordinator: He not only acquires a familiarity with the contractor's personnel, organization, and plant, but also has an effective opportunity to promote the degree of personnel interest which the contractor manifests in the conduct of his reliability program.

While visits to contractor facilities, as discussed here, are not intended primarily for program evaluation, they nevertheless provide the SPO Reliability Coordinator with information which is of value in assessing program progress (see 4.1 for discussion of use of visitation to evaluate programs). Also, through a first-hand understanding of problems which may prevail in contractor activities, the Reliability Coordinator can more effectively formulate appropriate solutions or provide direction.

TABLE 3-7

SUMMARY OF RESPONSIBILITIES RELATING TO LIAISON ACTIVITIES

Air Force Document	Level To Which Assigned	Statement of Responsibility	Par. No.
AFR 80-5 4 June 1962	AFSC	Insure uniform implementation of reliability policy and procedures at appropriate levels and coordinate with related activities	6.a
AFSCR 80-1 14 Dec. 1962	AFSC/DCS	Establish and maintain channels for the exchange or reliability information with: (a) Operating commands to obtain information for the establishment of realistic quantitative requirements. (b) AFLC to obtain reliability information compiled by AFLC and to provide information from which AFLC may program adequate support for systems becoming operational. Data exchange channels will be established with any military, industrial, or academic agency which requires or may provide reliability data.	5.a.(2)
	AFSC Divisions and Centers	Provide technical assistance to the CMR's in execution of their reliability responsibilities.	6.g
	System Program Offices (SPO's)	Establish a liaison with AFLC for developing a failure reporting system which will be administered by AFLC during system testing and the timely feedback of the generated information to the development engineering activity and the central data office. In addition, the SPO will assure the delivery to AFLC of additional information required to program AFLC support of the system upon its becoming operational.	7.g
AFBSDR 80-5 28 Dec. 1962	SPO Reliability Coordinators	Assure proper utilization of available manpower resources by consumating SPO/AFPRO-CMR agreements and validating requirements for SE/TD support as necessary.	6.b.(3)

3.1.4.4.2 Coordination with On-Site Surveillance Agencies

The SPO Reliability Coordinator should integrate his administrative activities with those of Air Force agencies having related responsibilities. For example, Air Force Plant Representatives who report to the Contract Management Region Office are stationed at the facilities of most large prime contractors. The function of these Plant Representatives is to maintain surveillance during development and production of equipments being procured by the Air Force. In most cases, an AFPRO will include a specific reliability and/or quality control group.

Early in a given program, the SPO Reliability Coordinator should take the following essential actions:

(1) Initiate contact with the appropriate AFPRO personnel to determine their local practices and procedures and to coordinate respective activities.

(2) Advise the AFPRO of the specific nature and requirements of the reliability program as contracted.

The results of this early coordination effort should be stipulated in written form and issued as a joint memorandum of agreement.

3.1.4.5 Problems and Special Considerations Relating to Liaison Activities

3.1.4.5.1 Non-Interference with Contractor Operations

It is often argued that frequent visits by a customer representative reduce the contractor's available time for performing necessary managerial and technical functions. Such an opinion by a manager within a contractor's organization can frequently be attributed to the fact that the manager assumes an obligation to prepare for customer visits and to accompany customer representatives during the duration of such visits. There will, of course, be certain occasions when a SPO Reliability Coordinator's visit will be related to an official purpose (e.g., conduct of a formal program review as discussed in 4.2). However, on other occasions, the Reliability Coordinator may simply desire to tour the facility unofficially or to discuss general items of interest in the program. In such cases, little or no preparation by the contractor is necessary, and expenditure of management time is not essential.

The SPO Reliability Coordinator may or may not desire to advise the contractor in advance of his intention to visit. If advance notice is given, the purpose of the visit should be clarified and the specific degree of preparation (if any) that is anticipated should be stated. This procedure will minimize non-essential interference with a contractor's operations.

3.1.4.5.2 Contact with Proper Contractor Authorities

During visits to a contractor's facility, a SPO Reliability Coordinator may come in contact with a large number of personnel. It is essential that he avoid issuing verbal directives to personnel without proper reference to intermediate contractor authority. In every program, the SPO Reliability Coordinator will have a primary point of contact within the contractor's organization (usually the reliability manager for the program). He must establish and maintain official communication channels with this contact and issue program directives accordingly. Any directive having an influence upon the contract must be formally issued through the cognizant contracting officer.

Verbal directives are usually not proper or effective in the administration of a program. When such directions are given for reasons of expediency, they should be subsequently documented as soon as possible.

3.1.4.5.3 Relation Between SPO and AFPRO

When difficulty or confusion exists between the SPO Reliability Coordinator and the AFPRO as to relationship of duties, the problem can usually be attributed to lack of proper coordination effort early in the program. Hence, the SPO Reliability Coordinator should take steps to prevent such occurrence by proper contact with the AFPRO at the earliest possible convenience.

3.1.4.6 Additional References on Liaison Activities

Reliability and Product Assurance, R. R. Landers, Prentice-Hall, 1963, pp. 449-452.

The Role of the Buyer in Reliability, R. T. Dewey, Proceedings, Ninth National Symposium on Reliability and Quality Control, January 1963.

3.1.5 Customer Internal Reliability Reports

3.1.5.1 Definition

The periodic status reports discussed in 3.1.1 pertain to those submitted by a contractor. In addition to such reports, the System Program Office is required, in turn, to periodically report the status of reliability effort in a contracted program to higher Air Force authority. Requirements relating to the preparation and submittal of these internal reliability reports are discussed in 3.1.5.

3.1.5.2 Air Force Policy

Air Force policy indicating a need for internal reporting activity is typified by the following statement from AFR 80-5: "Achieving reliability is a growth process. The collection, analysis, and feedback of information to both the Air Force and industry are fundamental to the control of this process."

3.1.5.3 Responsibilities for Internal Reliability Reports

Assigned responsibilities of the System Program Offices (and thus the SPO Reliability Coordinators) and associated levels of authority relating to internal reporting on reliability status are summarized in Table 3-8.

3.1.5.4 Implementation of Internal Reliability Reports

The general responsibility of the SPO Reliability Coordinator with respect to internal reliability reporting is to screen the information that is submitted by the contractor and select that which is of sufficient significance to pass on to higher Air Force management. AFSCR 80-1 prescribes in detail the information which is to be incorporated in internal reliability reports and the procedures for preparing such reports. Two distinct types of reports are prescribed: (1) a monthly reliability report and (2) a quarterly reliability status report.

TABLE 3-8

SUMMARY OF RESPONSIBILITIES
RELATING TO INTERNAL REPORTING WITHIN AIR FORCE

Air Force Document	Level to Which Assigned	Statement of Responsibility	Par. No.
AFSCR 80-1 14 Dec. 1962	AFSC DCS/ Systems	(1) Prescribe policies and procedures as general guides to be followed by AFSC systems divisions and centers in monitoring and reporting on the reliability programs for the various systems, subsystems, and equipment under development.	5.a.(4)
	System Program Offices (SPO's)	(1) As requested, report current status of reliability programs to higher management levels of the Air Force.	9.b
		(2) Forward all major reliability problems which cannot be resolved by the SPO, with the recommended actions, including implications for operational utilization and effectiveness, to the appropriate levels of Air Force management.	9.c
		(3) Define major reliability program checkpoints or milestones on both activities and results (as available) and integrate them into over-all weapon system program control procedures, including computer or other mechanized procedures.	9.d
		(4) Provide the following general information in reliability status reports to higher Air Force authorities:	9.e
		(1) Requirements. Status of actions to incorporate quantitative requirements, requirements for demonstration, a comprehensive reliability program or effort, and reporting on that effort by the contractor in program and contractual documents.	9.e.(1)
		(2) Reliability Program. Status of each major reliability activity comprising the system contractor efforts, as appropriate, including adequacy and timeliness of each activity.	9.e.(2)
		(3) Design Considerations. Status of design for reliability, including techniques employed to achieve system, subsystem and component reliability;	9.e.(3)

TABLE 3-8 (Continued)

SUMMARY OF RESPONSIBILITIES

RELATING TO INTERNAL REPORTING WITHIN AIR FORCE

Air Force Document	Level to Which Assigned	Statement of Responsibility	Par. No.
AFSCR 80-1 14 Dec. 1962	System Program Offices (SPO's)	results of environmental and statistical testing, and the degree of risk in achieving reliability (including identification of all critical items). Whenever possible, estimation of risk will be made by numerical comparison of requirements (failure rates or other appropriate measurement) with past experience on like items. In every case, critical items must be identified, whether by engineering tests and judgment or quantitative analysis of data. Unknowns, such as items receiving no test to date, will be indicated.	9.e.(3)
		(4) Corrective Actions. The status of actions taken to correct or alleviate critical technical and program problems by contractor and/or Air Force agencies.	9.e.(4)
		(5) Systems Analysis. The results of systems analysis including trade-offs between reliability, time, cost, schedules, performance, and system effectiveness. Such analysis begins in the conceptual phase of a program, is progressively refined as system characteristics are defined in more detail, and additional data becomes available as a result of testing. Explicit definition of all factors and identification of all assumptions should be one of the early products of this analysis.	9.e.(5)
		(6) Results. The prediction, estimation, or measurement of results for the system, major subsystems, and where practicable, major components. Graphical presentation of results is desirable. Confidence figures or other numbers indicating significance of the results must be shown.	9.e.(6)

TABLE 3-8 (Continued)

SUMMARY OF RESPONSIBILITIES

RELATING TO INTERNAL REPORTING WITHIN AIR FORCE

Air Force Document	Level to Which Assigned	Statement of Responsibility
AFSCR 80-1 14 Dec. 1962	System Program Offices (SPO's)	(7) Significance of Results from an Operational Standpoint. Implications of reliability and system effectiveness for operational utilization including, as appropriate, the relationships to such factors as availability or incommission rates, target allocation, number of systems required, maintenance workload, and requirements for spares and ground support equipment. Par. 9.e.(7)

3.1.5.4.1 Monthly Reliability Report

Detailed instructions for the preparation and submittal of the Monthly Reliability Report are contained in PMI 1-5.

3.1.5.4.2 Quarterly Reliability Status Report

For a given contracted program, the System Program Office is to prepare a Reliability Status Report at the end of each calendar quarter and submit it to AFSC (SCSNR) not later than 45 calendar days after the end of the quarter. The report is to be divided into three parts:

Part I, Reliability Program, which includes certain basic information such as significant dates and quantitative requirements.

Part II, Reliability Status, which includes the minimum acceptable, predicted, and current status values for reliability, maintainability, and availability (at system level and for subsystems).

Part III, Reliability Problems, which includes a narrative statement of any existing problems.

The quarterly reliability status report must be prepared according to detailed instructions attached to AFSCR 80-1. For information purposes, the "Instructions" attachment of AFSCR 80-1 and a sample reliability status report form (AFSC Form 144) are reproduced here as Figure 3-2 and Figure 3-3, respectively.

3.1.5.5 Problems and Special Considerations Relating to Customer Internal Reliability Reports

3.1.5.5.1 Determination of Status Values for Numerical Reliability

Past experience has shown that, for development programs, the determination of the status of numerical reliability is usually quite difficult. The reason for such

FIGURE 3-2

AFSCR 80-1 INSTRUCTIONS FOR PREPARATION OF AIR FORCE INTERNAL RELIABILITY STATUS REPORTS

INSTRUCTIONS FOR PREPARATION OF QUARTERLY RELIABILITY STATUS REPORTS (RCS: AFSC-R44)

Part I, "Reliability Program." Complete items 1 through 13, part I of AFSC Form 144. Items not listed below are self explanatory:

Item 8 - Enter average number of man-months of effort per month expended by contractor during the reporting period, e.g., if the contractor assigned 3 engineers for 1 month and only 1 engineer for the other 2 months, the entry in this item would be 1.66.

Item 11 - Enter numerical figure and units such as "100 hours MTBF (Mean Time Between Failures)," "98% reliability based on mission time of 10 hours with 90% confidence," or "effectiveness (uptime)," etc.

Item 12 - Enter numerical figure and constraints such as "1 hour MTTR (Mean Time To Repair) (active time only)" or "12 hours mean down time including 3 hours travel to site," etc.

Part II, "Reliability Status." Complete part II of AFSC Form 144 as follows:

Column A - Enter subsystem designations.

Check appropriate box above columns B, C, and D to indicate whether entries pertain to MTBF, Percent, or both.

Check appropriate box above columns E, F, and G to indicate whether entries pertain to MTTR, Max Down Time, or both.

Columns B, E, and H - These figure entries should be either the contractually required ones or the contractor's allocation to equipment or subsystem, and should be identified by a footnote at bottom of the page. If not applicable, enter "NA."

Columns C, F, and I - These prediction figures should be in the same units as "Minimum Acceptable" and will be assumed to be contractor's most recent prediction unless identified and dated to another period.

Columns D, G, and J - These status figures are the "Reliability" status of this system, subsystem, or equipment at the time of this report. They should be in the same units as the "Minimum Acceptable" figures.

