SSD-TR-91-21

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AEROSPACE REPORT NO.
TR-92(2904)-3

System Specification Preparation Guidebook SSD-GB-4A

Prepared by

E. WADE
Systems Effectiveness Subdivision
Electronics and Sensors Division

February 1992

Prepared for

SPACE SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
Los Angeles Air Force Base
P. O. Box 92960
Los Angeles, CA 90009-2960

Programs Group

THE AEROSPACE CORPORATION
El Segundo, California

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This final report was submitted by The Aerospace Corporation, El Segundo, CA 90245-4691, under Contract No. F40701-88-C-0089 with the Space Systems Division, P. O. Box 92960, Los Angeles, CA 90009-2960. It was reviewed and approved for The Aerospace Corporation by J. Meltzer, Systems Engineering Directorate, Programs Group. The project officer was Lt. Col. A. E. Stevens.

This report has been reviewed by the Public Affairs Office (PAS) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nationals.

This technical report has been reviewed and is approved for publication. Publication of this report does not constitute Air Force Approval of the report's findings or conclusions. It is published only for the exchange and stimulatio of ideas.

FOR THE COMMANDER

Arthur E. Stevens

Arthur E. Stevens, Lt Col, USAF
Director, Acquisition Support

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) TR-92(2904)-3	5. MONITORING ORGANIZATION REPORT NUMBER(S) SSD-TR-91-21
6a. NAME OF PERFORMING ORGANIZATION The Aerospace Corporation 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION Space Systems Division Air Force Systems Command
6c. ADDRESS (City, State, and ZIP Code) 2350 E. El Segundo Blvd. El Segundo, CA 90245-4691	7b. ADDRESS (City, State, and ZIP Code) Los Angeles Air Force Base P. O. Box 92960 Los Angeles, CA 90009-2960
8a. NAME OF FUNDING/SPONSORING ORGANIZATION Space Systems Division Air Force Systems Command 8b. OFFICE SYMBOL (If applicable) SDS	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code) Los Angeles Air Force Base P. O. Box 92960 Los Angeles, CA 90009-2960	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. | PROJECT NO. | TASK NO. | WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)

System Specification Preparation Guidebook SSD-GB-4A

12. PERSONAL AUTHOR(S)

E. Wade

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM 1989 TO 1991	15 October 1991	281

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	System Specification; GB-4; Preparation Guide; MIL-STD-490A; Space Systems

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The preparation of a system specification is the primary subject of this document. The set of detailed requirements presented in this guidebook serve as a complete baseline for space systems. To make this guidebook easy to use, the applicable instructions from MIL-STD-490A and DI-CMAN-8008A have been extracted and incorporated into the text to avoid detailed referencing. Problems and inconsistencies within DI-CMAN-8008A and MIL-STD-490A have been noted and resolved as indicated in the text to assure consistent interpretation by all users. A model space system specification is provided in the appendices along with diskettes for popular word processing application programs.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT [X] UNCLASSIFIED/UNLIMITED [X] SAME AS RPT. [ ] DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL Lt. Col. Arthur E. Stevens, USAF	22b. TELEPHONE (Include Area Code) (310) 363-3223 22c. OFFICE SYMBOL SDS

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete

SECURITY CLASSIFICATION OF THIS PAGE

Unclassified

FOREWORD

The preparation of the system specification by the program office is the primary subject of this guidebook. In addition to aiding in the preparation of the initial system specification, this guide can assist in preparing subsequent revisions that may be necessary as the acquisition progresses, such as subtier system segment specifications. This guidebook, including Appendix A, can serve also as a yardstick for use by those reviewing any system specification, regardless of the preparer.

The acquisition of a new system is typically arranged to be the responsibility of a single government organization. The government office responsible for the acquisition of the new system usually is a System Program Office (SPO). Preliminary system specifications are prepared first by the SPO during the concept development phase of the program. For complex Air Force programs, the program management directive, and any other available top-level documents, are used to prepare the initial draft of the system specification. The system specification describes the system and the functional requirements for the system to whatever extent they are known at the time the specification is prepared.

As the acquisition progresses, the requirements can be definitized in greater detail and allocated to lower-tier elements usually called system segments. Each system segment typically is arranged to be the proposed delivered product of a single contractor or organization. Each system segment specification would be prepared using the same format and guidelines as used for the system specification. During program initiation, the program offices also may prepare preliminary development specifications for the prime items in the system segments and for critical lower-tier items. These preliminary specifications form the basis for study and for the preparation during subsequent acquisition phases of more detailed specifications.

For Air Force programs, AFR 65-3 and AFSC Pamphlet 800-7 establish the general requirement that program-peculiar specifications are to be prepared in accordance with MIL-STD-490A that was issued 04 June

1985. For system specifications, MIL-STD-490A makes reference to Data Item Description DI-CMAN-80008 for details. The initial issue of DI-CMAN-80008 had so many deficiencies and errors that it was essentially unusable. A long and complex change and revision cycle has resulted in the "A" revision, DI-CMAN-80008A, issued 29 February 1988. The "A" revision is clearly flawed, but at least it is usable and may be interpreted so that its problems and deficiencies are overcome.

The set of detailed requirements presented in this guidebook should be viewed as the complete baseline for all possible space system requirements. To make this guidebook easy to use, the applicable instructions from MIL-STD-490A and DI-CMAN-80008A have been extracted and are incorporated directly in the text to avoid detailed referencing. Problems and inconsistencies within DI-CMAN-80008A and MIL-STD-490A are noted and resolved as indicated in the text to assure consistent interpretation by all users, while providing exact compliance with the stated requirements. Requirements then have been added to the specified requirements to provide a complete guide for the preparation of a space system specification.

Although the emphasis and added details in the guidebook are primarily for Air Force space systems, it should be clear that the guidebook can be used easily to prepare a system specification for any type of system. Other types of systems might have requirements for aircraft, missiles, tanks, or ships that would result in other added categories instead of requirements for space vehicles. In that case, in place of requirements in the guidebook that were added to accommodate space vehicles, another type of system instead might include requirements applicable to aircraft, missiles, tanks, or ships. Most systems include ground equipment; but even there the actual requirements applicable to the ground equipment vary with the type of system being acquired. As outlined in Sections 1 and 2, requirements that are applicable to the system under consideration would be addressed instead of the space vehicle and other space system requirements that are addressed in the guidebook.

The requirements for a system segment specification in DI-CMAN-80008A and MIL-STD-490A are exactly the same as for a system specification. This means that although the guidebook is primarily for a system specification, it can be used also to prepare any system segment specification. As outlined in Sections 1 and 2, each of the levels of assembly simply shift one level lower for a system segment specification.

For the convenience of the user, a copy of Data Item Description DI-CMAN-80008A is included in Appendix B. Appendix C addresses the availability of word processor diskette copies of Appendix A, the Model specification.

Although every effort was made to be correct and accurate, the responsibility for the contents of this guide resides with the author. Publication is solely for the convenience of the technical community in the interest of information exchange.

NO DATA

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FIGURES

1. INTRODUCTION

1.1 TERMINOLOGY

The acquisition process used by System Program Offices (SPOs) has remained essentially unchanged for the last several years, but the review committees and the document terminology used at higher Department of Defense (DoD) levels has changed frequently. For example, a Mission Need Statement (MNS) now is used at the DoD level as the initial document that starts considerations for any major new program. In 1986, the MNS was called the Justification for Major System New Start (JMSNS); before 1986, it was called the Mission Element Need Statement (MENS); and before about 1982, it was called the Statement of Operational Need (SON). In accordance with AFR 57-1, *Operational Needs, Requirements, and Concepts*, the SON still is used within the Air Force as the initial document that starts considerations for any new Air Force program. When the Air Force program is such that it is considered at the DoD level, an MNS is prepared based on the SON. Most of the changes in the reviews and the terminology for documents used at higher DoD levels have been attempts to achieve procedural and terminology consistency among the various DoD Components and to align the acquisition process with the Congressional appropriations process. Although history does not provide much assurance, it is believed that future changes will be minor, or at least they will not affect the major content of this guidebook. The current terminology, policies, and procedures for the acquisition of major new systems are given in DoD Directive 5000.1 and in DoD Instruction 5000.2.

1.2 PROGRAM INITIATION

Each DoD Component has a requirement for continuing analysis of its mission area to reveal deficiencies and to determine more effective means of performing its assigned tasks. When new mission needs are identified within the Air Force, they are documented in a SON or for DoD level considerations in an MNS. The MNS is reviewed and coordinated through appropriate DoD channels; after approval, the MNS becomes the basis for studies and acquisitions that will satisfy the mission need. Before the acquisition of a major new system can begin, approval by the Defense Acquisition Board (DAB) is required. The start and milestone progress of major new systems are considered by the DAB concurrent with the Office of the Secretary of Defense Orbital Support Document (OSD) Program Objective Memorandum (POM) review. Approval by the DAB for the start of a major new system is based on the need to satisfy a specific major deficiency within a Component's mission area as documented in an MNS and the reviews and recommendations of the appropriate DAB Acquisition Committee(s). An Acquisition Decision Memorandum (ADM) is issued promptly following DAB meetings to the Head of the DoD Component(s) involved in order to document the decisions and approvals reached. Initial approval of a major new system by the DAB is identified as the Milestone 0 - Program Initiation/Mission-Need Decision, and the concept exploration/definition phase of the acquisition process follows. The Acquisition Decision Memorandum and the associated Mission Need Statement serve as the top-level DoD documents governing the program activities within the assigned DoD Components for the Concept Exploration/Definition Phase.

For major Air Force programs, the internal top-level program document is the Program Management Directive (PMD) issued by the Secretary of the Air Force based upon the applicable ADM. Like the ADM, the PMD addresses administrative as well as some technical issues. The PMD is intended to impose the program requirements on the Air Force organizations involved. It also documents the general agreements of the Air Force with other government organizations that will participate in the program. The initial issue of a PMD formally starts the program acquisition. This initial issue also is the basis for establishing the SPOs and for appointing a program manager for each SPO. This initial issue also is the basis for the preparation of the System Operational Requirement Document (SORD) by the lead operating command in accordance with AFR 57-1, *Operational Needs, Requirements, and Concepts.* For selected Air Force acquisition programs, another formal top-level program baseline document also is prepared that expands the PMD. This top-level document is the

Program Baseline Document (PBD) prepared in accordance with AFR 800-25, *Acquisition Management.*

1.3 SYSTEM OPERATIONAL REQUIREMENT DOCUMENT

1.3.1 General

The System Operational Requirement Document (SORD) is prepared in accordance with AFR 57-1 for each funded program to serve as a program planning document that identifies the top-level performance, operation, and support parameters, characteristics, and requirements for the system. It documents how the system will be operated, deployed, employed, and supported and provides initial guidance for the implementing, supporting, and participating commands and agencies. The SORD is prepared by the lead operating command during the Concept Exploration/ Definition Phase of the program acquisition. The SORD then is updated by the lead operating command during each subsequent phase of the program acquisition to reflect any changes in the requirements and any cost and performance tradeoffs.

1.3.2 Content

An SORD is prepared in five parts, with two mandatory attachments, in accordance with AFR 57-1.

> Part I of a System Operational Requirement Document, "Mission," very briefly addresses the mission area, the mission element need, and any joint-service or multinational applicability of the program or system being developed.
>
> Part II of a System Operational Requirement Document, "Basis of Need," addresses the new information, threat change, or technology opportunity that form the basis for the need.
>
> Part III of a System Operational Requirement Document, "Assessment of Capability," summarizes the existing and the planned capability, focusing primarily on the shortfalls of the existing capability to meet the threat.

Part IV of a System Operational Requirement Document, "Needed Capability," is the body of the document that addresses the following areas in considerable detail:

a. General Operational Requirements. (A list of the critical requirements described in these paragraphs that form the basis of the first mandatory attachment, i.e. the Requirements Correlation Matrix)

b. Related Support Factors

c. Possible Solutions

d. Upgraded System Description (if applicable)

e. New System Description (if applicable)

f. Any Other Solutions (if applicable)

Part V of a System Operational Requirement Document, "Proposed Program," describes the acquisition strategy, the schedule, and the funding profile.

Attachment 1 of a System Operational Requirement Document, "The Requirements Correlation Matrix (RCM)," traces each of the critical parameters from values stated in the initial Statement of Need, through the values stated in each version of the System Operational Requirement Document, in terms of specification values and test criteria.

Attachment 2 of a System Operational Requirement Document, "Threat Assessment," also is mandatory.

Attachment 3 of a System Operational Requirement Document, "Funding," is prepared if the funding information is too extensive to include in the text.

1.4 PROGRAM BASELINE DOCUMENT

1.4.1 General

A Program Baseline Document (PBD) is prepared for selected programs to serve as a program integration document that identifies the top-level program requirements and allocates those requirements to the various independent government organizations involved.

1.4.2 Content

A PBD is prepared in three parts in accordance with AFR 800-25, "Acquisition Management."

Part I of a Program Baseline Document, "Requirements," describes the need for the program or system being developed and identifies by reference the source documents, such as Statement of Need (SON), Mission Need Statement (MNS), Joint Strategic Operational Requirement (JSOR), System Operational Requirement Document (SORD), System Operational Concept (SOC), Information Systems Requirements Document (ISRD), Functional Description (FD), et cetera, which contain the operational and supportability requirements the program is to satisfy.

Part II of a Program Baseline Document, "Program Content," describes the program being pursued. It is subdivided into major sections such as:

A. System Definition

B. Performance

C. Operations Concept

D. System Readiness

E. Integrated Logistics Support

F. Maintenance Concept

G. Communications, Data Automation, and Information Systems Resources

H. Test and Evaluation

I. Training

J. Facilities

K. Acquisition Strategy

L. Schedule

Part III of a Program Baseline Document, "Approved Funding," identifies the program funding approved in the Congressional Appropriations Bill and in the Five-Year Defense Program.

When the Program Baseline Document is signed by all the program participants and HQ USAF, it becomes the formal Program Baseline Agreement. When a PBD is not prepared or when it does not cover specific details, it should be recognized that other formal interagency coordination documentation may be needed to avoid subsequent misunderstandings. Requirements, even if coordinated at a technical level, cannot be unilaterally imposed on one government organization by another *independent* government organization. The cooperative program activities required among the government organizations involved can be assured only by signed agreements. Interagency requirements that are not included in a Program Baseline Agreement usually are documented by "memoranda of agreement," "memoranda of understanding," "interface control documents," or any combination of these.

1.5 ACQUISITION POLICY

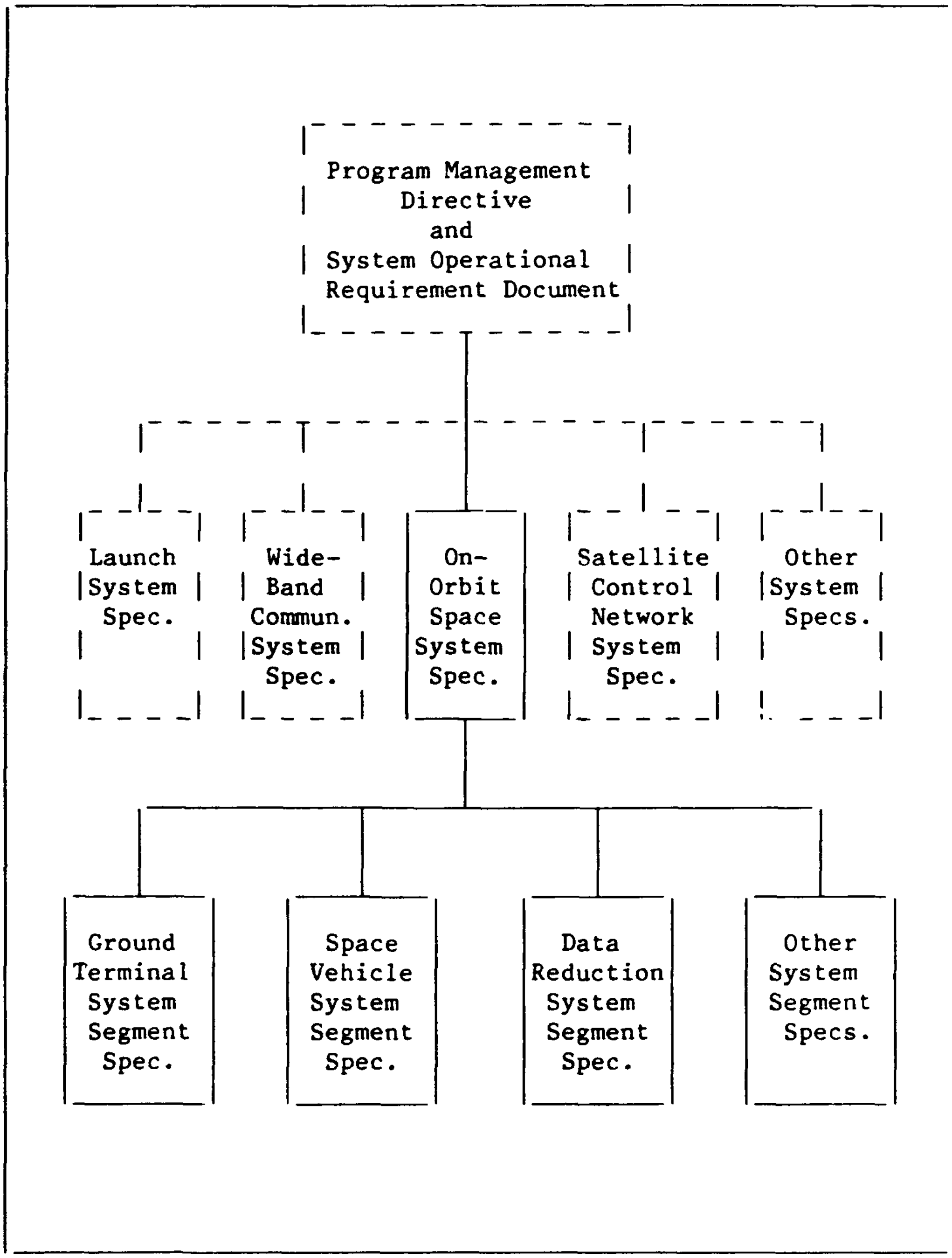
The general acquisition management policies to be followed by the SPOs and the program managers within the Air Force Space Systems Division (SSD) are stated in AFR 800-2, *Acquisition Program Management*. This Air Force regulation implements requirements to follow applicable DoD directives on major system acquisitions, identifies the various program phases, and establishes formal decision milestones during the program life cycle. The specific acquisition strategy to be followed is determined by an Acquisition Strategy Panel (AFSC Regulation 550-21, *Acquisition Strategy*) and is documented in the Acquisition Plan.

1.6 APPROACH TO SPECIFICATION PREPARATION

As shown in Figures 1 and 2, several system specifications are typically required to describe all of the requirements of a major DoD program. In the space program shown, the program includes not only the on-orbit space system, but also the launch system and other associated systems such as the satellite control network system for tracking and commanding the satellite, a wide-band communications system, and perhaps other systems. Each of the system specifications is typically prepared by a different government organization or at least by an independent SPO. Figure 1 shows that the on-orbit space system for the program illustrated has been subdivided into three system segments plus other possible system segments that have not been identified. Figure 2 shows that the launch system for the program illustrated has been subdivided into two system segments plus other possible system segments that have not been identified. The specifications that are the responsibility of a single SPO, including subtier system segment specifications, are shown with solid lines. Specifications for interfacing elements are shown with dashed lines. Although the space vehicle really is the payload of the launch vehicle, and therefore is a critical element of the actual launch system, it is shown by dashed lines in Figure 2 as an interfacing element to the launch system, since it is defined--at least in this case--as part of the on-orbit space system.

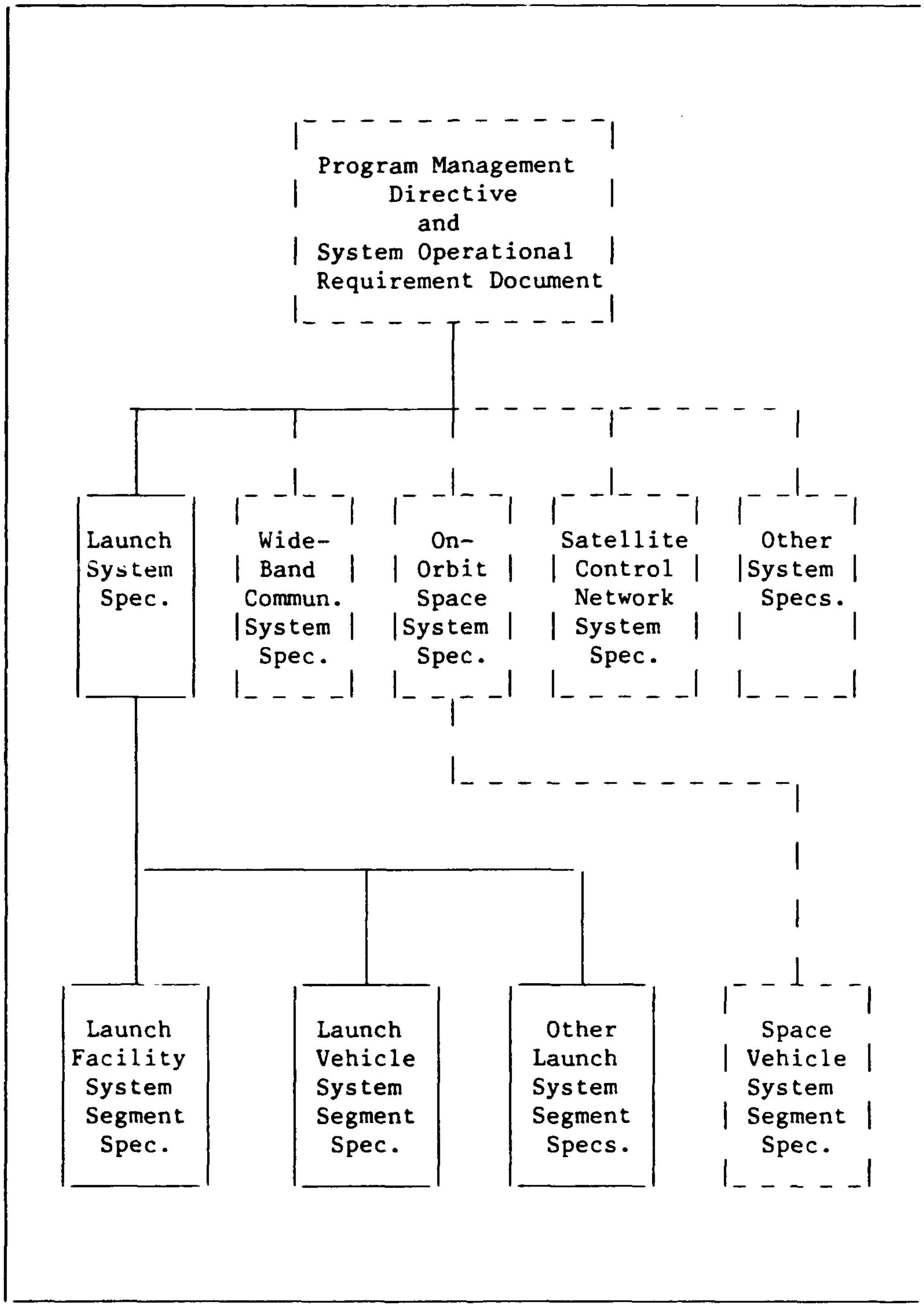
Each of the government organizations involved prepares a system specification for the procurement of its portion of the total program. These system specifications are based on the PMD, the SORD, and, if available, the Program Baseline Agreement. The equipment and software requirements in each system specification may be subdivided by the responsible program office into separate functional areas identified as system segments or, for simple systems, directly into prime items.

A system segment is simply a major element of a system that is so identified by the responsible program office for management expediency or to facilitate separate procurements. When system segments are identified by the program office, they should be identified also in the system specification. A system segment should included the delivered products of a single contractor or organization. For example, a space vehicle system segment typically would include the space vehicle as well as the ground support equipment for the vehicle, interfacing equipment to be carried in the Space Transportation System Orbiter (if used), and other items to be delivered by the space vehicle contractor.



Note: Interfacing Systems Shown by Dashed Lines

Figure 1. Typical On-Orbit Space System Specification Tree



Note: Interfacing Systems Shown by Dashed Lines

Figure 2. Typical Launch System Specification Tree

The system and system segment specifications form the technical basis for procurements conducted by the SPO responsible for the system acquisition. For that reason, each system specification documents only those program functions and requirements allocated to the SPO or government organization preparing that system specification. The interfacing system or system segment specifications required to define external interfaces may not actually exist when they are required for the preparation of the system specification, because the "cooperating" independent government organizations responsible for their preparation may not have given the task a high enough priority, or they simply may have not been designed. Deficiencies in the availability of reference documents make it difficult to prepare a complete system specification, but they should not abort the effort. The system specification should be as complete as possible under the circumstances that exist when it is prepared.

To illustrate typical program complexity, an Air Force meteorological satellite vehicle may be launched by the National Aeronautics and Space Administration (NASA) Space Transportation System (STS) to produce data to be used in the Department of Commerce weather forecasting system. The preparation of the various system specifications required to describe this total program would be the responsibility of the various government organizations involved. NASA would document the STS in system and subtier specifications, the Department of Commerce would document the data system for worldwide exchange of weather data and forecasts, and the DoD would prepare a space system specification for the acquisition of the satellite system.

1.7 APPROACH TO SYSTEM SPECIFICATION CONTENT AND FORMATTING

The general content and format requirements for the preparation of program-peculiar specifications for DoD programs are covered in MIL-STD-490A, dated 04 June 1985. For Air Force programs, either Form 1a specifications or Form 1b specifications as defined in MIL-S-83490 may be used. Form 1a requires strict format compliance with military standards, whereas Form 1b requires only limited format compliance. However, Form

1a allows the addition of new paragraphs for added subjects as long as the added paragraphs follow the stipulated paragraphs in each section, so that the stipulated paragraphs do not require renumbering. Because the technical content of a Form 1b specification should be the same as the technical content of a Form 1a specification, the government usually requires a Form 1a specification, since using a standard format should not cost any extra money. On the other hand, using a Form 1b specification should not cause any major problems for the government.

In the terminology of the referenced standards, a system specification is a Type A specification, and its preparation is covered in Appendix I of MIL-STD-490A. Although it may be difficult to follow, Appendix I of MIL-STD-490A references Data Item Description DI-CMAN-80008 that provides most of the details. Problems and inconsistencies within DI-CMAN-80008 and with MIL-STD-490A meant that DI-CMAN-80008 was really impossible to use; so Revision A, dated 29 February 1988, was prepared and released. Problems and inconsistencies still exist with this revision, DI-CMAN-80008A; however, strict format compliance can generate a suitable system specification, provided the inconsistencies are properly resolved. Towards that end, the detailed requirements in Data Item Description DI-CMAN-80008A and the general requirements in MIL-STD-490A have been extracted and are included in this guide to avoid referencing and to resolve possible problems. If a contractor is tasked to prepare a system specification and this guide cannot be followed for some reason, it is recommended that the specification be prepared as Form 1b. In that way, the contractor will have some flexibility in the format used. In any case, DO NOT TRY TO FOLLOW THE ORIGINAL VERSION OF THE DATA ITEM DESCRIPTION, DI-CMAN-80008, SINCE IT IS NOT USABLE.

In order to instill a discipline to not state detailed requirements too early in the acquisition, the system specification is organized with a logical expansion in the detail requested for requirements as one progresses from Section 1, Scope; to Section 3.1, Definition; to general requirements in Subsections 3.2, 3.3, 3.4, 3.5, and 3.6; and finally to Subsection 3.7, Subtier Requirements. This expansion allows the first sections to be completed early in the acquisition, with little expectation that completed sections subsequently would require major changes.

1.8 ADDED SPECIFICATION REQUIREMENTS FOR SPACE SYSTEMS

For a space system, it is cost effective to add "lesson learned" requirements that are not specifically addressed in the general system specification format to help avoid repeated failures. In this guidebook, space system requirements missing in MIL-STD-490A and DI-CMAN-80008A have been added to the specified requirements to provide a complete guide for the preparation of space system specifications. Therefore, the content requirements and format presented in this guide assure both compliance with MIL-STD-490A and DI-CMAN-80008A and coverage of the critical and unique requirements for space systems. In other words, this guide should be followed exactly to obtain a Form 1a space system specification.

1.9 ADDED REQUIREMENTS FOR OTHER TYPES OF SYSTEMS

Although the emphasis and added details in the guidebook are primarily for Air Force space systems, it should be clear that the guidebook can be used easily to prepare a system specification for any type of system. Another type of system, and perhaps some space systems, might have requirements for other classes of items, such as aircraft, missiles, balloons, tanks, or ships, that need to be included. In that case, in place of requirements in the guidebook for a space vehicle, another type of system might include requirements for the other applicable classes of items, such as aircraft, missiles, balloons, tanks, or ships.

Of course, almost all systems include ground equipment, so provisions for ground equipment requirements would be expected in all system specifications. Other classes of requirements that are applicable to the system under consideration would be addressed instead of, or in addition to, the space vehicle requirements that actually are addressed in the guidebook. This would require some paragraph renumbering in the guidebook, and some paragraphs would have different titles; but the changes would be at subtier levels that should not affect compliance with DI-CMAN-80008A and MIL-STD-490A.

1.10 APPROACH TO SYSTEM SEGMENT SPECIFICATION PREPARATION

The requirements for a system segment specification in DI-CMAN-80008A and MIL-STD-490A are exactly the same as for a system specification. This means that although the guidebook is primarily for a system specification, it can be used also to prepare any system segment specification. The levels of assembly simply shift one level lower. The term "configuration item" always replaces "prime item." The term "prime item" always replaces "system segment." The term "system segment specification" always replaces "system specification." The term "system segment" replaces "system" in many places; but one must read the text to be sure, since the correct word still could be "system" in some cases. Almost all system segments include ground equipment, so provisions for ground equipment requirements would be expected in all system segment specifications. Except for space vehicle system segment specifications, a typical system segment does not include requirements for a space vehicle. The requirements shown in the guidebook for a space vehicle then would be deleted; however, there might be added requirements for other classes of items, such as aircraft, missiles, balloons, tanks, or ships, that would be addressed instead of the space vehicle requirements. In any case, this would result in some paragraph renumbering, and some paragraphs would have different titles; but the changes should be at subtier levels that would not affect compliance with DI-CMAN-80008A and MIL-STD-490A.

NO DATA

2. SYSTEM SPECIFICATION PREPARATION

2.1 SPACE SYSTEM MODEL SPECIFICATION

A model of a space system specification giving the format and standard boilerplate requirement statements for each section is included as Appendix A of this guidebook. In other words, Appendix A is a model specification which states typical requirements that would be expected in all space system specifications. By adding the program-peculiar requirements to the boilerplate requirements given in this model specification, a complete space system specification can be quickly and competently prepared for any program. To highlight some of the paragraphs in the model specification where program-peculiar requirements should be added, the acronym TBS is used to indicate "to be supplied" by the government. The body of this guide summarizes pertinent comments and requirements for preparing these supplementary program-peculiar requirements for the various subparagraphs.

Note that the level of technical detail increases substantially during the acquisition process. In the initial phases of a program, after the program-peculiar requirements have been added to the boilerplate requirements in this model specification, requirements still may not be firm or may not have been identified for many of the headings in the specification. In those cases, it is recommended that all paragraph headings be retained but that a notation be made to indicate the government's intent. If there are no requirements that have been defined or that are applicable for a paragraph at the time the system specification is prepared, the acronym "TBS" may be added after the heading to mean that the missing requirement is "to be supplied" by the government in the course of the acquisition. Alternatively, the missing requirement may be marked "TBD" (to be determined) or "Not applicable." The acronym "TBD" would be added to a missing requirement to mean that the missing requirement is "to be determined" by the contractor in coordination with the government. "Not applicable" would be added to mean that there are no requirements stated, and none are anticipated by the government. The intent is to format the initial draft of the specification so that substantial renumbering of the major paragraphs in the document will not occur as additional details become available during the acquisition process.

If a stated requirement is not considered firm at the time the system specification is prepared, the requirement may be stated using "weighting factor" terminology as discussed in the text for Paragraph 3.8.2, Requirement Weighting Factors, or the requirement may be annotated with a (TBR). The acronym "TBR" added to a requirement would mean that the requirement is "to be reviewed" for appropriateness by the contractor or the government, and may be changed by the government in the course of the acquisition. The purpose of this is to prepare the specification in ways that convey the maximum information to those doing trade studies and allocating requirements to subtier elements.

The *Model Space System Specification*, Appendix A, was prepared as a Form 1a specification using the format shown in Figure 3 (and presented in expanded detail in Section 3). This format exactly follows the format of DI-CMAN-80008A and MIL-STD-490A. Paragraphs that have been added to accommodate the unique requirements of space systems are indicated by an asterisk (*). This format generally is common with other specification formats established by MIL-STD-490A, so that it provides a good basis for the preparation of lower-tier specifications. This last point is significant, since the use of a common format for the system specification, the system segment specifications, and subsequent lower-tier development specifications has clear advantages to those preparing the lower-tier specifications. It means that the allocation of requirements from the top-level specifications to lower-tier specifications is primarily on a paragraph to corresponding paragraph basis. It also simplifies the program management review of contractor-prepared specifications for subtier items, because requirement allocation verification and traceability of requirements between higher- or lower-tier specifications is more straightforward. The desired use of a common format does require an increase in detail of the specified format for the subsections of the system specification, particularly subsections of Section 4, Quality Assurance.

However, in addition to the other advantages, the increased detail in Section 4 allows for and encourages the identification of special tests and the identification of related test equipment as early as possible in the acquisition cycle. The early definition of these requirements permits better design and scheduling of the special test equipment and test facilities required by manufacturing and the field organizations than would otherwise be possible. The requirements in Section 4 of the specification also should provide the technical basis for the imposition of required quality levels and quality management systems in the Statement of Work (SOW) or contract.

2.2 SPACE SYSTEM SPECIFICATION PREPARATION STEPS

For the convenience of those preparing a space system specification, a copy of the model specification (Appendix A) and a copy of the entire guidebook are available on a diskette at the back of this report for use on word processing systems. Because revisions to the guidebook and to the model specification will be made from time to time, it is advisable to obtain the latest copy prior to any serious applications.

The recommended sequential steps in preparing a space system specification for a major new program are:

a. Obtain a diskette copy of the Model space system specification, Appendix A, for use on word processing systems, and print a copy on your word processing system to be sure of your starting point.

b. Obtain a copy of the available top-level program documents such as the SORD, the PBD if prepared, the PMD, the ADM, and the MNS.

c. Extract the applicable technical requirements for the system from the top-level program documents and add them, in applicable paragraphs as outlined in Section 3 of this guidebook, to the Model system specification to obtain a draft system specification for the system.

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* Means added to DI-CMAN-80008A

Figure 3. System Specification Format

d. Check each paragraph of the resulting draft system specification with the general requirements outlined in Section 3 of this guidebook in order to assure content and format compliance.

e. Verify all requirements in each paragraph of the draft system specification against program need in order to assure their applicability to the program.

f. Update the reference documents listed in Section 2 of the resulting draft system specification by including all added documents (and by deleting those no longer referenced). Verify and update to the latest revisions, notices, and dates of issue [see the DoD Intelligence Information System (DoDISS)].

g. Update the table of contents of the resulting draft system specification.

h. Print a coordination copy of the resulting draft system specification for formal review.

The number of people involved in preparing this coordination copy of the draft system specification for a major new program should be kept to a minimum. Above all, never ask 50 or so different experts to each prepare a paragraph for one of the 50 or so different subject or functional areas in the specification, expecting to staple the paragraphs together to obtain the draft specification. That process never can produce a consistent and technically valid specification. Always start with a good baseline (i.e., the Model specification). When the draft specification is ready, have the 50 or so different experts on the coordination list review it and prepare comments. Note that it is impossible to provide valid comment on a single paragraph extracted from the draft specification. Everyone involved with the coordination and review should have the entire specification, even if they are expected to review and comment on only a single paragraph. In fact, for a good specification review, each expert needs to have available, or be familiar with, the top-level program documents such as the SORD, the PBD, the PMD, the ADM, and the MNS.

2.3 SPECIFICATION PREPARATION STEPS FOR OTHER TYPES OF SYSTEMS

Although the emphasis and added details in the guidebook are primarily for Air Force space systems, it should be clear that the guidebook can be used easily to prepare a system specification for any type of system. The recommended sequential steps in preparing a system specification for a major new program that is not a space system are:

a. Obtain a diskette copy of the Model space system specification (Appendix A) for use on word processing systems, and print a copy on your word processing system to be sure of your starting point.

b. Obtain a copy of the available top-level program documents such as the SORD, the PBD if prepared, the PMD, the ADM, and the MNS.

c. Verify the general requirements in the draft system specification against the program need in order to assure their applicability to the program. Delete space vehicle requirements and add paragraphs for other applicable types of equipment, such as aircraft, missiles, balloons, tanks, or ships, to obtain a Model system specification for the system.

d. Extract the applicable technical requirements for the system from the top-level program documents and add them, in applicable paragraphs as outlined in Section 3 of this guidebook, to the Model system specification generated in "c" above in order to obtain a draft system specification for the system.

e. Check each paragraph of the resulting draft system specification with the general requirements outlined in Section 3 of this guidebook to assure content and format compliance.

f. Verify all requirements in each paragraph of the draft system specification against program need in order to assure their applicability to the program.

g. Update the reference documents listed in Section 2 of the resulting draft system specification by including all added documents (and by deleting those no longer referenced). Verify and update to the latest revisions, notices, and dates of issue (see the DoDISS).

h. Update the table of contents of the resulting draft system specification.

i. Print a coordination copy of the resulting draft system specification for formal review.

The number of people involved in preparing this coordination copy of the draft system specification for a major new program should be kept to a minimum. Above all, never ask 50 or so different experts to each prepare a paragraph for one of the 50 or so different subject or functional areas in the specification, expecting to staple the paragraphs together to obtain the draft specification. That process never can produce a consistent and technically valid specification. Always start with a good baseline (i.e., the Model specification). When the draft specification is ready, have the 50 or so different experts on the coordination list review it and prepare comments. Note that it is impossible to provide valid comment on a single paragraph extracted from the draft specification. Everyone involved with the coordination and review should have the entire specification, even if they are expected to review and comment on only a single paragraph. In fact, for a good review, each expert needs to have available, or be familiar with, the top-level program documents such as the SORD, the PBD, the PMD, the ADM, and the MNS.

2.4 PREPARATION STEPS FOR A SYSTEM SEGMENT SPECIFICATION

The requirements for a system segment specification in DI-CMAN-80008A and MIL-STD-490A are exactly the same as for a system specification. This means that although the guidebook is primarily for a system specification, it can be used also to review or to prepare any system segment specification. The levels of assembly identified in a system specification simply shift one level lower in a system segment specification.

To generate a guidebook for preparing a system segment specification from Section 3 of this report, the term "configuration item" always replaces "prime item." The term "prime item" always replaces "system segment." The term "system segment specification" always replaces "system specification." The term "system segment" replaces "system" in many places, but one must read the text to check whether the correct word is "system" or "system segment."

To generate a "Model" system segment specification from the Model space system specification (Appendix A) in this guidebook, always replace the term "configuration item" with "prime item." The term "prime item" always replaces "system segment." The term "system segment specifica-tion" always replaces "system specification." The term "system segment" replaces "system" in many places, but one must read the text to check whether the correct word is "system" or "system segment."

Except for space vehicle system segment specifications, a typical system segment specification does not include requirements for a space vehicle. The requirements shown in these system segment documents for a space vehicle then would be deleted; however, there might be added requirements for aircraft, missiles, balloons, tanks, or ships that would be addressed instead of the space vehicle requirements. In any case, that would result in some paragraph renumbering and some paragraphs would have different titles, but the changes would be at subtier levels that would not affect compliance with DI-CMAN-80008A and MIL-STD-490A. The resulting system segment specification requirements document and Model system segment specification then can be used as a guide to prepare system segment specifications or to review system segment specifications prepared by others.

The process is explained in more detail in the following recommended sequential steps in preparing the system segment specifications that are part of a specific system:

a. Obtain a diskette copy of the applicable system specification for use on word processing systems. If the applicable system specification is not available, a draft copy of the system specification can be developed as described above and used as the starting point for preparing the system segment specifications. Or the Model space system specification, Appendix A, can be used as the starting point for preparing a Model space system segment specification. In any case, print a copy to be sure of your starting point.

b. The levels of assembly for a system specification simply are shifted one level lower in a system segment specification. First, globally replace the term "prime item" in the system specification with "configuration item." Then, globally replace the term "system segment" in the system specification with "prime item." Then, globally replace the term "system specification" in the system specification with "system segment specification." The term "system segment" replaces "system" in many places, but one must read the text to check whether the correct word is still "system." This process creates a document in the format of a system segment specification that contains all of the requirements for all of the system segments. In other words, each of the requirements still needs to be allocated to the applicable system segments.

c. To create a draft specification for a specific system segment, create a new document that is a copy of the document that was created in "b" above (that is, in the format of a system segment specification and that contains all of the requirements for all of the system segments). Then, using the results of trade studies, system engineering processes, and common sense, simply delete all requirements in that document that are not applicable or allocated to that specific system segment.

   A new document will need to be created for each of the system segment specifications that are part of the system.

   The requirements in Subsection 3.7 in the system specification that were allocated to the various system segments then will need to be merged into the other requirements in the applicable system segment specifications.

d. Check each paragraph of the resulting draft system segment specifications with the general requirements outlined in Section 3 of this guidebook to assure content and format compliance.

e. Verify all requirements in each paragraph of the draft system segment specifications against program need to assure their applicability to the program.

f. Update the reference documents listed in Section 2 of the resulting draft system segment specifications by including all added documents (and by deleting those no longer referenced). Verify and update to the latest revisions, notices, and dates of issue (see the DoDISS).

g. Update the table of contents of the resulting draft system segment specifications.

h. Print a coordination copy of the resulting draft system segment specifications for formal review.

The number of people involved in preparing the coordination copies of the draft system segment specifications should be kept to a minimum. Above all, never ask 50 or so different experts to each prepare a paragraph for one of the 50 or so different subject or functional areas in the specification, expecting to staple the paragraphs together to obtain the draft specification. That process never can produce a consistent and technically valid specification. Always start with a good draft baseline generated by a few individuals. When the draft specification is ready, have the 50 or so different experts on the coordination list review it and prepare comments. Note that it is impossible to provide valid comment on single paragraphs extracted from the draft specification. Everyone involved with the coordination and review should have the entire specification, even if they are expected to review and comment on only a single paragraph. In fact, for a good review, each expert needs to have available or be familiar with all of the system segment specifications, the system specification, and perhaps the top-level program documents such as the PBD, the PMD, the ADM, and the MNS.

3. SPACE SYSTEM SPECIFICATION REQUIREMENTS

This section discusses the addition of the program-peculiar requirements to the model specification boilerplate in order to prepare a space system specification for a specific program. The steps are straightforward. Simply start with a copy of the *Model Space System Specification* (Appendix A), and then check each item with the program requirements and with the following subsection entries. Unless otherwise indicated, the paragraph numbers referenced in the following subsections refer to those of Appendix A. At each step, the program-peculiar requirements also need to be added to or merged with the boilerplate requirements in the Model specification. The contents, organization, and boilerplate material shown in Appendix A should be changed whenever alteration of the specification content is required to meet the needs of a particular system. Nevertheless, it is recommended practice to comply with the boilerplate, and the other suggestions contained herein, unless there are good reasons for changes.

For the convenience of those who might worry about exact compliance with MIL-STD-490A and Data Item Description DI-CMAN-80008A, notes are included with the text of the following subsections to indicate any inconsistencies in DI-CMAN-80008A or MIL-STD-490A and how they are resolved. In addition, notes are included with the text of the following subsections to indicate where additions to the format have been made to accommodate what would otherwise be missing space system requirements. In accordance with accepted convention, adding paragraphs and requirements to the format is entirely acceptable, as long as the paragraph titles and numbers specified in DI-CMAN-80008A are not changed. In other words, the detailed format requirements included in this guide are in exact compliance with DI-CMAN-80008A and the general requirements of MIL-STD-490A. This means that there is no need for the specification preparer to be confused by reading DI-CMAN-80008A or MIL-STD-490A.

The specification preparer should add the program-peculiar requirements to the model specification boilerplate (Appendix A), and comply with the instructions provided in this guidebook.

3.1 TITLE PAGE

The title page of the system specification shall contain the applicable information as indicated by the title page of the Model specification (see Appendix A). Note that although there may be approval and authentication signatures on the document, the version referenced in the contract is what guides the contractor.

3.2 TABLE OF CONTENTS

The system specification shall contain a table of contents as indiated in Appendix A. Because the format and paragraphing should be the same for all space system specifications, the major changes in a table of contents for a particular system specification would be in the page numbers and in identifying any added subparagraphs. For system specifications that are printed on only one side of the paper, the table of contents would start on page ii (the title page is page i, but is always unmarked). For system specifications that are printed on both sides of the paper, the back of the title page would be page ii and the table of contents would start on page iii. If the table of contents ends on an odd-numbered page, a blank page would be added so that Section 1 would start on a right-hand page (i.e., an odd-numbered page).

3.3 SECTION 1, SCOPE

As shown in Appendix A, the first section, SCOPE, starts on Page 1 of the specification.

> Note that SECTION 1, SCOPE does not contain design, construction, or quality assurance requirements, only brief statements that expand on the specification title to provide identification and very general descriptive information pertinent to the overall system. Words such as "*shall*" or "*will*" should not be used in this section.

3.3.1 Subsection 1.1, IDENTIFICATION

The material to be included in this subsection should be brief and should use wording similar to that in Appendix A. The approved identification number and title of the system should be stated. If an abbreviation or acronym for the system is used, it should also be stated.

3.3.2 Subsection 1.2, SYSTEM OVERVIEW

The material to be included in this subsection should consist of a clear, concise abstract in one paragraph of the system mission or purpose. It should include a description of how the system functions and interfaces with other external systems.

3.3.3 Subsection 1.3, DOCUMENT OVERVIEW

The material to be included in this subsection should be a concise statement of the content and intended application of the specification.

3.3.4 Subsection 1.4, SYSTEM CLASSIFICATIONS

In many large systems, the requirements for the final system can be considerably different than the requirements for its initial configuration. In those cases, it is important to have a means to label and to differentiate between requirements applicable to the configuration for the initial operational capability and those applicable to succeeding baseline configurations. The names of the various baseline configurations or classifications of systems should be established in this paragraph. A brief description of the mission or functional differences of each may also be included; however, if the descriptions of the mission, function, usage, or purpose of each baseline configuration are extensive, they should be stated in appropriate paragraphs in Section 6. Of course, the quantitative requirements associated with each baseline configuration would be stated in appropriate paragraphs in Sections 3, 4, and 5 of the Model specification, not in this subsection. However, a statement generally is added that all requirements stated for a particular baseline configuration (starting with the initial operational capability baseline) also would be applicable to succeeding baseline configurations, unless stated otherwise.

> Note that Subsection 1.4, "Classification," should be deleted if only one system baseline configuration or system classification category is covered by the specification. Although DI-CMAN-80008A does not require a Subsection 1.4, "Classification," the general requirements of MIL-STD-490A do require it, so it has been included in this guidebook. One alternative to this paragraph is to write the system specification for the initial operational capability only, and at some later time write another system specification for each succeeding baseline configuration. In general, a smooth transition is always required from the initial operational capability baseline configuration to each succeeding baseline configuration. For that reason, the requirements for the different baseline configurations of the space system are best covered in the same specification by assigning different classification names that can be referenced. The Model specification presents a typical set of space system classifications that could be followed to avoid any confusion or problems.

3.4 SECTION 2. APPLICABLE DOCUMENTS

As shown in Appendix A, government documents are listed in Subsection 2.1 in numerical order under each of the subheadings shown. Nongovernment documents are listed in Subsection 2.2. Nongovernment documents are those issued by no government organization and include documents issued by technical associations, technical societies, commercial organizations, and contractors.

The words, subheadings, and format should be followed with the understanding that subheadings will be omitted if they do not contain applicable documents. A parenthetical source statement should follow each group of related publications indicating the address of the source of the document so that copies may be obtained directly from the source.

All and only those documents identified and referred to in Sections 3, 4, and 5 of the specification, or in mandatory compliance appendices, are listed in Section 2 of the specification. However, if detailed drawings are referenced, it is necessary to list only the applicable assembly drawing in Section 2, as long as the assembly drawing itself lists the detailed drawings.

Note that a specific issue, revision letter, and the date of issue are given for each of the referenced documents. The revision letters, amendments, notices, and effective dates shown for the documents listed in the Appendix may not be current; so they would require updating to the date of issue for each particular specification. Note also that amendments to military specifications supersede earlier amendments, so only the most recent amendment would be listed. Notices, however, are accumulative; only those notices to be made applicable would be listed. For example, if all three notices were applicable, they would be listed as Notices "1" through "3" with the date being that for Notice "3." Note too that the preferred method of stating the date of issue for each document is day, month, and year. The day would be given in two digits, the month in three capital letters, and the year in two digits. If a different date format is used, it should be used consistently for all of the documents listed. As the acquisition process moves forward, many of the specific documents referenced may be amended, revised, or superseded. Just because a referenced document may have been updated does not mean that the revision should be referenced. The actual updating of the date of issue for each of the references in the specification, however, must be considered and controlled by the program office in the same manner as any other change in the specification.

It must be understood that the whole of a referenced document is not made applicable by its inclusion in Section 2. The extent of applicability is only that which is clearly defined, and specifically indicated, at the place it is referenced. The documents listed in Section 2 of Appendix A are those that are referenced already in the boilerplate requirements. As other requirements are added during the preparation of a particular system specification, other documents may be referenced; they would also be added in Section 2.

Government regulatory documents, such as directives, regulations, manuals, pamphlets, and policies, usually are not cited for compliance in a specification. These documents generally are intended for internal use by government organizations only and are not intended for contractor use. Also, contractor internal specifications or documents generally are not cited in a system specification. Contractor documents typically are for internal contractor use only and usually are not so general as to be directly applicable or transferable to a different contractor. For a system, usually several different contractors are involved, so documents from one contractor could be misinterpreted by the other contractors. Also, contractor documents are not readily available to reviewing organizations or to the other contractors that may be involved.

Military standards or other DoD standardization documents that address or include nonproduct or management requirements never should be referenced in a specification. DoD Directive 5000.19L, Vol. II, *Acquisition Management Systems and Data Requirement Control List*, provides a complete list of the nonproduct DoD standardization documents that should not be referenced in a specification.

> Note that there are very minor differences in the introductory words in SECTION 2, APPLICABLE DOCUMENTS, between this guidebook and DI-CMAN-80008A (Appendix I of MIL-STD-490A). This guidebook addresses all order of precedence issues in Subsection 3.8 rather than some in Section 2 and some in Subsection 3.8.

3.5 SECTION 3, SYSTEM REQUIREMENTS

As shown in Appendix A, the system requirements are stated in subsections of Section 3. The requirements should be stated in terms of the performance, reliability, design constraints, functional interfaces, and so forth that are necessary to assure a practical and reasonable development effort. The requirements should clearly describe the space system and should include any unique space requirements such as those for manufacturing process control of critical items. Note that the major elements of the space system may include ground equipment as well as space equipment. Requirements that are applicable only to some of the elements should not be stated in ways that would make those requirements applicable to the entire system. Functional statements of the requirements should predominate in system specifications with fabrication details specified only to assure matching interfaces with existing elements. As the acquisition progresses, the TBSs and TBDs would be determined; those requirements would be incorporated in the specification and, if appropriate, in lower-tier specifications. The major effort in the initial phases of a program is in the allocation of the requirements to lower levels of assembly and the preparation of specifications for the system segments and, if applicable, for lower-tier prime configuration items or critical configuration items.

Referencing military, federal, and DoD-adopted industry specifications and standards is the approved method for establishing requirements that are adequately set forth in the referenced documents. Before referencing any document, be sure to read the specific issue of the referenced document to assure the applicability of the requirements. Tailoring of the references should be accomplished to limit the extent of applicability of the requirements such as illustrated in the following examples:

a. *The design of electronic components shall be in accordance with DOD-E-8983* would incorporate only the design requirements of DOD-E-8983 for all electronic components covered by the specification (both ground and space). The quality assurance provisions would not be made applicable by such a reference.

b. *The design of the receiver X shall be in accordance with DOD-E-8983* would incorporate only the design requirements of DOD-E-8983 for receiver X, but not for any other possible receivers or applications in the system being specified.

c. *Electronic components for space vehicle applications shall be in accordance with DOD-E-8983* makes all requirements (design and quality assurance) in DOD-E-8983 applicable to the electronic components to be used in space vehicles covered by the specification. Requirements in DOD-E-8983 would not be made applicable to ground components or to aircraft components by such a reference.

As a general rule, program-peculiar specifications external to the system being specified should not be referenced except to identify an interface. Instead, the applicable requirements should be extracted and incorporated in their entirety. This is particularly true of requirements stated in specifications that are viewed as higher-tier specifications or stated in specifications prepared by different government agencies. Sometimes a reference is made to a higher-tier specification in the belief that such a reference will ensure that the specified item will be required to comply with all of the applicable requirements in the higher-tier specification. That is not the case, because the requirements in the higher-tier specification are allocated among its subtier specifications. The applicable allocation must be stated in each of the subtier specifications to be clear. In other words, a reference to requirements in a higher-tier specification usually is not clear, because the proper allocation of the higher-tier requirements is unknown by contractors working at a lower tier and could be interpreted differently by each contractor or individual involved. In the case of a reference to requirements in a specification prepared by a different government agency, experience shows that the actual hardware and the requirements stated in the referenced specification may differ, and this may place an unfair burden on contractors that are directed to comply with both. The practice of extracting requirements and incorporating them in the applicable specifications rather than referencing them also avoids the possibility of two documents each referencing the other, and each document stating that it takes precedence over the other document. These problems need to be solved, but words in the specification may not be enough. The words in a specification cannot achieve a resolution of unknown problems that require SPO action to resolve, nor can they initiate integrating contractor verification tasks to have the contractor solve the problems, since a task can be initiated only by the contract SOW (not by the specification).

All requirements in the specification should be stated as product-oriented technical requirements for the system being specified. Product-oriented requirements are of a form such as *The item shall...*, or *The test shall....* This is in contrast to nonproduct or management requirements that are of a form such as *The contractor shall...*, or *The delivered data shall ....* For example, management requirements for configuration control, work breakdown structure, safety program, quality assurance, reliability, design reviews, audits, parts control, cost reporting, and scheduling would be included in the SOW or other contract provisions, if applicable, but they never would be included as requirements in the specifications. Military standards or other DoD standardization documents that address or include nonproduct or management requirements therefore would never be referenced in the specification. In fact, DoD Directive 5000.19L, Vol II, *Acquisition Management Systems and Data Requirements Control List*, provides a complete list of the nonproduct DoD standardization documents that should not be referenced in a specification. The list includes MIL-STD-490A, MIL-STD-483A, DOD-STD-2167A, and thousands of others. Applicable product-oriented requirements that happen to be included in nonproduct DoD standardization documents usually would be extracted and incorporated directly in the specification, rather than being incorporated by reference. Of course, there may be exceptions, but they should be minimized.

3.5.1 Subsection 3.1, DEFINITION

The intent of the material included in this subsection and subtier paragraphs is to clearly define the system that is being specified. As with any definition, the intent is not to state detailed "shall" requirements but simply to describe the system and to identify its major physical elements, its functional areas, and its functional and physical interfaces. Depending upon the amount of system engineering that may have been completed and the complexity of the system being specified, the definition subparagraphs may include block diagrams; functional diagrams; logic diagrams; schematic diagrams; specification trees; pertinent organizational, operational, and logistic concepts; identification of major system segments; and any other pertinent descriptive material.

These definition paragraphs are particularly important in a space system specification. In the initial draft of the specification, Subsection 3.1, System Definition, may have most of the text, because defining the system being specified is always the first step in preparing a space system specification. As the trade studies, analyses, and system development progress, additional requirements can be stated. Eventually, the subtier elements of the system can be identified to provide the framework of standard terminology to be used. By that means, all participants can recognize common items, procedures, schedules, costs, interfaces, or other common elements of the system and of the program. Although the primary focus in these paragraphs is on the description of the space system, including the identification of subtier elements of the system, the system interfaces with the rest of the world also may be identified. How-ever, details of these external interfaces should be included in Paragraph 3.2.3 of the specification, not in the definition.

By including the definition in the requirements section, contractors and others using the specification can recognize the intent to assure compliance with the space system description given. Although requirements may include definitions, note that definitions are not an appropriate place to include detailed performance, design, construction, or test requirements. This subsection and its subparagraphs are definitions that are intended to be descriptions of the system to be fulfilled by the detailed design, as opposed to stating "shall" requirements or specifying a precise set of verifiable performance requirements. All the detailed requirements are stated in subsequent subsections of the specification.

As shown in Appendix A, Subsection 3.1, Definition, may be only a heading (title) with text in subtier paragraphs. If text is included with the header, it should be very brief, and most of the required text should be within the subtier paragraphs. The subtier paragraphs include lists that define the terminology used in subsequent subsections of the specification. These lists are for the convenience of those using the specification and are incorporated into the specification to the extent the information is available. For example, the subtier elements of the system, such as the system segments or prime configuration items, may not be identified until after the initial trade studies have been completed. Of course, the lists shown in Appendix A are typical and should be changed to conform to the particular system being specified.

> Note that Subsection 3.1 in DI-CMAN-80008A does not require any lists or subtier paragraphs. On the other hand, this guidebook has added a required set of subtier paragraphs. They provide an organizational framework and check lists of the definition material for the convenience of those using the specification.

Paragraph 3.1.1, System Description, is included to provide a brief statement of the purpose or major functions of the system and to identify other systems with which it interfaces.

Paragraph 3.1.2, System Segments, is included to identify the system segments of the system. This is a list of the system segments that may be known at the time the space system specification is prepared.

Paragraph 3.1.3, Specification Tree, should incorporate the system specification tree when the system segments of the system and at least some of the subtier prime configuration items or other subtier elements of the system segments have been identified. A specification tree is a configuration item (CI) oriented diagram or chart that shows the allocated CIs that make up the item being specified. The specifications which identify each subitem would be shown on the tree. Other specifications that serve to identify external interfaces, including the government-contractor interfaces, also may be shown. The applicable portions of the specification tree for the entire program should be included, if they are available, to assist in the identification of the system and interfaces. In any case, the space system specification tree would be incorporated to identify the system segments and any subtier CIs that may be known at the time the specification is prepared. When the specification trees are depicted in a separate document or on a drawing whose size prevents incorporation into the specification, they would be referenced by document or drawing number.

Paragraph 3.1.4, Top-Level System Functions, usually is only a heading (title) with text in subparagraphs.

A system function is a statement of a capability that the system must possess. The ultimate system function expressed in the Mission Need Statement commonly is decomposed into subtier functions illustrated on a master flow diagram in a functional analysis. The system must be capable of performing or satisfying all of the system functions identified for it in one or more prescribed sequence(s) in order to satisfy the system function expressed in the Mission Need Statement. A functional flow diagram defines functions that must be satisfied and the required sequences for doing so.

For each block on the master flow diagram, one or more functional requirements statement(s) are written that are then allocated (assigned) to the lower-tier elements. This iterative process of decomposing the Mission Need Statement into lower-tier functions and allocating them to system elements is called functional analysis. It is a method for decomposing the system need into lower-tier elements that subsequently will be designed, fabricated, tested to prescribed requirements, and produced to satisfy the stated need. The two products of this process are the architecture elements of the system to which the functional requirements have been allocated and the precursors of some of the performance requirements for those elements.

Paragraph 3.1.4.1, Top-Level System Functional Relationships, should incorporate the top-level master flow diagram (functional flow diagram). If a top-level functional flow diagram for the program is developed, it should also be incorporated into this paragraph. The program-level diagram provides the framework for describing the system being specified and can be used to identify interfaces with other systems. It is the basis for an expansion of the applicable program-level functions to the various systems associated with the program.

When available, layout drawings or other graphic portrayals which establish the general relationship of functional areas and the major elements of the system may be included.

Paragraph 3.1.4.2, Description of System Functions, provides an expanded description of the system from that given in Paragraph 3.1.1. A separate subparagraph should be used to address each of the top-level system functions identifying in Paragraph 3.1.4.1. Each subparagraph would contains a description of the top-level functions and their relationships to each of the operational states and modes identified in Paragraph 3.1.5.

Paragraph 3.1.4.3, Missions, is included to provide a description of the operational missions that could affect the system design.

Paragraph 3.1.4.4, Threat, is included to identify potential threats to the system that should be considered in the design so that the system performance would not be jeopardized if the threat conditions materialized. For space elements, the threat might include nuclear attack, pellet attack, laser attack, electronic jamming, all of the above, or any combination. For ground elements, potential threats might include sabotage, electronic jamming, conventional weapons attack, nuclear attack, and so forth. The correct entry for a specific system would be provided by the SSD Directorate of Intelligence. Just as for any other definition, the threat description may be prepared as a separate document and referenced in this paragraph. Also, as for other requirements, the quantitative threat environments should be stated or referenced in other applicable paragraphs of the specification, such as Paragraphs 3.2.2 or 3.2.6, but not in the definition.

> Note that DI-CMAN-80008A says that the mission and the threat should be addressed in Section 6, Notes, which is not a compliant section of the specification. Believing that the system should be designed to meet the mission and to operate in (or survive) the threat requirements, this guidebook requires both the mission and the threat to be stated here, i.e., in Section 3, Requirements.

Paragraph 3.1.5, System States and Modes, identifies each of the operational states and modes. Once the system architecture elements derived through functional analysis are known, they may be thought of as existing in and transitioning between various states while accomplishing the system functions, where a state is a condition of a system or system element. System states may be identified and organized into state transition diagrams, where circles represent the states and arrowheaded lines connecting the circles represent possible transitions between states. The analyst refines performance requirements derived from the functional analysis activity and allocated to the elements covered by the state diagram into more precise, quantified performance requirements statements. Paragraph 3.1.5 provides a single place where these state definitions may be captured. States may include prelaunch, launch, operational, maintenance, recovery, and others that could be appropriate to a particular system. Within each state, the system may have various substates or modes, such as: (a) surveillance, (b) threat evaluation, (c) target designation and acquisition, (d) weapon deployment, and (e) data reduction. Modes may include various configurations, power levels, or other differences that may occur during one of the states that require special design attention. It is recognized that the operational states and modes can be identified and incorporated into the specification only when the information becomes available; however, many performance parameters are associated with particular states and modes, so it is helpful to list them all in one place.

Paragraph 3.1.6, Operational and Organizational Concepts, usually is included in a system specification to provide operational information that could help define the system and that could affect the design. This may include:

a. The basic performance parameters upon which the using activities can base tactics which utilize the capabilities of the system and which should be recognized in the design.

b. Description of the mission in terms of relationships to other items of the system or to other systems.

c. Anticipated deployment of the system equipment, both geographically and organizationally, such as the number of operational vehicles, number of ground support installations, and their operating locations.