Part III, "Significant Reliability Problems." (Reference item 13, part I, AFSC Form 144.) Prepare on 8- by 10½-inch bond paper (allow 3/4-inch binding margin at left of page) in narrative style. Enter system or major subsystem title and number as well as the as of date of the report at top of each page. Use the following outline headings:

A. Area or Subsystem or Equipment.

B. Brief Statement of Problem.

C. Proposed Resolution.

D. Action Agency.

E. Current Status.

F. Remarks.

FIGURE 3-3

SAMPLE FORM FOR QUARTERLY RELIABILITY STATUS REPORT

(As per AFSCR 80-1 "Instructions" Attachment---See Figure 3-2)

RELIABILITY STATUS REPORT (Use 8 x 10½" bond paper for remarks or continuation of items, identifying each one by item number)	AS OF DATE 30 June 1962	DATE PREPARED 2 July 1962	REPORTS CONTROL SYMBOL AFSC-R44

PART I - RELIABILITY PROGRAM

1. SYSTEM OR MAJOR SUBSYSTEM TITLE: SAC Control System
2. SPO (System number): 465L
3. DATE INITIATED (SPP approved): Sep 1958
4. DATE R PROGRAM INITIATED AS A CONTRACTUAL REQMT: Sep 1958
5. CONTRACTOR R SPECIFICATIONS: IEC 60020
6. GOVERNMENT R SPECIFICATIONS AND WORK STATEMENT: MIL-R-27542
7. DATE R PROGRAM APPROVED BY SPO: May 1961
8. CONTRACTOR MAN-MONTHS EXPENDED FOR RPRTG PERIOD:
9. CONTRACTUAL REPORTING REQUIREMENTS (Indicate when initial report is due and frequency thereafter): June 1960, quarterly
10. FORMAL DEMONSTRATION REQUIRED: [X] YES (Indicate method and schedule) [ ] NO (Explain)
    First Article to Run 3 Times MTBF
11. QUANTITATIVE R REQUIREMENTS (MTBF, probability, availability, confidence level, etc.): 0.999 (Availability)
12. MAINTAINABILITY REQUIREMENTS (MTTR, maximum down time, etc.): 5 Min Max Down Time
13. SIGNIFICANT PROBLEMS: [ ] NO [X] YES (If yes, prepare Part III as prescribed by AFSCR 80-1)

PART II - RELIABILITY STATUS

DESIGNATION a	[X] MTBF [ ] PERCENT			[X] MTTR [ ] MAX DOWN TIME			AVAILABILITY		
	MINIMUM ACCEPTABLE b	PREDICTION c	STATUS d	MAXIMUM ACCEPTABLE e	PREDICTION f	STATUS g	MINIMUM ACCEPTABLE h	PREDICTION i	STATUS j
OVERALL SYSTEM	--	379	--	5	12	--	0.999	0.9994	--
SUBSYSTEMS AN/FYQ2	630	630	--	30	30	--			
AN/FYQ3	250	444	--	30	15	--			
AN/FYQ4	1000	1130	1577	30	19	76			
AN/FYQ5	175	277	113	30	12	35			
AN/FYQ6	185	262	750	36	19	66			
AN/FYQ7	150	170	--	30	30	--			
AN/FYQ8	150	200	203	18	9	170			
AN/FSQ-31*	25	25	56	45	30	22			

*Group display equipment only. Based on test of development model of new "Fast Film" projector.

FIGURE 3-3 (Continued)
SAMPLE FORM FOR QUARTERLY RELIABILITY STATUS REPORT
(As per AFSCR 80-1 "Instructions" Attachment -- See Figure 3-2

PART II (contd)									
DESIGNATION	☐ MTBF ☐ PERCENT			☐ MTTR ☐ MAX DOWN TIME			AVAILABILITY		
	MINIMUM ACCEPTABLE	PREDICTION	STATUS	MAXIMUM ACCEPTABLE	PREDICTION	STATUS	MINIMUM ACCEPTABLE	PREDICTION	STATUS

FIGURE 3-3 (Continued)
SAMPLE FORM FOR QUARTERLY RELIABILITY STATUS REPORT
(As per AFSCR 80-1 "Instructions" Attachment -- See Figure 3-2

PART III - RELIABILITY PROBLEMS

465L SAC Control System Program	As of Date: 30 Jun 62
Area or Subsystem or Equipment	Group Display Generator, Data Display Central
Brief Statement of Problem	First development model exhibited poor reliability and performance. Fell far short of subsystem requirements.
Proposed Resolution	Use new process for generating displays and complete redesign of equipment.
Action Agency	International Electric Corp
Current Status	Development model of new "fast film" process equipment undergoing testing.
Remarks	Preliminary results indicate the redesigned equipment will exceed the required reliability.

difficulty is the sparsity of test data during early phases of system development. The most effective means of alleviating this problem is by strict enforcement of the contract requirements which relate to the process of failure reporting and recording of operating time.

3.2 Reliability Program Controls

3.2.1 Definition

Program controls, as discussed in this section, pertain to those devices or tools which can be employed by System Program Offices and SPO Reliability Coordinators to follow the progress of contracted reliability programs -- that is, to compare actual achievements with desired or planned attainments. Surveillance and review activities which may be considered as actions for "controlling" the over-all adequacy of contractors' reliability programs are considered in section 4.

3.2.2 Air Force Policy

Air Force policy relating to establishment of program controls is summarized in Table 3-9.

TABLE 3-9

SUMMARY OF AIR FORCE POLICY RELATING TO PROGRAM CONTROLS

Air Force Document	Statement of Policy
AFR 80-5	(1) Achieving reliability is a growth process. The collection, analysis, and feedback of information to both the Air Force and industry are fundamental to the control of the process.---------------Par. 3.c (2) Management control of reliability effort is necessary throughout a system program. -----------Par. 3.f
AFSCR 80-1 14 Dec. 1962 AFBSDR 80-5 28 Dec. 1962	(1) Procedures for program control will be developed and applied to the management activity at individual systems management level. Par. 4.h/ Par. 5.a

3.2.3 Responsibilities for Program Controls

The responsibilities of SPO Reliability Coordinators and associated agencies relating to program controls are summarized in Table 3-10.

TABLE 3-10

SUMMARY OF RESPONSIBILITIES RELATING TO PROGRAM CONTROLS

Air Force Document	Level to Which Assigned	Statement of Responsibility
AFSCR-80-1 14 Dec. 1962	AFSC Divisions and Centers	Maintain complete, factual and timely information regarding the status of reliability programs as well as associated program areas. Par. 6.f
	System Program Offices (SPO's)	Maintain complete, factual and timely information regarding the status of reliability estimates and contractor reliability programs as well as associated and program problem areas Par. 7.h
AFBSDR 80-5 28 Dec. 1962	SPO Reliability Coordinators	Maintain a current status of reliability program activities, achievements, and predictions. Par. 6.b.(3)

3.2.4 Implementation of Program Controls

A variety of devices in common usage, including periodic status reports (see 3.1.1) and reliability growth curves (see Figure 3-6 in 3.2.4.2.3), may properly be classed as program controls since they, in some manner, permit comparison between actual and planned rates of progress. However, the task of administering a typical reliability program is of such complexity that status reports and simple growth charts usually do not entirely satisfy the need for program controls. As reliability programs become more comprehensive, a basic challenge posed to Air Force management is the handling, coordinating, and display of vast amounts of information so as to establish a satisfactory basis for program decisions. The prime objective of a program control device is to identify those events and activities which are the keynotes of program success.

As a result of increasing attention devoted to development of program control devices in recent years, several systems are now in existence. These systems differ greatly in degree of sophistication. For example, schedules, milestone charts, or checklists have been used in some specific applications to depict planning and accomplishment of program activities. In other instances, more sensitive devices are being continually developed and refined (e.g., the PERT and RMI systems discussed in following sections).

Any specific control device will be characterized by certain advantages and, at the same time, certain limitations. For example, a milestone chart identifies activities and events and indicates intended (and/or actual) dates of accomplishment, but it does not depict existing constraints affecting accomplishment. Likewise, a network diagram as used in the PERT system shows constraints (i.e., activities to be accomplished) between events, but does not provide a visual indication of the "quality" with which events are performed.

In some cases, the SPO Reliability Coordinator will be associated with a program wherein a specific control system or device is contractually or otherwise officially prescribed for use throughout the program. The primary function of the Reliability Coordinator, then, is to comply with the over-all program procedure. He must become familiar with the details of the control system, and fully exploit it in the administration of the reliability program.

Certain significant control systems which have been utilized with success in past programs are discussed in 3.2.4.1 (Formal Program Controls) for purposes of illustration and information. Other control forms which are less sophisticated but which could be used by a SPO Reliability Coordinator in his own applications are discussed in 3.2.4.2 (Simplified Control Devices).

3.2.4.1 Formal Program Controls

3.2.4.1.1 Program Evaluation and Review Technique (PERT)

The Program Evaluation and Review Technique familiarly known as "PERT" was originally developed by the Navy Special Projects Office and has since received the endorsement of both the Department of Defense and the National Aeronautics and Space Administration. While its application is not necessarily confined to reliability activities, its increasing use for administering reliability programs warrants brief consideration herein. (Publications listed in the bibliography for 3.2 will provide fuller instructions as to the details of PERT.)

It should be realized that the basic PERT system is not a device for measuring the reliability of a product. Rather, it is more accurately described as a means for coordinating the many disciplines involved in reliability technology.

The essential terms associated with the PERT system are:

(1) Event -- An ambiguous point in time in the life of a project.

(2) Activity -- A technological operation which consumes time, money, and manpower. Each activity is characterized by a specific initial event and terminal event.

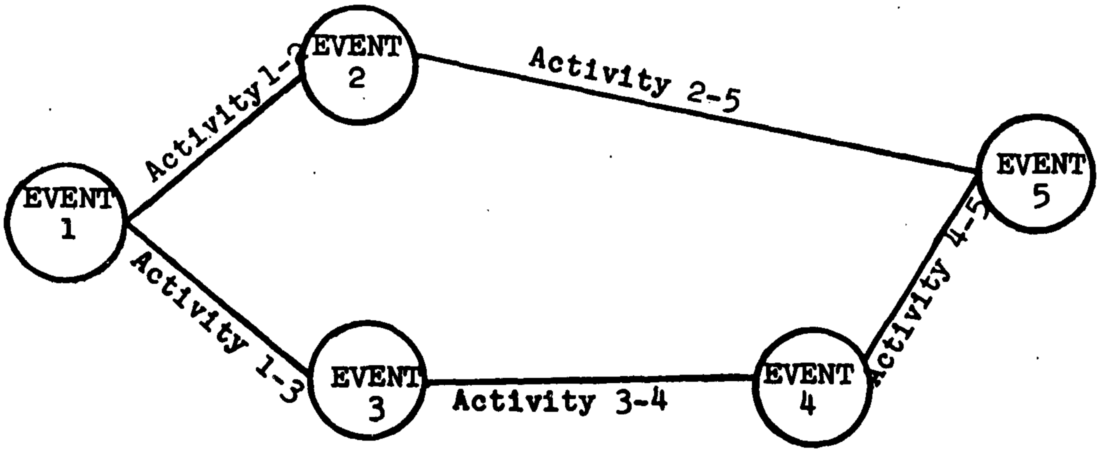
(3) Network -- A visual presentation of events and activities which depicts interdependencies.

3.2.4.1.1.1 PERT Networks

An example of a PERT network is shown in Figure 3-4. Note that events are joined together in a manner which illustrates constraints. The method utilized in developing any PERT network is to combine various technologies such as design, testing, drafting, reliability, etc. into a single system. However, it is possible to select any one area of endeavor, such as reliability, and confine the network to its associated events and activities. Such a network would be of considerable value to a reliability manager in administering his program.

FIGURE 3-4

EXAMPLE OF A PERT NETWORK



Possibly the most difficult task associated with a PERT program is the initial selection of significant program events. Reliability program specifications are usually general in nature. Hence, it becomes necessary to translate these generalities into carefully defined occurrences which can be associated with specifically defined hardware items. In selecting events which are to be controlled, there are certain factors which must be considered. The more significant of these include the following:

(1) Events must represent instantaneous points in time.

(2) Events must be identifiable as the responsibility of a particular working group within the contractor's organization.

(3) The activity joining two distinct events must be capable of definition.

(4) The time, cost, and manpower expenditure for activities joining two events must be capable of estimation.

Once a network has been developed, there are a variety of subsequent procedures which could be followed. These include:

(1) Estimating the time required to complete each activity.

(2) Estimating the cost to accomplish each activity.

(3) Estimating the resources (in terms of materials or manpower) required to accomplish each activity.

In some variations of the basic PERT system, multiple estimates are made. For example, instead of formulating a single estimate of time to accomplish a specific activity, it is possible to supplement an "expected" time with an optimistic estimate and a pessimistic estimate. In so doing, statistical processes are employed to determine the probability of accomplishing an event within a given time.

3.2.4.1.1.2 Advantages of PERT

The greatest single advantage of a management system such as PERT is that it forces a contractor to define the elements of his reliability program. In many complex reliability efforts, this could represent the most difficult task of all. Other primary advantages of PERT are that it can be used in:

(1) Establishing schedules and cost budgets.

(2) Forecasting total costs and time.

(3) Illustrating time and cost status.

(4) Analyzing manpower requirements.

(5) Determining the effects of simulated program changes.

(6) Providing basis for time/cost trade-offs.

(7) Assisting in the making of vital management decisions.

3.2.4.1.2 Reliability Maturity Index (RMI)

The Reliability Maturity Index is a management system which provides managers with the information necessary to monitor, control, and evaluate the progress of a reliability documentation program and to determine its effect upon the reliability of the end product. The RMI system is included herein to illustrate its features for recording, summarizing, and displaying reliability program information.

The RMI system, which has been pilot-tested on the Polaris A3 configuration, is composed of two separate but equally integral categories: the Schedule Compliance Evaluation (SCE) and the Technical Quality Evaluation (TQE). The SCE provides the planning, scheduling, reporting, and monitoring function of the RMI, and the TQE provides an independent technical quality audit of each reliability event document.

Specific advantages of RMI as a management information system are:

(1) Means are provided for visualizing the required elements of an effective operational reliability program and progress (or non-progress) in performance of these elements.

(2) Goals are established for technical documentation and performance reporting.

(3) The approach employed is flexible and adaptable to the needs of different subsystems.

(4) New paperwork is kept to a minimum through use of existing forms and communication channels; required documentation is compatible with PERT.

(5) A definitive, consistent communication procedure is established in respect to reliability documentation.

3.2.4.2 Simplified Control Devices

The PERT and RMI systems discussed in 3.2.4.1 are examples of program control systems which represent relatively large-scale operations. In addition to these highly sophisticated techniques, there are several other control devices which have been successfully applied in specific situations. These include component reliability status documents, milestone charts, various plots depicting program progress (e.g., reliability growth curves), and plots of program expenditures.

3.2.4.2.1 Component Reliability Status Document

This type of document was prescribed within the General Work Specifications for Atlas Standard Space Launch Vehicle Reliability Assurance and Quality Assurance Requirements (August 1962) as an optional control device which might be employed by the contractor. It is, however, also adaptable to use by the customer for program control purposes.

For the purposes of the component reliability status document, a component is defined as an assembly of parts into a functional device which generally is repairable by replacing a failed part and which ordinarily does not perform a useful task by itself. For each component under a particular program, the document should include information regarding use in each system and subsystem configuration and design or production status. The following information is prescribed for inclusion in the document:

(1) Purpose or application of component in configuration.

(2) Effect of failure of component on system.

(3) Summary of design review analyses.

(4) Reliability estimates and growth curves.

(5) Development schedules and development progress.

(6) Approval status.

(7) Development, qualification, acceptance, and demonstration test summary and results.

(8) Reliability problems and proposed solutions.

(9) Reliability as designed, developed, and tested (comparison of estimates versus demonstrations).

The status document should be continually updated to serve as a means of comparing actual achievements and progress against goals.

3.2.4.2.2 Milestone Charts

Milestone charts are devices which enable identification and scheduling of significant or key events in a reliability program and appropriate notation of the completion of such events. These charts are often initially developed as part of a contractor's reliability program plan.

Figure 3-5 shows a typical milestone chart for tasks to be accomplished in a reliability assurance program. While this chart was intended primarily to illustrate a situation involving a small company (and hence a relatively small program), the technique is applicable to programs of any size.

The same format as illustrated by Figure 3-5 could be utilized to establish a control device for significant documents to be submitted by the contractor. Hence, a listing of those demonstration plans, environment reports, periodic status reports, failure report summaries, or other documents vital to the reliability program could be made the subject of a special milestone chart with scheduled and completion dates appropriately depicted.

3.2.4.2.3 Plots Depicting Program Progress

A plot of achieved numerical reliability as a function of time could be superimposed on a plot of planned reliability growth to serve as an effective program control device. A display such as that shown in Figure 3-6 would provide an excellent visualization of program status, provided, of course, that the data were valid.

Early in a development program, there may be little observed data to serve as the basis for plotting program progress. As the program matures, however, flight test or field evaluation data will be available in greater amount and can be used effectively in depicting progress. One common plotting technique is illustrated by Figure 2-11 in 2.1.1.4.8,which shows the relationship of successful missions to total trial missions for space vehicle launchings. In that figure, both a cumulative plot of the success-to-trial ratio and a running plot of the ratio for the previous 20 trials are presented.

3.2.4.2.4 Plots of Program Expenditures

The SPO Reliability Coordinator is concerned with control of program costs as well as program progress. A plot of cumulative expenditures for reliability on a calendar time basis can be employed for visual comparison of planned versus

FIGURE 3-5

EXAMPLE OF MILESTONE CHART FOR RELIABILITY PROGRAM*

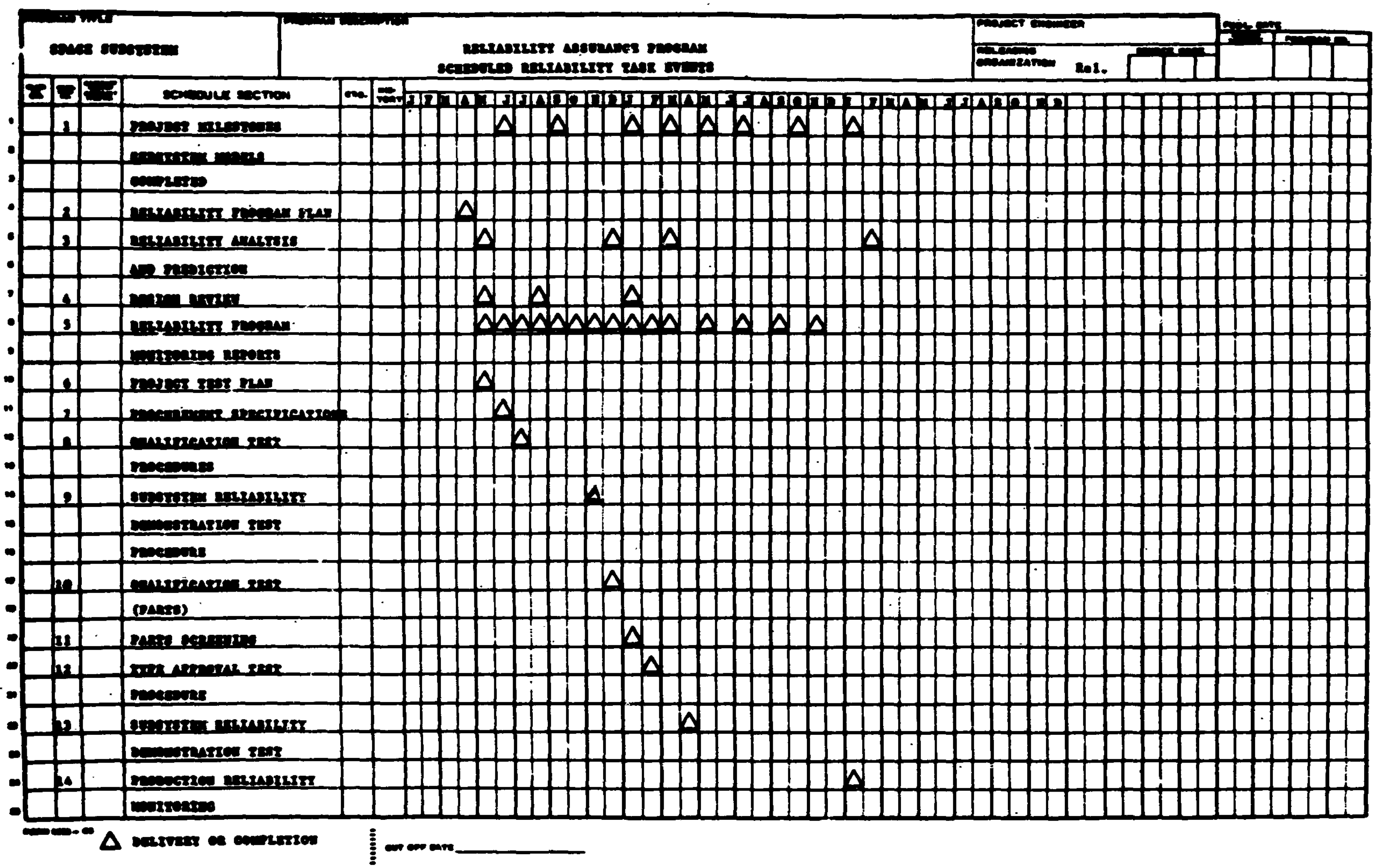
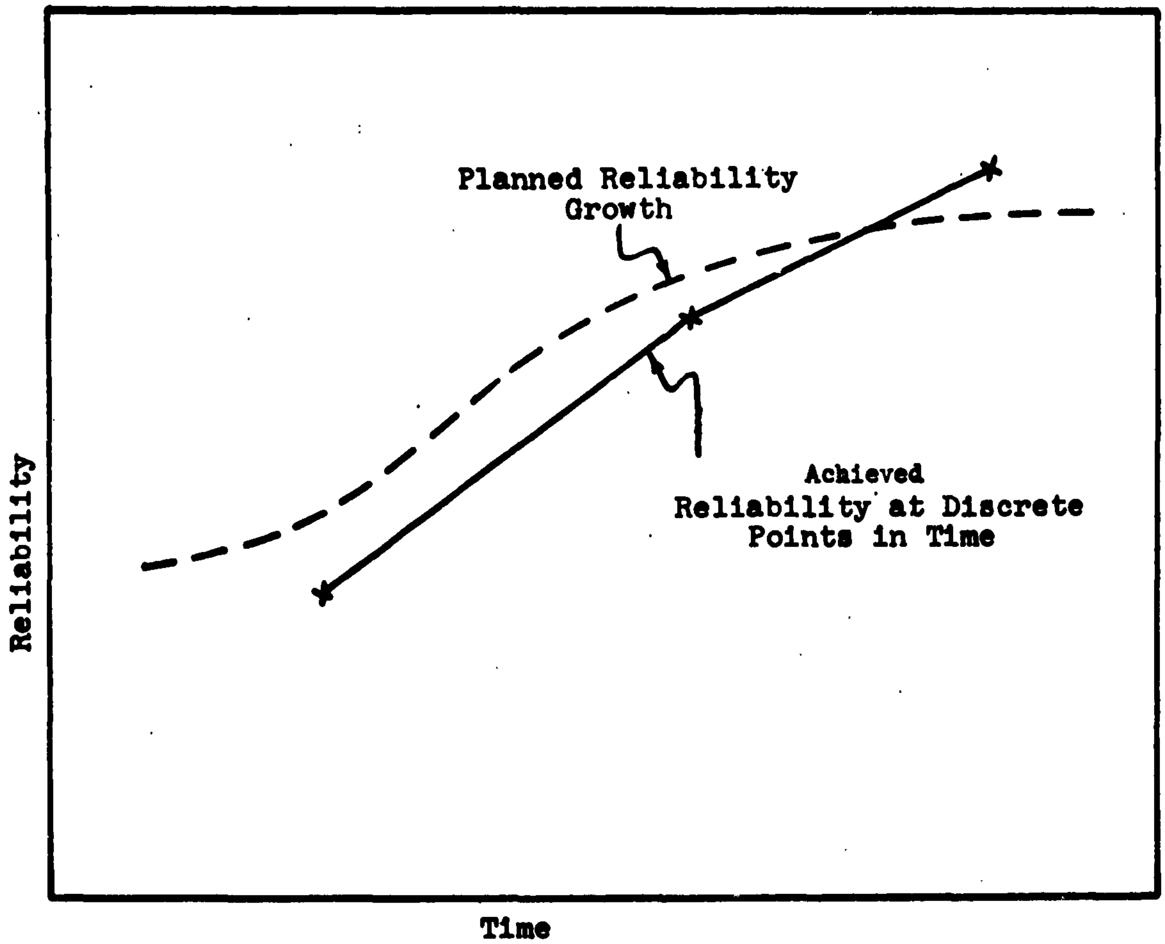


*Chart taken from Reliability -- Small Companies -- Space Subsystems, M. D. Johnson, Proceedings, Ninth National Symposium on Reliability and Quality Control, January 1963.

FIGURE 3-6

COMPARISON OF PLANNED AND ACHIEVED RELIABILITY GROWTH



actual expenditures for a reliability program. Figure 3-7 illustrates one method of plotting such information.