Note that the model specification provides general words for a space system in which the space vehicle is launched using either the STS or is launched using an expendable launch vehicle. The requirements should, of course, be changed to reflect the actual operational concept. In addition, any organizational concepts that could affect the design should be included in added paragraphs.

3.5.2 Subsection 3.2, CHARACTERISTICS

This subsection generally is only a heading (title) with text in subtier paragraphs. The requirements and constraints stated are those that may be applicable to the system as a whole or to more than one system segment. The requirements stated in this subsection and in the subsequent subsections of Section 3 are those that were alluded to in the definition and descriptions stated in the paragraphs of 3.1. In other words, requirements were identified in Paragraph 3.1 only to help define the system, but the actual detailed requirements for the system including interface details are stated in this and subsequent subsections. This characteristics subsection therefore is intended to state clearly and in quantitative terms the pertinent performance requirements and physical characteristics of the system. Requirements that are known to be applicable only to a single system segment or to a single prime CI, such as the space vehicle, should be stated in the appropriate paragraph in Subsection 3.7 and not in this subsection.

Paragraph 3.2.1, Performance Characteristics, generally is only a heading (title) with text in subparagraphs. The content of this paragraph or of the subparagraphs should included a description of the static and dynamic performance requirements for the system, to the extent possible at the time the system specification is prepared. This paragraph or the subparagraphs should state the general and detailed system performance requirements, i.e., what is expected of the system, including both the range of values and tolerances for each mode of each system state. This paragraph or subparagraphs shall specify the performance requirements of the system and provide sufficient guidance to form the basis for technical features and development. As a general guide, include such considerations as:

a. Dynamic actions or changes that occur (e.g., rates, velocities, movements, and noise levels).

b. Quantitative criteria covering endurance capabilities of the equipment required to meet the user needs under stipulated environmental and other conditions, including minimum total life expectancy. Indicate required mission duration and planned utilization rate.

c. Performance requirements for the operational modes and states.

d. Security criteria.

The combined performance of the entire system, or at least that of two or more of the system segments, is addressed in this paragraph and the subparagraphs. The performance of a single system segment or of an individual CI would be addressed in Subsection 3.7 of the system specification (see Appendix A, 3.7). The specification generally includes the subparagraphs shown. Other subparagraphs for other performance characteristics may be added in this subsection, depending upon the system.

> Note that there is a conflict in DI-CMAN-80008A between the required content of Subsection 3.7 and the required level of detail including performance requirements for subtier elements in this Paragraph 3.2.1 (and subparagraphs). Instructions in DI-CMAN-80008A for Subsection 3.7, and the general requirements of MIL-STD-490A, say to include all requirements identified with individual subtier elements in Subsection 3.7. This guidebook resolves this conflict by following the general Paragraph 3.2.1 structure required by DI-CMAN-80008A but suggests that all subtier requirements be put in Subsection 3.7 instead of in subparagraphs of 3.2.1. There also is another question as to the interpretation of DI-CMAN-80008A for this Paragraph 3.2.1 and its subparagraphs. The instructions in DI-CMAN-80008A say to include, in quantitative detail, the performance requirements for *each capability* of the system, in each mode, of each state. *Each capability* is not defined; however, they are required to be identified by name and a project-unique identifier. *Each capability* might be each top-level function or it might mean each prime item. In either case, this seems to be a subtier level of detail that

generally is not available at the time the system specification is prepared. Putting whatever subtier performance requirements that are available in Subsection 3.7 instead of in subparagraphs of 3.2.1 is a good compromise for resolving these problems with DI-CMAN-80008A, and it is the course implemented.

Paragraph 3.2.1.1, Performance Requirements for Each System State, generally is only a heading (title) with text in subparagraphs.

Subparagraph 3.2.1.1.x (beginning with 3.2.1.1.1), Performance Requirements for Each System State, is included to establish a set of subparagraphs for performance requirements for each state of the system identified or defined (see Paragraph 3.1.5). A separate subparagraph should be used for each state of the system. In each subparagraph, the static and dynamic performance requirements for each capability of the system, in each mode, for that state of the system may be stated to the extent possible at the time the system specification is prepared.

Paragraph 3.2.1.2, Endurance, states the quantitative criteria covering endurance capabilities of the system required to meet user needs under stipulated environmental and other conditions, including minimum total life expectancy. The required mission duration and planned utilization rate in the various modes should be indicated. The endurance requirements in Appendix A are typical and should be changed to the times and requirements of the specific system.

Paragraph 3.2.1.3, Other, is shown to highlight the fact that other performance areas can be addressed. Any essential aspects of system performance which cannot be located more appropriately under another heading in this outline shall be stated here.

Paragraph 3.2.2, System Capability Relationships, generally is only a heading (title) with text in subparagraphs.

Paragraph 3.2.2.1, Reference Timelines, is where typical or baseline functional and performance timelines would be stated so that the same timelines could be used in designing the various items within the system.

Paragraph 3.2.2.2, Description, is where the system timelines would be described in words, or other aspects of the interrelationships of the system capability would be described.

Paragraph 3.2.3, External Interface Requirements, may be only a heading (title) with text in separate subparagraphs for each external system with which the system interfaces.

Paragraph 3.2.3.x (beginning with 3.2.3.1), Description of External Interface with System x, is where the external interfaces of the on-orbit space system with elements of System x are identified and detailed quantitative interface requirements are stated. The text of each paragraph or subparagraph should be organized to describe in quantitative terms the interfaces, including the purpose of each interface and its relationship with each of the modes in each of the states of the system. Quantitative hardware-to-hardware interface requirements may include items such as interface dimensions, tolerances, input/output voltages, loads, speeds, or communications protocol. Quantitative hardware-to-software interface requirements may include items such as interface bits per second, word length, message formats, serial versus parallel, priority rules, or protocols. Quantitative software-to-software interface requirements may include items such as interface data format, communication protocols, or frequency of transfer.

These external interface descriptions may involve references to other system specifications or to documents prepared by other agencies. It is important to recognize the *uncontrolled* nature of these external interface references. For example, a DoD space system specification may describe an interface by referencing an STS specification issued by NASA. That reference, however, does not assure that the actual interface will be as stated or that it will not be changed by NASA at some later time.

In the early phases of a system acquisition, the referencing of higher-level specifications or external documents is the only reasonable course to follow in describing the interfaces. As the acquisition progresses, an effort should be made to eliminate these external *uncontrolled* references. This can be accomplished by the preparation and joint approval of interface control documents. The interface control documents then could be referenced in the specification, or they could be the basis for the direct incorporation of the definitized interface requirements. Eventually, detailed CI specifications would be prepared for the actual procurement of the various system elements. These CI specifications should be *standalone* documents and should not reference higher-level specifications or externally controlled documents. This practice of extracting the interface requirements and incorporating them in the applicable specifications rather than referencing them avoids the possibility of two documents each referencing the other and each document stating that it takes precedence over the other document. Of course, extracting the interface data is a necessary step in any case before production drawings can be made or computer software produced. Extracting the interface requirements and incorporating them in the applicable specifications makes them readily available.

Paragraph 3.2.4, Physical Characteristics, generally is only a heading (title) with text in separate subparagraphs. Physical characteristics include:

a. Weight limits, center-of-gravity constraints, and moments of inertia constraints for elements of the system.

b. Dimensional and volume limitations, crew space, operator station layout, ingress, egress, and access for maintenance.

c. Requirements for tiedowns, pallets, packaging, and containers for transport and storage.

d. Durability factors to indicate degree of ruggedness.

e. Vulnerability factors, including consideration of atomic, chemical, biological and radiological operations, electromagnetic radiation, fire, and impact.

f. Health and safety criteria, including consideration of adverse explosive, mechanical, and biological effects. Included in these criteria are the toxicological effects of the item or component thereof on the user and the adverse effects of any electromagnetic radiation that might emanate therefrom. In systems with nuclear warheads, general requirements for peacetime operations, troop safety in handling and firing, and any other nuclear considerations shall be included.

g. Security criteria.

The physical characteristic requirements that are applicable only to a single system segment or to an individual CI usually would be addressed in the appropriate paragraphs in Subsection 3.7 and not in this paragraph. To assure completeness, and to avoid any possible oversight, reference to the applicable paragraphs in Subsection 3.7 should be included in this paragraph. Subparagraphs, in addition to those shown in Appendix A, may be added, depending upon the system requirements.

> Note that many paragraphs under Subsection 3.2 and other subsections in DI-CMAN-80008A address subject areas in which various types of equipment would be expected to have quite different general requirements. For example, space vehicle equipment, fixed ground equipment, mobile ground equipment, shipboard equipment, aircraft equipment, and other major types of equipment typically have quite different requirements in many of the areas addressed in the specification, and the requirements for each need to be stated clearly. In those cases in which the system includes various types of equipment with requirements that are known to be different, subparagraphs should be added to separate clearly the requirements applicable to each type of equipment. For the convenience of those using Appendix A, a required set of subtier paragraphs are included to separate general boilerplate requirements applicable to space vehicle equipment from those applicable to ground equipment. On the other hand, the boilerplate material shown in Appendix A, should be changed if changes are needed to specify the needs of a particular space system.

Paragraph 3.2.4.1, Protective Coatings, states the applicable protective coating requirements to assure protection from corrosion, abrasion, or other deleterious action.

Paragraph 3.2.4.2, Mass and Size Properties, generally is only a heading (title) with text in separate subparagraphs that follow. The subparagraphs state requirements for limiting and controlling the mass and size properties of the system elements. This includes the identification of the coordinate systems used in the system and any envelope constraints imposed on the system. Usually, general mass and size property requirements are stated in subparagraphs for space elements such as the space vehicle, the space vehicle support equipment for use in the STS Orbiter, and for the payload. In other subparagraphs, general mass and size property requirements for fixed and mobile ground equipment usually are stated to avoid excessive floor loading, to avoid excessive road loading, or to allow transportability.

Paragraph 3.2.4.3, Power, generally is only a heading (title) with text in separate subparagraphs that follow. The subparagraphs state the requirements both for external electrical power to be supplied to the various elements of the system and for power to be generated by the various elements of the system and supplied to other items. Care should be taken to distinguish between power supplied to, and power being supplied from, each of the system items during each of the operating modes in each system state.

Paragraph 3.2.4.4, Survivability, is where requirements would be stated for consideration of atomic, chemical, biological, radiological, fire, and impact vulnerability and survivability.

Paragraph 3.2.4.5, Other, is shown to highlight the fact that other physical characteristics can be addressed.

Paragraph 3.2.5, System Quality Factors, generally is only a heading (title) with text in separate subparagraphs that follow.

Note that Quality Assurance Provisions are stated in Section 4 of the specification, not in this paragraph.

Paragraph 3.2.5.1, Reliability, and the associated subparagraphs, state requirements for the reliability of the system to perform within specified limits for the service life of the system. Other subparagraphs may be added to cover areas other than mean time between failures (MTBF) and redundancy.

Paragraph 3.2.5.1.1, Mean Time Between Failures, is where MTBF requirements are stated for the system. The boilerplate in the model specification is typical but should be changed to reflect actual program requirements.

Paragraph 3.2.5.1.2, Redundancy, is a typical general statement of redundancy requirements for all elements of a space system. Specific requirements may be added, or changes to the boilerplate may be made, based upon the system requirements.

Paragraph 3.2.5.1.3, Space Vehicle Reliability, is a general statement of reliability requirements for space vehicles.

Paragraph 3.2.5.1.4, Failure Tolerance of Payloads Using the STS, is a general statement of requirements for payloads using the STS.

Paragraph 3.2.5.1.4.1, Critical Hazards, is a definition and general statement of requirements for critical hazards.

Paragraph 3.2.5.1.4.2, Catastrophic Hazards, is a definition and general statement of requirements for catastrophic hazards.

Paragraph 3.2.5.1.5, Ground Equipment Reliability, is a general statement of reliability requirements for ground equipment.

Paragraph 3.2.5.2, Maintainability, generally is only a heading (title) with text in separate subparagraphs that follow. The subparagraphs should specify the quantitative maintainability requirements in the planned maintenance and support environments. The requirements may include such items as:

a. Mean and maximum down time, reaction time, turnaround time, mean and maximum times to repair, and mean time between maintenance actions.

b. Maximum effort required to locate and fix an error.

c. Maintenance man-hours per flying hour, maintenance man-hours per specific maintenance action, operational ready rate, maintenance hours per operating hour, frequency of preventative maintenance.

d. Number of people and skill levels, variety of support equipment.

e. Maintenance costs per operating hour, man-hours per overhaul.

Note that contractor maintenance generally is applicable to space systems and that the same maintainability requirements usually are not applicable to all elements of the system.

Paragraph 3.2.5.2.1, Maintainability of Space Vehicle Equipment, specifies the quantitative maintainability requirements of the space vehicle equipment. Unless maintenance or servicing in space is specifically stated as a program requirement, space vehicles and experiments usually are designed so as to not require any scheduled maintenance, repair, or servicing during their service life.

Paragraph 3.2.5.2.2, Maintainability of Ground Equipment, specifies the quantitative maintainability requirements of the ground equipment.

Paragraph 3.2.5.3, Availability, may include availability requirements for on-orbit operations, for launch readiness, and for recovery. Availability is the degree to which the system shall be in an operable and committable state at the start of a mission in which the mission is called for at an unknown or random point in time. When the STS is used, limitations are imposed, particularly during the prelaunch and launch sequence, on access or availability of the system space equipment for test or maintenance activities. When applicable, these limitations should be stated in this paragraph because of their possible impact on the space equipment design and on the design and location requirem nts for ground support equipment.

Paragraph 3.2.5.4, Additional Quality Factors, shall specify system quality requirements not defined in the above subparagraphs (e.g., durability, integrity, efficiency, or correctness requirements of the system).

Paragraph 3.2.6, Environmental Conditions, generally is only a heading (title) with text in separate subparagraphs that follow. The subparagraphs that follow provide for statements of the various environmental levels for the system during the various operating phases. If environmental levels are specified, they should be the design levels that include the desired margins and the allowable measuring error. Where various levels are possible during a system state or mode, the environmental levels or ranges specified may be a composite that covers the maximum and minimum values. If the use of composite values is not appropriate, a further subdivision should be used to make the necessary distinction in design levels for the various states, modes, configurations, or categories. If the environmental conditions applicable to each of the various system segments are different from each other, the environmental conditions could be addressed in the appropriate paragraphs in Subsection 3.7 and not in this paragraph. To assure completeness, and to avoid any possible oversight, references to the applicable paragraphs of Subsection 3.7 should be included in that case. The environments should include:

a. Natural environment (e.g., wind, rain, temperature, geographic location).

b. Induced environment (e.g., motion, shock, noise, electromagnetic radiation).

c. Environments due to enemy action (e.g., overpressure, explosions, radiation).

Note that Paragraph 3.2.6 in DI-CMAN-80008A does not establish an organization for subparagraphing. In those cases in which the system includes various types of equipment with environmental requirements that are known to be different, subparagraphs should be added to separate clearly the requirements applicable to each type of equipment. For the convenience of those using Appendix A, a required set of subtier paragraphs is included to clearly separate general boilerplate requirements applicable to space vehicle equipment from those applicable to ground equipment. On the other hand, the boilerplate material shown in Appendix A should be changed if changes are needed to specify the needs of a particular space system.

Paragraph 3.2.6.1 Environmental Design Margins, is intended to present the environmental design margins for all system items.

Paragraph 3.2.6.2 Environmental Conditions for Space Equipment, is intended to present the design environmental requirements for all space equipment.

Paragraph 3.2.6.2.1, Launch Environments, is intended to present the design environmental requirements for all system items that undergo launch. This would be specified as the STS payload environment for STS launches, the launch environment inside the nose fairing for an expendable booster if that is appropriate, or it could be a composite of both launch modes if that is appropriate.

Paragraph 3.2.6.2.2, On-orbit Environments, states the design environmental requirements for orbiting elements of the space system. This could include separation from the STS, injection, various on-orbit modes, and recapture by the STS as may be appropriate for the particular program.

Paragraph 3.2.6.2.3, Ground Environments for Space Equipment, specifies the ground environment requirements prior to launch and possibly after return from orbit. If any of the handling, transportation, or other ground environments for any of the orbiting elements exceed the design values specified for launch or on orbit, then those ground environments should be specified. Either added environmental protection then could be developed for ground operations, or the ground environments would be considered in the design of the orbiting elements.

Paragraph 3.2.6.2.4, Other Environments for Space Equipment, is intended to specify the design environmental requirements for the various space elements of the space system during other applicable modes not covered by launch, on orbit, or ground handling, such as reentry or crash.

Paragraph 3.2.6.3, Environmental Conditions for Ground Equipment, is intended to present the design environmental requirements for all space system ground equipment.

Paragraph 3.2.6.4, Environmental Conditions for Other Equipment, is intended to present the design environmental requirements for all other types of space system equipment.

Paragraph 3.2.7, Transportability, generally is only a heading (title) with text in separate subparagraphs that follow. The subparagraphs should specify the requirements for system transportability. Make sure the specified requirements are consistent with the ground environmental provisions specified in the environment paragraphs of the system specification (Paragraph 3.2.6). In addition, all system elements that, due to operational or functional characteristics, will be unsuitable for normal transportation methods shall be identified.

> Note that Paragraph 3.2.7 in DI-CMAN-80008A does not establish an organization for subparagraphing. For the convenience of those using Appendix A, a required set of subtier paragraphs is included to suggest general boilerplate requirements applicable to space vehicle equipment and those applicable to ground equipment. On the other hand, the boilerplate material shown in Appendix A should be changed if changes are needed to specify the needs of a particular space system.

Paragraph 3.2.8, Flexibility and Expansion, shall specify areas of growth which are required to support planned system flexibility and expansion. Note that some requirements stated in other sections of the specification, such as limit loads or structural margins of safety, also may be a factor in some aspects of the system flexibility and expansion. It is not the intent that those requirements be repeated in this section or moved to this section. Essentially, this subparagraph specifies features and spare capacity requirements of specific elements of the system which are not stated elsewhere in the specification and that are require to support flexibility and expansion of the system.

> Note that there is an apparent conflict between the requirements of Paragraph 3.2.8, Flexibility and Expansion, in DI-CMAN-80008A and the requirements of Paragraph 3.3.11 in DI-CMAN-80008A titled Computer Resources Reserve Capacity. Computer resources reserve capacity is essentially a system flexibility and expansion issue that is best addressed here and not in a separate Paragraph 3.3.11. Paragraph 3.2.8 in DI-CMAN-80008A does not establish an organization for subparagraphing. However, to highlight the inclusion of computer resource reserves as a system flexibility and expansion requirement, Subparagraphs 3.2.8.1, Operational Computer Resource Reserves, 3.2.8.2, Nonoperational Computer Resource Reserves, and 3.2.8.3, Other Flexibility and Expansion Requirements, have been established in Appendix A. In other words, the requirements for a Paragraph 3.3.11 in DI-CMAN-80008A have been moved to Subparagraphs 3.2.8.1 and 3.2.8.2 in this guide, and in Appendix A. Care should be taken to separate the reserves requirements applicable to operational computer resources (Subparagraph 3.2.8.1) and those applicable to nonoperational computer resources (Subparagraphs 3.2.8.2) such as for test equipment or trainers. Other subparagraphs of 3.2.8.3 should be established as appropriate to the system. On the other hand, the boilerplate material shown in Appendix A should be changed if changes are needed to specify the needs of a particular space system.

Subparagraph 3.2.8.1, Operational Computer Resource Reserves, addresses one of the primary areas involving requirements for system flexibility or expansion. The key to assuring adequate performance of the space system, and of its potential to grow, is to assure that the space system functions properly under the delivered worst case throughput conditions, that the required throughput reserves are present and can be utilized, and that adequate reserves in memory, processing time, and channel capacity are present. The Appendix A example deals with both the throughput reserves and the reserves applicable to the data processing subsystem components. The design process, as it evolves, should ensure that the system-level reserves and the component reserves are compatible. Note that, in general, the requirements for operational computer resource reserves in the operational space elements are different from the operational computer resource reserves in the operational ground elements, so separate subparagraphs were established for each area.

Expansion requirements for computer resources usually take the form of reserves in all types of computer memory, processing instruction time, and data channel capacity. These three characteristics of computer resources typically combine to provide a space system capability to *throughput* the data processing actions of the space system. The throughput is necessary to allow the overall space system to perform in accordance with its system specification. To ensure that the delivered data processing subsystem has both sufficient engineering margin to meet worst-case throughput needs and the expansion capability necessary to provide flexibility in modifying system performance subsequent to initial delivery of the space system, reserve throughput requirements also must be specified. Each space system is unique in its demands on its data processing function due both to what the overall space system is supposed to do and to what is chosen to be the space system design. Because the details of the space system design are not apparent when a system specification is first prepared, a worst-case throughput requirement cannot be stated exactly but instead must be derived in light of the emerging system design. However, the data processing subsystem design that eventually emerges comprises computer hardware and software that in and of themselves must have reserves compatible with the final agreed-upon throughput reserve applicable to the overall space system. These individual data processing subsystem margins should be specified. The Appendix A example deals with both the space system throughput reserves and the reserves applicable to the data processing subsystem components. The design process, as it evolves, should assure that the system-level reserves and the component reserves are compatible.

The key to adequate performance of the space system, and of its potential to grow, is to establish and measure that the space system functions properly under the delivered worst-case throughput conditions; that the required throughput reserves are present and can be utilized; and that the reserves in memory, processing time, and channel capacity are present. (Note that this ensemble of related requirements must be verified as being delivered by a composite of testing and analysis. In the actual development of the space system defined by the system specification, it will be necessary to develop test scenarios, prepare test plans and procedures and execute the tests, and plan for and conduct measurements to ascertain that reserves are preserved during execution of the worst-case throughput situation, both in system throughput and in component reserves. Subparagraph 4.2.2.2.3.4 specifies computer resources reserves verification tests.) As noted above, the data processing subsystem's requirement to provide a reserve in delivered throughput capability can impact the design or selection of the computer resources components in that they must provide compatible reserves in memory, processing time, or data channel capacity. In the general case, all the system reserves discussed above tend to be constrained, under normal design conditions, to be compatible with the design approach selected for the system. System extensions conceivably could be specified that may or may not be compatible with the throughput reserve design approach. In this case, the ability to employ the throughput reserve may not be achievable, and costly redesign may be required. Where broad flexibility in system extension is anticipated, careful control over the selected data processing subsystem design must be exercised.

Subparagraph 3.2.8.1.1, Computer Resource Reserves for Operational Space Elements, addresses requirements in operational space elements for system flexibility or expansion. For the purposes of this specification, the data processing subsystems of the operational space elements are defined to comprise all computer hardware, software, and firmware in the space vehicle(s), including all interfacing space equipment and payloads except government-furnished equipment (GFE) payloads required to support operational missions. The typical requirements shown in Appendix A should be changed to specify the needs of a particular space system. In general, the requirements for operational computer resource reserves in the space elements are different from the computer resource reserves in the ground elements.

Paragraph 3.2.8.1.2, Computer Resource Reserves for Operational Ground Elements, addresses requirements in operational ground elements for system flexibility or expansion. For the purposes of this specification, the operational data processing subsystems of the ground elements of the space system are defined to comprise all computer hardware, software, and firmware required to support operational missions that are not in space elements. The typical requirements shown in Appendix A should be changed to specify the needs of a particular space system. In general, the requirements for operational computer resource reserves in the ground elements are different from the computer resource reserves in the space elements.

Subparagraph 3.2.8.2, Nonoperational Computer Resource Reserves, addresses another of the primary areas involving requirements for system flexibility or expansion. Care should be taken to define nonoperational computer resources in the specification (see Paragraph 3.3.8). Nonoperational computer resources typically are included in *nonspace* or ground items such as test equipment or trainers, where the flexibility or expansion requirements could be quite different than for operational computer resources.

Subparagraph 3.2.8.3, Other Flexibility and Expansion Requirements, addresses requirements in other elements of the system, other than computer resource, for system flexibility or expansion. For example, if the system includes electrical power generation equipment, or fuel storage tanks, should there be a single unit or a number of parallel units with the potential to add additional units? Also, what surplus capacity should be provided?

Paragraph 3.2.9, Portability, shall specify requirements for portability which are applicable to system equipment and software to permit employment, deployment, and logistic support. In Appendix A this paragraph is marked *Not applicable* because the portability requirements for most space systems already are included in other paragraphs of the specification. The portability requirements for computer resources are stated in

Paragraph 3.3.11 and subparagraphs, and in Paragraph 3.3.7 and subparagraphs for transportation. Of course, Appendix A should be changed if changes are needed to specify the needs of a particular space system.

3.5.3 Subsection 3.3, DESIGN AND CONSTRUCTION

This subsection generally is only a heading (title) with text in separate subtier paragraphs. The intent of the paragraphs included in this subsection is to specify minimum system design and construction standards which have general applicability to system equipment and are applicable to major classes of equipment (e.g., space vehicle equipment, ground support equipment, etc.) or are applicable to particular design standards. To the maximum extent possible, these requirements shall be specified by incorporation of references to the established military standards and specifications. In addition, this paragraph shall specify criteria for the selection and imposition of federal, military, and contractor specifications and standards. Design and construction requirements and constraints that are applicable to a special system function (as might be defined ultimately in greater detail in a single system segment or to a single CI) usually would be stated in the appropriate paragraphs of Subsection 3.7 and not in this subsection. In that case, the paragraphs in this subsection should reference the appropriate paragraphs in Subsection 3.7 in order to avoid any possible oversight.

Paragraph 3.3.1, Materials, generally is only a heading (title) with text in separate subtier subparagraphs. Subparagraph 3.3.1.1 in DI-CMAN-80008A is the only subparagraph established. However, other subparagraphs are to be added to specify those system-peculiar requirements governing use of materials, parts, and processes in the design of system equipment. The subparagraphs shall direct attention to prevent unnecessary use of strategic or critical materials. (A strategic and critical materials list may be obtained from the contracting agency.) In addition, any requirements for the use of standard and commercial parts and parts for which qualified products lists have been established shall be specified in the subparagraphs.

For the convenience of those using Appendix A, a required set of other subtier subparagraphs is included to suggest general boilerplate requirements applicable to space vehicle equipment and those applicable to ground equipment. On the other hand, the boilerplate material shown in Appendix A should be changed if changes are needed to specify the needs of a particular space system.

Paragraph 3.3.1.1, Toxic Products and Formulations, shall specify requirements for the control of toxic products or formulations to be used in the system or to be generated by the system. The general provisions of a government contract require compliance with the laws of the land that already impose many controls of toxic products or formulations. This paragraph needs to address only additional controls peculiar to the system.

> Note that Paragraph 3.3.1.1 in DI-CMAN-80008A is the only subparagraph established. For the convenience of those using Appendix A, a required set of other subtier paragraphs is included to suggest general boilerplate requirements applicable to space vehicle equipment and those applicable to ground equipment.

Paragraph 3.3.1.2, Materials, Processes, and Parts for Space Vehicle Equipment, and the subparagraphs that follow state general boilerplate requirements for the space vehicle. Deletions or additions should be made where appropriate to satisfy the requirements for a particular system. Note that the management task of establishing a parts, materials, and processes control program for space vehicle equipment is not included in the specification but would be stated as a task in the SOW when it is a formal requirement.

Paragraph 3.3.1.3, Materials, Processes, and Parts for Ground Equipment, and the subparagraphs that follow state general boilerplate requirements for the space system ground equipment. Deletions or additions should be made where appropriate to satisfy the requirements for a particular system. Note that the management task of establishing a parts, materials, and processes control program for ground equipment is not included in the specification but would be stated as a task in the SOW when it is a formal requirement.

Paragraph 3.3.2, Electromagnetic Radiation, states the general requirements for electromagnetic compatibility (EMC). The requirements in the paragraph should address both the radiation environment in which the system must operate as well as that which the system is permitted to generate. If there are technical TEMPEST requirements imposed to limit radiation from the elements of the system, they should be stated.

Paragraph 3.3.3, Nameplates and Product Marking, states the general boilerplate product marking requirements that will be required to identify equipment when it is produced. The paragraph shall contain requirements for nameplates, part marking, serial and lot number marking, software media marking, and other identifying markings required for the system. Reference may be made to existing standards on the content and application of markings. Because these requirements usually are more severe in space systems than for other military equipment, and they may impact other design and construction requirements, it is appropriate to include detailed requirements in the system specification.

> Note that in Appendix A, all software media marking requirements are stated in the computer resources Paragraph 3.3.11 and subparagraphs. Of course, Appendix A should be changed if changes are needed to specify the needs of a particular space system.

Paragraph 3.3.4, Workmanship, states the general workmanship requirements for equipment to be produced during system development and requirements for manufacture by production techniques. This includes workmanship requirements for development models or prototypes to be produced during the system development.

Paragraph 3.3.5, Interchangeability, specifies the requirements for system equipment to be interchangeable and replaceable. Entries in this paragraph, or subparagraphs, are for the purpose of establishing a condition for design and not to define the conditions of interchangeability required by the assignment of a part number.

Paragraph 3.3.6, Safety, states the safety design requirements which are basic to the design of the system, with respect to equipment characteristics, methods of operation, and environmental influences. This paragraph also shall specify those safety design requirements which prevent personal injury and equipment degradation without degrading operational capability (e.g., restricting the use of dangerous materials; where possible, classifying explosives for purposes of shipping, handling, and storing; abort/escape provisions from enclosures; gas detection and warning devices; grounding of electrical system, cleanliness, and decontamination; and explosion proofing).

Safety-related requirements applicable to a single functional area should not be addressed in this paragraph but should be stated with the requirements for the functional area. For example, safety requirements applicable to explosive ordnance should be addressed in Paragraph 3.3.9.6, Explosive Ordnance, and safety requirements applicable to pressurized components should be addressed in Paragraph 3.3.9.4, Pressurized Components. This discipline of putting together all requirements for a product area or type in one place is intended to assure that critical requirements, including safety, are not overlooked by the various design, manufacturing, and quality experts. Similarly, safety-related requirements applicable only to a single system segment or to a single subtier CI usually would be addressed in the appropriate paragraph in Subsection 3.7 and not in this paragraph. Reference to the applicable paragraphs in Subsection 3.7 can be included in this paragraph if one wants to assure completeness.

Note that the management task of establishing a safety program based upon an approved safety plan is not included in the specification. If constraints are to be applied to the management of a contractor safety program, they would be stated as tasks in the SOW, and the approval of the safety plan would be required by an appropriate entry on the Contract Data Requirements List (CDRL).

Paragraph 3.3.7, Human Engineering, states the general boilerplate design requirements for accommodating man-equipment interactions. This paragraph should reference applicable documents (e.g., MIL-STD-1472) and also specify any special or unique requirements such as any constraints on allocation of functions to personnel, constraints on verbal communications, and personnel-equipment interactions. This paragraph shall include requirements for those specific areas, stations, or equipment which would require concentrated human engineering attention due to the sensitivity of the operation or criticality of the task; i.e., those areas in which the effects of human error would be particularly serious.

Paragraph 3.3.8, Nuclear Control Requirements, states the general requirements for controlling nuclear material. These requirements may include component design, in-flight controls, prevention of inadvertent detonation, and nuclear safety rules that are applicable to design or construction.

Paragraph 3.3.9, System Security, shall specify security requirements that are basic to the design of the system with respect to the operational environment of the system. This subparagraph also shall specify those security requirements necessary to prevent compromise of sensitive information or materials that are applicable to design or construction.

Paragraph 3.3.10, Government-Furnished Property Usage, shall specify any GFE to be incorporated into the system design. In addition, this paragraph *shall specify any government-furnished information* (GFI) and government-furnished software (GFS) to be incorporated into the system. This list shall identify the government-furnished property by reference to its nomenclature, specification number, and/or part number. If the list is extensive, it may be included as an appendix or in a separate document which then would be referenced in this paragraph. The lists in the model specification are typical and should be changed to conform to the particular system. *Specific quantities, including spares, should* be indicated.