3.2.5 Problems and Special Considerations Relating to Program Controls

3.2.5.1 Responsibility for Establishment and Maintenance of Controls

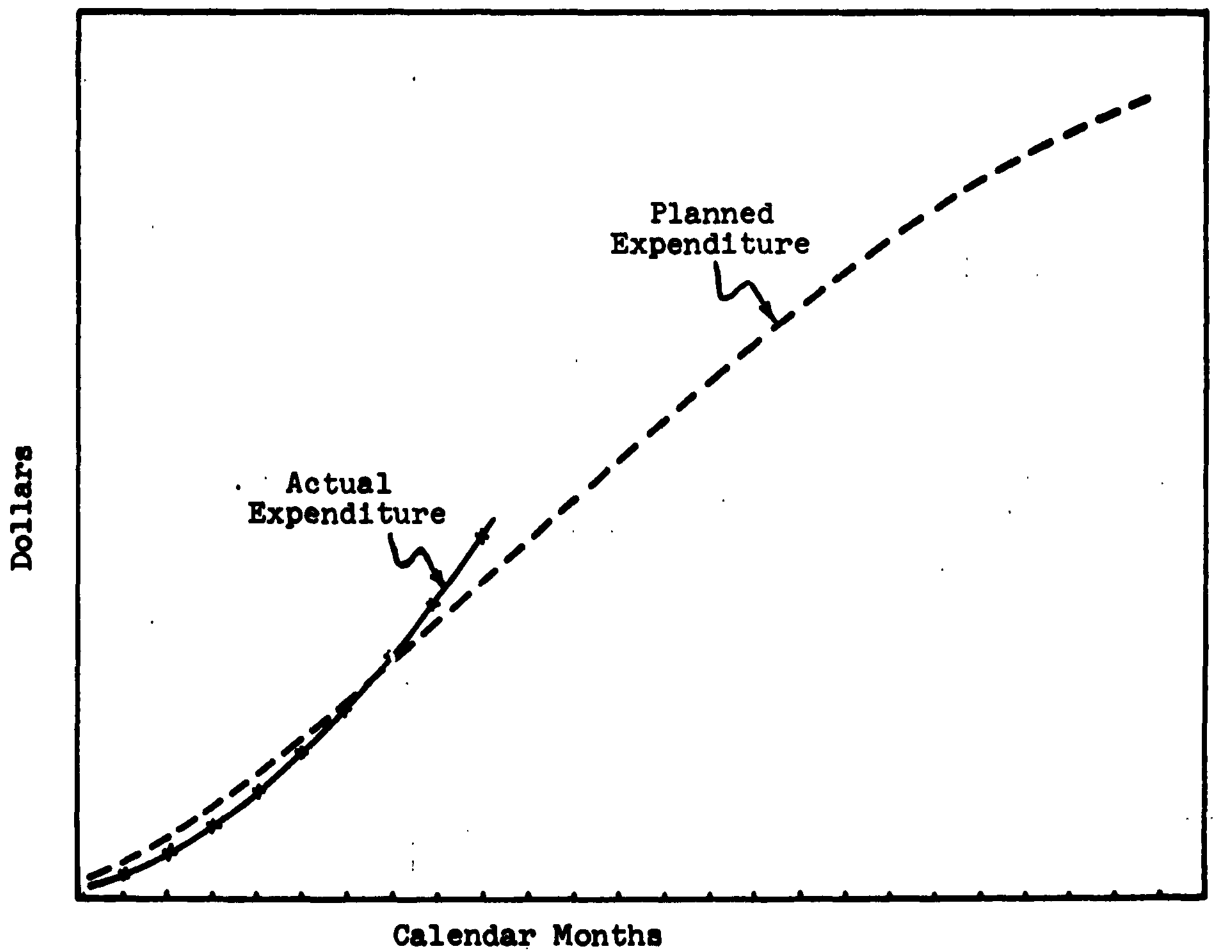
Since program controls are of equal interest to both the customer and contractor management, it is logical to describe the task of establishing and maintaining such devices as a joint responsibility of both parties. In some programs, it has been the specified responsibility of the contractor to establish and maintain particular program control devices (e.g., PERT networks, milestone charts, etc.). In other programs, such devices have been utilized by the customer to provide visual displays of program progress at his own facility. Either approach can be equally effective, providing both the contractor and the customer have sufficient access to the required information.

3.2.5.2 Selection of Control Technique

Because of the many program control devices developed within recent years, confusion may exist as to the specific technique or techniques which would most advantageously serve a given situation. The selection of a basic method (such as PERT) is usually not the decision of the SPO Reliability Coordinator but rather is the result of planning effort at higher levels of authority. Consequently, the major responsibility of the Reliability Coordinator is to provide effective contribution to and derive maximum benefit from a required over-all control system in administering a reliability program. This is not to imply that the Reliability Coordinator cannot initiate program controls at his own level of administration. Rather, he should augment any larger program control system by establishing and maintaining supplementary control devices (milestone charts, program expenditure plots, etc.).

FIGURE 3-7

COMPARISON OF PLANNED AND ACTUAL EXPENDITURES
FOR RELIABILITY PROGRAM



3.2.5.3 Availability of Time for Maintenance of Controls

It is not uncommon for an administrative group to design an elaborate program control device and later discover that insufficient time is available to maintain the device. Hence, in selecting control devices for use in a specific reliability program, the SPO Reliability Coordinator should envision the maintenance requirements and plan according to anticipated availability of time for properly updating information used in the devices. The Reliability Coordinator can minimize the expenditure of his own time by taking advantage of visual displays of program progress or other controls which the contractor is implementing and by insuring that contractor submittals of information are consistent with the format of those control devices maintained at the SPO facility.

3.2.6 Additional References on Program Controls

Reliability and Product Assurance, R. R. Landers, Prentice-Hall, 1963, Chapter 19, "Reliability Control," pp 445-469.

PERT-PEP Reliability Controls Techniques Simplified, H. C. Romig, Proceedings, Eighth National Symposium on Reliability and Quality Control, January 1962.

PERT Summary Report, Phase I and Phase II, Special Projects Office, Bureau of Naval Weapons.

3.3 Technical Direction of Reliability Programs

3.3.1 Definition

As a program administration task, technical direction comprises those activities necessary to assure implementation of a reliability program plan and utilization of organized resources in actual operations to achieve planned objectives of the program. Technical direction may involve a great variety of decisions, requests, and orders required to interpret or revise an originally established plan. Closely allied to these decisions are analytical studies or fact-finding efforts initiated by either the contractor or the customer.

3.3.2 Air Force Policy

Air Force policy regarding the technical direction of reliability programs is stated in Table 3-11.

TABLE 3-11

SUMMARY OF AIR FORCE POLICY
RELATING TO
TECHNICAL DIRECTION OF RELIABILITY PROGRAMS

Air Force Document	Statement of Policy
AFBSDR 80-5 28 Dec. 1962	It is a management responsibility to provide direction and control to each effort to achieve required reliability of systems. Par. 5.b

3.3.3 Responsibilities for Technical Direction

Assigned responsibilities of SPO Reliability Coordinators and other associated levels of authority relating to technical direction of reliability programs are summarized in Table 3-12.

TABLE 3-12

SUMMARY OF RESPONSIBILITIES
RELATING TO
TECHNICAL DIRECTION OF RELIABILITY PROGRAMS

Air Force Document	Level to Which Assigned	Statement of Responsibility	Par. No.
AFR 80-5 4 June 1962	AFSC	Assume responsibility for all reliability design and development testing, provide technical guidance to the program, and evaluate and validate the results on all systems.	6.e
AFSCR 80-1 14 Dec. 1962	AFSC Division and Center	Provide technical assistance to the CMR's in execution of their reliability responsibilities.	6.g
AFBSDR 80-5 28 Dec. 1962	SPO Reliability Coordinators	Assume complete and over-all management responsibilities for all aspects of the system reliability program.	6.b.(3)
	SE/TD Contractors	Be responsible for systems engineering and technical direction of the associate contractor's reliability program.	6.c.(1)

3.3.4 Implementation of Technical Direction

The effective execution of the technical direction task requires that the SPO Reliability Coordinator:

(1) Be cognizant of those typical situations which require a decision on his part.

(2) Utilize available information and initiate special studies to form a basis for program direction.

3.3.4.1 Situations Requiring Technical Direction

The following sections describe several common occurrences in contracted reliability programs which require technical direction actions by the SPO Reliability Coordinator.

3.3.4.1.1 Changes in Scope

The normal course of a reliability program may lead to a point of decision regarding a change in scope or reorientation of effort. Many reasons might be cited as to the need for changing the scope of a reliability program from that contractually defined. As one example, a parts qualification program might develop information that certain parts, previously thought to be adequate, are wholly inadequate and that major development work will be necessary to obtain parts that are useable. As another example, a reliability program plan may call for a major effort in qualification testing of subassemblies, assemblies, and units and a minor effort in flight testing; results of lower-level qualification tests, however, may indicate a need for greater emphasis on flight-testing.

3.3.4.1.2 Granting of Waivers

Situations may arise in any program wherein the contractor encounters an impossible or impractical requirement. The SPO Reliability Coordinator must determine the necessity and the procedures for granting such a waiver. Any waiver should be documented and can be made only after consideration of the effect upon product reliability and after higher authority approval if it affects a directive of a higher command level. In addition, the possibility of decreased cost should be considered whenever a waiver is contemplated.

Usually waiver actions are initiated by a contractor request, but the SPO Reliability Coordinator should consider initiating them himself when such actions are in the best interests of the program.

3.3.4.1.3 Acceptance or Rejection of End Item

At the time of delivery of an end item, a decision must be made to accept or reject the item. This decision can only be based on the contractual requirements established in the specifications and work statement. Fulfillment of these requirements is often sufficiently subjective that acceptability is open to technical judgment.

3.3.4.1.4 Withholding of Contract Funds

Payments to a contractor are dependent upon fulfillment of contractual requirements. Hence, it is the responsibility of the System Program Office to determine the Air Force's right to withhold funds.

3.3.4.1.5 Approval of Contractor Submittals

In every reliability program, there are numerous document submittals which require customer approval (e.g., the contractor's reliability program plan). The act of approval (or disapproval) constitutes a form of technical direction and warrants timely and efficient action by the SPO Reliability Coordinator.

3.3.4.1.6 Interpretation and Amplification of Contract Requirements

One of the more common forms of technical direction provided by the SPO Reliability Coordinator is the interpretation and amplification of contract requirements. Such direction could be the result of a specific request by the contractor or could be motivated by the Reliability Coordinator. Some typical actions have been discussed at length in other sections (e.g., see 2.3.1, which discusses instructions to the contractor for preparing program plans, and 3.1.1.4.1, which considers instructions for periodic status reports).

3.3.4.2 Basis for Executing Technical Direction

Technical questions may arise at any point in the progress of a reliability program, and the ultimate responsibility for answering such questions most often rests with the SPO Reliability Coordinator. In deciding such questions, some basis for judgment will always prevail. This basis is desirably found in existing data, information, or experience, but more usually an analytical approach is required. Hence, the Reliability Coordinator may, in some cases, find it necessary to direct a special study intended to provide required answers. This study could be undertaken by laboratory tests, literature searching, data collection, or other means.

3.3.4.2.1 Use of Trade-Off Curves

The use of trade-off curves in the management of a reliability program is usually considered a planning function, but the concept of trade-off can be equally valid during the performance of technical direction activities. Further, as a program progresses, more quantitative information will become available for establishing trade-off curves. When so established, these curves provide an effective basis for formulating technical direction decisions.

Since trade-off curves have been used only recently in managing reliability programs, quantitative data relating to reliability trade-offs are not in abundance. However, considerable work is being devoted to the development of the concept. Each SPO Reliability Coordinator has the opportunity to foster this development through application of the trade-off principle to specific situations.

The effectiveness of any system is a function of many interacting operational and design factors, including reliability, design adequacy, cost, schedule, weight, and maintainability. Thus, reliability can be traded-off in a great number of ways. Trade-off considerations for reliability are discussed in detail in 2.1.1.4.5. An extensive treatment of the subject can also be found in the IRE Reliability Training Text, Second Edition, March 1960.

3.3.4.2.2 Use of Outside Assistance

Because of the range of specialties involved in the technical direction of a large reliability program, provision of technical assistance to the SPO Reliability Coordinator may be warranted. A common procedure of the Air Force is to contract with a technical organization which has demonstrated capability in technical management to supplement Air Force technical direction effort. The services of this organization may be procured for a specific program (to support the entire effort or only a portion of the program) or on a full-time basis covering all programs.

Technical direction of a large-scale aerospace reliability program requires an experienced, highly competent reservoir of technical capability to support the reliability efforts within the various program offices and their many contractors. These efforts may present problems which require long or continuing study or evaluation by specialists in the reliability aspects of one or more specific engineering areas.

The Aerospace Corporation Reliability Support Group is organized on a functional basis and includes sections for:

(1) System analysis for boosters, spacecraft, AGE, and applied problems.

(2) Statistical and mathematical analysis.

(3) Environmental studies.

(4) Surveillance and failure studies.

(5) Reliability data retrieval(IDEP).

The detailed functions of each of these sections are as follows:

<u>Systems Analysis Section</u>

Within each of the four major activity areas (boosters, spacecraft, AGE, and applied problems), provide assistance to SPO reliability staffs in formulating work statements; generating, guiding, monitoring, and reviewing contractor reliability programs; and reviewing and analyzing reliability potentials, including:

(1) Assessment of reliability potential.

(2) Review of electrical circuits.

(3) Review of component parts selection.

(4) Review of packaging design.

(5) Review of structural and mechanical design.

(6) Review of thermal design.

(7) Review of materials and processes.

(8) Review and analysis of contractor test programs, test plans, test procedures, etc.,for physical significance, thoroughness, and competence.

Statistical and Mathematical Analysis Section

(1) Analyze contractor failure summaries and flight data.

(2) Establish acceptance test procedures and reliability demonstration criteria.

(3) Develop reliability models for evaluation and assessment.

(4) Generate statistical guides for equipment on parts acceptance and reliability demonstration and review design of contractor reliability models.

(5) Establish and maintain a statistical manual for reliability analyses.

(6) Investigate mathematics of reliability models.

(7) Assist personnel with statistical and probability problems.

(8) Supply computational assistance.

Environmental Studies Section

(1) Compile, review, and analyze on a continuing basis all environmental data and documents concerning the effects of earth and space environments on the reliability and performance of spacecraft, missiles, and earth- or lunar-based support equipment.

(2) Assist SPO's in establishing environmental guides and specifications for missile and space weapon systems.

(3) Determine the environmental requirements and specifications for missile and space weapon systems being considered for development.

(4) Assess contractor capability for environmental testing efforts.

(5) Assist with state-of-the-art information as required in the field of environments or testing.

(6) Monitor environmental research and development, qualification, and acceptance tests.

Surveillance and Failure Analysis Section

(1) Review and guide the efforts of missile and space system contractors in establishing and maintaining failure reporting systems within the scope of applicable contractual documents such as MIL-R-27542A, the work statement, and the program plan.

(2) Monitor contractor failure reporting for thoroughness, timeliness, accuracy, and effectiveness of corrective actions.

(3) Review and guide contractor physical analysis of failed items for cause of failure and determination of corrective actions.

(4) Develop and maintain a failure reporting and analysis capability at a systems level.

(5) Review the final system configuration effectiveness from the flight test reports.

(6) Review contractor quality efforts in quality assurance, quality control, and their appropriate documentation.

Reliability Data Retrieval Section (IDEP)

(1) Maintain and extend the scope of the Inter-Service Data Exchange Program (IDEP) to eligible Air Force missile and space contractors.

(2) Strengthen and maintain liaison with the Army and Navy IDEP organizations.

(3) Act as a primary data source for other aerospace organizations for current test information on electrical, electronic, electromechanical, mechanical, hydraulic, pneumatic, and rocket engine components.

(4) Assist in the interchange of "high reliability" specifications among contractors.

(5) Maintain data histories on parts through IDEP contractor participation.

3.3.5 Additional References on Technical Direction

Air Force Manual 25-1, The Management Process, September 1954, pp. 35-42.

3.4 Customer Support of Reliability Programs

3.4.1 Definition

The measures taken to establish and administer a reliability program are negated unless the customer includes a plan for supporting that program. Resources and services which the Air Force renders in support of contractor programs can be classified as: (1) funding, (2) provision of facilities, and (3) provision of a variety of guidance information. Through these support media, the customer demonstrates concern for the reliability of the product to be designed, developed, or produced and assists the contractor in ways which may or may not be covered contractually.

3.4.2 Air Force Policy

Air Force policy pertaining to support of the contractor in performance of a reliability program is stated in Table 3-13.

TABLE 3-13

SUMMARY OF AIR FORCE POLICY
RELATING TO
SUPPORT OF RELIABILITY PROGRAMS

Air Force Document	Statement of Policy
AFSCR 80-1 14 Dec. 1962	New programs will include adequate funds for reliability effort in design proposals and initial program funding. Par. 4.g
AFBSDR 80-5 28 Dec. 1962	Adequate funds will be made available in the initial program funding for ballistic missile system programs to provide for the implementation of a complete and well-balanced reliability program. Par. 5.d

3.4.3 Responsibilities for Program Support

Specific responsibilities of the System Program Offices and the SPO Reliability Coordinators relating to customer support of a contractor are not explicitly cited in Air Force directives, but will be stressed in the following section on implementation.

3.4.4 Implementation of Program Support

3.4.4.1 Program Funding

One of the more tangible and important forms of support which the Air Force provides to a reliability program is the monetary resources necessary to execute the activity. Although funding is mainly a planning consideration, it nevertheless remains an essential factor throughout all phases of the program.

The question of "how much" to allocate to the reliability program is not easily answered. Although several theories have been advanced, the optimum allocation of reliability funds still represents one of the more significant challenges which confronts the SPO Reliatility Coordinator, and one which requires a deliberate course of action on his part.

BSD-TDR-62-48 (Analysis of Reliability Management in Defense Industries, June 1962) discusses the question of costs in a detailed manner, and cites a study by Eric Pieruschka (Optimum Allocation of Funds for Reliability Program for Guided Missiles, Army Rocket and Guided Missile Agency, Redstone Arsenal, Alabama, January 1955, revised 1958). To quote from BSD-TDR-62-48:

"Pieruschka argued that to judge a missile program by the total cost of all missiles produced, good or bad, is misleading, and bad missiles produced are liabilities rather than assets. His analysis of the total cost of a missile program was related to the "good" missiles only. Therefore, the over-all reliability exhibits its outstanding influence on the over-all economy of a missile program. He further claimed that the most significant cost factor for judging the over-all economy of a reliability program is the ratio between the total cost of a missile program and the cost of the "good" missiles that will eventually hit the target. Pieruschka observed that the over-all effect of a reliability program depends not only on the amount of reliability money available, but also on the skill of the activities concerned with the program.

His conclusions of this study were:

a. It is highly uneconomical to spend too little effort and money for reliability.

b. There is little if any, risk of spending too much for reliability.

c. The optimum amount of funds for reliability expenditure should be higher than indicated by the minimum expenditure factor, because of military and political necessity.

d. Contractors' low skill factor results in a low over-all reliability and a higher total cost of a missile program."

The conclusion that "there is little, if any, risk of spending too much for reliability" is generally accepted by those in the field of reliability engineering. However, a System Program Director must have more factual information available to allocate program funds in an appropriate manner. He is dependent upon the SPO Reliability Coordinator to provide him with substantial justification for his allocations.

There are a variety of ways in which the SPO Reliability Coordinator can contribute to the task of properly allocating program funds. These include such activities as analysis of the cost of "unreliability," analysis of the worth of reliability effort, and collection of cost analysis data, which are discussed in the following sections.

3.4.4.1.1 Analysis of Cost of Unreliability

Quite often comprehensive reliability effort is justified through an emphasis of the costs of "unreliability," as pointed out in BSD-TDR-62-48:

> "There are many direct and indirect costs related to unreliability. The major direct costs are (1) additional systems that are required to carry out a given mission, (2) additional spares used in support of the systems, (3) added bases and installations from which to launch aircraft and missiles, and (4) additional maintenance workload caused by frequent failures. The indirect costs are (1) loss of prestige due to failures of our missile and space systems, (2) loss of weapon system effectiveness, and (3) false security which jeopardizes this country's defense posture."

It was determined in one study* that yearly support costs for observed equipments were as much as 12 times the initial procurement costs, as shown in Table 3-14:

TABLE 3-14

EQUIPMENT PROCUREMENT COST VERSUS YEARLY SUPPORT COST*

	Equipment Cost	Maintenance Manpower Cost	Material Cost	Yearly Support Cost
Radar	$400,000	$230,000	$10,000	$240,000
Communication	6,000	70,000	1,200	71,200
Navigation	5,000	29,000	700	29,700

It is obvious from such figures that a significant incentive prevails for reducing unreliability.

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*The Measurement and Specification of Product Abilities, J. A. Cafaro and H. D. Voegtlen, Quality Control, March 1962, pp. 20-26.

3.4.4.1.2 Analysis of Net Worth of Reliability Effort

Quantitative measurement of the value of improved reliability may be difficult to achieve but nevertheless provides a significant and plausible challenge in justifying financial support of reliability effort. Many case histories have been cited wherein effort expended during development has resulted in increased reliability with a substantial savings to the government. Some of these examples include:

(1) The AN/ARN-21 TACAN, purchased by the Air Force in 1958 (see Reliability -- Whose Responsibility, H. L. Hoffman, IRE Transactions on Reliability and Quality Control, August 1961, pp. 4-8).

(2) T-38 Reliability Support Program, funded by the Air Force in January 1949 (see BSD-TDR-62-48, pp. 8-13 to 8-17).

(3) B-58 Reliability Program, established by the Air Force in 1959 (see BSD-TDR-62-48, pp. 8-17).

In each of the above cases, analysis showed the economic advantage derived from a separately funded reliability effort.

3.4.4.1.3 Collection of Cost Analysis Data

The difficulty of assessing the value of each activity within a reliability program can never be alleviated unless positive action is taken to compile cost information with respect to program elements. Hence, the SPO Reliability Coordinator should exploit every opportunity to attain the guidance standard in AF Specification Bulletin No. 506, 11 May 1959, which states:

> "The program should be so well defined and broken down to such detail that the people, skills, facilities, and elapsed time requirements for each specified activity can be estimated with sufficient effectiveness to establish program cost."

3.4.4.2 Provision of Facilities and Equipment

It is often necessary for the Air Force to support a contractor's reliability effort through provision of special facilities and/or equipment. Facilities may be provided for use only in a particular program or may be of general applicability, extending over many programs and being available, through special arrangements, to more than one contractor.

An obvious example of provided facilities is the vast complex at Cape Canaveral. It is in the national interest to provide such a site where many contractors can perform part of their work using equipment available to all by arrangement. Other facilities such as test equipment are made available to contractors depending upon their need and the need of the program. Military vehicles are made available for tests when appropriate to the national interest. Such use of government facilities and equipment avoids needless duplication.

The SPO Reliability Coordinator's responsibility with respect to facilities support is threefold:

(1) He should be congizant of the type, location, and availability of those government-owned facilities which could be used in support of his program.

(2) He should apprise the contractor of these facilities and encourage him to initiate requests for their use.

(3) He should act on contractor requests for use of government-owned facilities and equipment in a manner consistent with the best interests of the program.

3.4.4.3 Provision of Guidance Information

Examples of types of guidance information which are available to contractors as a part of customer support of reliability programs are described in following sections.

3.4.4.3.1 Military Standards, Specifications, Bulletins, and Exhibits

Certain of the published documents within this general category may well be referenced in the contract for a particular program. However, there may be others which are not referenced contractually but which would nevertheless provide substantial assistance to the contractor (e.g., Air Force Specification Bulletin No. 510, Guides for Reliability Organization). The SPO Reliability Coordinator should acquire knowledge of government documents which are issued for purposes of guidance in contracted programs and inform the contractor of the availability of documents appropriate to his program.

3.4.4.3.2 Educational Films

A variety of educational films dealing with reliability engineering are currently available through government agencies. These films cover a wide range of subjects and are designed to reach personnel at various levels of technical proficiency. The SPO Reliability Coordinator should apprise the contractor of the availability of these films and encourage their use where appropriate.

Included in the available films are:

AGREE in Action -- Produced by Aeronautical Systems Division, USAF. This film is a report on what is being done within the present state-of-the-art in attaining a high level of reliability in electronic equipment for a manned military aircraft. Within its scope is a statement of policy concerning the AGREE task group, definitions, procurement and testing.

Available from: Air Force Film Library Center
Air Photography Charter Service
St. Louis, Missouri
Film No. TFI-5463

No Second Chance -- Produced by Boeing Airplane Company. An interesting story about how one weapon system, an interceptor missile on the Bomarc Project, was made reliable. An excellent dissertation on the establishment of the reliability functions within a corporation. Time: 27 minutes.

Available from: Air Force Film Library Center
Air Photography Charter Service
St. Louis, Missouri
Film No. DO-41SEP-456

The Price of A Goof -- Produced by Redstone Arsenal. The story of a failure of a missile flight that is traced from a solder joint to the abort. The film illustrates how the improper joint managed to get through all the inspection techniques and processes, check-out procedures, and other functions prior to the firing of the missile. Time: 18 minutes.

Available from: U. S. Army Ordnance District
Dallas Regional Office
Dallas 2, Texas

Navy Reliability Engineering Film Series (10 Films) -- Produced by Bureau of Naval Weapons, Department of the Navy.

Available from: Bureau of Naval Weapons
ATTN: PREN-8
Reliability Safety Section
Engineering Branch
Washington 25, D. C.

3.4.4.3.3 Data Exchange Services

Notable among the data exchange services is IDEP (Interservice Data Exchange Program), a government-sponsored tri-service exchange of parts test data. The prime purpose of IDEP is avoidance of duplicate test effort, but the process of data exchange also assists in the selection and testing of non-standard parts and ultimately contributes to improvement of system performance and reliability.

IDEP has created a constantly expanding and up-to-date file of documents relating to all phases of parts testing. These documents are primarily test reports on "off-the-shelf" hardware likely to be available among participants in the service. In addition to reports on usual laboratory-controlled tests, the file includes tabulations of parts data histories, general technical data of particular significance to parts-using activities, contractor specifications on high-reliability parts, and accounts of planned or in-process parts testing activities.

Participants in IDEP are government agencies and prime contractors and major sub-contractors engaged in parts testing activities. They are part users, rather than parts manufacturers or vendors.