> Note that government contracts usually contain an Attachment which lists the applicable GFE including the availability dates. Care should be taken to ensure that the contract Attachment and the specification agree.

Paragraph 3.3.10, Government-Furnished Property Usage, is the last subparagraph established in Subsection 3.3 by DI-CMAN-80008A, since the requirements for a Paragraph 3.3.11, Computer Resource Reserve Capacity, in DI-CMAN-80008A have been transferred to Paragraph 3.2.8.1, Computer Resource Reserves, in this guide, and in Appendix A.

For space systems, there are a number of system design and construction requirement areas that are not addressed clearly by the required paragraphs of Subsection 3.3 of DI-CMAN-80008A. Paragraphs therefore have been added starting with a new Paragraph 3.3.11, Computer Resources, in Appendix A. This new paragraph recognizes that there are system-level computer resource requirements (other than reserve capacity) and provides a location for them. Other subtier paragraphs for system design and construction requirements that have not been addressed also are included to document general requirements applicable to space vehicle equipment and those applicable to ground equipment. The boilerplate material shown in Appendix A should be changed if changes are needed to specify the needs of a particular system.

Paragraph 3.3.11, Computer Resources, states general requirements applicable to computer resources to be developed as elements of the system (other than reserve capacity which is addressed in Paragraph 3.2.8.1). Computer resources include all computer software and the associated computational equipment included within the system. Computational equipment is the equipment that is capable of executing symbolically expressed instructions as well as all of the associated peripheral devices. The computational equipment and the associated peripheral equipment include processing units; main storage; peripheral data storage; special-purpose computation devices; input/output units such as printers, graphic displays, and video display devices; and other associated devices.

This paragraph, and the associated subparagraphs, should be prepared with the understanding that the specification usually is written before the functional requirements are allocated to specific computers or to specific computer software. Nevertheless, past experience has shown that a large fraction of system problems and system life cycle costs eventually will be attributed to the computer resources. It is therefore important to document as early as possible the known technical requirements. Of course, requirements that naturally fall in categories covered by other paragraphs of the system specification should be stated in those paragraphs, even though eventually they may be allocated to specific computer resources. Only the general technical requirements having significant impact on the performance, selection, design, sizing, interfaces, or scheduling of the computer resource elements should be stated in this and the associated subparagraphs.

In stating the computer resources requirements for the overall space system, often it is necessary to categorize the computer resources into various functional areas of the space system. This is because the requirements for computer resources in each of the system functional areas may not be identical. In Appendix A, computer resources are grouped and identified as those that functionally support operations, those used for computer software maintenance, those embedded in test equipment, and those included in other functional areas such as in trainers. Of course, if all the general requirements for computer resources apply to all functional areas, it is not necessary to distinguish between the functional areas, since all of the requirements would apply fully to all areas. Appendix A indicates how the general requirements typically are tailored within each of the functional areas. This type of subdivision of the system computer resources should be used to avoid overspecifying computer resources requirements within a particular system functional area. More than four functional area categories may be required for some systems and less than four for other systems.

Paragraph 3.3.11.1, Operational Computer Resources, states any general requirements for computer resources which are required to support functional operations during one or more phase(s) or mode(s) of the system service life. The operational computer resources may include on-line and off-line data processing, communications, display, and control functions. The operational computer resource requirements are grouped by subparagraphs into those applicable to equipment, computer operating systems, application computer software, and other special areas such as firmware. Although most operational computer resources in space systems are on the space vehicles or on the ground, they also may be on other vehicles such as on launch vehicles, aircraft, ships, and trucks. Care should be taken to distinguish differences in the requirements that may be applicable to the different vehicles.

Paragraph 3.3.11.2, Computer Software Maintenance Resources, states any general requirements for computer software maintenance resources required during the system operational service life to develop and test changes to operational computer software. These resources and facilities often are the same as, or similar to, those used for the development of the computer software. However, it is not appropriate to include requirements for computer software development resources or facilities in a specification, because they are simply development tools and not part of the system being specified. Only requirements for the computer software maintenance resources and facilities required to support computer software changes during the operational service life should be included in the specification. These requirements include those applicable to equipment, computer operating systems, application computer software, firmware, data archives, and maintenance tools.

Paragraph 3.3.11.3, Computer Resources in Test Equipment, states any general requirements for computer resources embedded in the test equipment that will be required to support the maintenance, repair, and checkout of the system hardware following system deployment.

Paragraph 3.3.11.4, Computer Resources in Trainers, states any general requirements for computer resources embedded in equipment used for the training of system operators. Of course, if there is no training equipment in the system, then this paragraph will be deleted. If there were other types of computer resources required by the system, other paragraphs could be added as appropriate.

Paragraph 3.3.12, Space Vehicle Design Requirements, generally is only a heading (title) with text in separate subparagraphs that follow. The subparagraphs address:

3.3.12.1 General Structural Design

3.3.12.2 Strength Requirements

3.3.12.3 Stiffness Requirements

3.3.12.4 Structural Factors of Safety

3.3.12.5 Design Load Conditions

3.3.12.6 Space Vehicle Fluid Subsystems

3.3.12.7 Moving Mechanical Assemblies

3.3.12.8 Explosive Ordnance

3.3.12.9 Wiring Harness

3.3.12.10 Electronic Components

3.3.12.11 Solar Arrays

Paragraph 3.3.13, Operational Ground Equipment: General Design Requirements, generally is only a heading (title) with text in separate subparagraphs that follow. The subparagraphs address:

3.3.13.1 General Structural Design

3.3.13.2 Strength Requirements

3.3.13.3 Stiffness Requirements

3.3.13.4 Structural Factors of Safety

3.3.13.5 Design Load Conditions

3.3.13.6 Fluid Subsystems

3.3.13.7 Electronic Components

Paragraph 3.3.14, Nonoperational Ground Equipment: General Design Requirements, may be only a heading (title) with text in separate subparagraphs that follow. In Appendix A, nonoperational ground equipment for the system is defined in this paragraph. Subparagraphs address the requirements for Embedded Nonoperational Elements and Other Nonoperational Ground Equipment (Test Equipment and Trainers).

Paragraph 3.3.15, General Construction Requirements, may be only a heading (title) with text in separate subparagraphs that follow.

Paragraph 3.3.15.1, Processes and Controls for Space Vehicle Equipment, states the general requirements for manufacturing processes and controls for space vehicle equipment. The intent of the subparagraphs is to clearly impose manufacturing process control requirements needed to assure the achievement of the high levels of reliability required for initial and subsequent production of the critical elements of the space system. These process control requirements are particularly applicable whenever production of more than one item is planned. The manufacture of additional space system items usually is planned with interrupted production, because the scheduled need dates may be months or even years apart. Simply screening completed items is not an adequate method of assuring the pedigree of critical space equipment. Therefore, the requirement is that the supplier be able to construct any additional production units the same way and with the same quality that was used for the initial production.

Paragraph 3.3.15.2, Processes and Controls for Ground Equipment, states the general requirements for manufacturing processes and controls for ground equipment.

3.5.4 Subsection 3.4, DOCUMENTATION

This subsection shall specify the requirements for system documentation such as specifications, drawings, technical manuals, test plans and procedures, and installation instruction data. Note that only documents or data listed on the CDRL are deliverable. The requirements stated here are to assure that the contractors have visibility for the designs, procedures, and specifications by which all processes, operations, inspections, and tests are accomplished.

3.5.5 Subsection 3.5, LOGISTICS

This subsection states the logistic considerations and conditions that apply to the operational requirements. These considerations and conditions may include:

a. Maintenance

b. Transportation modes

c. Supply-system requirements

d. Impact on existing facilities

e. Impact on existing equipment

The focus should be on requirements that constrain the system design and impact the system life cycle cost. The allocation of the program-level logistic requirements to the system and to lower-tier levels generally is based on minimizing the program and system life cycle cost. Even including the possible retrieval of space vehicles by the STS, the maintenance or refurbishment opportunities for space equipment are extremely limited when compared to other military equipment. In addition, the production quantities of space vehicles totals only a few of each type, and, for this and other valid reasons, the use of standard military parts or items in space equipment is trivial. These factors usually mean that requiring contractor logistic support for the service life of the space equipment can avoid many of the added costs associated with using military personnel for logistic support and the military logistic supply system for spare parts. Unless the ground equipment associated with the system is to be located in the *front lines* in the event of a conflict, life cycle cost considerations usually dictate that the contractor be assigned responsibility for all logistic support for the service life of the space system. If for any reason the space system design should be based on other than contractor logistic support, it is important to provide detailed requirements in the maintenance, supply, and facilities subparagraphs. Even when contractor logistics support is planned, there may be requirements that should be stated in the subparagraphs to assist the design personnel in the contractor organization.

> Note that Subsection 3.5 in DI-CMAN-80008A does not establish an organization for subtier paragraphing. For the convenience of those using Appendix A, a suggested set of subtier paragraphs is included. The boilerplate material shown in Appendix A should be changed if changes are needed to specify the needs of a particular space system.

Paragraph 3.5.1, Support Concept, shall specify the support concept. This subparagraph shall include the following:

a. Use of multipurpose test equipment

b. Repair versus replacement criteria

c. Organizational levels of maintenance such as the extent of maintenance to be accomplished at specific locations such as at the launch site, on orbit, at the landing site, at operating sites, at the depot (if one is to be used), or at the factory

d. Maintenance cycles, and test, repair, and refurbishment time lines

e. Accessibility

f. Other requirements not previously mentioned such as the use of module versus part replacement

Paragraph 3.5.2, Support Facilities, usually is only a title heading for the subparagraphs that follow. Nevertheless, one could address the impact, if any, of the system on existing facilities and facility equipment or any requirements for new facilities or ancillary equipment to support the system logistics. The facility and facility equipment requirements, if any, eventually would be transferred to separate facility specifications or other appropriate documents to support their procurement. Generally, facility procurements and space system equipment procurements are entirely separate contracts, and separate specifications would be appropriate.

Paragraph 3.5.2.1, Hardware Support, shall specify the system requirements for hardware support facilities and equipment. Quantitative requirements shall be stated for usage of existing facilities and equipment in sufficient detail so that availability may be verified. Quantitative requirements shall be stated for new or modified facilities and equipment in sufficient detail to permit planning of construction or procurement.

Paragraph 3.5.2.2, computer software configuration item (CSCI) support, shall specify, directly or by reference, the facilities, equipment, and software required for CSCI support during the system's operational life. The Computer Software Maintenance Resources to be developed as required by Paragraph 3.3.11.2 are for this purpose, so they should be referenced. (The requirements could be moved to this paragraph and omitted from Subsection 3.3: however, that was not done.) Note that the Computer Software Maintenance Resources to be developed should be equivalent to the computer resources used for development of the computer software. The Computer Software Maintenance Resources are envisioned as becoming a government-furnished facility for computer software maintenance during the operational life of the system, whereas the specific computer resources used for development might not be planned for delivery to the government.

> Note that Paragraph 3.5.2.2 in Appendix A simply states that the Computer Software Maintenance Resources to be developed as required by Paragraph 3.3.11.2 shall be used for CSCI support during the system's operational life. Care should be taken in writing the acquisition contracts to assure that the required Computer Software Maintenance Resources will be delivered to the government, or that other suitable arrangements are made for CSCI support during the system's operational life (such as contractor maintenance of the computer software).

Paragraph 3.5.3, Supply, could address such items as:

a. Introduction of new parts or items into the supply system.

b. Supply or re-supply methods.

c. Distribution and location of item stocks.

d. Special storage requirements for parts or items.

3.5.6 Subsection 3.6, PERSONNEL AND TRAINING

This subsection generally starts with a title heading for the paragraphs that follow. For space systems where life cycle cost is a primary consideration, operators and maintenance personnel usually are provided by the system contractors. In that case, personnel and training requirements typically would be determined by the contractors as part of the design tradeoff studies. For some systems, there may be a hard stipulation that military personnel will operate or maintain the system equipment. In that case, care should be used to provide the detailed personnel and training requirements needed by the system designers.

Paragraph 3.6.1, Personnel, should address the personnel requirements for operators and for maintenance personnel which must be integrated into the system design. These requirements shall be stated in terms of numbers plus tolerance and shall be the basis for contractor design and development decisions. Requirements stated in this paragraph shall be the basis for determination of system personnel training, training equipment, and training facility requirements. Personnel requirements shall include, but not be limited to:

a. Numbers and skills of support personnel for each operational deployment mode and the intended duty cycle, both normal and emergency.

b. Skills and numbers of personnel that shall be allocated to the operation, maintenance, and control of the system.

When military personnel are to be used, it is important that the required number of personnel at each of the available skill levels be identified. Care should be taken to avoid personnel requirements that are too lax, because they can impose costly constraints on the equipment design and on other areas of the program such as requirements for spares. Care also should be taken to avoid personnel requirements that are overly restrictive, because suitable military personnel may not be readily available. For contractor operation or maintenance, it would be appropriate to describe, in general terms, the educational background, experience, or other qualifications desirable for personnel selected to be trained to operate and maintain the system.

Paragraph 3.6.2, Training, should address training requirements to the extent they are known and to the extent that they might effect the design of the system. This could include:

a. Contractor and government responsibility for training requirements. This subparagraph also shall specify the concept of how training shall be accomplished (e.g., school, contractor training).

b. Equipment being developed that will be required for training purposes.

c. Training devices to be developed, characteristics of the training devices, and training and skills to be developed through the use of training devices.

d. Training time and locations available for a training program.

e. Source material and training aids to support the specified training.

Note that Paragraph 3.6.2, in Appendix A, states some task-related requirements such as training times and locations; but remember that the specification cannot be used to buy services, only to state requirements that can help in the design process of the system or of the training equipment. Care should be taken in writing the acquisition contracts to assure that the required training equipment will be delivered to the government, and that other suitable contractual arrangements are made for contractor training service.

3.5.7 Subsection 3.7, CHARACTERISTICS OF SUBORDINATE ELEMENTS

This subsection generally starts with a title heading for the paragraphs that follow. Subtier paragraphs are established in this subsection to provide places to identify and describe requirements that have been allocated from the system requirements to a system segment or that describe interfaces among the system segments. These requirements eventually could form the core of system segment specifications or prime item specifications that would be developed as the acquisition progresses. However, requirements need not be allocated to any of the system segment subtier elements in order to prepare a system specification. All entries and subtier paragraphs in Subsection 3.7 are optional. As a system acquisition progresses, system requirements will be allocated to Subtier Elements (system segments or prime items). The allocated requirements can be put directly into the system segment specifications or into prime items specifications just as easily as in Subsection 3.7. When system segment or prime item specifications can be identified, the subtier specifications should be referenced in these subtier paragraphs. Referencing the subtier specifications is far better than trying to repeat the details directly in these subtier paragraphs. The Model specification (Appendix A) should be changed if changes are needed to specify the needs of a particular space system.

Note that Subsection 3.7 in DI-CMAN-80008A states that subtier paragraphs shall be established to identify and describe each segment of the system. DI-CMAN-80008A also states that the subparagraphs shall describe the relationships between the segments and shall provide the following information for the segment:

a. State the purpose of the segment.

b. Provide a brief description of the segment.

c. Identify the system capabilities the segment performs.

These DI-CMAN-80008A information requirements will be met when system segment or prime item specifications have been prepared; they are referenced in these subtier paragraphs. As in other sections of the system specification, requirements cannot be included if they do not exist, such as is the case at the start of a new system acquisition. For the convenience of those using the Model Space System Specification (Appendix A), suggested subtier paragraphs are discussed in considerable detail; however, it is entirely acceptable to mark Subsection 3.7 or any subtier paragraphs *TBS* or *Not applicable* if that is appropriate.

Paragraph 3.7.1, Requirements Allocated to Subtier Elements, generally starts with a title heading for the subparagraphs that follow. A subparagraph typically would be established to address each of the system segments. If the content of any of these system segment paragraphs or subparagraphs is extensive, the material should be organized similar to the planned organization of a system segment specification that would be developed for the segment as the acquisition progresses. In fact, the requirements in these paragraphs may be stated by referencing the applicable system segment specifications if they exist. For the space system, the space system segment requirements may be so extensive that it may be desirable to prepare the space system segment specification at the same time the space system specification is prepared. In that case, the space system segment specification would be referenced in its paragraph. Requirements of the other system segments could either be incorporated directly in their appropriate paragraphs or incorporated by referencing separate specifications prepared for them. The purpose of preparing separate segment specifications at the same time the space system specification is prepared is to avoid ambiguity in the requirements. The use of separate system segment specifications also may help allocate the general requirements among the various elements of the system. The detailed allocation of performance, errors, reliability, and other requirements among the various system segments and CIs should be the subject of trade studies to be conducted during the concept development phase by either the contractors, the government, or both. If no requirements have been allocated to or identified with a particular subtier system segment at the time the system specification is being prepared, the paragraph for that system segment may be omitted. In fact, initial system specifications may be prepared without any requirements being stated in any paragraphs or subparagraphs in Subsection 3.7.

Paragraph 3.7.2, Internal Interface Requirements, shall be divided into the following subparagraphs to describe the internal interfaces. (To achieve maximum system design flexibility, the subparagraphs below, which specify the internal interfaces in detailed terms, normally are completed by the contractor rather than the contracting agency. The contracting agency may provide this information when necessary to meet system needs.)

Requirements that describe interfaces among the segments are internal interfaces in the system specification, but they are external interfaces in the system segment specifications. Interfaces among the segments typically are documented in interface control documents signed or approved by the system segment contractors. If interface control documents exist, they may be referenced in these subtier paragraphs; eventually they would be referenced in the applicable system segment specifications or prime items specifications.

Paragraph 3.7.2.1, Internal Interfaces Identification, shall identify all interfaces between hardware CIs and computer software CIs in this system. This subparagraph may reference a system internal interface diagram to identify the interfaces.

Paragraph 3.7.2.2, Internal Hardware CI-to-Hardware CI Interfaces, shall specify by name and number all hardware CI-to-Hardware CI interfaces within the system. If a signal is transmitted between hardware CIs, the hardware CI transmitting the signal and the hardware CI receiving the signal shall be specified. In addition, where required, each interface shall be specified in detailed quantitative terms (e.g., input/output voltages, dimensions, tolerances, loads, speeds).

Paragraph 3.7.2.3, Internal Hardware CI-to-Computer Software CI Interfaces, shall specify by name and number all hardware CI-to-computer software CI interfaces within the system. For each interface, the hardware CI or computer software CI transmitting the signal and the hardware CI or computer software CI receiving the signal shall be specified. In addition, where required, each interface shall be specified in detailed quantitative terms (e.g., bits per second, word length, message format, frequency of messages, priority rules, protocol).

Paragraph 3.7.2.4, Internal Computer Software CI-to-Computer Software CI Interfaces, shall specify by name and number all computer software CI-to-computer software CI interfaces within the system. For each interface, the computer software CI transmitting the data and the computer software CI receiving the data shall be specified. In addition, where required, each interface shall be specified in detailed quantitative terms (e.g., data format, communication protocol, frequency of transfer).

Paragraph 3.7.3, Requirements Traceability Matrices, is an optional paragraph in which a summary matrix can be referenced that correlates the allocation of system functions first to the system segments and then, for each system segment, to the corresponding subtier Hardware CI(s) and Computer Software CI(s) in the system segment.

To be clear as to what we are discussing, a Requirements Traceability Matrix is a list of the Section 3 and Section 5 requirements down the left side of a page, with a series of vertical columns for each of the subtier elements across the page. Usually, the Section 3 and Section 5 requirement paragraphs should be expanded to provide the necessary clarification, identification, and separation of requirements. The matrix should provide a column to identify each system requirement by paragraph number, sequence number within the paragraph (a, b, c, etc.), and name. The matrix should indicate the allocation (full, partial, or zero) for each requirement to each of the lower-tier elements in the appropriate column. A separate matrix usually would be prepared for each tier. The top-level matrix would indicate the allocation of system requirements to system segments. The next level matrices would be for the system segments. Each of these matrices would indicate the allocation of system segment requirements to the top-level Hardware CI(s) and Computer Software CI(s) in that system segment. Additional matrices could be prepared for lower tiers.

The matrix cannot be prepared until the Hardware CI(s) and Computer Software CI(s) in each of the system segments have been identified. The matrix helps summarize and trace the allocation of system requirements to lower tiers. The matrix cannot be used to add requirements that are not already in Sections 3 and 5 of the system specification. The matrix can be used only to help verify the requirements that are, or should be, included in Sections 3 and 5 of subtier specifications. Because an actual matrix is extensive, it should always be prepared as a separate document and simply referenced in this paragraph, if the matrix is included at all. This is an optional requirement as far as the specification is concerned; however, other contract provisions may require the completion of the Requirements Traceability Matrices by the contractor. In that case, it could be referenced here as a guidance document.

Although the Requirements Traceability Matrix may be included in the system specification, the allocation of the system requirements to lower tiers occurs after the system specification has been prepared and does not add any new system-level information. For that reason, the words included in this paragraph in the model specification indicate that the matrix is *Not applicable.* If for some reason the words are changed to include or reference the matrix, be sure that the words do not try to make the matrix mandatory or impose requirements that should be in other paragraphs of the specification or in the SOW or CDRL. If the contractor is required to prepare or update the matrix, that requirement must be stated in the contract SOW and the matrix listed in the CDRL.

3.5.8 Subsection 3.8, PRECEDENCE

This subsection generally starts with a title heading for the paragraphs that follow.

Note that DI-CMAN-80008A does not establish a requirement for subtier paragraphing in Subsection 3.8. For the convenience of those using the Model Space System Specification (Appendix A), a suggested set of subtier paragraphs is included. The paragraphs in Appendix A are typical boilerplates for a space system specification. These paragraphs are intended to help resolve any conflicts that may occur among the high-priority program requirements. These high-priority requirements typically include design and performance requirements, schedule constraints, and system life cycle cost. Unless some attempt is made to formally establish relative values or priorities among the various program requirements, inconsistent priorities may be used by the various participants as they make trade studies and decisions regarding detail requirements for items at lower levels of assembly. The boilerplate material shown in Appendix A should be changed if changes are needed to specify the needs of a particular space system.

Paragraph 3.8.1, Conflicts, states the overall considerations in resolving conflicts that may occur with referenced documents. The general rule is that requirements stated in a document take precedence over conflicting requirements given in referenced documents. In the early phases of a system acquisition, the identification of external system interfaces usually requires the referencing of other system specifications, documents prepared by other agencies, and descriptions of government-furnished property. Usually, it is not desirable to provide a definitive order of precedence for conflicts that may be identified involving these external interfaces. For example, if the requirements in a specification for interfacing equipment were given precedence over the requirements stated in the system specification, then the system contractors would seem to be obligated to constantly follow any changes that might be made by others in the interfacing equipment. On the other hand, if the requirements stated in the system specification took precedence over those in the referenced external interface documents, the system might not work properly if there were a conflict in the interfaces. Of course, it is important that any conflicts in the external interfaces be identified and resolved. Rather than provide a definitive order of precedence, the boilerplate words in the model specification direct the resolution of unresolved conflicts, such as any external interface conflicts, to the contracting officer. In this way, the program office will be notified of any apparent conflicts, and the appropriate program office actions can be taken for their resolution.

Note that there are minor differences in conflict resolution in this guidebook and in DI-CMAN-80008A (Appendix I of MIL-STD-490A). This guidebook addresses all orders of precedence issues in Paragraph 3.8 rather than some in Section 2 and some in Paragraph 3.8. Also, in

Section 2 of DI-CMAN-80008A (Appendix I of MIL-STD-490A), it is suggested that requirements in referenced higher-tiered specifications take precedence over requirements contained in the specification being prepared. Generally, that is the desire of everyone involved; but saying it in the specification does not make it so, and the contractor implementing the specification does not have any way to assure compliance. This guidebook simply refers external interface conflicts to the contracting officer, and that should avoid any confusion or problems.

Paragraph 3.8.2, Requirement Weighting Factors, states the relative importance of the various requirements included within the specification, since all requirements may not be of equal importance. This may be accomplished by indicating the relative importance of the various paragraphs or requirements in the specification. For example, in a particular system specification, it might be stated that interface requirements have the highest priority, that performance and weight of space items have slightly lower priority, and that all other requirements have equal but even lower priority in the system design.

In addition, requirements that are not *hard* mandatory requirements can be included using *may, preferred, should,* or *shall, where practicable* to indicate their relative importance as contrasted to the *shall* requirements. In essence, the use of weighting factors simply documents current practice. The suggested four weighting factors may be expanded using other verbs or modifiers if warranted, may be decreased by using only two or three categories, or may not be used at all, depending upon the content of the specification being prepared. Unless other contract provisions are made, only the *shall* requirements would be compliance requirements for the contractors. Requirements with lower weighting factors would be goals. However, the use of the weighting factors in the specification allows a contract or SOW to be written to interpret the desired contractor compliance with the other weighted requirements. For example, if the program office wanted to impose a very strict technical management on the contractor during a particular phase of an acquisition, the SOW might require contracting officer approval whenever the contractor wanted to implement any alternatives to the *shall, where practicable* requirements. The SOW also might require technical approval during the preliminary design review of alternatives to the *preferred* or *should* requirements, or it could state other possible contractor actions that might be desired. Note that weighting factors are appropriate only in specifications during the early program phases and are not appropriate in detailed product specifications intended to support a production contract. The general rule is that weighting factors should not be used unless they serve a useful purpose in the particular specification.

Paragraph 3.8.3, Life Cycle Cost, states the general requirement that system life cycle cost is an important requirement. This paragraph is intended to clearly require costs, schedules, and other program considerations to be considered in the prioritization of the requirements and in the design process. The Model specification (Appendix A) provides typical wording; however, the last two sentences of this paragraph should be modified to state the particular order of precedence established for the program. If an order of importance of the requirements is not established with respect to life cycle cost, the last two sentences should be deleted. In establishing the priorities, it should be obvious that minimizing the system life cycle cost may not result in minimizing the program life cycle cost if the program includes several systems. Of course, minimizing the program life cycle cost is the goal. However, usually it can be assumed that minimizing the life cycle cost for each of the systems is sufficient. Because a system is normally the responsibility of a single government agency, minimizing the system life cycle cost is the most that should be expected within the usual program management structures.

Paragraph 3.8.4, Supplementary Specifications and Standards, provides general instructions regarding the order of precedence and course of action to be taken if the documents referenced in the system specification do not provide the reliability, quality level, or technical performance required.

3.5.9 Subsection 3.9, QUALIFICATION

DI-CMAN-80008A states that this subsection should state the requirements for system qualification. The boilerplate material shown in Appendix A, Subsection 3.9, usually is appropriate, but it should be changed if changes are needed to specify the needs of a particular space system.

Note that there is a conflict in DI-CMAN-80008A between the required content of Subsection 3.9 and the required content of Section 4. DI-CMAN-80008A states that quality assurance provisions should be stated in subsections of Section 4. DI-CMAN-80008A also states that each qualification test shall be identified in a separate subparagraph in Subsection 3.9, and the specific application shall be described. Qualification is stated to be the verification or validation, as applicable, of capabilities in a specific application. Subsection 3.9 of DI-CMAN-80008A also states that requirements also shall be included for the conditions of testing, the time (program phase) of testing, period of testing, number of items to be tested, and any other pertinent qualification requirements. The situation is further complicated by those who maintain that qualification never is imposed at the system level of assembly, so qualification requirements would not be appropriate in the system specification. This guidebook resolves these conflict by stating all qualification requirements in Section 4. Subsection 3.9 should not include details but should reference Section 4. This allows the details of all testing, including qualification, to be in Section 4 where they belong. Qualification requirements are an important and costly aspect of the quality assurance provisions imposed on various subtier elements of the system to assure mission success, so it is appropriate to include them in the system specification.

3.5.10 Subsection 3.10, STANDARD SAMPLE

DI-CMAN-80008A apparently was trying to establish a standard format for subtier items, since this heading clearly does not apply to a system or system segment specification. DI-CMAN-80008A states that this subsection shall describe requirements, if applicable, for the production of one or more standard samples. Standard samples shall be limited to the illustration of qualities and characteristics that cannot be described using detailed test procedures or design data or that cannot be definitively expressed. The *Not applicable* shown in Appendix A, in Subsection 3.10, is appropriate for any system or system segment specifications imaginable.

3.5.11 Subsection 3.11, PREPRODUCTION SAMPLE, PERIODIC PRODUCTION SAMPLE, PILOT, OR PILOT LOT

DI-CMAN-80008A apparently was trying to establish a standard format for subtier items, since this heading clearly does not apply to a system or system segment specification. DI-CMAN-80008A states that this subsection shall describe requirements, if applicable, for producing a preproduction or periodic production sample, a pilot model, or a pilot lot. The *Not applicable* shown in Appendix A, Subsection 3.11, is appropriate for any system or system segment specifications imaginable.

3.6 SECTION 4, QUALITY ASSURANCE PROVISIONS

As shown in Appendix A, the quality assurance provisions for the system are stated in subsections of Section 4. The quality assurance provisions are intended to provide the technical requirements for the inspection and test programs to be developed and implemented during the acquisition. In a system specification, the quality assurance provisions would not be stated in such detail as to constitute a complete quality assurance program. The intent of the quality assurance requirements in the system specification is primarily to state general top-level requirements for formal verification and testing of the system, and subtier elements, that will be imposed during the system acquisition. That includes testing compliance with the system performance, system design characteristics, system interfaces, and system operability stated in Section 3 of the specification. Because the same quality assurance provisions may not apply to all elements of the system, care should be taken to identify the applicability of the requirements. In addition, the requirements stated should establish the framework for the quality program and testing program in sufficient detail so that adequate test equipment, facilities, personnel, training, procedures, and other items may be identified for all levels of assembly as early in the acquisition process as possible. The expansion of the system-level quality assurance provisions into subtier details normally would occur in lower-tier specifications, in test planning documents, and in test procedure documents.

3.6.1 Subsection 4.1, RESPONSIBILITY FOR INSPECTION

This subsection usually states the general boilerplate requirement that the contractor is responsible for all tests and inspections.

> Note that Subsection 4.1 in DI-CMAN-80008A does not establish an organization for subtier paragraphs. For the convenience of those using Appendix A, a set of subtier paragraphs is included to cover the suggested subject areas. On the other hand, the boilerplate material shown in Appendix A should be changed if changes are needed to specify the needs of a particular space system.

Paragraph 4.1.1, Philosophy of Testing, shall describe the overall testing philosophy and approach that is to be used to show that all of the system requirements have been satisfied.

Paragraph 4.1.2, Location of Testing, shall specify the location(s) for the performance of tests.

3.6.2 Subsection 4.2, SPECIAL TESTS AND EXAMINATIONS

This usually is only a title heading for the subtier paragraphs.

> Note that Subsection 4.1 in DI-CMAN-80008A does not establish an organization for subtier paragraphs. For the convenience of those using Appendix A, a required set of subtier paragraphs and subparagraphs is included to clearly list all tests and inspections and to separate general boilerplate requirements applicable to operational elements from those applicable to nonoperational elements. Typically, most of the identified test requirements are for the operational elements of the space system. Because the requirements are different, the test requirements for the operational elements must be separated into those applicable to space elements (space vehicle equipment) and those applicable to nonspace elements (typically ground equipment and computer software). On the other hand, the boilerplate material shown in Appendix A should be changed if changes are needed to specify the needs of a particular space system.

Paragraph 4.2.1, Classification of Inspections and Tests, identifies all the inspection and test categories included in the specification. This paragraph is essentially the table of contents for the remainder of Subsection 4.2. In Appendix A the organization is as follows:

Inspections and Tests of Operational Elements of the On-orbit Space System (4.2.2)

Inspections and Tests of Space Elements (4.2.2.1)

Space Vehicle Parts, Materials, and Process Controls (4.2.2.1.1)

Space Vehicle Design Verification Tests (4.2.2.1.2)

Qualification Tests (4.2.2.1.3)

Acceptance Tests (4.2.2.1.4)

Space Vehicle Service Life Verification Tests (4.2.2.1.5)

Inspections and Tests of Ground Equipment and Computer Software (4.2.2.2)

Part, Material, and Software Unit Development Tests and Evaluations (4.2.2.2.1)

Step 1 - Component Tests and Evaluation (Development) (4.2.2.2.2)

Step 2 - Configuration Item Compliance Tests (Qualification and Acceptance) (4.2.2.2.3)

Step 2.1 - Single CI or CSCI Compliance Tests (4.2.2.2.3.1)

Step 2.2 - Combined CI/CSCI Compliance Tests (4.2.2.2.3.2)

Step 3 - Integrated System Testing (4.2.2.2.4)

Step 4 - Initial Operational Test and Evaluation (IOTE) (4.2.2.2.5)

Step 5 - Follow-on Operational Test and Evaluation (FOT&E) (4.2.2.2.6)

Inspections and Tests of Operational Elements of the On-orbit Space System Not Required for On-orbit Support (Nonoperational Elements) (4.2.3)

Prelaunch Validation Tests (4.2.4)

Space Vehicle Prelaunch Validation Tests (4.2.4.1)

Launch System Prelaunch Validation Tests (4.2.4.2)

On-orbit System Prelaunch Validation Tests (4.2.4.3)

Certification for Flight (4.2.4.4)

Paragraph 4.2.2, Inspections and Tests of Operational Elements of the On-orbit Space System, generally starts as a title heading for the subparagraphs that follow. There is a subparagraph added in Paragraph 4.2.2 for each inspection and test category identified for the operational elements of the on-orbit space system. It is intended that the inspection and test categories would be the same as those planned for lower-tier specifications.

Paragraph 4.2.2.1, Inspections and Tests of Space Elements, generally starts as a title heading for the subparagraphs that follow.

Paragraph 4.2.2.1.1, Space Vehicle Parts, Materials, and Process Controls, is intended to document those quality assurance provisions that assure the continuing quality of the critical space elements of the system. The primary reason for requiring the supplier to adhere rigidly to a certifiable manufacturing baseline is to provide assurance that subsequent production will be equivalent in every respect to the space items that were qualified initially. This is particularly important in cases in which production is not continuous, and there is the possibility that critical information will be lost during the production gaps. For example, if the baseline materials and processes that produced acceptable items are not known, it is much more difficult to take corrective actions if problems occur in some subsequent production run.

Paragraph 4.2.2.1.2, Space Vehicle Design Verification Tests, summarizes requirements, if any, for the completion of verification testing of system designs to demonstrate compliance with the specified performance margins. The design verification tests identified in the system specification usually would be concerned with high risk areas, new technology, new applications, or new interfaces that should be verified by special tests early in the acquisition process.

Paragraph 4.2.2.1.3, Qualification Tests, summarizes what qualification tests are required for the space vehicle and the space vehicle components.

Paragraph 4.2.2.1.4, Acceptance Tests, summarizes what tests and inspections will be the basis for government acceptance of the space vehicle and of the space vehicle components submitted for delivery by the contractor.

Paragraph 4.2.2.1.5, Space Vehicle Service Life Verification Tests, summarizes any tests or inspections required to monitor aging of potentially life-limited devices and to verify life extensions.

Paragraph 4.2.3, Ground Equipment and Computer Software Inspections and Tests, generally starts as a title heading for the subparagraphs that follow. There is a subparagraph added in Paragraph 4.2.2 for each inspection and test category identified. The primary test phases in the ground equipment specifications usually are identified as the Steps 1, 2, 3, 4, and 5 tests. Not all steps need to be specified, and different names may be used, depending upon the program characteristics and the specification subject. Each step may have substeps defined, depending upon the system complexity. In addition, there may be part, material, and process quality assurance requirements, including tests, imposed directly or indirectly by the specifications. Qualification and acceptance testing of all piece parts and of all materials typically is required by the contractor simply to avoid assembling defective items. The next higher level of assembly, the subassembly, may require in-process screening or inspections; but these also usually are determined by the contractor and not specified for ground equipment in the system specifications.

In system specifications, the lowest level of assembly for ground equipment that usually is discussed is the component level. Step 1 development tests of critical hardware components and of all software components usually are required. Testing at the next higher level of assembly, the subsystem, usually is not specified, and any in-process screening or inspection requirements would be determined by the contractor. The next major higher level of assembly for ground equipment is the CI level where Step 2 testing is required. The qualification (if required) and acceptance tests for each hardware CI are specified by the Step 2.1 tests. The qualification tests for each CSCI also are specified by the Step 2.1 tests. Expanding strings of CIs and CSCIs then are tested in additional steps until all ground equipment CIs and CSCIs, including their interfaces, are tested. The integrated system tests of Step 3 incorporate the interfaces of the ground equipment and software with other elements of the system, such as the space or launch vehicles. The Step 3 tests are intended to demonstrate design requirements of the system related to such items as performance, EMC, reliability, maintainability, system safety (hazardous noise, radiation hazards, pressure vessels), logistics supportability, operational procedures, and personnel performance. The Step 3 tests usually are divided into two parts, the Preliminary Integrated System Tests of Step 3.1 and the Final Development Tests and Evaluation of Step 3.2. Step 4 tests, the Initial Operational Tests and Evaluation, are conducted with the equipment in its operational location, using operational software, and by the operational personal assigned. The Step 4 tests are intended to demonstrate and verify the initial operational requirements of the system. Satisfactory completion of the Step 4 tests is the milestone for initial operational capability (IOC). Step 5 tests, the Follow-on Operational Test and Evaluation (FOT&E), are intended to demonstrate subsequent capabilities to support all missions.

Paragraph 4.2.3.1, Parts and Materials Qualification and Acceptance, is intended to document those quality assurance provisions that assure the continuing quality of the critical ground elements of the system. The tests of parts and material for ground equipment are the qualification and acceptance tests imposed on the suppliers by the part and material specifications plus any in-house verification tests such as may be conducted by incoming inspection. Usually, the system specifications would require the use of standard military parts, where applicable, so the testing of nonstandard parts would be the only possible concern that might be addressed. For ground equipment, as contrasted to space equipment, the parts and material testing usually is not as critical; if that is the case, no government requirements need be imposed. That would mean that the contractor would determine the part and material tests to be imposed on the suppliers and those to be conducted by incoming inspection.

Paragraph 4.2.3.2, Step 1 - Component Tests and Evaluation (Development), states requirements for the development tests conducted by the development contractor to support the design and development of ground equipment hardware components and software components. These tests are intended to demonstrate feasibility, minimize design risk, and evaluate design alternatives and tradeoffs required to best achieve the program objectives. These tests are conducted by the contractor developing the component. Usually, the computer software development tests and evaluations are required to be conducted in an approved test bed.

Paragraph 4.2.3.3, Step 2 - CI/CSCI Compliance Tests (Qualification and Acceptance), states requirements for the compliance tests of ground equipment hardware components and software components that are conducted to assure CI/CSCI compliance with their allocated requirements. These are formal tests conducted using detailed test procedures. Completion of these tests usually is made contingent on the satisfactory completion of subsequent system tests.

Paragraph 4.2.3.3.1, Step 2.1 - Single CI or CSCI Compliance Tests, states the formal test requirements for qualification and acceptance of components and CIs. Compliance tests for computer software components are specified as Preliminary Qualification Tests (PQTs) and for CSCIs as Formal Qualification Tests (FQTs). Compliance tests for the ground equipment hardware components usually are specified as the configuration item acceptance tests; however, qualification of critical components or CIs also could be required. These are formal tests conducted by the contractor developing the component or CI, using detailed test procedures. Usually, the computer software qualification tests are required to be conducted in an approved test bed.

Paragraphs 4.2.3.3.2, 4.2.3.3.3, and 4.2.3.3.4, Steps 2.2, 2.3, and 2.4 - Combined CI/CSCI Compliance Tests, state requirements for the tests where expanding strings of CIs and CSCIs are tested until all ground equipment CIs and CSCIs, including their interfaces, are involved. These integrated CI/CSCI tests are conducted at the contractor's test facility to the extent feasible; however, the final test step in this sequence (Step 2.4) should be conducted at the launch site or another appropriate operational location. The tests in the initial steps usually are conducted by the system segment contractor with support from the contractors developing the CIs. Step 2.4, the final test step in this sequence, is conducted by the system contractor with support from the system segment contractors and the contractors developing the CIs as may be required. However, both the locations and the agencies conducting the tests are not appropriate subjects for the specification. The specification should focus on the technical requirements for the tests.

Paragraph 4.2.3.4, Step 3 - Integrated System Testing, states requirements for integrated system tests that incorporate the interfaces of the ground equipment and software with other elements of the system, such as the space or launch vehicles. The Step 3 tests are intended to demonstrate design requirements of the system related to such items as performance, EMC, reliability, maintainability, system safety (hazardous noise, radiation hazards, pressure vessels), logistics supportability, operational procedures, and personnel performance. The Step 3 tests usually are divided into Preliminary Integrated System Tests (Step 3.1) and Final Development Tests and Evaluation (Step 3.2).

Paragraph 4.2.3.4.1, Step 3.1 - Preliminary Integrated System Tests, is the required initial test to verify, to the extent feasible, that the system performs as specified. If a reliability demonstration is required, it may be run in parallel. If a maintainability demonstration is required, it will be a separate test. This step also includes any required system safety tests and evaluations. These could include such areas as hardware inspections for electrical and mechanical hazards, including caution labeling; evaluation of the fire suppression system; evaluation of emergency systems; use of any hazardous materials; possibility of personnel exposure to any equipment and ambient noise levels considered hazardous (See AFR 161-35); RF radiation testing to determine actual levels of radiation to which personnel may be exposed and to evaluate the accuracy of the mathematical predictions of radiation levels; proper functioning of any radiation warning systems; and proper procedures for inspection, operation, and maintenance of pressure vessels. These Preliminary Integrated System Tests are conducted by the system contractor with support from the system segment contractors and the contractors developing the CIs as may be required. However, both the location and the agencies conducting the tests are not appropriate subjects for the specification. The specification should focus on the technical requirements for the tests.

Paragraph 4.2.3.4.2, Step 3.2 - Final Development Test and Evaluation (FDT&E), is a comprehensive verification of the system performance that is conducted by the government with support from the system contractor and the system segment contractors. The interfaces of the ground equipment and software with operational elements of the system, such as actual space or launch vehicles, may be by simulation. As before, the specification should focus on the technical requirements for the tests.

Paragraph 4.2.3.5, Step 4 - Initial Operational Test and Evaluation (IOTE), states requirements for tests conducted at an operational site in an operational configuration, utilizing operational software by assigned operating personnel, to demonstrate initial operational requirements. Satisfactory completion of Step 4 testing is the basis for establishing the IOC. Conducting these tests is the responsibility of the government; however, support from the system contractor and the system segment contractors may be required by their contracts. As before, the specification should focus on the technical requirements for the tests.

Paragraph 4.2.3.6, Step 5 - Follow-on Operational Test and Evaluation (FOT&E), states requirements for testing that are conducted as a follow-on to Step 4 tests to demonstrate additional operational requirements. Conducting these tests is the responsibility of the government; however, support from the system contractor and the system segment contractors may be required by their contracts. As before, the specification should focus on the technical requirements for the tests.

Paragraph 4.2.4, Prelaunch Validation Tests, is intended to document any special prelaunch validation tests to be included as part of the prelaunch test sequence that might influence the system design. Prelaunch validation tests of the first operational system or of the first operational space vehicle usually are conducted as part of the Step 4 testing. All subsequent operational space vehicles are subjected to prelaunch validation tests to assure that there are no out-of-tolerance conditions or anomalous behavior.

Paragraph 4.2.4.1, Space Vehicle Prelaunch Validation Tests, is intended to document any special space vehicle prelaunch validation tests to be included as part of the prelaunch test sequence that might influence the system design. Prelaunch validation tests of the first operational space vehicle may be conducted as part of the Step 4 testing. All subsequent operational space vehicles are subjected to prelaunch validation tests to assure that there are no out-of-tolerance conditions or anomalous behavior.

Paragraph 4.2.4.2, Launch System Prelaunch Validation Tests, is intended to document any special launch vehicle prelaunch validation tests to be included as part of the prelaunch test sequence that might influence the system design. Prelaunch validation tests of the first operational launch vehicle may be conducted as part of the Step 4 testing. All subsequent launch vehicles are subjected to prelaunch validation tests to assure that there are no out-of-tolerance conditions or anomalous behavior.

Paragraph 4.2.4.3, On-orbit System Prelaunch Validation Tests, is intended to document any special on-orbit system prelaunch validation tests to be included as part of the prelaunch test sequence that might influence the system design. Prelaunch validation tests of the first operational on-orbit system may be conducted as part of the Step 4 testing. All subsequent on-orbit systems are subjected to prelaunch validation tests to assure that there are no out-of-tolerance conditions or anomalous behavior.

Paragraph 4.2.4.4, Certification for Flight, is intended to document any special requirements to be included as part of the prelaunch test sequence that might influence the system design. The concept of product flight accreditation is used to assure that the critical components satisfy all requirements that have been found necessary for successful space missions. Flight accreditation is a process in which the status of each item is under continuing evaluation from program inception to final accreditation for flight. The extent of reviews required is dependent upon the specific qualification and production status of the items to be flown and the suitability of their as-qualified design for the intended mission application. Unless specifically excluded, flight accreditation should incorporate all technical assessment activity from inception of the program through manufacturing, qualification, transportation, handling, storage, and post-delivery operations leading to final installation and checkout prior to flight. Upon completion of the integrated system tests, the test history of the integrated equipment shall be reviewed to determine its acceptability for flight. The assessment activity involves incremental reviews and culminates in documentation that all accreditation requirements have been met. After completion of the final review for each item, the acceptability or nonacceptability for flight is documented.

3.6.3 Subsection 4.3, REQUIREMENTS CROSS REFERENCE

This subsection generally references a table or listing that correlates each system requirement in Sections 3 and 5 to the quality assurance provisions specified in Section 4 of the specification. This matrix is an optional feature that helps summarize the requirements. The matrix cannot be used to add requirements that are not already in Sections 3, 4, and 5 of the specification. Because an actual matrix is extensive, it should be prepared as a separate document and simply referenced in this paragraph if it is included. If the contractor is required to prepare or update the matrix, that requirement must be stated in the contract and listed in the CDRL.

The Requirements Cross Reference matrix usually is a list of the Section 3 and Section 5 requirements down the left side of the page with a series of vertical columns across the page. There would be a vertical column to indicate the verification method to indicate the assembly level, and another to indicate the corresponding Section 4 paragraph. Usually, the Section 3 and Section 5 requirement paragraphs should be expanded to provide the necessary clarification, identification, and separation of requirements. The matrix should provide a column to identify each system requirement by paragraph number, sequence number within the paragraph (a, b, c, etc.), and name. The verification methods column should indicate whether the verification method to be used is by:

A - ANALYSIS
D - DEMONSTRATION
I - INSPECTION
T - TEST
N/A - NOT APPLICABLE

The assembly level column would be to indicate which of the following assembly levels is to be used for the verification method specified:

1 - PART OR MATERIAL
2 - COMPONENT
3 - VEHICLE LEVEL
4 - SYSTEM LEVEL

The matrix is a list of the Section 3 and Section 5 requirements and indicates during which of the Section 4 quality assurance tests or inspections each requirement would be verified. The matrix also indicates how the Section 3 and Section 5 requirements that are not intended to be verified by the quality assurance provisions would be verified, if at all. For that reason, a *Not applicable* classification is provided as well as a *By analysis* classification. Care should be taken so that the contractor does not interpret the lack of a *By analysis* classification to mean that an analysis is not required. Just because a requirement is to be verified by a quality assurance provision does not mean that an analysis is not required in the design process. Most system-level requirements involve ground equipment, computer software, as well as space equipment; the quality assurance provisions typically would be different for each of these elements. That may mean that each of the Section 3 paragraphs should be expanded to provide the necessary clarification and separation of requirements. Usually, this would occur automatically in lower-tier specifications.

Although the verification cross reference matrix may be included, the requirements and quality assurance provisions in a system specification usually are of such broad scope that the matrix may have little value except as a summary or checklist. For that reason, the words included in this paragraph in the Model specification indicate that the matrix is for guidance and is provided simply as summary information. If for some reason the words are changed to make the matrix mandatory, be sure that the words do not try to impose requirements that should be in the SOW or CDRL. Remember that the specification will not impose management tasks or data delivery tasks on the contractor. For example, the matrix will not establish requirements for a government review or audit of the *By analysis* data packages. Government reviews and audits are management tasks for the contractor and are not imposed on the contractor by words in the specification.

3.7 SECTION 5, PREPARATION FOR DELIVERY

This is a major section heading for text to specify requirements for the preparation of the system and all its components for delivery, including packaging and handling. This section shall include requirements to document any nonstandard practices in appropriate system end item specifications. This section may impose requirements to comply with standard practice by referencing appropriate military specifications and standards to be used as the basis for preparing Section 5 of each specification for system end items.

However, there are seldom any preservation, packaging, packing, or marking requirements that might influence the space system design, so the *Not applicable* shown in Appendix A usually is the proper entry. The preparations for delivery requirements for space systems and items typically are included in other documents or in lower-level product specifications where preservation, packaging, packing, and marking of the packages is directly applicable.

3.8 SECTION 6, NOTES

As shown in Section 6 of Appendix A, the Notes section is used primarily to include explanatory information that may be beneficial to the contractor in understanding the requirements of the specification. Compliance requirements never are stated in the Notes section. In addition, the Notes section may contain information useful to associate contractors or interfacing agencies. If the notes become extensive, some or all of the notes may be included as one or more nonmandatory appendices.

3.8.1 Subsection 6.1, INTENDED USE

This subsection should state the intended uses of the space system being specified (see Subsection 1.4).

> Note that DI-CMAN-80008A says that the mission and the threat should be addressed in this subsection, which is not a compliant section of the specification. If it is believed that the system should be designed to meet the mission and to operate in (or survive) the threat requirements, then this guidebook should require both the mission and the threat to be stated as requirements (Section 3). To be fully compliant with DI-CMAN-80008A, the Model specification (Appendix A) includes Subparagraphs 6.1.1 for missions and 6.1.2 for threat, but each only references Section 3 paragraphs. Actually, it is unnecessary for the Notes section to reference the text; so Subparagraphs 6.1.1 and 6.1.2 may be deleted, and compliance with DI-CMAN-80008A may be obviated.

3.8.2 Subsection 6.2. ORDERING DATA

This subsection states information which should be included in invitations for bids and purchasing documents. It is primarily to provide instructions to the contracting officer to help avoid oversights. Reference should be made to all parts of the specification in which options can be exercised or contracting officer actions are indicated. For example, if different classifications of the system are defined in Subsection 1.2, or when precedence requirements are specified in Subsection 3.8, specific ordering data flagging those items may be appropriate. If only one item of ordering data is listed, it follows the Subsection 6.2 heading. If more than one item is listed, the Subsection 6.2 heading is only a title heading, and each item of ordering data is a separate paragraph.

Note that DI-CMAN-80008A does not address this or any of the following subject areas covered in the Notes section of Appendix A. The suggested set of notes should be added in subtier paragraphs for the convenience of those using the specification.

3.8.3 Subsection 6.3. DEFINITIONS

In this subsection, the various key terms that are subject to ambiguous or variant interpretations should be defined. As a general practice, terms that are used only in a single paragraph or subsection should be defined in the text where they are first used. Definitions that are included in the text or that are defined adequately in the referenced documents need not be repeated in this subsection. Two different definitions should not be given for the same term in a single document nor should two different terms be used for the same thing. A glossary of terms and their definitions that are included in the commonly referenced military specifications and standards is available for use as a checklist to avoid creating new definitions. Terms that are defined adequately in *Webster's Collegiate Dictionary* or in the *IEEE Standard Dictionary of Electrical and Electronic Terms* (IEEE STD 100-197) should not be defined in the specification.

3.8.4 Subsection 6.4. ABBREVIATIONS AND ACRONYMS

This subsection provides a single reference point where all abbreviations and acronyms used in the document are decoded. However, the use of abbreviations and acronyms in the specification text should be minimized as a service to those not intimately familiar with the program who may have occasion to use the document. If the list of acronyms is extensive, the text of the specification will be difficult to understand. In that case, to enable the text of the specification to be read easily, the acronyms should be spelled out the first time they are used in each paragraph or the first time they are used on each page. An extensive acronym list should be prepared as an appendix, or as a separate document, which then would be referenced in this paragraph.

3.8.5 Subsection 6.5. GUIDANCE DOCUMENTS

This subsection lists any other documents that may be of help to the contractor or those using or reviewing the document. Any requirements included in the documents listed in this subsection are not compliance requirements as far as the system specification is concerned. Documents listed in this subsection should not be listed in Section 2, and the documents listed in Section 2 should not be listed in this subsection.

3.8.6 Subsection 6.6. TAILORED APPLICATIONS

This subsection addresses the contractor's actions if he/she believes there are cost or technical excesses or other problems with the specified requirements including the referenced requirements.

3.8.7 Other Subsections

Other subsections may be added if needed to provide other guidance information that may be pertinent to the particular system, to the system contractors, or to others using the document.

3.9 APPENDICES

As shown in Appendix A, appendices may be used to specify extensive details which are the subject of the basic specification. An appendix must be within the scope of the specification, and it must be referenced in the basic portion of the specification to indicate applicability. For the convenience of the reader, a statement indicating whether or not any of the material in an appendix is a mandatory part of the specification should appear as a preamble at the beginning of each appendix. The appendices, if any, usually are an integral part of the specification. Identification of appendices is alphabetical such as Appendix A, Appendix B, and Appendix C. To the extent it is practicable, the internal arrangement of each appendix should parallel the arrangement of the specification. The first subsection of each appendix should be *Scope*, and the second subsection should be *Applicable Documents*. Only documents referenced in the appendix are listed in the applicable document section of the appendix. Other subsections would depend upon the subject and content of the appendix. As previously stated, documents referenced in mandatory appendices also are listed in Section 2 of the specification.

If what would otherwise be an appendix is bound separately due to its bulk or security classification, it still can be called an appendix. In that case, it would be prepared like an integrally bound appendix, but it would be bound separately with the addition of a cover and other features that might be appropriate, such as a table of contents or index If an appendix is bound separately, a page is inserted in the specification where that appendix normally would be located, indicating that it is bound separately. Alternatively, separately bound material can be prepared as any appropriate document type and then would be treated as any other referenced document. Whether or not the separately bound material is prepared as an appendix or as some other type of reference document, it would be listed in Section 2 of the parent specification if it is a mandatory part of the specification. If compliance is not mandatory, it still should be listed in Section 2 unless the only reference is in Section 6, in which case, it should be listed only in Subsection 6.5.

3.10 INDEX

An alphabetical index may be placed at the end of a specification to permit ready reference to its contents. The use of an index is limited to lengthy specifications or to those having an extensive subject matter breakdown.

4. CERTAINTY OF TERMS

Specifications should be written in clear and simple language. They should not contain vague, indefinite, conflicting, or ambiguous requirements. Punctuation should be minimized by the use of short, concise sentences with a well planned word order. Plain language is preferred to unfamiliar expressions or trade usage.

4.1 ACRONYMS AND ABBREVIATIONS

Acronyms and abbreviations should be avoided. If it is necessary to use acronyms or abbreviations, the word or term shall be spelled out in full the first time it is used in the text, followed by the acronym or abbreviation in parentheses. Abbreviations shall be in accordance with MIL-STD-12, where applicable.

4.2 SYMBOLS

The only symbols that shall be used in the text are degree (^{o}) and the +, -, and $\pm$ to express ranges or tolerances. Other symbols may be used in equations and tables. Graphic symbols, when used in figures, shall be in accordance with the graphic symbols requirements applicable to engineering drawings as stated in MIL-STD-100.

4.3 PROPRIETARY NAMES

Trade names, copyrighted names, or other proprietary names applying exclusively to the product of one company shall not be used unless the item(s) cannot be described adequately because of the technical involvement, construction, or composition. In such instances, one, and if possible several, commercial products should be included, followed by the words *or equal* to assure wider competition and that bidding will not be limited to a particular make specified. The same applies to a manufacturer's item numbers or drawing numbers for minor items when it is impracticable to specify the exact requirements in the specification. Insofar as practical, the particular characteristics required shall be included to provide a standard against which *or equal* may be measured.

4.4 CATCH-ALL REQUIREMENTS

It should be recognized that general catch-all requirements in specifications will produce only substantial compliance or substantial completion by the supplier. In other words, general and unspecific terms such as *best design practice*, *smooth*, *good workmanship*, *black finish*, *clean*, or *suitable for the intended purpose* should be used only to state requirements where limited supplier performance will be acceptable. If strict compliance to a requirement is desired, the requirement must be specific and capable of measurement to the accuracies specified. Because there may be characteristics of materials, parts, items, and systems that are impossible to define exactly or to measure in a universally acceptable way, the use of general catch-all requirements may have a place in some specifications. The inclusion of these general requirements requiring only substantial compliance does not reduce the supplier's commitment for strict compliance to all of the definitive requirements. In other words, the doctrines of strict compliance and substantial compliance are not incompatible, but they should be understood by those preparing the specification. It should also be recognized that if a dispute arises regarding the interpretation of a requirement, the supplier's interpretation, if reasonable, will generally prevail.

4.5 CONSISTENCY

A consistency of terms used in a specification also is important in achieving clarity. If two or more terms are used for the same thing, it may create confusion as to what is really required. To avoid that possibility, the most generally acceptable term should be selected and used throughout the document. If different terms are used, they normally would be construed to be different things or to have different interpretations.

Another type of uncertainty occurs when a subparagraph in the specification is not related to the parent paragraph. In that case, requirements can be overlooked easily or invalidated. For example, the inclusion of requirements in the definitions, or the inclusion of inspection requirements in design requirements, causes confusion and generally invalidates the mislocated requirements.

4.6 LIMITED USAGE TERMS

Usage limitations of certain terms are as follows:

a. Use of *and/or*. The term *and/or* shall not be used in specifications. In specifications and standards, where definitive, precise language is imperative, the phrase *and/or* has no place.

b. Use of *flammable* and *nonflammable*. The terms *flammable* and *nonflammable* shall be used in specifications in lieu of the terms *inflammable* and *noninflammable*.

c. Use of *will*. *Will* may be used only to express a declaration of purpose on the part of the government or when simple futurity is required in stating a fact. Because of these limitations, the use of *will* should be infrequent in specifications.

4.7 CONTRACTUAL AND ADMINISTRATIVE REQUIREMENTS

The specification should not include contractual or administrative requirements which are properly a part of the contract or of the SOW. For example, do not include costs, item quantities, delivery of data, data item descriptions, management system requirements, method of payment, warranty provisions, or provisions for disposing of items damaged or destroyed in tests. The DoD standardization documents listed in DoD Directive 5000.19L, Vol II, *Acquisition Management Systems and Data Requirement Control List (AMSDL)*, should not be referenced in the specification. The exception might be a reference to a management document to incorporate technical requirements that it contains if they are of a type or volume that would make extraction impractical.

NO DATA

5. LANGUAGE STYLE

5.1 GRAMMAR

The *United States Government Printing Office Style Manual* shall be used as a guide to capitalization, spelling, punctuation, syllabification, and language style. Additional guidelines that should be followed are:

a. In stating limitations, the phrase shall be stated thus: *The diameter shall be not greater than* ... for maximum limit or *The diameter shall be not less than* ... for minimum limit.

b. Capitalize the words *drawing*, *bulletin*, and so forth, only when they are used immediately preceding the number of the referenced document. However, specifications, standards, and handbooks will be identified in the text only by their document identifier (MIL-E-000, not Specification MIL-E-000).

5.2 REFERENCING

Be sure to read the specific issue of a referenced document to assure the applicability of the requirements. Tailoring of the references should be accomplished to limit the applicability of the requirements. Additional guidelines that should be followed are:

a. Referenced documents shall be cited thus:

(1) *conforming to ...*

(2) *as specified in ...*

(3) *in accordance with ...*

In any case, use the same wording throughout a given document and a series of directly related documents.

b. *Unless otherwise specified* shall be used to indicate an alternative course of action. The phrase shall always come at the beginning of the sentence and, if possible, at the beginning of the paragraph.

c. When referring to a requirement in the specification which is obvious or not difficult to locate, the simple phrase *as specified herein* is sufficient and should be used.

d. The phrase *...to determine compliance with...* or *...to determine conformance to...* should be used in place of *...to determine compliance to....* In either case, use the same wording throughout.

Note that the identification number, version, applicable change notice, date of issue, and complete title are given in Section 2 for the referenced documents. The reference to a document within the text, however, should be by the identifier number only and should not indicate the version, applicable change notice, date of issue, or title for the document. In that way, discrepancies can be avoided between the text reference and the Section 2 listing. Also, revisions to documents can be incorporated simply by revising the listing in Section 2. For a similar reason, references never should be made to paragraph numbers of the referenced documents listed in Section 2. References in the text that limit the applicability of a document should indicate the subject matter (usually the paragraph title) rather than the paragraph number.

5.3 NUMBERS

Numbers that include decimal digits and numbers 10 and larger are always written using the actual digits, such as, 0.03, 6.1, 10, 10.1, 151, 1510.2, and so forth. The sentence structure used should be such that numbers expressed using digits do not begin a sentence. Numbers one through nine usually are written out unless they are for units of measurement or are closely associated with the use of digits. For example, a person should write one dog, 2 meters, three books, 4 ohms, five buildings, 6 seconds, seven chairs, 8 volts, or nine apples, if each item and number were isolated from the others. That sentence, however, does not illustrate good practice, because the use of digits, or numbers written out, should be consistent within the same sentence and within the same paragraph or related paragraphs. The use of all digits would be the best practice in the example and in most cases.

NO DATA

6. FORMAT

The format used for a specification is intended to help present the requirements to readers in a clear and logical manner. Inconsistencies in format and organization can distract a reader from understanding the requirements presented. In addition, time may be wasted trying to find material or trying to decide if there are some hidden meanings implied by the format inconsistencies. Therefore, consistent format rules should be established and uniformly followed throughout each specification. Variations from the MIL-STD-490 format rules have been made in a few cases in this guidebook, when the variation represents a current practice and the variation is consistent with more recent standardization documents, such as DoD 4120.3-M.

Although the format guidelines chosen for a document are a matter of personal preference, there are many advantages that accrue by the consistent use of the same rules in all specifications. The guidelines presented are intended to provide the basis to achieve this desired format consistency. On the other hand, some format variations may be appropriate among various specifications depending upon the following:

a. Length of the document

b. Number of major headings (sections plus appendices)

c. Content of the document such as the number and size of figures and tables

d. Limitations of the equipment to be used in the document preparation (word processor, typewriter, typesetter, etc.)

e. Documentation standards of the preparing organization

In all cases, the page size shall be 8-1/2 x 11 inches with a 2-inch margin at the binding edge to allow large-size three-hole punching and binding. A 3/4-inch margin at the top of the page, above the header, and a 1/2-inch margin at the bottom of the page, below the page number, should be provided. Printing should be single spaced on both sides of the paper.

6.1 TITLE PAGE

The first page of the specification is the title page and cover. It includes the specification number, the appropriate federal supply code of the preparing organization from Cataloging Handbook H4-1 (code identification number), and date of issue in the upper right corner. If no contractor is involved in preparing the specification, the code identification number of the preparing government organization is used. The federal supply code for specifications prepared by SSD is 07868 as shown in Appendix A. The specification title is centered a few lines lower, and, down the page, the contract number, the CDRL sequence number, the name of the acquisition agency that the specification was prepared for, and finally the name of the organization preparing the specification.