The SPO Reliability Coordinator should actively encourage contractor participation in programs such as IDEP. In some programs, participation in IDEP has been a contractual stipulation.

3.4.3.4 Information Services

The most exhaustive of the information services currently in existence is the Defense Documentation Center (DDC). Operated by the Department of Defense. DDC provides a central service for the collection and interchange of technical and scientific reports which have direct bearing on defense research and development efforts. The scope of coverage provided by the service is virtually unlimited and includes subject matter directly related to reliability programs. Information concerning the availability of reports and data is provided through published bibliographies and semimonthly announcement bulletins of new acquisitions. In addition, DDC provides, on request, bibliographies on specially selected subjects.

The DDC service is available not only to all government agencies but also to contractors and subcontractors engaged in defense programs.

The SPO Reliability Coordinator should therefore encourage reliability program participants to utilize the DDC facilities to the fullest extent.

3.4.5 Problems and Special Considerations Relating to Program Support

3.4.5.1 Stability of Contract Funding

Efficient planning and subsequent implementation of reliability programs depends to a large extent on the stability of funding support. Fluctuation of funds in a program can greatly hinder the task of planning.

There is no ready solution to assurance of a constant adequacy of funds since certain readjustments will usually be a budgetary necessity in most programs. However, the SPO Reliability Coordinator should exert any effort possible to minimize the occurrence of unstability in funding support. The Reliability Coordinator can contribute to the provision of stable and adequate funding support by:

(1) Specifying elements of work within the contract in a clear, concise manner, thereby enabling a prospective contractor to estimate costs realistically.

(2) Insuring that the interests of the reliability program are adequately represented and justified in apportioning over-all program funds.

(3) Assessing reliability achievements (or potential achievements) from the standpoint of economic advantage.

(4) Assuring that currently allotted funds are being expended in an efficient manner. This can only be accomplished through the maintenance of appropriate cost-breakdown information for a program.

3.4.6 Additional References on Program Support

Funding Reliability Programs, E. F. Dertinger, Proceedings, Ninth National Symposium on Reliability and Quality Control, January 1963, p. 16.

Minimizing the Cost of Reliability Testing, R. T. Maloney, Proceedings, Seventh National Symposium on Reliability and Quality Control, January 1961, p. 313.

The Dollar Value of Improved Reliability, E. L. Welker and C. E. Bradley, Proceedings, Seventh National Symposium on Reliability and Quality Control, January 1961, p. 323.

Reliability -- Buy Now and Don't Pay Later, W. F. Stevens, Proceedings, Sixth National Symposium on Reliability and Quality Control, January 1960, p. 93.

Rework Costs Related to Reliability Requirements, W. R. Kuzmin, Proceedings, Sixth National Symposium on Reliability and Quality Control, January 1960, p. 95.

Reliability Versus the Cost of Failure, G. A. Raymond, Proceedings, Fourth National Symposium on Reliability and Quality Control, January 1958, p. 187.

The Price of Reliability, A. L. Lambert, Proceedings, Fourth National Symposium on Reliability and Quality Control, January 1958, p. 189.

R. and D Reliability and Dollars, E. T. Welmers, National Symposium on Reliability and Qualtiy Control, January 1958, p. 194.

4. SURVEILLANCE AND REVIEW OF A RELIABILITY PROGRAM

In a reliability program, the desired end product is a system which exhibits (usually in the field) a capability of accomplishing a mission with some pre-defined probability of success. The effectiveness of the program can only be judged by the performance which the system achieves. Because of the scope of most reliability programs, however, the Air Force cannot afford to withhold evaluation until the end product results. It is essential, therefore, that some form of evaluation be practiced throughout the duration of the program -- to insure that performance is in accordance with established standards and that the standards continue to reflect the program needs.

The evaluation function, as discussed in section 4, involves two distinct areas of activity -- "surveillance" (4.1) and "review" (4.2).* These activities are defined as follows:

(1) Surveillance -- the observation of individually defined work elements of a program at frequent, repetitive intervals. Close, continual supervision of the program is implied.

(2) Review -- a formal and official action which occurs periodically and which cumulatively considers all elements of the program.

Both surveillance and review of a reliability program are clearly within the responsibility assignment of a SPO Reliability Coordinator. Each task requires a three-step management process: development of a plan (including establishment of evaluation standards and criteria), execution of the plan, and feedback of results to the reliability program.

The bases for program evaluation, in either surveillance or review, comprise both qualitative and quantitative criteria. Qualitative criteria are concerned mainly with the "goodness" of the end product or program accomplishments, and their application results in some value statement

*Other terminology such as "monitoring" and "audit" have frequently been used in practice to describe program evaluation functions which are equal or similar to those discussed in section 4.

or judgment of varying accuracy and objectivity. Quantitative criteria are concerned with the magnitude of product capability or program progress, with their application results in some numerical expression involving units of count or measurement.

When the effectiveness of an operational system is judged, the strictly qualitative criteria usually far outweigh the quantitative aspects in number and importance. Hence a manager must often must decide "how good" is the contractor's performance, or, is he doing a "satisfactory" job? On the other hand, a program manager cannot operate without facing some need for quantitative data. Such questions as how long will it take to complete a given job, how many working days of how many people will be required, how much of the necessary materials must be used, and how much will the job cost must all be answered in quantities. Hence, quantitative standards of performance are an essential requirement for program management and evaluation.

4.1 Program Surveillance

4.1.1 Definition

As previously defined, surveillance connotes customer activities associated with continual, close supervision of the individual elements of work in a contractor's reliability program. Surveillance commences upon completion of the establishment of the program (see section 2) and continues throughout its duration.

4.1.2 Air Force Policy

Air Force policy with respect to the task of surveillance is summarized in Table 4-1.

TABLE 4-1

SUMMARY OF AIR FORCE POLICY
RELATING TO SURVEILLANCE OF RELIABILITY PROGRAMS

Air Force Document	Statement of Policy
AFR 80-5 4 June 1962	The Air Force will maintain surveillance over the contractor's reliability program, reliability testing, and quality control activities. Par. 4.d
AFBSDR 80-5 28 Dec. 1962	Specific reliability programs will be established and monitored for all ballistic systems or portions thereof having separate Air Force contracts for their development/procurement. Par. 5

4.1.3 Responsibilities for Program Surveillance

The specific surveillance responsibilities of SPO Reliability Coordinators and associated levels of authority are summarized in Table 4-2.

TABLE 4-2

SUMMARY OF RESPONSIBILITIES
RELATING TO SURVEILLANCE OF RELIABILITY PROGRAMS

Air Force Document	Level to Which Assigned	Statement of Responsibility	Par. No.
AFR 80-5 4 June 1962	AFSC	(1) Determine the adequacy of each Air Force contractor's reliability program for achieving and demonstrating Air Force product reliability goals.	6.d
AFSCR 80-1 14 Dec. 1962	AFSC DCS/Systems	(1) Prescribe policies and procedures as general guides to be followed by AFSC systems divisions and centers in monitoring and reporting on the reliability programs for the various systems, subsystems, and equipment under development.	5.a.(4)
	AFSC DCS/ Procurement and Materiel	(1) Prescribe policies and procedures as guidance for the CMR supporting the system program office (SPO in achievement of contractual reliability requirements.	5.b.(2)
		(2) Prescribe policies and procedures for maintaining surveillance during all phases of development and production over the contractor's quality control activities.	5.b.(3)
	System Program Offices (SPO's)	(1) Maintain an adequate staff for monitoring and guidance of the reliability program for the system with which they are concerned.	7.a
	CMR	(1) Maintain surveillance during development and production to assure contractor's compliance with the contractual reliability requirements.	8
BSDR 80-5 28 Dec. 1962	SPO Reliability Coordinators	(1) Evaluate all aspects of the contractor's reliability program and take action as necessary to assure the adequacy of this program.	6.b.(3)
	SE/TD Contractors	(1) Evaluate and assure that data and assumptions used by the contractor are valid prior to preparation of plans for demonstration of achieved reliability.	6.c.(3)
		(2) Analyze the over-all performance of the weapon system and its components as observed during tests and compare achievements to reliability predictions and established goals.	6.c.(10)

4.1.4 Implementation of Program Surveillance

The task of surveillance is implemented through a three-step process -- development of a positive plan with well-defined surveillance standards and schedules, translation of the surveillance plan into effective actions, and feed-back of surveillance results to the contractor and Air Force authorities.

4.1.4.1 Development of Surveillance Plan

Development of a surveillance plan for application to a specific reliability program should encompass the following procedures:

(1) Determine and list the elements of work to be surveyed.

(2) Determine and list the standards which will be used in supervising each element of work.

(3) Determine the frequency with which judgments of program progress and quality (based on comparison of standards and accomplishments) will be made.

4.1.4.1.1 Elements of Work to Be Surveyed

Ideally, the specific elements of work to be surveyed should have been previously established by the original contractual statement of requirements and/or the contractor's reliability program plan. Hence, if appropriate, definition of the areas of surveillance may simply involve reference to those documents.

For purposes of illustration, the major elements of work could be described by the following listing:

(1) General considerations.

(2) Numerical reliability requirements.

(3) Program reviews.

(4) Reliability interface with total program.

(5) Design reviews.

(6) Design change and control.

(7) Mathematical models

(8) Integrated test program

(9) Exchange of data.

(10) Problem control and corrective action.

(11) Reliability demonstration.

(12) Failure reporting system.

(13) Reports submittal.

The above listing of reliability program elements is only representative of many that have been developed; other examples can be found in standard specifications, technical papers, and in Appendix A to this handbook.

The degree of detail to which the elements are to be defined is subject to the discretion of the individual SPO Reliability Coordinator and available manpower. For small reliability programs, a listing of the major work categories requiring surveillance, such as that above, may be sufficient. For large or "comprehensive" reliability programs, it is usually more practical to expand the major categories and define more detailed levels of surveillance. Examples of such descriptive listings of elements to be surveyed can be found in the following sources:

(1) Reliability Program Check List, Aerospace Corporation Publication No. 1923-1-325 -- This check list is keyed to the activities and tasks of MIL-R-27542, MIL-Q-9858, MIL-STD-105, MIL-STD-414, and MIL-STD-810. The listing was compiled for use in checking work statements, proposals, or program plans for new or intended programs.

(2) Guides for Reliability Organization, Air Force Specification Bulletin No. 510, dated 30 June 1959 -- This document incorporates a master check list of reliability program elements for use on complex military weapon systems.

4.1.2.1.2 Standards for Surveillance

An outline of the elements of a reliability program, as presented in the contract and/or the reliability program plan, merely identifies the areas of surveillance.

The second step in the development of the surveillance plan is the establishment of standards for judging work performance. There are two basic standards which givern surveillance actions:

(1) Was planned work accomplished in accordance with pre-established schedules?

(2) Was the work performed with sufficient quality?

4.1.4.1.2.1 Surveillance of Compliance to Schedule

Judging a contractor's performance for compliance to schedule presumes the existence of defined tasks, a schedule for completion of these tasks, and an inherent ability to determine positively whether the task was completed. Consequently, this surveillance function is closely related to the specific program control devices (see 3.2) which are employed. The PERT and RMI control systems (see 3.2.4.1.1 and 3.2.4.1.2) require definition and scheduling of tasks or activities and provide means for ready visualization of compliance to schedule. In the RMI system, for example, task completions are identified by submittals of specifically titled documents generated in the course of a program.

4.1.4.1.2.2 Surveillance of Quality of Performance

In judging the quality of a contractor's performance, it becomes necessary to attach a figure of merit to each element of work. This figure of merit could be a numerical score or a judgment of "satisfactory" or "unsatisfactory." As applicable to the task of quality surveillance, general Air Force policy can be interpreted as follows: Pre-established standards should be utilized to the extent that they provide an effective vehicle for judgment, but judgment should not be based solely on these standards.

The quantity of factors which must be considered in surveillance of reliability program elements suggests that a check list approach could be utilized. This approach would comprise selection of a controllable number of work elements which cumulatively describe the reliability program (see 4.1.4.1.1) and compilation of quality standards and check lists for each element. For the most part, appropriate standards will be reflected by the contract statement of requirements and by the contractor's reliability program plan. However, supplemental instructions and directives issued by the Air Force (specifically to the contractor or as general publications -- e.g., Air Force Specification Bulletins Nos. 506 and 510) as well as sound engineering practice may also determine quality standards.

One method of setting forth surveillance standards is to compile a notebook which is specifically tailored to the program of interest. The notebook should be divided into sections which represent the major elements of work to be surveyed. Then, for each major element, all pertinent contract statements, reliability program plan statements, and supplemental instructions and schedules would be accumulated in the appropriate section of the notebook. In addition, check lists which represent implied standards could be included.

The compilation of a standards notebook for a program must be considered a dynamic rather than static task. In any program, originally stipulated standards (i.e., those appearing in the contract) will be continuously amplified and interpreted. Hence, it is logical that the initial notebook would also be subjected to continual refinement and expansion. In this sense, the notebook provides a vehicle for convenient filing and location of standards resulting from normal management of the program.