If the specification has a security classification, the title page, and all other pages, must be marked in accordance with provisions of the DoD Industrial Security Manual for classified material, DoD 5220.22M, and other applicable security instructions. The title page is page i but is unmarked. The back of the title page is ii when the specification is printed on both sides of the paper. Page ii may contain coordination or approval signatures, or it may be left blank.

6.2 TABLE OF CONTENTS

A table of contents should be included as part of the specification if the specification is lengthy, i.e., over 30 pages in length. The table of contents, if included, would start on page iii if the specification were printed on both sides of the paper. This page begins with the heading "CONTENTS" in capital letters. Identification numbers and headings for sections, subsections, and paragraphs shall be shown in the listing (three digits) and may be shown for subparagraphs (four digits). The contents also shall include a reference to all appendices and the index. The contents should include a separate listing for the figures and tables, particularly when the figures or tables are not incorporated in the text adjacent to the paragraph where they are referenced A separate caption FIGURES shall head the list of figures, and a caption TABLES shall head the list of tables. Page numbers shall be shown for each listing in the table of contents.

6.3 PAGE HEADER

A page header identifying the document and the date of issue is in the upper corner of each page of the document opposite the binding edge, i.e., in reversed position when printed on both sides of the page. The basic page header for an appendix should be the same as the header for the associated document. The appropriate appendix identification, such as "Appendix A," should be added to the basic page header for each appendix if there are numerous appendices or if one of the appendices is lengthy or separately bound.

6.4 SECTION FORMATS

Most specifications, particularly those longer than 30 pages, are prepared in a sectionalized style format where each section starts at the top of an odd-numbered page. In the sectionalized style format, the section heading is centered at the top of the page and starts on the third line below the page header. The section heading includes the section number, and the section title is on the second line below the section number. The section heading should not be underlined but should be typed with all capital letters or printed in bold face type. Three blank lines should follow the section heading to set it apart from the first subsection heading (or text).

Short specifications, such as those less than 30 pages, should be prepared in a continuous style format with the section number and title on the same line and starting flush left. The title is typed in all capital letters without underlining or alternatively may be printed in boldface type. The first section starts at the top of page 1, but subsequent sections are separated from the text in the prior paragraph by two blank lines. A blank line should follow the section heading to set it apart from the first subsection heading (or text).

6.5 SUBSECTION AND PARAGRAPH HEADINGS

Subsections, paragraphs, and subparagraphs are numbered consecutively within each section of the specification, using a decimal point to separate the number representing each breakdown. The subsection numbers start flush with the left margin, and the paragraph numbers and subparagraph numbers are tabbed in five spaces from the left margin. The titles start on the same line two spaces from the end of the number. The subsection titles should be typed with all capital letters and underlined or printed in boldface type. Paragraph and subparagraph titles have the initial letter of each significant word in the title capitalized, and the titles are underlined or printed in boldface type. A blank line separates the subsection, paragraph, and subparagraph headings from prior text, listings, or headings.

A subtier breakdown always has two or more elements. What would otherwise be a single subtier paragraph or subparagraph should be incorporated into the parent paragraph. Note that all the titles used in the first tier subparagraph of a parent paragraph should be different and should not duplicate the heading for the parent paragraph.

The following outline illustrates the general format for the headings of a Section 3 and of the subsections and subparagraphs.

Example

SECTION 3
TITLE
3.1 FIRST SUBSECTION TITLE (No text follows)
3.1.1 First Paragraph Title. (Text follows)
3.1.1.1 First Subparagraph Title. (Text follows)
3.1.1.2 Second Subparagraph Title. (Text follows)
3.1.2 Second Paragraph Title. (Text follows)
3.2 SECOND SUBSECTION TITLE (No Text follows)

6.6 LISTINGS

Short lists of items within the text are identified by small letters, i.e., a., b., c., and so forth, and usually are run into the sentence structure within the paragraph. When it is desirable to highlight the listing, or if the listing is lengthy or complex, an indented block style is used for the listing. A lengthy listing is one with six or more elements. A complex listing is one that has text associated with the elements in the list or that has a second tier list, i.e., a list within a list.

The elements in the first tier listing in the block style are identified by small letters, i.e., a., b., c., and so forth, that are tabbed in 10 spaces from the left margin. Second-tier listings (listings within a listing) are identified by sequential numbers in parentheses, i.e., (1), (2), (3), and so forth, that are tabbed in 15 spaces from the left margin. Usually, listings do not have extensive text with each element and do not have titles. Where titles are used, the titles would be formatted similar to a paragraph title but blocked with the text associated with the listing. A blank line is used to separate items in a listing from prior items in the listing or from prior text.

In those cases in which the text associated with a listing is lengthy, i.e., more than two sentences per element, consideration should be given to reformatting. Typically, the material should be arranged as a series of subtier paragraphs under the parent paragraph. In other words, the extensive text that had been drafted as elements of the listing would become subtier paragraphs. In some cases, it may be desirable to retain the highlighting feature of a listing, even when there is extensive text associated with each element. In that case, each of the elements should be given an identifying name, and a listing would be prepared listing those names. The extensive text then should be arranged as subtier paragraphs that would follow the listing that identifies each of tne elements.

6.7 TEXT FORMATTING

The organization of the text in a specification should require paragraph numbering of no more than six digits, and listings, if used, should be limited to two tiers within any paragraph or subparagraph. If the proposed text cannot easily conform to these restrictions, serious consideration should be given to the transfer of some of the proposed text to subtier specifications or other documents that could then be referenced. Quite often, this creation of a subtier specification or other type of document that can be referenced helps clarify the requirements. For example, the creation of a preliminary space vehicle specification rather early in the acquisition process may help simplify and clarify a space system segment specification. A reference to the vehicle specification in the segment specification would retain the requirements but would transfer the text of the detailed requirements applicable only to space or to the space vehicle from the segment specification to the vehicle specification. This would reduce the bulk of the segment specification and clearly would distinguish requirements applicable only to space or that have been allocated to the space vehicle.

When text is associated with a numbered paragraph or subparagraph, a period is placed at the end of the title, and the text is run in on the same line following the period. Subsequent lines of text are continued flush with the left margin.

When text is associated with a listing, it is prepared in a block format with the left margin of the listing tabbed in 15 spaces from the left margin of the specification for first-tier listings and tabbed in 20 spaces for second-tier listings.

In some cases, an untitled paragraph may be used to highlight material or to provide additional organization to lengthy material. Untitled paragraphs are not numbered. Untitled paragraphs start with the first word of the first line tabbed in five spaces and continue with subsequent lines flush with the left margin. A blank line is used to separate untitled paragraphs from prior text, listings, or other material.

In some cases, text is directly associated with a section heading or with a subsection heading. In that case, it would be formatted like an untitled (unnumbered) paragraph. The text starts with the first word of the first line tabbed in five spaces and continues with subsequent lines flush with the left margin.

6.8 FORMAT OF APPENDICES

Each appendix should be formatted as though it were a major section of the specification. However, a sectionalized style is always used, so the appendix would start at the top of an odd-numbered page. The heading is centered at the top of the first page and starts on the third line below the page header. The heading includes the identification, such as APPENDIX A, and the title on the second line below. The heading (including the title) should be typed with all capital letters or printed in boldface type. Three blank lines should follow the section heading to set it apart from the first subsection heading (or text).

Subsections and subtier paragraphs in an appendix are formatted similar to the equivalent tier level in the body of a specification prepared in a sectionalized format.

A separately bound appendix would include a separate title page and a table of contents prepared similar to that for a specification.

6.9 PAGE NUMBERING

Page numbers shall be either centered at the bottom of each page or placed in the lower corner of the page opposite the binding edge, i.e., in reversed positions when printed on both sides of the page. Page numbers should be printed on otherwise blank pages, and those pages should be marked "THIS PAGE INTENTIONALLY LEFT BLANK."

Pages usually are numbered consecutively throughout the document with arabic numerals starting with page 1 corresponding to the page where Section 1, SCOPE, starts. As indicated previously, the foreword, table of contents, and any other pages prior to page 1 in the document are numbered consecutively with lower case Roman numerals starting with ii as the page after the title page.

When the specification is prepared in a sectionalized style format with each section starting at the top of an odd-numbered page, either continuous style pagination as described above or sectionalized style pagination may be used. For sectionalized style pagination, a reference number representing the section number is used with a sequential page number within each section. For example, the page numbers for Section 3 would start 3-1, 3-2, 3-3, and so forth and for Section 4 would start 4-1, 4-2, 4-3, and so forth. If sectionalized pagination is used for the body of the specification, it should be used for the appendices. The page numbers for Appendix A therefore would be A-1, A-2, A-3, and so forth, to the end of Appendix A.

The selection of the sectionalized style pagination is recommended, if the document is produced on a typewriter. Continuous style pagination usually is used if the document is prepared on word processing equipment. With most word processing systems, continuous style pagination is accomplished easily, whereas sectionalized style pagination may require the creation of separate word processor documents for each section. The creation of separate word processor documents can cause coordination problems in formatting, word searches, editing, and final printing. Therefore, when word processor preparation is used, sectionalized pagination is recommended only for extremely long documents and, as indicated below, for appendices.

Appendices usually are integrally bound with the specification, and the page numbers then may be the sequential continuation of those used in the body of the specification. However, even when continuous style pagination is used in the body of the specification, it would be desirable to paginate the appendices in a sectionalized style if they are lengthy, numerous, or separately bound. In that case, sequentially number the pages of each appendix starting with its first page. A reference letter should be used with the page number to identify the appendix. For example, the page numbers for Appendix A would be A-1, A-2, and so forth and for Appendix B would be B-1, B-2, and so forth.

6.10 TABLES

A table is an arrangement of data in lines and columns. It shall be used when data can be presented more clearly in this manner than in text. Elaborate or complicated tables should be avoided. References in the text shall be sufficiently detailed to make the purpose of the table clear. The table shall be restricted to data pertinent to the associated text. The tables shall be placed immediately following the paragraph or within the paragraph containing the reference. If space does not permit, the table may be placed at the top of the following page. If a table is large enough to require a separate page, it should be placed on the first available page following the first reference in the text. If the number of tables in a section is so large that the tables could disrupt the understanding of the text, they should all be placed in numerical sequence at the end of the section in which they are referenced.

6.10.1 Table Format

Tables shall be boxed with border lines at the sides, top, and bottom of each table. Headings of tables should be typed to ensure that the vertical columns will accommodate the longest entry in the column to the greatest extent possible. Horizontal and vertical border lines and separation lines within the table shall be typed or drawn with black reproducible ink or reproducible pencil, if they cannot be created electronically. Where practicable, data shall be single spaced within the table and different groups of data distinguished through capitalization, indentions, or subgrouping.

6.10.2 Table Numbering and Title

All tables shall be numbered consecutively throughout the document with Roman numerals in the order of their appearance in the text. For example, table numbers would start Table I, Table II, Table III, Table IV, and so forth to the end of Section 6. Table numbers in appendices should use a sectionalized style to associate the table number with the appendix. For example, table numbers in Appendix B would start Table B-I, Table B-II, and so forth. All tables shall be titled with the initial letter of each significant word in the title capitalized. Table titles shall not be underlined and shall have a period at the end of the title. Table titles shall be centered above the table and begin on the same line with the table number. If the title of the table is too long to end on the same line, additional lines may be used. Two blank lines normally separate the bottom line of the title and the top border line around the table.

If a listing or tabulation appears within a paragraph as an integral part of that paragraph and obviously does not require a title, the listing or tabulation need not be titled, is not given a table number, and is not to be boxed in.

6.10.3 Continuation of Tables

Large tables may be broken and, if possible, printed on facing pages (even and odd pages, not on odd and even pages). If a table is continued to additional page(s), a horizontal line need not be drawn at the end of the page, unless the table is a group or method type that requires a line of separation between the groups. In that case, it is not desirable to split a group and carry part of the listing to the next page. The entire group should be completed on one page. When the table is continued to the next page, the title shall include an appropriate notation such as (Page 1 of 2 pages). Repeat the entire heading at the top of the page on which the continuation is presented with an appropriate notation such as (Continued) or (Page 2 of 2 pages). The table shall be closed with a horizontal line when all data have been typed.

6.11 FIGURES

A figure is an illustration, example, or graph and constitutes an integral part of the specification. It shall be clearly related to, and consistent with, the text of the associated paragraph. Figures should not be confused with numbered and dated drawings which shall not be an integral part of the specification but shall be incorporated by reference and listed in Section 2 of the specification. The figures shall be placed immediately following the paragraph or within the paragraph containing the reference to the figure. If a figure is large enough to require a seprate page, it should be placed on the first available page following the first reference in the text. In the case of numerous table and figure references on the same page, this may be several pages later. If the number of figures, or figures plus tables, in a section is large enough to disrupt the understanding of the text, the figures should be placed in numerical sequence at the end of the section in which they are referenced.

6.11.1 Figure Format

Figures shall be boxed in with border lines at the sides, top, and bottom of each figure. These border lines shall be typed or drawn with black reproducible ink or reproducible pencil, if they cannot be created electronically.

6.11.2 Figure Numbering and Title

All figures shall be numbered consecutively throughout the document using Arabic numerals, preferably in a sectionalized style in the order of their appearance in the text. For example, figure numbers in Section 3 would start Figure 3-1., Figure 3-2., Figure 3-3., and so forth to the end of Section 3; figure numbers in Section 4 would start Figure 4-1., Figure 4-2., Figure 4-3., and so forth; and figure numbers in Appendix A would start Figure A-1, A-2, and so forth. All figures shall be titled, with the initial letter of each significant word in the title capitalized. Figure titles shall not be underlined and shall have a period at the end of the title. Figure titles shall be centered below the illustration or graphic and shall be typed on the same line with the figure number. If the title of the figure is too long to be completed on the same line, additional lines may be used.

6.11.3 Continuation of Figures

Large figures may be broken and, if possible, printed on facing pages (even and odd pages, not on odd and even pages). When a figure is continued on the next page, the title shall include an appropriate notation such as (Page 1 of 2 pages). Repeat the entire heading below the continued figure with an appropriate notation such as (Continued) or (Page 2 of 2 pages).

6.12 FOOTNOTES

Footnotes should be avoided if possible. When footnotes are used in the text, the footnotes shall be placed at the bottom of the text on the page providing the footnote reference(s). Footnotes referenced from tables shall be identified easily as such and shall be stated one time only for each table immediately following the table. Except where ambiguity would result, superscript Arabic numerals should be used to identify the footnote reference. Alternatively, the symbol _/ may be used in conjunction with the footnote numbers (Examples: 1/, 2/, etc.) to identify both the footnote reference and the footnote. Footnotes shall be numbered consecutively starting with one (1) on each page of the specification. Where the use of Arabic numerals, the superscript, or the _/ symbol will cause ambiguity (for example, in connection with a chemical formula), asterisks, daggers, or other symbols may be used.

6.13 FOLDOUTS

Foldouts shall be avoided except where required for legibility or when necessary for the proper utilization of the data. Large tables or figures that are broken so that they may be printed on facing pages are preferred to foldouts. When foldouts are required, they should always be placed on a right-hand (odd-numbered) page. No printing and no page number should appear on the back of a foldout, but it shall be assigned an even page number for pagination purposes. Suitable reference to the location of foldouts shall be included in the table of contents.

NO DATA

7. CLASSIFIED MATERIAL

If a proposed specification contains classified material, the System Program Office may decide to separate the classified portion of the specification from the remainder of the specification. Usually that decision is made when the number of pages containing the classified material accounts for less than 24 percent of the total pages in the specification. The classified material removed from the specification would be separately bound in a classified appendix. The specification so modified would be rewritten to reference the classified appendix. If the number of pages containing classified material accounts for more than 24 percent of the total pages in the specification, the specification itself usually is classified. A classified specification or a separately bound classified appendix would be marked in accordance with provisions of the DoD Industrial Security Manual for classified material, DoD 5220.22M, and other applicable security instructions.

In a classified specification or separately bound classified appendix, the classification notation associated with each heading or item of text, i.e., (U), (C), or (S), shall be incorporated as part of the title or as part of the text when the document format rules presented in Chapter 6 of this guidebook are interpreted. However, note that the page format for a classified document requires at least a 3/4-inch margin at the bottom of each page, instead of 1/2-inch, to allow for the classification markings required.

NO DATA

8. CHANGES

After initial publication of a program-peculiar specification, many factors will necessitate making changes. These include, but are not limited to, the correction of errors, the determination of previously unspecified requirements, the allocation of requirements to lower levels of assembly, the results of life cycle cost analyses, the results from trade studies of alternatives, the introduction of new technology, the establishment of internal interface constraints, and the establishment of external interfaces. How these changes are prepared and approved depends upon the acquisition phase of the program, the contractual status of the specification, and the configuration control procedures established for the program at the time the changes are proposed and approved. If the specification represents an approved contractual document, the changes usually would be made by the program office approving specification change notices. If the specification is not on contract, or the changes are extensive, a complete revision of the specification would be made rather than issuing a change notice.

8.1 SPECIFICATION CHANGE NOTICES

A specification change notice (SCN) is used by a contractor to propose, transmit, and record changes to a program-peculiar specification. The SCN numbers are assigned in the sequence that the changes are proposed for a particular issue of a specification starting with Number 1. Each SCN is to be independent of previously proposed SCNs unless linkage is required and is clearly established by the SCN. Because all proposed SCNs may not be approved, the specification in effect on a particular date is the basic issue plus all of the SCNs that have been approved as of that date. Generally, SCNs include revised pages that replace or add to the current issue of the specification. The SCNs are not used to make or transmit complete revisions of the specification, because the SCN number sequence should start again with Number 1 for the revision.

8.1.1 Paragraph Changes

When new paragraphs are added to the specification, they should be added in such a way that renumbering of paragraphs is unnecessary. When numbered subsections or numbered paragraphs are deleted from the specification, the number should be retained so that the remaining paragraphs need not be renumbered. When the number is two or three digits, the title also should be retained and *Not applicable* added immediately following the title. When the paragraph number has four or more digits, the word *Deleted* should follow the paragraph number.

8.1.2 Table Additions

Tables added after the highest numbered table are assigned the next higher number. If tables are added between existing tables, the table number of the added tables shall be that of the preceding table, followed by a lower case alphabetical designation showing the intended order of the added tables. For example, two tables added between Table I and Table II are numbered Table Ia and Table Ib, and two tables added between Table Ia and Table Ib are numbered Table Ia-1 and Table Ia-2.

8.13 Figure Additions

Figures added after the highest numbered figure are assigned the next higher number. If figures are added between existing figures, the number of the added figure shall be that of the preceding figure followed by a lower-case alphabetical designation showing the intended order of the added figures. For example, two figures added between Figures 3-1 and 3-2 are numbered 3-1a and 3-1b.

8.1.4 Page Changes

Generally, revised pages are prepared on which the desired changes have been incorporated. These revised pages usually are prepared for direct incorporation in the specification by the removal of old pages and the insertion of the new pages. All revised pages are identified in the header by the incorporation of the date of issue of the SCN directly below the specification number. All portions affected by the change shall be indicated by an asterisk or line in the right-hand margin indicating all changed portions. If a revised page replaces an original page, the revised pages would be numbered the same as the page it replaces. If an additional page is to be inserted in revising a page or pages, it shall be identified by the previous page number followed by the small letter *a*. For example, if the specification were printed on both sides of the paper, and if three revised pages were to be issued to replace the original Page 8, then the SCN would transmit two sheets printed on both sides. The first sheet would have the original Page 7 reproduced with the revised Page 8 printed on the back side. The second sheet would be identified as Page 8a and, on the back side, the third revised page would be marked Page 8b. Pages 8, 8a, and 8b would incorporate the SCN date in the header to indicate they are page changes.

8.2 REVISIONS

A revision is a complete reissue of the revised document. A revision is accomplished only with the specific approval of the contracting officer. Normally, this occurs when the number of change notices becomes excessive, or when it serves the purposes of the program office. At that time, the entire specification should be analyzed and brought up to date by the revision. The revision is prepared as a new document incorporating, as a minimum, all approved SCNs. A revision would be approved in the same manner as a new specification. A specification revision is indicated by incorporating a capital letter immediately following the specification number. The first revision would be marked with the letter *A*, and succeeding revisions would be indicated by other letters in alphabetical sequence. The date of issue would be changed to the date of the reissue.

For the convenience of those using the revision, the margins may be marked with an asterisk or line to indicate where new additions, modifications, corrections, or deletions from the previous issue were made. If the changes are marked, a note of caution should be included in the Notes section. That note would state:

The margins of this specification are marked with an asterisk (or line) as a convenience to indicate where changes were made from the previous issue (through SCN __). The government assumes no liability whatsoever for any inaccuracies in the notations. Bidders and contractors are cautioned to evaluate the requirements of the document based on the entire content, irrespective of the marginal notation and relationship to the previous issue.

In general, marking of the changes is not done in revisions of program-peculiar specifications at SSD; in that case, a statement to that effect should be included in the Notes section. That note would state:

Symbols are not used in this revision to identify changes with respect to the previous issue.

APPENDIX A
MODEL SPACE SYSTEM SPECIFICATION

This appendix is a Model space system specification containing typical boilerplate requirements.

APPENDIX A

SPEC NUMBER SS-01
CODE IDENT 07868
15 OCT 91

SYSTEM SPECIFICATION

FOR

(TBS - INSERT SPACE SYSTEM AND PROGRAM NAME)

CONTRACT NO. (TBS - INSERT CONTRACT NUMBER)

CDRL SEQUENCE NO. (TBS - INSERT CDRL SEQUENCE NUMBER)

Prepared for:

(TBS - INSERT CONTRACTING AGENCY NAME AND DEPARTMENT CODE)

Prepared by:

(TBS - INSERT CONTRACTOR NAME AND ADDRESS)

Authenticated by____________________ (Contracting Agency)

Approved by__________ (Contractor)

Date ____________________________

Date__________________

This Appendix is part of Aerospace Report No.
TR-91(2904-12)-
(SSD-SR-91-??)

CONTENTS

CONTENTS (Continued)

CONTENTS (Continued)

CONTENTS (Continued)

CONTENTS (Continued)

CONTENTS (Continued)

CONTENTS (Continued)

CONTENTS (Concluded)

FIGURES

TABLES

SECTION 1

SCOPE

1.1 IDENTIFICATION

This system specification sets forth the requirements of the (TBS - insert space system title or nomenclature) space system. This system is a major element of the (TBS - insert program identification). This system is identified as (TBS - insert system identification number or abbreviation, if applicable) and is hereinafter referred to as the system.

1.2 SYSTEM OVERVIEW

This system (TBS - insert brief statement of the purpose or major function of the system).

1.3 DOCUMENT OVERVIEW

This specification sets forth the performance, design, development, construction, and test requirements of the system. This specification is intended for compliance in the acquisition contract for the system.

The term *"TBD"* applied to a missing requirement means that the contractor should determine the missing requirement in coordination with the government. The term *"TBS"* means that the government will supply the missing information in the course of the contract. The term *"TBR"* means that the requirement may be reviewed for appropriateness by the contractor or the government and may be changed by the government in the course of the contract.

1.4 SYSTEM CLASSIFICATIONS

The operational capability of this system is to be implemented incrementally such that the system can transition without major disruption through the following baseline classifications:

a. IOC System (initial operational capability system)

b. MOC System (middle operational capability system)

c. FOC System (final operational capability system)

The requirements stated in this system specification that are not identified as applying to a specific system classification apply to all of the system classifications. Requirements stated as applying to the initial operational capability system also apply to the middle operational capability system and the final operational capability system, unless stated otherwise in the text.

SECTION 2

APPLICABLE DOCUMENTS

2.1 GOVERNMENT DOCUMENTS

The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, see Section 3.8.

SPECIFICATIONS:

Federal

QQ-N-290A 12 Nov 71	Nickel Plating (Electrodeposited)
QQ-C-320B 10 Apr 87	Chromium Plating (Electro-deposited)

(TBS)

Military

MIL-M-3171C 14 Mar 74 Notice 3	Magnesium Alloy, Processes for Pretreatment and Prevention of Corrosion on
MIL-E-4158E (USAF) 11 Jan 73 Amendment 3 31 Dec 85	Electronic Equipment, Ground; General Specifications for
MIL-C-5541C 4 Apr 81	Chemical Conversion Coatings on Aluminum Alloys
MIL-F-7179F 20 May 85	Finishes, Coatings, and Sealants for the Protection of Aerospace Weapons Systems, General Specification for

APPENDIX A

MIL-M-8090F 01 Feb 74	Mobility, Towed Aerospace Ground Equipment, General Requirements for
MIL-A-8421F 25 Oct 74 Notice 1, 28 May 87	Air Transportability Requirements, General Requirements for
MIL-S-8516E 29 Sep 72	Sealing Compound, Polysulfide Rubber, Electric Connectors and Electric Systems, Chemically Cured
MIL-A-8625D 30 Jun 85	Anodic Coatings, for Aluminum and Aluminum Alloys
DOD-E-8983C 29 DEC 77	Electronic Equipment, Aerospace, Extended Space Environment, General Specification for
MIL-F-14072C 01 Jun 86	Finishes for Ground Electronic Equipment
MIL-S-19500G 22 Sep 86 Supplement 1, 11 Mar 85 Supplement 1B, 24 Aug 87 Amendment 1, 25 Aug 87	Semiconductor Device, General Specification for
MIL-S-23586E 10 Jul 87	Sealing Compound, Electrical, Silicone Rubber, Accelerator Required
MIL-C-28748A 04 Feb 85 Supplement 1	Connector, Electrical, Rectangular, Rack and Panel, Solder Type and Crimp Type Contacts, General Specification for

MIL-M-38510H 12 Feb 88 Supplement 1, 08 Mar 88 Amendment 1, 31 Aug 88	Microcircuit, General Specification for
MIL-C-38999H 30 Sep 86 Supplement 1	Connector, Electrical, Circular, Miniature, High Density, Quick Disconnect (Bayonet, Threaded, and Breech Coupling), Environment Resistant, Removable Crimp and Hermetic Solder Contacts, General Specification for
MIL-C-55302E 09 Apr 86	Connectors, Printed Circuit Subassembly and Accessories
MIL-I-81550C 14 Jul 83	Insulating Compound, Electrical, Embedding, Reversion, Resistant Silicon
MIL-S-81733C 13 Mar 80	Sealing and Coating Compound, Corrosion Inhibitive
DOD-W-83575A 22 DEC 77	Wiring Harness, Space Vehicle, Design and Testing, General Specification for
MIL-S-83576 01 Nov 74	Solar Cell Arrays, Space Vehicle, Design and Testing, General Specification for
MIL-A-83577B 01 FEB 88	Assemblies, Moving Mechanical, for Space and Launch Vehicles, General Specification for
DOD-E-83578A 15 OCT 87	Explosive Ordnance for Space Vehicles, General Specification for
MIL-C-83723D 27 Dec 77 Supplement 1	Connector, Electrical (Circular, Environment Resisting) Receptacles and Plugs, General Specification for

Other Government Activity Specifications

(TBS - include any Program Specifications)

STANDARDS:

Federal

(TBS)

Military

MIL-STD-171D 29 Feb 80	Finishing of Metal and Wood Surfaces
MIL-STD-454K 14 Feb 86 Notice 1, 29 Aug 86 Notice 2, 26 Feb 87 Notice 3, 10 Sep 87 Notice 4, 12 Feb 88	Standard General Requirements for Electronic Equipment
MIL-STD-721C 12 Jun 81	Definitions of Terms for Reliability and Maintainability
MIL-STD-889B 21 Nov 79 Notice 1, 04 Mar 79 Notice 2, 04 Mar 88	Dissimilar Metals
MIL-STD-1246B 04 Sep 87	Product Cleanliness Levels and Contamination Control Program
MIL-STD-1250 31 Mar 67	Corrosion Prevention and Deterioration Control in Electronic Components and Assemblies
MIL-STD-1472C 31 DEC 74 Notice 1, 01 Sep 83 Notice 2, 10 MAY 76 Notice 3, 17 MAR 87	Human Engineering Design Criteria for Military Systems, Equipment, & Facilities

MIL-STD-1474B 18 Jun 79 Notice 1, 10 Oct 84 Notice 2, 20 Apr 84	Noise-limits For Army Materiel
MIL-STD-1522A 28 MAY 84 Notice 1, 21 Dec 84 Notice 2, 20 Nov 86	Standard General Requirements for Safe Design and Operation of Pressurized Missile and Space Systems
MIL-STD-1539 73 AUG 01	Electrical Power, Direct Current, Space Vehicle Design Requirements
MIL-STD-1540B 10 OCT 82 Notice 1, 31 Jul 89	Test Requirements for Space Vehicles
MIL-STD-1541A 31 DEC 87	Electromagnetic Compatibility Requirements for Space Systems
MIL-STD-1542A(USAF) 01 MAR 88	Electromagnetic Compatibility (EMC) and Grounding Requirements for Space System Facilities
MIL-STD-1547A 01 DEC 87	Electronic Parts, Materials, and Processes for Space and Launch Vehicles
MIL-STD-1568A 24 Oct 79	Materials and Processes for Corrosion Prevention and Control in Aerospace Weapon Systems
MIL-STD-1574A(USAF) 15 Aug 79	System Safety Program for Space and Missile Systems
DOD-STD-1578B 01 JAN 87	Nickel-cadmium Battery Usage Practice for Space Vehicles
MIL-STD-1589C 06 JUL 84	JOVIAL (J73)
ANSI/MIL-STD-1815A 22 Jan 83	Ada Programming Language

Other Government Activity Standards

(TBS)

DRAWINGS:

(TBS)

OTHER PUBLICATIONS:

Manuals

(TBS)

Regulations

(TBS)

(TBS)

Handbooks

MIL-HDBK-5E 01 JUN 87 Notice 1, 01 May 88	Aerospace Vehicle Structures, Metallic, Materials and Elements for
MIL-HDBK-17A 01 SEP 73 Notice 1, 08 Jun 87	Plastics for Aerospace Vehicles - Part 1, Reinforced Plastics
MIL-HDBK-17A 08 JUN 77	Plastics for Aerospace Vehicles - Part II, Transparent Glazing Materials
DOD-HDBK-263 02 May 80	Electrostatic Discharge Control Handbook for Protection of Electrical and Electronic Parts, Assemblies and Equipment
MIL-HDBK-340 01 Jul 85 Notice 1, 31 Jul 89	Application Guidelines for MIL-STD-1540B; Test Requirements for Space Vehicles

OTHER GOVERNMENT DOCUMENTS, DRAWINGS, AND PUBLICATIONS

FIPS PUB 1	Code for Information Interchange (Federal Information Processing Standard; National Bureau of Standards. This document is the same as ANSI-STD X 3.4-1968.)
SP-R-0022	Vacuum Stability Requirements of Polymeric Materials for Spacecraft Applications (NASA JSC)
SAMTO HB S-100	Space Transportation System Payload Ground Safety Handbook (Joint NASA/Air Force document designated by NASA as KHB 1700.7)
KHB 1700.7	Space Transportation System Payload Ground Safety Handbook (Joint NASA/Air Force document designated by the Air Force as SAMTO HB S-100)
NHB 1700.7	Safety Policy and Requirements for Payloads Using the Space Transportation System (STS) (NASA)
JSC 07700	Space Shuttle System Payload Accommodations, Vol XIV, (NASA JSC)

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

2.2 NONGOVERNMENT DOCUMENTS

The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, see Section 3.6.