A sample section of the suggested standards notebook for one major program element -- the failure reporting system -- is presented as Figure 4-1. Each major element of the over-all reliability program could be similarly treated. Items 1 through 5 represent official documentation which is included in a normal program. Item 6, "Other Quality Standards," represents those factors which result from implication or interpretation of contract statements. In essence, these factors are "check list" items that are developed by the SPO Reliability Coordinator on the basis of his own experience or information contained within available literature.

FIGURE 4-1

SAMPLE SECTION OF STANDARDS NOTEBOOK
FOR SURVEILLANCE OF RELIABILITY PROGRAMS

SURVEILLANCE STANDARDS FOR:

Failure Reporting System
(Program Work Category)

(1) Applicable paragraphs, Statement of Work: (Reference paragraphs and attach copies as exhibit)

(2) Applicable paragraphs, MIL-R-27542: (Reference paragraphs and attach copies as exhibit)

(3) Applicable paragraphs, Reliability Program Plan: (Reference paragraphs and attach copies as exhibit)

(4) Supplemental standards: (e.g., Contractor Document No. XXX, XYZ Company standard operating procedure for failure reporting)

(5) Scheduling standards: (e.g., Monthly failure summaries to be submitted 15th of each month -- attach copy of required summary contents as exhibit)

(6) Other quality standards:

(a) Are forms being completely filled out? (Check sample of 100 submitted forms, to determine percentage completion for selected items.)

(b) Are operating times being recorded on failure forms?

(c) From sampling, do all reported failures appear in failure summary?

(d) From sampling, what is average time required to close out a failure report?

(e) What percentage of reported failures have been classified as to cause?

(f) Are failure reports being screened for accuracy?

(g) Are failure reports being received from vendors?

(h) Does contractor know which reports are not yet closed out?

4.1.4.1.3 Scheduling of Surveillance

The final step in the development of a surveillance plan is the determination of the frequency of surveillance activities. One approach is to perform surveillance on a continuous basis. This approach is not normally conducive to organized execution, particularly since the surveillance function involves other administrative duties. Hence, it is more practical to establish a working schedule for conduct of the function.

A surveillance schedule need not be complex. For example, the thirteen major areas of consideration previously listed in 4.1.4.1.1 could be utilized as the basis for the schedule with each element scheduled on either a random or regular basis. The decisions necessary in development of the schedule include:

(1) The frequency with which each defined element will be investigated.

(2) The amount of time to be expended in each investigation.

These decisions are dependent on the amount of time to be allotted to the surveillance function.

4.1.4.2 Conduct of Surveillance

The effectiveness with which any particular element of work is investigated will depend on the degree of completeness with which the quality standards and schedule compliance standards have been previously developed. The execution of the surveillance plan involves comparison of these standards with demonstrable progress, as manifest in program documentation, observation of events, and interviews with appropriate personnel.

In conducting surveillance, the SPO Reliability Coordinator should coordinate his activities with the Air Force Plant Representative Office assigned to the contractor's facility. The AFPRO objective of on-site inspection coincides with the surveillance task of the Reliability Coordinator. Since the specific relationship between the SPO and the AFPRO may vary with the Air Force management policy for each individual program, it is incumbent on the SPO Reliability Coordinator to coordinate the execution of the reliability program surveillance plan with the AFPRO inspection activities. (See par. 3.1.4.4.2)

4.1.4.3 Feedback of Surveillance Results

The manner in which the results of surveillance are used will depend on the criticalness of the deficiencies found. Significant departures from quality or schedule compliance standards or problems which cannot be resolved through usual communication channels should be formally reported to higher Air Force authority. In instances of less significant deficiencies, the SPO Reliability Co-ordinator may elect to advice the contractor in a more routine manner.

The results of surveillance actions provide important contributions to formal program reviews (see 4.2). Therefore, it is paramount that the results be compiled in documentary form.

4.1.5 Additional References on Program Surveillance

Aspects of An Effective Reliability Program Implemented for An Advanced Bombing-Navigation System, F. W. Blackburn and A. M. Letow, Proceedings, Eighth National Symposium on Reliability and Quality Control, January 1962, pp. 272-280.

Scheduling Supplier Surveys, D. L. Field, Proceedings, Eighth National Symposium on Reliability and Quality Control, January 1962, pp. 431-433.

Military System Reliability, J. Spiegel and E. M. Bennett, IRE Transactions on Reliability and Quality Control, Vol. RQC-10, No. 2 (August 1961), pp. 53-63.

Talos Missile Reliability Data System Contribution to Management, R. R. Wendt, Fourth National Symposium on Reliability and Quality Control, January 1958, p. 225.

Steps to Be Taken to Produce Reliable Products, L. J. Paddison, Third National Symposium on Reliability and Quality Control, January 1957, pp. 133-135.

4.2 Program Review

4.2.1 Definition

The review of a reliability program differs from surveillance of the program in that the former is more formal and deliberate in nature and occurs at discrete points in time, while the latter is a continual, supervisory type of action. Further, a program review is concerned more with the progress of the over-all reliability program rather than its individual elements.

Since the review of a reliability program could employ a variety of techniques and be governed by a variety of procedures, the success of this activity is contingent upon the precise stipulation of organized procedural details.

4.2.2 Air Force Policy

Air Force policy relating to formal review of reliability programs is summarized in Table 4-3.

4.2.3 Responsibilities for Program Review

Assigned responsibilities of SPO Reliability Coordinators and other associated groups relating to program review are presented in Table 4-4.

4.2.4 Implementation of Program Review

The review function is discussed under two separate headings:

(1) Periodic program reviews

(2) Major milestone reviews

TABLE 4-3

SUMMARY OF AIR FORCE POLICY
RELATING TO REVIEW OF RELIABILITY PROGRAMS

Air Force Document	Statement of Policy	Par. No.
AFR 80-5 4 June 1962	(1) Management review of reliability effort is necessary throughout a system program. The review must include an evaluation of predicted operational reliability and, as applicable, measurement of achieved reliability at every step in the program.	3.f
	(2) Reliability monitoring points generally will be established in the following sequence: (1) Detailed design study (2) Preprototype (3) Prototype (4) Preproduction demonstration (5) Demonstration of service readiness (6) Service evaluation (7) Full-scale production (8) Demonstration of major product improvement However, this generalization is not intended to delineate the complete or ideal system life cycle, but to emphasize the typical points at which the program should be monitored.	4.h
AFSCR 80-1 14 Dec. 1962	(1) Procedures for periodic management review will be developed and applied to the management activity at individual systems management level. Review points will be designated as formal monitoring points for Air Force assessment of reliability programs to provide a basis for management decisions regarding any major reorientation of the reliability program.	4.h
	(2) Major reliability check points or milestones on both activities and results (as available) will be defined and integrated into over-all weapon system program control procedures, including computer or other mechanized procedures.	9.d
AFBSDR 80-5 28 Dec. 1962	(1) Procedures for periodic management review will be developed and applied to the management of all aerospace and support system programs.	5.a

TABLE 4-4

SUMMARY OF RESPONSIBILITIES
RELATING TO REVIEW OF RELIABILITY PROGRAMS

Air Force Document	Level to Which Assigned	Statement of Responsibility	Par. No.
AFR 80-5 4 June 1962	AFSC	(1) Assume responsibility for all reliability design and development testing, provide technical guidance to the program, and evaluate and validate the results on all systems.	6.e
		(2) Collaborate with the operating commands to verify achieved reliability in the operational environment during operational testing of systems.	6.f
	Operating Commands	(1) Participate with AFSC and AFLC in the periodic formal review of reliability programs.	8.d
AFSCR 80-1 14 Dec. 1962	System Program Offices (SPO's)	(1) Maintain an adequate staff for monitoring of the reliability program for the system with which they are concerned.	7.a
	CMR	(1) Obtain objective evidence to determine compliance or degree of non-compliance with contractual reliability requirements.	8.b
AFBSDR 80-5 28 Dec. 1962	SPO Reliability Coordinators	(1) Implement a system mathematical model for the periodic assessment of system reliability and solution of problem areas.	6.b.(3)

4.2.4.1 Periodic Program Reviews

It is a common practice in most programs for the Air Force and the contractor to meet periodically for program reviews. Depending on the procedures established, these reviews may be concerned solely with the reliability program or may consider that program as only one factor among many. At such meetings, the contractor usually makes an oral presentation of program status and progress, with the customer serving primarily as interrogator.

The procedures associated with the conduct of periodic program reviews are not stereotyped, but must usually be developed for each individual program. The factors listed in Table 4-5 are offered for guidance in establishing and conducting a series of program reviews.

If separate technical meetings (see 3.1.2) not primarily intended for review purposes are conducted, care should be taken to insure distinction between the two procedures. Also, care must be taken to insure that surveillance activities (see 4.1) and periodic status reporting activities (see 3.1.3) complement rather than duplicate the periodic program review activities.

Program reviews in which the Air Force is a participant (as observer, interrogator, or director) should be independent of and in addition to any reviews conducted internally by the contractor.

4.2.4.2 Major Milestone Reviews

Major milestone reviews are similar to periodic program reviews in that the cumulative requirements of the program represent the area of interest. They differ from the periodic reviews, however, to the extent that the milestone reviews are usually more comprehensive and involve a deliberate investigative effort conducted by the SPO Reliability Coordinator.

The approach to performing major milestone reviews requires essentially the same processes as the implementation of program surveillance: the SPO Reliability Coordinator must develop a plan, execute that plan, and feedback results into the program. In developing the plan for milestone reviews, the Reliability Coordinator must determine the elements of work to be surveyed, determine the number of milestones to be reviewed, and establish standards for the reviews.

TABLE 4-5

FACTORS TO BE CONSIDERED
IN CONDUCTING PROGRAM REVIEWS

Factor	Requirement or Responsibility
(1) Conduct of program review	Should be specified in the contract statement of work.
(2) Frequency of reviews	Should be decided on basis of comprehensiveness of the reliability program.
(3) Preparation of agenda	Should be responsibility of contractor and should be provided to the Air Force at some prescribed time prior to the review.
(4) Presentation	Should be responsibility of contractor.
(5) Representation of contractor	Should include reliability management personnel.
(6) Content of review	Should include all major elements of the reliability program.
(7) Published synopsis of review	Should be furnished to Air Force by contractor at some prescribed time after the review and should list all action items established.
(8) Review duration	Should depend on frequency, but if meetings are held monthly, it is advisable to confine their duration to one or two days.

4.2.4.2.1 Elements of Work to Be Surveyed

Ideally, as in the surveillance task (see 4.1.4.1.1), the elements of work which are to be surveyed at each major milestone in a reliability program should have been pre-established by the requirements of the contract work statement and/or the contractor's reliability program plan.

4.2.4.2.2 Number of Major Milestones to Be Reviewed

Existing Air Force policy (see Table 4-3) stipulates that major program milestones for review shall be pre-established. Table 4-6 illustrates three distinct methods which can be used to identify major milestones, although many other ways are also available.

There is no one listing of major program milestones which is applicable to all programs. Hence, it is advisable for the SPO Reliability Coordinator to establish milestone review requirements for a specific reliability program at his own discretion. He should be guided in this task by the following factors:

(1) Any set of milestones established for major reliability review should be consistent with milestones established for the over-all program.

(2) The milestones should represent significant and definable points in time with respect to the system life cycle.

(3) The milestones should be confined to that period of time during which the SPO Reliability Coordinator is actively concerned with the program.

(4) The number of milestones should be held to a practical minimum so that sufficient attention can be devoted to the planned review.

(5) Establishment of major milestone reviews should take into consideration the frequency of periodic program reviews.

(6) Each individual major milestone review should be characterized by preliminary planning effort such as notifying the contractor, issuing instructions to him, etc.

TABLE 4-6

METHODS OF IDENTIFYING MAJOR PROGRAM MILESTONES

Air Force Specification Bulletin No. 506 11 May 1959	Navy Bureau of Weapons Instruction (issued under Serial No. BuWeps RREN-81:MPW)	Air Force Regulation No. 375-1 25 November 1963
(1) Detailed design study (2) Pre-prototype (3) Prototype (4) Preproduction demonstration (5) Demonstration of service readiness (6) Service evaluation (7) Full-scale production (8) Demonstration of major product improvement Note: Specification Bulletin 506 establishes review standards for each of the above.	(1) Feasibility study (2) Bid proposal (3) Basic design study (4) First experimental models (5) Additional experimental models (6) Applied engineering design (7) Demonstration of applied engineering design (8) Operational evaluation (9) Production (10) Product improvement	(1) Conceptual Phase. The period extending from the determination of a broad objective until the OSD approval of the Program Change Proposal covering the Definition Phase. (2) Definition Phase. The period between the conceptual and Acquisition Phases starting with the issuance of the System Definition Directive and ending with the issuance of the System Program Directive. (3) Acquisition Phase. The period starting after the issuance of the SP Directive until the acceptance by the user of the last operating unit in a certain series, or until the SOR has been demonstrated through Category II testing and all required updating changes resulting from the testing have been identified, approved, and placed on procurement, whichever occurs later. (4) Operational Phase. The period from acceptance by the user of the first operating unit until disposition of the system. The Operational Phase overlaps the Acquisition Phase.