SPECIFICATIONS:

(TBS)

STANDARDS:

AMERICAN NATIONAL STANDARDS INSTITUTE

ANSI STD X 3.4-1968 — Code for Information Interchange (Federal Information Processing Standard; National Bureau of Standards; FIPS PUB 1)

Application for copies should be addressed to:
American National Standards Institute
10 E. 40th Street
New York, NY 10016

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS

ANSI/IEEE Std 416-1978 — IEEE Standard Atlas Test Language

Application for copies should be addressed to:
Institute of Electrical and Electronics Engineers, Inc.
345 E. 47th Street
New York, NY 10017

DRAWINGS:

(TBS)

OTHER PUBLICATIONS:

(TBS)

(Technical society and technical association specifications and standards generally are available for reference from libraries. They also are distributed among technical groups and using federal agencies. The contracting officer should be contacted regarding the availability of any referenced document not readily available from other sources.)

SECTION 3

SYSTEM REQUIREMENTS

3.1 DEFINITION

3.1.1 System Description. This system (TBS - insert statement of the purpose or major functions of the system and identify other systems with which it interfaces). The major functional areas within the system include operational support functions, logistic support functions, computer software maintenance functions, training functions, and (TBS).

3.1.2 System Segments. The space system is an element of the (TBS - insert program). For convenience, the system has been subdivided into the following major system segments:

a. Space system segment

b. Ground terminal system segment

c. Data reduction system segment

d. (TBS - other system segments)

3.1.3 Specification Tree. The specification tree for the system is shown in Figure 3-1. The specification tree for the space vehicle system segment is shown in Figure 3-2. (If known at the time the system specification is prepared, the subtier configuration items in each system segment also would be identified.) The specification tree for the space vehicle is shown in Figure 3-3.

3.1.4 Top-Level System Functions

3.1.4.1 Top-Level System Functional Relationships. The top-level functional flow diagram for the system is shown in Figure 3-4. A more detailed functional flow diagram for the system is shown in Figure 3-5.

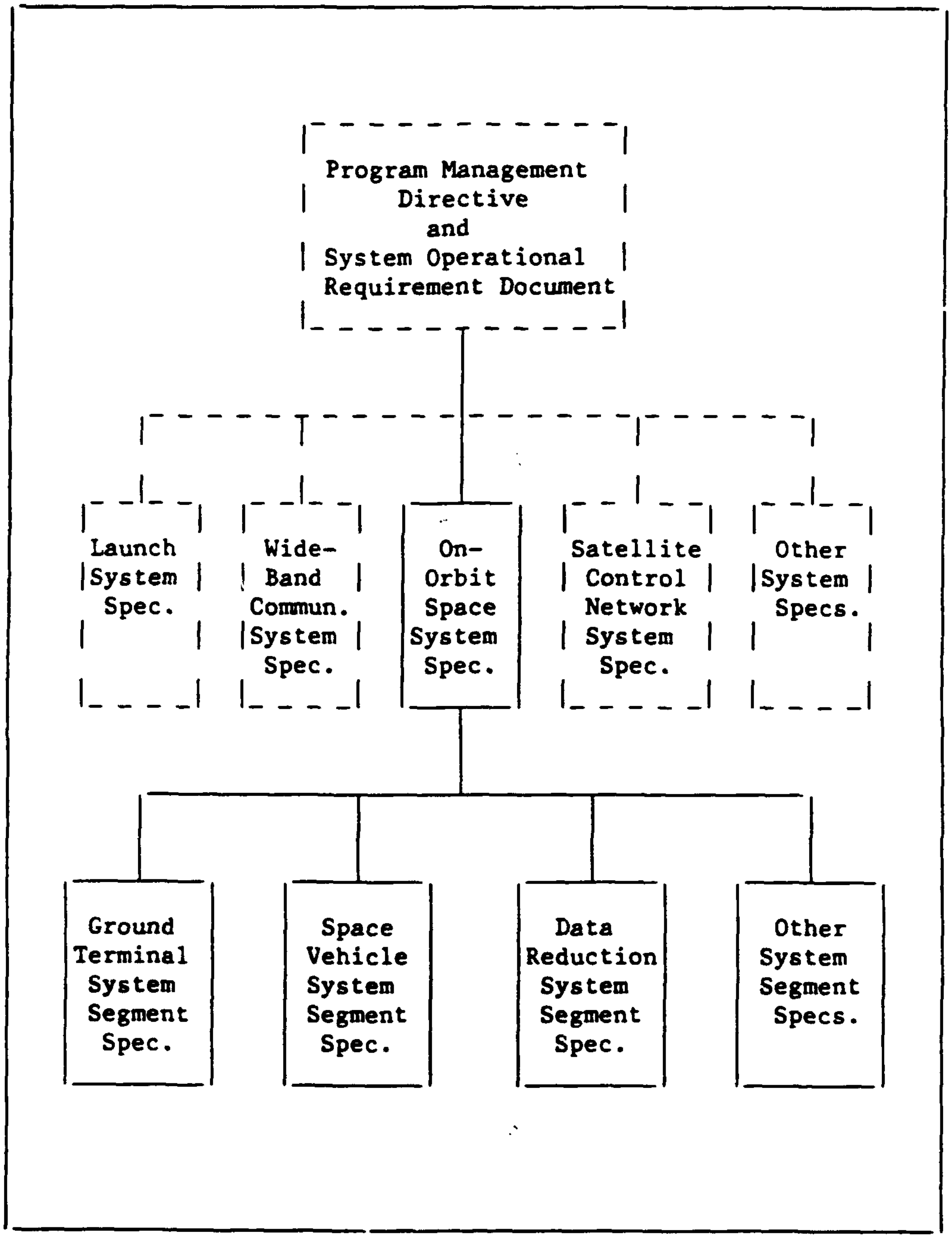

Figure 3-1. On-orbit Space System Specification Tree.

(Interfacing Systems Shown By Dashed Lines)

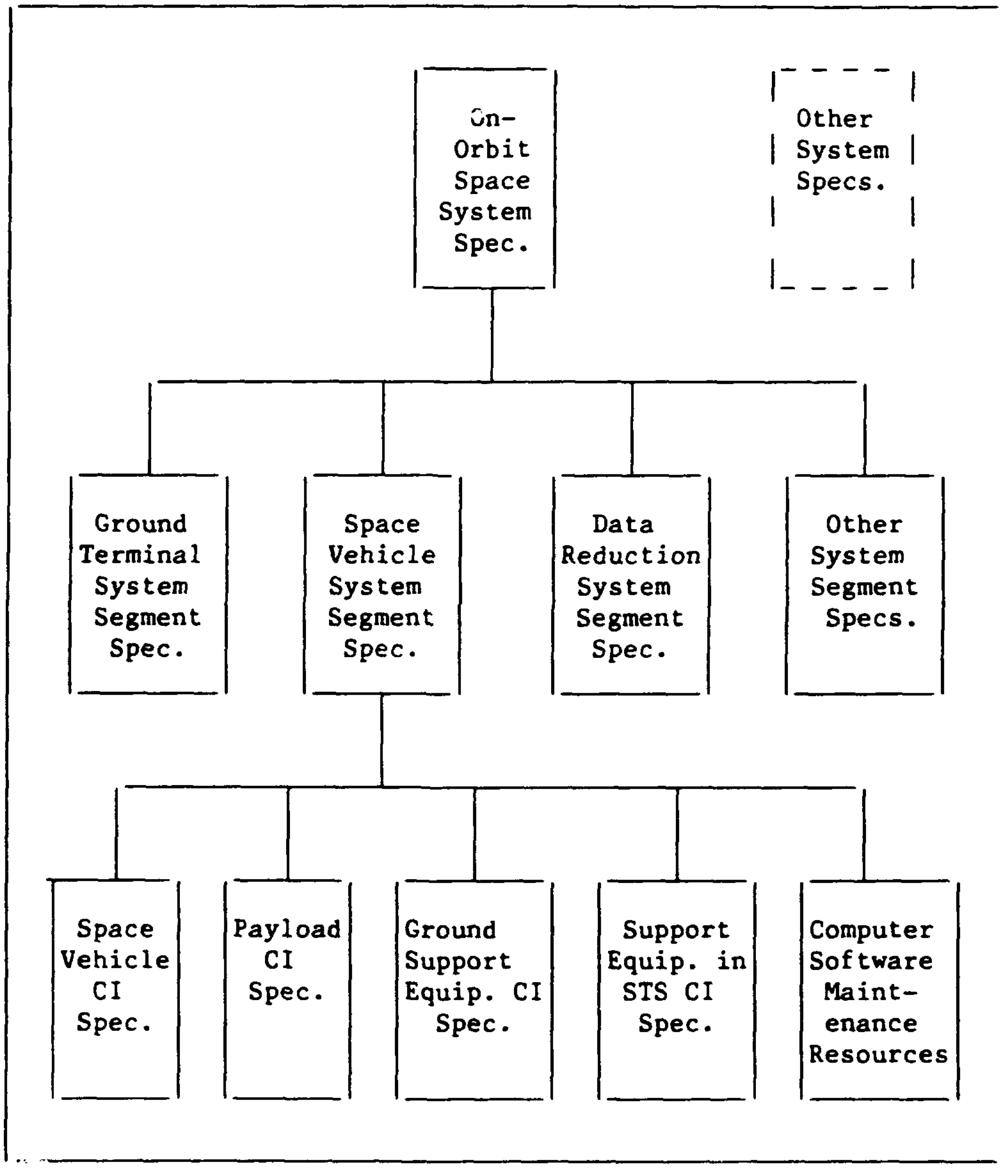

Figure 3-2. Space Vehicle System Segment Specification Tree.

Space Vehicle CI Spec.

- --- Propulsion subsystem CIs
- --- Thrust vector control subsystem CIs
- --- Reaction control subsystem CIs
- --- Data management subsystem CIs
- --- Computer software subsystm CIs
- --- Electrical power subsystem CIs
- --- Guidance and navigation subsystem CIs
- --- Telemetry, tracking, and command subsystem CIs
- --- Structural subsystem CIs
- --- Thermal control subsystem CIs
- - - Payload subsystem CIs (if appropriate)

Figure 3-3. Space Vehicle Specification Tree.

System Inputs — System Outputs

- Operational support functions
- Logistic support functions
- Computer software maintenance functions
- Training functions
- (TBS)

Figure 3-4. Top-level Functional Flow for the System.

TBS

Figure 3-5. Detailed Functional Flow for the System.

3.1.4.2 Description of System Functions. (TBS - List the major system functions and insert a subparagraph for each specific function named that describes the function, its purpose, and identifies its inputs and outputs to the extent known. The states and modes in which each function operates also shall be described to the extent known.)

3.1.4.3 Missions. (TBS)

3.1.4.4 Threat. The system is subject to the threat described in Appendix A.

3.1.5 System States and Modes. After initial deployment, the system may be commanded or be sequenced through the following states and modes:

a. Prelaunch state

1. Ground storage mode
2. Ground transportation mode
3. Launch pad assembly mode
4. Prelaunch countdown mode

b. Launch state

1. Launch mode
2. Orbit injection mode

c. Operational state

1. Standby mode, ground equipment
2. Standby mode, on-orbit equipment
3. Normal operational mode
4. Eclipse operational mode, on-orbit equipment
5. Maintenance mode, ground equipment
6. Maintenance mode, computer software
7. Maintenance mode, on-orbit equipment

d. Space vehicle recovery state

1. Space vehicle reentry mode
2. Space vehicle landing mode
3. Space vehicle refurbishment mode

e. (TBS - Other)

3.1.6 Operational and Organizational Concepts. The system supports a space vehicle launch and possible retrieval using the Space Transportation System (STS) or a launch using the (TBS) expendable launch vehicle. On-orbit operations are planned to be controlled from the mission control center (MCC) located (TBS) and remote tracking stations located (TBS).

3.1.6.1 STS Operational Concept. The following STS operational concept is supplied as a guide for use in the system design and for the preparation of operational plans and test plans.

3.1.6.1.1 STS Prelaunch. The space vehicle would be transported directly to the launch base where final space vehicle preparations and checkout would be accomplished at the Payload Preparation

Room of the STS launch facility. Final intersegment and launch verification tests would be accomplished after space vehicle and associated equipment installation in the STS and prior to launch.

3.1.6.1.2 STS Launch. During STS ascent to the parking orbit, various space vehicle subsystems or system equipments may be powered on or turned off in order to provide protection from the STS environments or to comply with STS safety requirements. Space vehicle telemetry to monitor vehicle status would be provided to the STS for monitoring and retransmission (in real time or playback) to the ground monitoring stations.

3.1.6.1.3 STS Parking Orbit Operations. While the space vehicle is attached to the STS, vehicle telemetry to monitor vehicle status continues to be provided to the STS for monitoring and retransmission (in real time or playback) to the ground. When the space vehicle is released from the STS, responsibility for monitoring and control would be transferred to the ground MCC. The STS may provide assistance for the resolution of anomalies when requested by the MCC. In the event of unsatisfactory deployment or unsatisfactory space vehicle checkout, the STS would retrieve the vehicle and return to the launch site.

3.1.6.1.4 Space Vehicle Orbit Injection. After release by the STS and successful vehicle checkout and appendage deployment, the vehicle would boost itself (or would be boosted) into its operational orbit under command from the ground.

3.1.6.2 Expendable Launch Vehicle Operational Concept. When the use of an expendable launch vehicle is planned, the following operational concept is the guide for use in the system design and for the preparation of operational plans and test plans.

3.1.6.2.1 Prelaunch. The space vehicle would be transported directly to the launch base where final vehicle preparations and checkout would be accomplished on the launch vehicle after mating. Final intersegment and launch system verification tests are accomplished prior to launch.

3.1.6.2.2 Launch and Injection. During launch and injection to the operational orbit, the various vehicle subsystems may be powered on or turned off in order to provide protection from the launch and injection environments or to comply with other specified requirements. Space vehicle telemetry to monitor vehicle status would be provided during launch and injection. Transmission using the launch vehicle telemetry may satisfy this requirement during the launch phase. Space vehicle telemetry transmission to ground monitoring stations would be used to the extent practicable during the injection phase. After release by the booster and reception of appropriate ground commands, the space vehicle would deploy appropriate appendages and boost itself (or would be boosted) into its operational orbit.

3.1.6.3 On-orbit Operational Concept. The following on-orbit operational concept is supplied as a guide for use in the system design and for the preparation of operational plans and test plans.

3.1.6.3.1 On-orbit Tests. The initial on-orbit period is devoted to a complete space vehicle checkout and the calibration and performance verifications of the payload(s). The space vehicle and payload performance verification tests may be repeated at appropriate times during the operational phase of the mission.

3.1.6.3.2 On-orbit Operations. The space vehicle and the applicable payload equipment would be commanded from the ground using commands transmitted for execution in real time and by commands transmitted and stored in the space vehicle for subsequent onboard execution. Protection would be provided in the space vehicle in the event of inappropriate commands or the lack of commands, i.e., the space vehicle may go into a contingency mode. In the contingency mode, the vehicle would be oriented to the sun and configured in a protected state that does not deplete electrical power. In the contingency mode, the vehicle would retain telemetry capabilities to facilitate fault isolation and command capabilities required to return to normal operation or to perform a controlled space vehicle deorbit.

3.1.6.3.3 Mission Completion. At the completion of the space vehicle mission, the space vehicle would be either deboosted to the STS retrieval orbit, deorbited, or all equipment would be commanded off. For STS retrieval, the space vehicle provides space vehicle safety status and other required verification data to the STS. Once captured, the space vehicle would be stored in the STS payload bay. At the appropriate point in the orbit, the STS would deorbit and return to Vandenberg Air Force Base. After STS rollout and safing, the STS would be brought to the STS Processing Facility, where the space vehicle would be removed and processed for transportation to the factory. In the event of an unsuccessful STS retrieval of the space vehicle, the space vehicle would be deorbited. Also, in the event of an aborted STS launch, it would be at this point that the space vehicle could be recycled back to the launch pad or to the factory. (Where mission completion consists of commanding all equipment off, that should be specified instead of retrieval or deorbit. Where it is planned that a space vehicle launched using an expendable launch vehicle may be retrieved or serviced using the STS, specific on-orbit or mission completion requirements would be described.)

3.2 CHARACTERISTICS

3.2.1 Performance Characteristics

3.2.1.1 Performance Requirements for Each System State

3.2.1.1.1 Performance Requirements for Prelaunch State. (TBS)

3.2.1.1.2 Performance Requirements for Launch State. (TBS)

3.2.1.1.3 Performance Requirements for Operational State. (TBS)

3.2.1.1.4 Performance Requirements for Space Vehicle Recovery State. (TBS)

3.2.1.2 Endurance. The ground-based elements of the system shall have a design service life of 20 years with an operations duty period of 24 hours per day, 7 days per week. The elements of the system associated with the STS Orbiter operations shall have a design service life of 15 years. The on-orbit design life of the space vehicle, as may be limited by mechanical wearout, battery life, solar array life, or the exhaustion of expendables, shall be no less than 5 years. The design of the space vehicle shall be such that space vehicle storage, under controlled conditions, may be planned for as long as 4 years. The design service life of the space vehicle shall be 10 years based on the sum of the allowed storage time, prelaunch checkout time, launch and injection time, on-orbit time, recovery time, and contingency time. (TBS)

3.2.1.3 Other

3.2.2 System Capability Relationships

3.2.2.1 Reference Timelines. (TBS)

3.2.2.2 Description. (TBS)

3.2.3 External Interface Requirements. The interfaces of the on-orbit space system with other elements of the space program are identified in Figure 3-6. Detailed quantitative interface requirements are stated in subsequent paragraphs.

3.2.3.1 Description of External Interface with Launch System. (TBS)

3.2.3.2 Description of External Interface with Communication System. (TBS)

3.2.3.3 Description of External Interface with Satellite Control Network. (TBS)

3.2.3.4 Description of External Interface with Other Systems. (TBS)

3.2.4 Physical Characteristics

3.2.4.1 Protective Coatings. The finishes used shall be such that completed devices shall be resistant to corrosion. The design goal shall be that there would be no destructive corrosion of the completed devices when exposed to moderately humid or mildly corrosive environments that could inadvertently occur while unprotected during manufacture or handling, such as possible industrial environments or sea coast fog that could be expected prior to launch. Destructive corrosion shall be construed as being any type of corrosion which interferes with meeting the specified performance of the device or its associated parts. Protective methods and materials for cleaning, surface treatment, and applications of finishes and protective coating shall be in accordance with MIL-F-7179. Chromium plating shall be in accordance with QQ-C-320. Nickel plating shall be in accordance with QQ-N-290. Corrosion protection of magnesium shall be in accordance with MIL-M-3171. Coatings for aluminum and aluminum alloys shall be in accordance with MIL-C-5541 or MIL-A-8625.

3.2.4.1.1 Space Vehicle Equipment Protective Coatings. Neither cadmium nor zinc coatings shall be used.

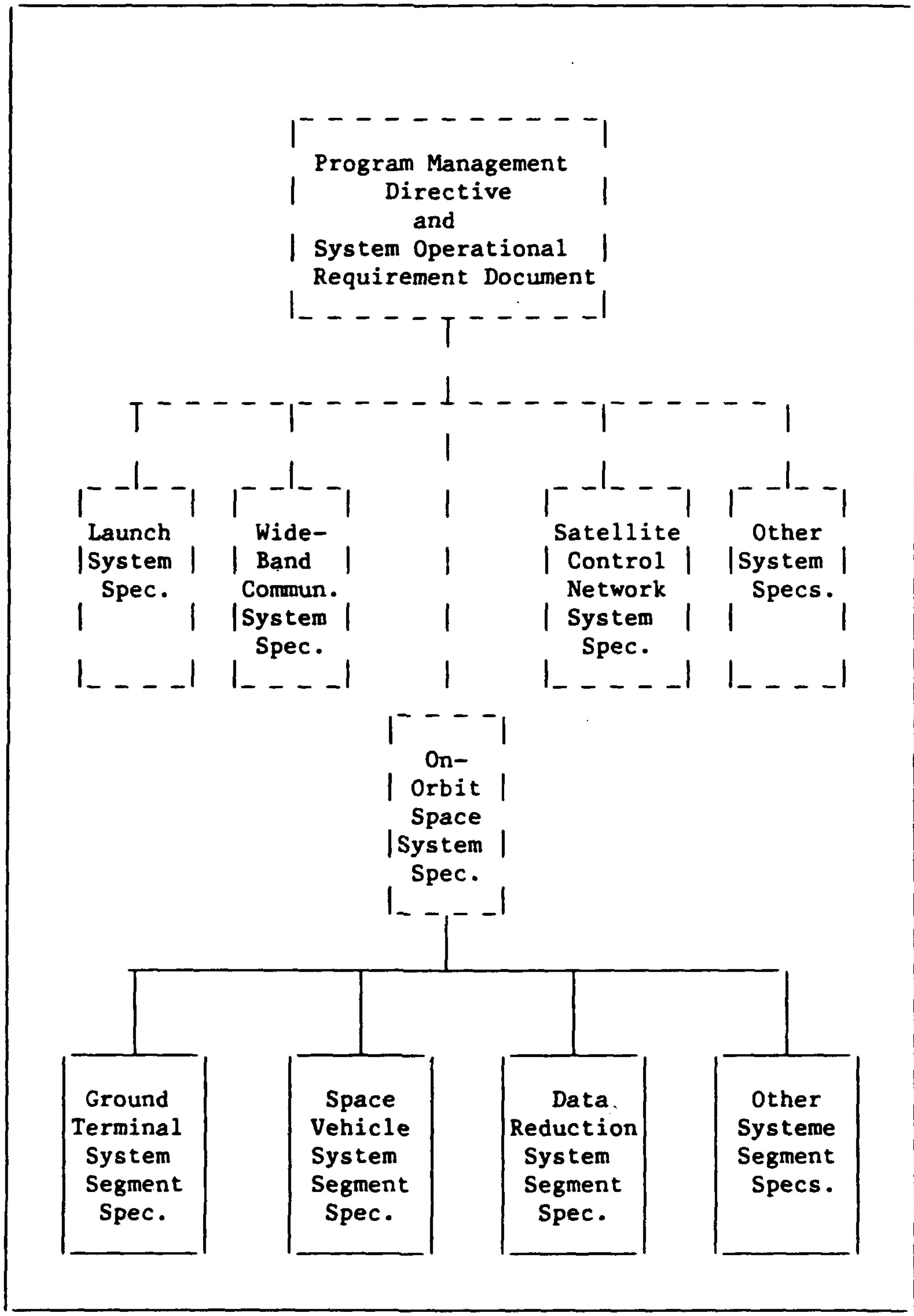

Figure 3-6. Major External System Interfaces.

3.2.4.1.2 Ground Equipment Protective Coatings. Finishes for ground electronic equipment shall be in accordance with MIL-F-14072C. (TBS)

3.2.4.2 Mass and Size Properties

3.2.4.2.1 Space Vehicle Size Properties. The coordinate system definitions and envelope constraints shall be as shown in Figure (TBS). For the spaceborne equipment, the envelope constraints shall be based upon the dynamic envelopes encountered during factory assembly, system test, transportation, integration with the booster, maintenance, launch, and other phases of operations. (TBS)

3.2.4.2.2 Space Vehicle Mass Properties. The mass properties of the space elements shall be determined as required to assure vehicle performance, stability, and control (TBS). The weight of the space vehicle shall not exceed (TBS). The weight of the space elements shall be controlled for the preservation of performance margins and as a control of other mass properties. The recommended weight contingency for space elements is as follows:

a. Preliminary design

New equipment	20 percent
GFE and existing equipment	5 percent

b. Critical design

New equipment	10 percent
GFE and existing equipment	3 percent

c. Final design

New equipment	5 percent
GFE and existing equipment	2 percent

3.2.4.2.3 Ground Equipment Size Properties. Ground elements of the system shall be assembled into racks and enclosures that conform to Requirement 55 of MIL-STD-454. Racks joined or grouped together shall have the same dimensions. Equipment and attachment cables intended for rack mounting shall conform to the rack dimensions. Front panels of equipment shall combine to provide a continuous front face of the rack.

Dimensions of the largest ground elements of the system intended to be transported as a unit shall not exceed 2.59 x 2.62 x 13.7 meters (8.5 x 8.6 x 45 feet) (WxHxL). Each item of assembled equipment, less all undercarriage and planned removable elements, shall not exceed the size limits of MIL-A-8421 for C130 aircraft, C141 aircraft, or C5-A aircraft using the 463L cargo system.

3.2.4.2.4 Ground Equipment Mass Properties. The mass and size properties of ground elements of the system shall be consistent with their intended application. The weight of hand-carried equipment shall not exceed (TBS). The center of gravity and tiedowns of ground equipment shall be such that probable seismic activity will not cause the equipment to upset.

The weight of ground elements shall be controlled to avoid excessive floor loading for fixed equipment and excessive road loading for mobile equipment. Equipment shall not exceed a floor loading of 900 kilograms per square meter (184 pounds per square foot). Each item of assembled equipment, less all undercarriage and planned removable elements, shall conform to the weight limits of MIL-A-8421 for C130 aircraft, C141 aircraft, or C5-A aircraft using the 463L cargo system.

3.2.4.3 Power

3.2.4.3.1 Space Vehicle Internal Power. Space vehicles and experiments shall be designed to operate from a 28 ± 6 volt dc, two-wire, single-point negative grounded power subsystem conforming to MIL-STD-1539. Nickel-cadmium battery usage shall be in accordance with MIL-STD-1578.

3.2.4.3.2 Space Vehicle External Power. Unless otherwise specified, space vehicles undergoing checkout shall be operated from a 28 ± 2 volt dc, two-wire, single-point negative grounded external power subsystem. The primary electrical power supplied to the system equipment mounted in the STS Orbiter shall be (TBS).

3.2.4.3.3 Ground Equipment External Power. The primary electrical power supplied to the ground-based elements of the system shall be (TBS).

3.2.4.4 Survivability. (TBS)

3.2.4.5 Other. (TBS)

3.2.5 System Quality Factors

3.2.5.1 Reliability. The probability of mission success for the nominal mission life of the space vehicle and experiments shall be at least 0.95. The probability of mission success shall include consideration of any potential failures in associated ground operations, such as commanding, that might not be corrected in time to avoid an impact on the space equipment. However, failures due to government-furnished equipment (GFE) power and GFE communications are excluded from the consideration. The reliability allocations shall assure that the overall mission reliability requirements are met, considering the most severe extremes of storage, transportation, testing, and operations. The system mean time between failures shall be evaluated in terms of events and usage cycles that occur during a typical service life cycle.

3.2.5.1.1 Mean Time Between Failures. System design shall be based on meeting the system reliability requirements as verified by the mean time between failures for the system as analytically determined for the elements of the system for each operating mode. The mean time between failures is as defined in MIL-STD-721. Piece part or component failure rates obtained from actual usage data shall be used where available. Failure rates estimated from standard data sources evaluated at anticipated operating conditions shall be used when data under actual usage are nonexistent or inadequate. Failure rates shall include failures attributable to computer software problems.

3.2.5.1.2 Redundancy. Redundancy to eliminate single point failure modes may be incorporated to meet the reliability requirements, unless the addition of the redundancy actually reduces overall reliability due to the added complexity. For designs that switch redundant units, components, or subassemblies autonomously, or by command, the failure rates for the switching circuits, and for the redundant equipment while in the off-line mode, shall be appropriately included in the reliability determination. Where practicable, provisions shall be incorporated to verify the operation of all switchable redundant paths without disassembly.

3.2.5.1.3 Space Vehicle Reliability. Space vehicle design shall be based on meeting the system reliability requirements as verified by` reliability analyses and failure mode effects and criticality analyses conducted on the space vehicle to the piece part level. The design of space equipment shall be such that a failure in one component shall not propagate to other components. Where practicable, the space vehicle shall be capable of detecting malfunctions while in orbit and automatically initiating protective measures to avoid catastrophic loss of the space experiment or of the host space vehicle.

The space vehicle probability of survival curve shall be represented by its equivalent Weibull function:

$$R(t) = e^{-(t/alpha)^{beta}}$$

where alpha = scale parameter
beta = shape parameter

The space vehicle probability of survival for the nominal service life shall be at least 0.5, assuming the probability of launch success to be at least 0.98. The space vehicle probability of survival shall include consideration of any potential failures in associated ground operations, such as commanding, that might not be corrected in time to avoid an impact on the space vehicle.

3.2.5.1.4 Failure Tolerance of Payloads Using the STS. The payloads using the STS shall tolerate a minimum number of credible failures and operator errors associated with hazardous functions. The criterion that applies depends upon the category of the hazardous event that occurs when the loss of a function or inadvertent occurrence of a function results in a hazardous event.

3.2.5.1.4.1 Critical Hazards. A critical hazard occurs where the potential result is damage to STS equipment or where the use of contingency or emergency procedures is required. A function that could result in a critical hazard shall be controlled by two independent inhibits whenever the hazard potential exists. When required, these inhibits may be monitored by the Orbiter flight crew or the ground in near real time. For deployable payloads, monitoring and safing of the two inhibits are not required when both inhibit power and control circuits for the function are connected to a bus that is not energized until the payload reaches a safe distance from the Orbiter.

3.2.5.1.4.2 Catastrophic Hazards. A catastrophic hazard occurs where the potential result is personnel injury or loss of the Orbiter, ground facilities, or STS equipment. A function that could result in a catastrophic hazard shall be controlled by a minimum of three independent inhibits whenever the hazard potential exists. One of these inhibits shall preclude operation by RF command. Monitoring and safing of the three inhibits which prevent the occurrence of a catastrophic function are not required when both the inhibit power and control circuits are connected to a bus that is not energized until the payload reaches a safe distance from the Orbiter. When the function power bus or control circuits are powered before achieving a safe distance from the Orbiter, monitoring shall be available to verify that at least two of the three inhibits are in place. Monitoring of these inhibits shall be available to the launch site when necessary to assure safe ground operations.

3.2.5.1.5 Ground Equipment Reliability. Ground equipment design shall be based on meeting the system reliability requirements as verified by failure mode effects and criticality analyses conducted on ground equipment to the level required to identify all single-point failure modes or component redundancy requirements for the ground equipment.

3.2.5.1.5.1 Ground Equipment Fault Tolerance. All subsystems which support the real-time Range Safety function (e.g. subsystems of communications, command and control, and timing) shall be fully redundant and designed in accordance with the fault-tolerant concepts outlined.

3.2.5.1.5.2 Ground Equipment and Software Interdependent Concept. Fault-tolerant responsibility shall be assigned jointly to both the hardware and the software. Failure control functions shall be shared between hardware and software in an interdependent manner to ensure that no single failure could prevent the Range Safety Officer from successfully transmitting Range Safety command(s) to a space vehicle during its launch phase.

3.2.5.1.5.3 Nonoperational Ground Equipment Reliability. Nonoperational ground equipment is ground equipment that is used off line in such areas as transportation, maintenance, or training and is not required during launch or on-orbit operations. Nonoperational ground equipment reliability shall be based on meeting a mean time between failure that is so large that failures would not be expected to interfere with the functional application of the items.

3.2.5.2 Maintainability

3.2.5.2.1 Maintainability of Space Vehicle Equipment. Unless maintenance or servicing in space is specifically stated as a program requirement, space vehicles and experiments shall be designed so as to not require any scheduled maintenance, repair, or servicing during their service life. The design shall incorporate test and telemetry points to allow verification of functional performance. The design shall accommodate easy installation and replacement of major components during factory assembly and of explosive ordnance devices, batteries, and other site replaceable items at the launch site when they are mated to the launch vehicle. Access shall be provided to those test plugs, harness break-in points, external umbilical connections, safe and arm devices, explosive ordnance devices, pressurant and propellant fill and drain valves, and other devices as might be required for prelaunch maintenance, alignment, and servicing. Alignment references for critically aligned components shall be visible directly or through windows or access doors.