4.2.4.2.3 Standards for Major Milestone Reviews

The approach to establishing appropriate standards for milestone reviews is similar to that discussed under 4.2.4.2.1 (standards for surveillance) except that, in this case, the standards must additionally be related to the pre-established milestones. To illustrate, reference is made to the matrix in Figure 4-2. Here it is assumed that the reliability program under consideration has been arbitrarily divided into thirteen elements of work and that the system life cycle is described by the conceptual, acquisition, and operational phases. Each block of the matrix, then, defines the basis for a set of standards which must be developed.

In 4.1.4.1.2, it was suggested that the SPO Reliability Coordinator compile a Standards Notebook for guiding his surveillance activities. The same format could be utilized in compiling standards for each major milestone review.

4.2.5 Additional References on Program Review

Reliability Management by Objectives and Results, L. W. Ball, Eighth National Symposium on Reliability and Quality Control, January 1962, pp. 156-162.

Management Policies for Assigning Departmental Reliability Responsibilities, L. W. Ball, Industrial Quality Control, Vol. 17, No. 10 (April 1961), pp. 16-19.

Reliability Audits, R. R. Landers, Machine Design, Vol. 33, No. 5 (March 2, 1961), pp. 76-83.

Methods for Evaluating Reliability Growth and Ultimate Reliability During Development of A Complex System, M. H. Saltz, Fifth National Symposium on Reliability and Quality Control, January 1959, pp. 89-97.

Keeping Score on Reliability, E. F. Dertinger and R. P. Bosely, Third National Symposium on Reliability and Quality Control, January 1957, pp. 49-52.

FIGURE 4-2

MATRIX RELATING ELEMENTS OF WORK
IN RELIABILITY PROGRAM
WITH PRE-ESTABLISHED PHASES OF SYSTEM LIFE CYCLE

	Conceptual Phase	Definition Phase	Acquistion Phase	Operational Phase
General Program Considerations				
Numerical Reliability Requirements				
Program Reviews				
Reliability Interface with Total Program				
Design Reviews				
Design Change and Control				
Mathematical Models				
Test Planning				
Exchange of Data				
Problem Control and Corrective Action				
Reliability Demonstration				
Failure Reporting System				
Reports Submittal				

5. EXPLANATION OF TERMS AND ABBREVIATIONS USED IN HANDBOOK

A number of terms and abbreviations used throughout this handbook have specialized meanings which may not be familiar to all users of the handbook. This appendix presents the definitions and identifications which are intended in the discussions of the present text. It is recognized, of course, that in rapidly expanding fields such as reliability engineering, aerospace technology, etc., the existence of different definitions for the same technical term is not an uncommon occurrence.
(See MIL-STD 721A, 2 August 1962, **Definition of Terms for Reliability Engineering**)

EXPLANATION OF TERMS

Acquisition phase	The period starting after the issuance of the SP Directive until the acceptance by the user of the last operating unit in a certain series, or until the Specific Operational Requirement has been demonstrated through Category II testing and all required updating changes resulting from the testing have been identified, approved, and placed on procurement, whichever occurs later.
Adjustment (application factor)	A multiplier applied to data to adjust for variable conditions.
Analysis of variance	The separation of sum-of-square variations from the mean into components which can be assigned to variations between classes, or subclasses, of appropriate data. Constituent portions of sums of squares indicate, through mean squares, the magnitude of class differences. The extent to which they vary from the residual mean square is a test of the hypothesis that such differences are governing the situation.
Apportionment	Allocation or assignment of the system reliability requirements to subsystems and components in accordance with their complexity and other factors, in such fashion that if each component or subsystem meets its allocated requirement, the system reliability requirement will be met.
Availability	Availability is the probability that the system is operating satisfactorily at any point in time when used under stated conditions where the total time considered includes operating time, active repair time, administrative time, and logistic time. (See Appendix F for definition of Intrinsic Availability and Operational Readiness)
Catastrophic failure	A sudden change in the operating characteristic of an item resulting in a complete lack of useful performance of the item.
Complexity level (equipment)	The figure of merit or measure of the quantity of related parts of circuits. The total number of electronic parts (n) is often used as a measure. Complexity units are sometimes used as a preliminary and approximate measure.

Explanation of Terms (Continued)

Failure mode	The physical description of the manner in which a failure occurs and the operating condition of the equipment or part at the time of the failure.
Failure rate	The number of failures per unit time of a specified item.
Feasibility study	The study of a proposed item or technique to determine the degree to which it is practicable, advisable, and adaptable for the intended purpose.
Flight proofing tests	Tests based on environmental stress-strain safety margins, with the equipment subjected to increasing levels of environmental stress. If no failures occur under the conditions imposed, the design is considered adequate. All equipment used is considered expended and may not be used in the field. These tests and the qualification tests usually fulfill the environmental qualification requirements for R and D equipment. Safety margins used are above the expected in-service levels to allow for the variability of in-service conditions and the individual characteristics of the equipment. The test conditions should not be so severe as to exceed reasonable safety margins or to excite unrealistic or improbable modes of failure.
Hazard rate	The instantaneous failure rate. It is defined as the limit of the failure rate as the interval length approaches zero. $z(t) = \frac{u(t)}{R(t)}$ where $R(t) = \int_t^{\infty} u(t)dt$ A constant hazard rate is equivalent to the exponential case.
Human factors	Facts about human behavior which affect the design of systems. As a discipline, its goal is to achieve an optimal system with an efficient man working in a safe and habitable environment.

Explanation of Terms (Continued)

Incentive contract (Reliability)	A system contract wherein the fee or profit margin is a function of the demonstrated reliability of the system produced by the contractor. The maximum fee is only attainable by the demonstrated reliability exceeding a stated contractual reliability specification.
Infant mortality failures (early life)	Failures occurring during the debugging phase or early portion of equipment life.
Maintainability	Maintainability is the probability that, when maintenance action is initiated under stated conditions, a failed system will be restored to operable condition within a specified total down time.
Mean life	The arithmetic average of the lifetimes of all items considered. The mean life values have meaning only in relation to the type of frequency distribution assumed by the data.
Mean-time-between-failure	The sum of individual operating times accumulated by a population of identical equipment items, divided by the number of failures occurring in the time of observation. The operating time must include that accumulated by items which did not fail, as well as the time accumulated on items which did fail.
Mean-time-to-repair	The average amount of time spent in correcting malfunctions.
Milestone	A significant and frequently critical event having qualitative and/or quantitative aspects which, when completed, indicates the accomplishment of a step in progress toward a predetermined goal.
Mission	A coordinated execution of functions according to a preconceived tactical operations plan for the accomplishment of an objective against the enemy.

Explanation of Terms (Continued)

Operational phase	The period from acceptance by the user of the first operating unit until disposition of the system. The operational phase overlaps the acquisition phase.
Parametric study	A determination of the relationships existing between the parameters of a system.
Prediction	The estimation of the future behavior of a system on the basis of knowledge of its parts, functions, operating environments, and their interrelationships.
Probability	A measure of the likelihood of occurrence of a particular event. The ratio of the number of ways a particular event can occur to the total number of events which can possibly occur.
Probability of failure	The likelihood that an item will fail during a specified period of time in a given environment. If P_f = probability of failure and P_s = probability of success, then: $P_f = 1 - P_s$ or $P_f + P_s = 1$
Probability of success	The likelihood of successful operation of an item for a specified period of time under a specified environment. The complement of the probability of failure.
Probability of survival	A numerical expression of reliability. It has the accepted nomenclature of P_s and a range of 0 to 1.0 where 0 and 1 indicate the extremes of "impossibility" and "certainty," respectively. In other words, the probability of a given equipment performing its intended function or the given use cycle.
Quality control	A factory-oriented operation to assure manufacture of a uniform product within specified defect limits in accordance with design requirements.

Explanation of Terms (Continued)

Redundancy	The existence of more than one means for accomplishing a given task, where all means must fail before there is an over-all failure to the system.
Reliability	The probability that an item will perform a required function under specified conditions for a specified period of time.
Reliability growth curve	A periodic record of reliability estimates by which trends can be observed and reliability growth determined.
Reliability index	Figures of merit, such as ratios, factors, etc., used to denote relative reliability.
Service readiness	Service readiness is the probability that at any point in time, the system is either operating satisfactorily or ready to be placed in operation on demand when used under stated conditions, including stated allowable warning time. The total calendar time is the basis for computation of service readiness.
Stress analysis	A technique somewhat similar to structural stress analysis, applied to equipment design to evaluate the influence of environmental, functional, and time stresses, as an aid to assuring design integrity or predicting reliability.
Subcontractor	A supplier of subsystems or equipments to the contractor.
System effectiveness	System effectiveness is the probability that a system (or a system complex) will accomplish a stated mission. (If the duration of time is important. it must be included in mission definition)
System life cycle	The complete life cycle of a system including conceptual phase, acquisition phase, and operational phase.

Explanation of Terms (Continued)

Trade-off	The procedure of trading a degree of one attribute to gain a degree of another attribute. E.g., a degree of reliability might be sacrificed to obtain a greater degree of performance under certain conditions, or vice versa.
Vendor	A supplier of parts or other items of low complexity levels to the contractor.

EXPLANATION OF ABBREVIATIONS

ADO	Advanced Development Objective
AFBSD	Air Force Ballistic System Division
AFLC	Air Force Logistic Command
AFPI	Air Force Procurement Instruction
AFPRO	Air Force Plant Representative Office
AFSC	Air Force System Command
AFSSD	Air Force Space System Division
AGE	Aerospace Ground Equipment
AGREE	Advisory Group on Reliability of Electronic Equipment, Office of Assistant Secretary of Defense (Research and Engineering)
ASPR	Armed Services Procurement Regulation
ASTIA	Armed Services Technical Information Agency
BSD	Ballistic System Division
CMR	Contracts Management Region
DOD	Department of Defense
DP	Development Plan
GFE	Government Furnished Equipment
IDEP	Interservice Data Exchange Program
IRE	Institute of Radio Engineers
NASA	National Aeronautics and Space Administration
OPR	Office of Primary Responsibility
PEP	Product Evaluation Program

Explanation of Abbreviations (Continued)

PERT	Program Evaluation and Review Technique
PSPP	Proposed System Package Plan
RFP	Request for Proposal
RMI	Reliability Maturity Index
SE/TD	Systems Engineering/Technical Direction
SOR	Specific Operational Requirement
SPO	System Project Office
SPP	System Package Plan
SSD	Space System Division

6. INDEX DESCRIPTION AND INSTRUCTIONS FOR USE

This index is applicable to both Volumes, 1 and 2, of the Reliability Management Handbook. Index entries with number-prefix page numbers apply to Volume I; the entries with letter-prefix page numbers apply to Volume II.

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OSBORNE 9-4661

1923.1-64-84
22 April 1964

To: All Recipients of the Reliability Management Handbook*

1. The Reliability Management Handbook is designed to assist Air Force System Program Office (SPO) Reliability Engineers in the performance of their assigned management tasks. This Handbook is intended to serve as an aid in the implementation of MIL-R-27542A (USAF) "Reliability Program Requirements for Aerospace Systems, Subsystems, and Equipment."

2. It is recognized that certain definitions and statements of philosophy expressed herein may be controversial. However, the Handbook is presented as an expression of current practice in the field of reliability program management. Although this Handbook has been extensively reviewed, it is inevitable that not all of the errors and inconsistencies have been eliminated. In order to make this work available to you within a reasonable time, while it is still meaningful, it is published in its present imperfect form. It is the intention of the Aerospace Corporation to review periodically and update the Handbook as required.

3. Recommendations for improvement of the Handbook are solicited from users, interested individuals, and organizations. It is recommended that appropriate comments be made directly on the pages of the Handbook. Copies of the marked pages and comments should be forwarded to the attention of F. P. Klein, Reliability Department, Aerospace Corporation, or Lt. Col. O. A. Bernhoff, SSD (SSSIR), USAF.

4. The Handbook is constructed so that individual pages or sections may be revised as required. It is intended that recipients of the Handbook receive copies of each revision. It is requested that each addressee sign the attached receipt and forward it to this office in order to ensure the receipt of future corrections, changes, and additions to this Handbook.

Very truly yours,

F. P. Klein
Head, Reliability Department

FPK/gm
Attch. (1) (To be completed by the recipient)
* Reliability Management Handbook, TOR-269(4303)-9, Vol. I and II
Replaces Previously Published Handbook ATN-64(4303)-1, dated 3 September 1963, Vol. I and II.

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1923.1-64-84
Attachment I

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Head, Reliability Department
Aerospace Corporation
P. O. Box 95085
Los Angeles 45, California

The Reliability Management Handbook, Volumes I and II were received by my office and are denoted by Serial Number 110. As corrections, changes, and additions are made to the Handbook, I will insert same into the Handbook as noted.

Name: (Please Print) ______________________

Signature: ______________ Date: __________

Address: ______________ Bldg. ______ Room ______

City: ______________ State: ______________

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