3.2.5.2.2 Maintainability of Ground Equipment. To the extent practicable, the ground elements of the system shall be based on high reliability designs that minimize scheduled maintenance or repair during their service life. The designs shall use modular construction and line-replaceable units, where practicable, to accommodate easy installation and replacement of major subassemblies, components, and other replaceable items. Equipment designs shall provide easy accessibility to line-replaceable units in order to minimize the mean time to restore. The equipment shall be designed to provide both fault detection and fault isolation capabilities. The designs shall incorporate built-in test features, self-test features, test points, and telemetry points as required to allow rapid verification of functional performance. The built-in test or self-test capabilities shall be capable of detecting 99 percent of equipment faults. The equipment shall include built-in test or self-test capability for fault isolation to a single line-replaceable unit 95 percent of the time and to a maximum of two line-replaceable units 99 percent of the time. Access shall be provided to those test plugs, harness break-in points, and other devices as might be required for maintenance, alignment, and servicing. Alignment references for critically aligned components shall be visible directly or through windows or access doors.

Equipment designs shall support the development of cost-effective operator-level maintenance, organizational-level maintenance, intermediate-level maintenance, and depot-level maintenance.

a. Operator-Level Maintenance. Operator-level maintenance shall be restricted to operational tests and nontechnical preventive maintenance routines which are suitable for accomplishment by operator personnel. This shall include self tests, simple fault diagnosis and fault isolation, and surface cleaning as required by environmental conditions.

b. Organizational-Level Maintenance. Organizational-level maintenance shall be conducted in the operational environment using contractor personnel, contractor-designated spares, contractor-approved maintenance manuals, and contractor-approved test procedures. Organizational-level maintenance shall consist of more complex fault diagnosis and fault isolation; removal and replacement of complete assemblies or line-replaceable units; alignment; and calibration necessary to restore the failed system to an operational condition.

c. Intermediate-Level Maintenance. Intermediate-level maintenance shall be accomplished at an on-site maintenance facility, using contractor personnel, contractor-designated spares, contractor-approved maintenance manuals, and contractor-approved test procedures. Intermediate-level maintenance shall consist of preventive maintenance and the repair and replacement of unserviceable complete assemblies or line-replaceable units. Corrosion control shall be accomplished as preventive maintenance.

d. Depot-Level Maintenance. Depot-level maintenance shall be accomplished at a designated maintenance facility. Depot level maintenance consists of all maintenance and repairs not accomplished at other maintenance levels. Depot-level maintenance shall be minimized.

3.2.5.2.2.1 Mean Time to Restore. The mean time to restore is as defined in MIL-STD-721. The mean time to restore shall include fault isolation, faulty line-replaceable unit removal, replacement with a good line-replaceable unit, and verification of operations. At the organizational level, the mean time to restore shall not exceed 0.5 hour, and the maximum time shall not exceed 1.0 hour at the 90th percentile. At the intermediate level, the mean time to restore shall not exceed 1.0 hour, and the maximum time shall not exceed 2.0 hour at the 90th percentile. Preventive maintenance shall not cause total down time but shall be scheduled so that a planned partial system capability is available at all times.

3.2.5.2.2.2 Maximum Downtime. The maximum downtime for ground elements of the system, including any combination of preventive and unscheduled maintenance time, shall be no greater that 2.0 hours at the 95th percentile of the downtime distribution. Ground elements of the system shall be considered *"down"* any time that they are not capable of providing the scheduled support.

3.2.5.2.2.3 Maintenance and Repair Cycles. All preventive maintenance shall be performed on a scheduled basis to prevent interference with operational support. No more than one two-hour period a week shall be required for preventive maintenance actions.

3.2.5.2.2.4 Fault Isolation. The following fault isolation capabilities shall be provided:

a. An expanding and collapsing loop test capability shall be provided to assist in isolating faults to the line-replaceable unit. Loop tests shall be controlled from the operator position.

b. Diagnostic capability and routines shall be provided to isolate faults to the line-replaceable unit level. Execution of diagnostic routines shall be controlled from the operator position.

c. Built-in test features, test points, signal injection capabilities, and status monitoring features shall be included to the maximum extent possible on off-the-shelf equipment. Newly developed or modified equipment also shall maximize these capabilities. Status monitoring, consistent with the skill level of contractor maintenance personnel, shall be provided for fault detection and isolation.

3.2.5.3 Availability. The system, when efficiently maintained, shall provide a functional availability to the operator position at any random time, equal to or greater than 0.997. The system availability requirement does not include the GFE power or GFE communication networks.

The availability of the system is defined as the portion of the total scheduled support time during which the system can provide the desired support. The availability "*A*" of the system is defined mathematically as:

$$A = \frac{\text{(Mean time between failures)}}{\text{(Mean time between failures)} + \text{(Mean time to restore)}}$$

The mean time to restore includes the mean administrative time associated with making repairs that delay the completion of the repairs, assuming an efficiently maintained system. Efficiently maintained means that the repair is started immediately upon system failure, and all necessary replacement parts, components, and subsystems are readily available. The administrative time associated with making repairs includes the time to obtain the necessary parts and procedures.

3.2.5.4 Additional Quality Factors. The system equipment shall be so designed and constructed that no fixed part or assembly shall become loose, no moveable part or assembly shall become undesirably free or sluggish, and no degradation shall be caused in the performance beyond that specified for the system equipment during operation or after storage.

3.2.6 Environmental Conditions. To provide a design factor of safety or margin, the various system CIs and their components shall be designed to function during or, if appropriate, following exposure to environmental levels that exceed, by the specified margins, the maximum environmental levels predicted for all applicable operational states and modes during the service life of the CIs.

3.2.6.1 Environmental Design Margins

3.2.6.1.1 Environmental Margins for Space Equipment. The required environmental design margins for space equipment are those specified in MIL-STD-1540. Therefore, the required environmental design values for each item of space equipment are as follows:

a. The thermal design range shall be 10 degrees C beyond the minimum and maximum predicted temperatures. Where practicable, each component shall be designed to operate continuously within an ambient temperature range of at least -34 degrees C to +71 degrees C. To prevent generation of a possible ignition source, the temperature of any part exposed to the atmosphere shall not exceed 178 degrees C.

b. The vibration design range shall be 6 dB greater than the maximum predicted level but not less than 12 g's (rms).

c. The acoustic design range shall be 6 dB greater than the maximum predicted level but not less than 144 dB overall.

d. The shock spectrum design range shall be 6 dB greater than the maximum predicted level.

3.2.6.1.2 Environmental Margins for Ground Equipment or Mobile Equipment. No environmental design margin is required for ground equipment or mobile equipment. The design values shall be the minimum and maximum predicted as applicable.

3.2.6.2 Environmental Conditions for Space Equipment. Unless otherwise specified, the maximum predicted design environments for the spaceborne equipment shall be determined in accordance with the definitions in MIL-STD-1540. Where practicable, each space component shall be designed to operate continuously within an ambient temperature range of at least -34 degrees C to +71 degrees C and at ambient pressures between sea level and deep space.

3.2.6.2.1 Launch Environments. The space elements shall be designed to function within performance specifications after or, if appropriate, during exposure in the launch configuration to their design environmental levels. These design environmental levels for launch exceed the maximum predicted launch environments for each item by the environmental design margin.

3.2.6.2.2 On-orbit Environments. The space elements shall be designed to function within performance specifications following or, if appropriate, during exposure in the on-orbit configuration to their design environmental levels. These design environmental levels for on orbit exceed the maximum predicted on-orbit environments for each item by the environmental design margin.

3.2.6.2.3 Ground Environments for Space Equipment. These space equipment environments are those associated with all ground operations except testing, including storage, transportation, and prelaunch operations. The space equipment shall be designed to function within performance specifications following or, if appropriate, during exposure in the ground configuration to environmental levels that exceed the maximum predicted ground environments. The design shall be capable of sustaining exposures up to 12 hours in humid and mildly corrosive environments that could occur inadvertently while the equipment is unprotected during manufacture or handling, such as possible industrial environments or sea coast fog that could be expected prior to launch. Relative humidities up to 100 percent can be encountered.

Environmental conditions for space equipment during processing, and during storage prior to shipment, shall be within the following limits:

a. Temperature: 21 degrees C ± 20 degrees C

b. Humidity: 50 percent ± 40 percent

Cleanliness shall be maintained during processing, storage, and transportation using appropriate protective containers or covers. Temperature and humidity conditions and transportation shock exposure shall be monitored subsequent to manufacture, and the measured levels shall be evaluated against the acceptance test limits.

3.2.6.2.4 **Other Environments for Space Equipment**. (TBS)

3.2.6.3 **Environmental Conditions for Ground Equipment.** The ground equipment shall be designed to function within performance specifications following or, if appropriate, during exposure to environmental levels that exceed the maximum predicted ground environments.

3.2.6.3.1 **Ground Equipment Natural Environments**

3.2.6.3.1.1 **Environmental Conditions for Ground Equipment During Storage and Transportation (Nonoperating).** Ground equipment shall perform within its specified design parameters after exposure in the storage and transport configuration (nonoperating) to any combination of the following storage and transportation environmental conditions:

a. Temperature. The ground equipment shall withstand an ambient temperature range between -55 degrees C and +68 degrees C (-65 degrees F and +155 degrees F).

b. Relative Humidity. The ground equipment shall withstand a relative humidity up to 100 percent, including condensation due to temperature changes.

c. Actinic Radiation. The ground equipment shall withstand actinic radiation as encountered in the tropics.

d. Barometric Pressure. The ground equipment shall withstand barometric pressure from 775 millimeters of mercury to 520 millimeters of mercury (equivalent to altitudes from sea level, 0 meter (0 foot), to altitudes of approximately 15,300 meters (50,000 feet).

e. Wind Velocity. Ground equipment shall withstand wind conditions of 240 kilometers per hour (150 miles per hour).

f. Salt Atmosphere. The ground equipment shall withstand salt atmosphere as encountered in coastal regions and during ocean transport (sea water in equilibrium with air at a pH of 8.3 and overall salinity of five parts per thousand.)

g. Precipitation. The ground equipment shall withstand rainfall of 127 millimeters per hour (5 inches per hour) at a steady wind of 64 kilometers per hour (40 miles per hour). Unsheltered equipment also shall withstand at least 1440 pascals (30 pounds per square foot) of loading of any combination of ice, snow, and other precipitation without permanent deformation.

h. Sand and Dust. The ground equipment shall withstand sand and dust as encountered in arid regions (0.18 to 0.30 millimeters diameter sand particles and 0.0001 to 0.01 millimeters dust) carried by winds blowing at 144 kilometers per hour (90 miles per hour).

i. Solar Radiation. The ground equipment shall withstand the combined effects of temperature and solar radiation. The equipment design shall be based upon a temperature of +49 degrees C (120 degrees F) and the full impact of solar radiation of 1136 watts per square meter (360 Btu per square foot per hour) for at least four hours.

3.2.6.3.1.2 Environmental Conditions for Mobile Ground Equipment During Deployment (Nonoperating). Mobile ground equipment shall perform within its specified design parameters after exposure during deployment at an operational site to any combination of the following environmental conditions:

a. Temperature. The mobile ground equipment shall be capable of being deployed at an ambient temperature of 0 degree C (32 degrees F) to 38 degrees C (100 degrees F).

b. Wind Velocity. The mobile ground equipment shall be capable of being deployed under wind conditions of less than 25 kilometers per hour (15 miles per hour).

c. Precipitation. The mobile ground equipment shall be capable of being deployed under zero precipitation with less than 7.6 centimeters (three inches) of snow covering the ground.

d. Deployment Site. The mobile ground equipment shall be capable of being deployed at unprepared, clear sites with ground slope of 5 percent or less, bearing capability of 718 kilopascals (15,000 pounds per square foot) or greater, and penetrable soil with resistivity of 1000 ohms per centimeter (2540 ohms per inch) or less.

3.2.6.3.1.3 Mobile Station Handling Shock and Vibration. The equipment shall be designed to withstand or be protected against the random and sinusoidal vibration and shock environments associated with shipment by common carrier and the worst probable combination of applicable external environments defined in Paragraph 3.2.6.

3.2.6.3.1.4 Environmental Conditions for Ground Equipment Operating Within an Environmental Shelter. Most ground equipment is designed for operation within a building or an environmentally controlled shelter. The air conditioning and heating shall be capable of maintaining the building or shelter's interior temperature in the range from 10 degrees C to 32 degrees C (61 degrees F to 90 degrees F) and the relative humidity in the range from 30 to 70 percent under the worst probable combination of operating conditions. Personnel ventilation shall conform to the requirements of MIL-STD-1472. However, in the event of failure of the air conditioning or heating, the system equipment required for state-of-health support of satellites shall be capable of continuing operations, with only minor degradation of performance, while operating in any combination of the following environmental conditions:

a. Temperature. The ground equipment shall withstand an ambient temperature range of +0 degree C to +49 degrees C (+32 degrees F to +120 degrees F).

b. Relative Humidity. The ground equipment shall operate in relative humidity up to 100 percent, including condensation due to temperature changes.

c. Barometric Pressure. The ground equipment shall operate within barometric pressure from 775 millimeters of mercury to 520 millimeters of mercury [equivalent to altitudes of from approximately 150 meters (500 feet) below sea level to approximately 3000 meters (10,000 feet) above sea level].

3.2.6.3.1.5 Environmental Conditions for Ground Equipment Operating Without an Environmental Shelter. Some ground equipment, such as antennas, may be designed to operate without an environmentally controlled shelter. Such equipment shall perform within its specified design parameters when operating in any combination of the following environmental conditions:

a. Temperature. The ground equipment shall withstand an ambient temperature range of -40 degrees C (-40 degrees F) to 49 degrees C (+120 degrees F) (total with or without the presence of solar radiation.)

b. Relative Humidity. The ground equipment shall operate in relative humidity up to 100 percent, including condensation due to temperature changes.

c. Actinic Radiation. The ground equipment shall withstand actinic radiation as encountered in the tropics.

d. Barometric Pressure. The ground equipment shall operate within barometric pressure from 775 millimeters of mercury to 520 millimeters of mercury [equivalent to altitudes of from approximately 150 meters (500 feet) below sea level to approximately 3000 meters (10,000 feet) above sea level].

e. Wind Velocity. Ground equipment shall operate within specified pointing accuracies and survive in wind conditions of 240 kilometers per hour (150 miles per hour) steady wind.

f. Salt Atmosphere. The ground equipment shall withstand salt atmosphere as encountered in coastal regions and during ocean transport (sea water in equilibrium with air at a pH of 8.3 and overall salinity of five parts per thousand).

g. Precipitation. The ground equipment shall withstand rainfall of 127 millimeters per hour (5 inches per hour) at a steady wind of 64 kilometers per hour (40 miles per hour). Unsheltered equipment also shall withstand at least 1440 pascals (30 pounds per square foot) of loading of any combination of ice, snow, and other precipitation without permanent deformation.

h. Sand and Dust. The ground equipment shall withstand sand and dust as encountered in arid regions (0.18 to 0.30 millimeters diameter sand particles and 0.0001 to 0.01 millimeters dust) carried by winds blowing at 144 kilometers per hour (90 miles per hour).

i. Solar Radiation. The ground equipment shall withstand the combined effects of temperature and solar radiation. The equipment design shall be based upon a temperature of +49 degrees C (120 degrees F) and the full impact of solar radiation of 1136 watts per square meter (360 Btu per square foot per hour) for at least four hours.

3.2.6.3.2 Ground Equipment Induced Environments

3.2.6.3.2.1 Ground Equipment Acoustic Noise Environment. The ground equipment shall not generate steady-state noise in excess of 65 dB(A) nor impulse noise in excess of 140 dB as measured inside work areas that may be occupied by operations personnel. Steady-state noise and impulse noise are as defined in MIL-STD-1474. Steady-state noise in internal areas not occupied by operations personnel, but which may be visited for maintenance or repairs, shall not exceed 85 dB(A) of steady-state noise, nor 140 dB of impulse noise.

3.2.6.3.2.2 Ground Equipment Nuclear Explosion Effects. The ground equipment required for state-of-health support of satellites shall be protected against an electromagnetic pulse (EMP phenomena associated with nuclear explosions) with the characteristics shown in Figure TBS. The magnetic field in ampere turns per meter equals the electric field in volts per meter divided by 377.

3.2.6.3.2.3 Ground Equipment Environments Induced by Transportation

3.2.6.3.2.3.1 Ground Equipment Environments Induced by Air Transportation. In the air transport configuration, the ground equipment and its associated support equipment shall be capable of withstanding the induced dynamic environments and loads noted below:

a. C-141 aircraft: per Aerospace Report No. TOR-0076(6892)-1
b. C-5A aircraft: per Aerospace Report No. TOR-0076(6403-01)-2

c. C-130 Aircraft: TBD
d. Cargo restraint criteria: per MIL-A-8421

3.2.6.3.2.3.2 Ground Equipment Environments Induced by Ground Transportation. The ground equipment shall be designed to withstand or be protected, in the ground transport configuration, against the random and sinusoidal vibration and shock environments associated with shipment by common carrier and to withstand the environments induced by travel over surfaces having roughness as defined in U.S. Army Test and Evaluation Command Test Operations Procedure TOP 1-1-010 for highways and gravel roads (Paragraphs 5.1 and 5.2, respectively).

3.2.6.4 Environmental Conditions for Other Equipment. (TBS)

3.2.7 Transportability

3.2.7.1 Equipment Handling Provisions. Handling tie-downs and sling points shall be incorporated in the design of the equipment as needed to optimize transportability and complement maintenance, warehousing, and other handling requirements.

3.2.7.2 Electrostatic Sensitive Items. Electrostatic sensitive items, such as most electronic assemblies and components containing explosives, shall be stored and transported in sealed packages using antistatic wrapping material. The antistatic wrapping material used should not produce nonvolatile residues. The antistatic wrapping material shall be grounded through a resistor prior to removal. The grounding resistor shall have a value between 100,000 ohms and 1 megohm.

3.2.7.3 Space Vehicle Equipment Transportability. The space equipment shall be designed for ground transportability and for air transportability. The space equipment to be mounted as an assembly in the STS shall be capable of being transported and handled in both the vertical and horizontal attitudes. Attach points for transportation and handling shall be provided on assemblies weighing more than 100 kilograms. The modes of transportation, support, and types of protective covers used shall be chosen to assure that transportation and handling do not impose thermal, vibration, acoustic, or shock environmental conditions which exceed those imposed by operational modes and states.

3.2.7.4 Ground Equipment Transportability. Ground equipment shall be designed to be handled in a vertical attitude. Attach points for transportation and handling shall be provided on major assemblies weighing more than 100 kilograms. Equipment shall be suitable for shipment by C-130 aircraft, C-141 aircraft, or C5-A aircraft using the 463L cargo system; or by military land vehicle.

3.2.7.5 Mobile Ground Equipment Transportability. Mobile ground equipment shall be designed for highways and improved cross-country terrain in accordance with the performance and roadability of Type III mobility, Group C or D, of MIL-M-8090. The Mobile Station shall be designed to be singly towed by standard fifth-wheel 48-inch or 50-inch tractors with air brakes. The mobile ground equipment shall have the capability to make complete turns to the left and right while negotiating a slope of 10 degrees, with the towing vehicle assuming a 90-degree angle with the trailer. The towing force required to move the mobile ground equipment from rest shall be comparable to that required for a commercial vehicle of similar size and weight. The mobile ground equipment shall cause load bearing pressures not greater than 718 Kilopascals (15,000 pounds per square foot) on road surfaces. Mobile ground equipment shall comply with Department of Transportation (DOT) and SAE requirements and practices for operation on U.S. highways and roads. Mobile ground equipment ramp capability shall be consistent with the constraints of air transportability loading and unloading.

3.2.8 Flexibility and Expansion. System flexibility and expansion shall be provided by computer resources reserves and other provisions specified. A distinction is made between the reserves required for operational computer resources and for nonoperational computer resources (see Paragraph 3.3.11).

3.2.8.1 Operational Computer Resource Reserves. A distinction is made between the computer resource reserves required for space elements and for ground elements of the space system. Modification, addition, or replacement of computer resources in space elements after launch is not planned. Where practicable, the reserve requirements for space elements shall be incorporated into the baseline design so that equipment modifications are not required to satisfy the reserve requirements. Where required computer resource reserves for space elements are allowed through modification, addition, or replacement, but are not incorporated into the baseline design, the design of the computer resources and of the space vehicle shall be such that equipment modifications may be readily made on subsequent production units to meet the growth requirements. Where required computer resources reserves for ground elements of the space system are allowed through modification, addition, or replacement, but are not incorporated into the baseline design, the design and installation of the ground elements shall be such that equipment modifications may be readily made after the initial installation to meet the growth requirements.

3.2.8.1.1 Computer Resource Reserves for Operational Space Elements. For the purposes of this specification, the data processing subsystems of the operational space elements are defined to comprise all computer hardware, software, and firmware in the space vehicle(s), including all interfacing space equipment and payloads except GFE payloads required to support operational missions. Note, however, that the worst case loading, capacity, throughput, and access rate requirements referred to in this specification shall consider and include the requirements placed upon the data processing subsystems of the space elements by the GFE payloads, as well as the requirements placed upon the data processing subsystems of the space elements by all other payload, launch vehicle, spacecraft, and system interfaces.

To support program expansion in terms of additional use of existing functions, the following reserve requirements shall be provided in the operational data processing subsystems of the space elements:

a. The data processing subsystems of the space elements shall be capable of data throughput that is 100 percent greater than that required to satisfy the worst case data processing requirements that could jointly load the data processing subsystems of the space elements.

b. Under the additional data throughput specified (i.e., 100 percent greater than that required to satisfy the worst case data processing requirements that could jointly load the data processing subsystems of the space elements), the data processing subsystems of the space elements shall meet the originally stated functional and performance computational requirements, including timing requirements.

In addition, the components of the data processing subsystems of the space elements shall satisfy the computer resource reserve requirements stated in the following subparagraphs. For the purpose of the following subparagraphs, the term *"processor"* is used to mean any single computer onboard a space vehicle, whether of general-purpose or special-purpose usage, including both single processor architecture and multiprocessor architecture computers. Thus, a processor comprises a collection of computational hardware, including one or more instruction processing units with their associated control units, main memory, internal busses, and circuitry, that function as a single integrated computational device (i.e., as a computer).

3.2.8.1.1.1 Data Processing Subsystems Processor Reserves. Within the processing environment of the data processing subsystems of the space elements, each processor shall:

a. Have an instruction execution rate sufficient to process a workload that is 100 percent greater than the worst case processor utilization workload that could load that processor.

b. Be capable of attaining, or of being augmented (through modification, addition, or replacement) to attain, an instruction execution rate sufficient to process a workload that is 200 percent greater than the worst case processor utilization workload that could load that processor.

Under the additional workload specified, the processor, or the augmented processor, shall meet the originally stated functional and performance computational requirements, including timing requirements, allocated to that processor.

3.2.8.1.1.2 Data Processing Subsystems Primary Memory Reserves. Within the environment of the data processing subsystems of the space elements, the primary memory for each processor shall:

a. Have 100 percent greater memory capacity than the worst case memory size requirement for that primary memory component.

b. Have, or be capable of having, memory added (through modification, addition, or replacement) to attain, a 200 percent greater memory capacity than the worst case memory size requirement for that primary memory component.

c. Have a memory access rate sufficient to process a workload that is 100 percent greater than the worst case memory access workload for that primary memory component.

d. Be capable of attaining, or of being augmented (through modification, addition, or replacement) to attain, a memory access rate sufficient to process a workload that is 200 percent greater than the worst case memory access workload for that primary memory component.

Under the additional workloads specified, any processor accessing a primary memory, or augmented memory, shall meet the originally stated functional and performance computational requirements, including timing requirements allocated to that processor.

3.2.8.1.1.3 Data Processing Subsystems Peripheral Data Storage (Secondary Memory) Reserves. Within the environment of the data processing subsystems of the space elements, each peripheral data storage (secondary memory) component shall:

a. Have 100 percent greater storage capacity than the worst case storage requirement for that peripheral data storage component.

b. Have, or be capable of having, storage added (through modification, addition, or replacement) to attain, a 200 percent greater storage capacity than the worst case storage requirement for that peripheral data storage component.

c. Have an access rate sufficient to process a workload that is 100 percent greater than the worst case access workload for that peripheral data storage component.

d. Be capable of attaining, or of being augmented (through modification, addition, or replacement) to attain, an access rate sufficient to process a workload that is 200 percent greater than the worst case access workload for that peripheral data storage component.

Under the additional workloads specified, any processor accessing a peripheral data storage component, or augmented peripheral data storage component, shall meet the originally stated functional and performance computational requirements, including timing requirements, allocated to that processor.

3.2.8.1.1.4 **Data Processing Subsystems Data Transmission Media**. Within the environment of the data processing subsystems of the space elements, each data transmission medium (e.g., local or global bus or channel) shall:

a. Have sufficient capacity to support data throughput that is 100 percent greater than the worst case data throughput that could load that data transmission medium.

b. Have, or be capable of being augmented (through modification, addition, or replacement) to have, sufficient capacity to support data throughput that is 200 percent greater than the worst case data throughput that could load that data transmission medium.

c. Have a data access rate sufficient to process a workload that is 100 percent greater than the worst case data access workload for that data transmission medium.

d. Be capable of attaining, or of being augmented (through modification, addition, or replacement) to attain, a data access rate sufficient to process a workload that is 200 percent greater than the worst case data access workload for that data transmission medium.

Under the additional workloads specified, any processor, or augmented processor, accessing the data transmission medium, or augmented data transmission medium, shall meet the originally stated functional and performance computational requirements, including timing requirements, allocated to that processor.

3.2.8.1.1.5 **Data Processing Subsystems Software/Firmware**. The software and firmware in the data processing subsystems of the space elements shall be designed (e.g., via parameterization, appropriate sizing of data structures, or other methods) so that utilization of the computer performance reserves specified due to additional use of existing functions can be accomplished without changes in the software or firmware logic. Any hardware augmentations necessary to meet the expansion requirements shall, where practical, be designed so that the software and firmware in the data processing subsystems of the space elements are upward compatible with the implementation of those augmentations.

3.2.8.1.1.6 **Exceptions**. Exceptions to the requirements may be granted by the Contracting Officer for specific special-purpose components in the data processing subsystems, e.g., special-purpose memory components, such as boot memory or memory whose size is tied to fixed hardware characteristics, or for other reasons that are properly justified.

3.2.8.1.2 **Computer Resource Reserves for Operational Ground Equipment**. For the purposes of this specification, the operational data processing subsystems of the ground elements of the space system are defined to comprise all computer hardware, software, and firmware required to support operational missions that are not in space elements. Note, however, that the worst case loading, capacity, throughput, and access rate requirements referred to in this specification shall consider and include the requirements placed upon the ground equipment data processing subsystems by the operational requirements and by all other space system functions.

To support program expansion in terms of additional use of existing functions, the following reserve requirements shall be provided in the ground elements of the operational data processing subsystems of the space system:

a. The data processing subsystems of the ground elements shall be capable of data throughput that is 100 percent greater than that required to satisfy the worst case data processing requirements that could jointly load the operational ground equipment data processing subsystems of the ground elements.

b. Under the additional data throughput specified (i.e., 100 percent greater than that required to satisfy the worst case data processing requirements that could jointly load the data processing subsystems of the ground elements), the data processing subsystems of the ground elements shall meet the originally stated functional and performance computational requirements, including timing requirements.

In addition, the components of the data processing subsystems of the ground elements shall satisfy the computer resource reserve requirements stated in the following subparagraphs. For the purpose of the following subparagraphs, the term *processor* is used to mean any single computer in the ground elements, of any size, whether of general-purpose or special-purpose usage, including both single processor architecture and multiprocessor architecture computers (e.g., a workstation, personal computer, microprocessor, minicomputer, mainframe, vector processor, and so forth).

3.2.8.1.2.1 Data Processing Subsystems Processor Reserves. Within the processing environment of the data processing subsystems of the ground elements, each processor shall:

a. Have an instruction execution rate sufficient to process a workload that is 100 percent greater than the worst case processor utilization workload that could load that processor.

b. Be capable of attaining, or of being augmented (through modification, addition, or replacement) to attain, an instruction execution rate sufficient to process a workload that is 200 percent greater than the worst case processor utilization workload that could load that processor.

Under the additional workloads specified, the processor, or the augmented processor, shall meet the originally stated functional and performance computational requirements, including timing requirements, allocated to that processor.

3.2.8.1.2.2 Data Processing Subsystems Primary Memory Reserves. Within the environment of the data processing subsystems of the ground elements, the primary memory for each processor shall:

a. Have 100 percent greater memory capacity than the worst case memory size requirement for that primary memory component, if operating under a nonvirtual operating system. If operating under a virtual operating system, the virtual memory capacity for that processor shall provide for 100 percent greater virtual memory capacity than the worst case virtual memory size requirement for that processor.

b. Have, or be capable of having memory added (through modification, addition, or replacement) to attain, a 200 percent greater memory capacity than the worst case memory size requirement for that primary memory component, if operating under a nonvirtual operating system. If operating under a virtual operating system, the virtual memory capacity for that processor shall have, or be capable of having memory added (through modification, addition, or replacement) to attain, a 200 percent greater virtual memory capacity than the worst case virtual memory size requirement for that processor.

c. Have a memory access rate sufficient to process a workload that is 100 percent greater than the worst case memory access workload for that primary memory component.

d. Be capable of attaining, or of being augmented (through modification, addition, or replacement) to attain, a memory access rate sufficient to process a workload that is 200 percent greater than the worst case memory access workload for that primary memory component.

Under the additional workloads specified, any processor accessing a primary memory, or augmented memory, shall meet the originally stated functional and performance computational requirements, including timing requirements allocated to that processor. Note that if any processor accessing a primary memory is executing under a virtual memory operating system, the worst case memory access workloads must consider memory accesses due to paging, in addition to memory accesses due to performing the functional requirements using that primary memory.

3.2.8.1.2.3 Data Processing Subsystems Peripheral Data Storage (Secondary Memory) Reserves. Within the environment of the data processing subsystems of the ground elements, each peripheral data storage (secondary memory) component shall:

a. Have 100 percent greater storage capacity than the worst case storage requirement for that peripheral data storage component.

b. Have, or be capable of having storage added (through modification, addition, or replacement) to attain, a 200 percent greater storage capacity than the worst case storage requirement for that peripheral data storage component.

c. Have an access rate sufficient to process a workload that is 100 percent greater than the worst case access workload for that peripheral data storage component.

d. Be capable of attaining, or of being augmented (through modification, addition, or replacement) to attain, an access rate sufficient to process a workload that is 200 percent greater than the worst case access workload for that peripheral data storage component.

Under the additional workloads specified, any processor accessing a peripheral data storage component, or augmented peripheral data storage component, shall meet the originally stated functional and performance computational requirements, including timing requirements, allocated to that processor. Note that if any processor accessing a peripheral data storage component is executing under a virtual memory operating system, the worst case memory access workloads must consider memory accesses due to paging, in addition to memory accesses due to performing the functional requirements using that peripheral data storage component.

3.2.8.1.2.4 Data Processing Subsystems Data Transmission Media. Within the environment of the data processing subsystems of the ground elements, each data transmission medium (e.g., local or global bus or channel) shall:

a. Have sufficient capacity to support data throughput that is 100 percent greater than the worst case data throughput that could load that data transmission medium.

b. Have, or be capable of being augmented (through modification, addition, or replacement) to have, sufficient capacity to support data throughput that is 200 percent greater than the worst case data throughput that could load that data transmission medium.

c. Have a data access rate sufficient to process a workload that is 100 percent greater than the worst case data access workload for that data transmission medium.

d. Be capable of attaining, or of being augmented (through modification, addition, or replacement) to attain, a data access rate sufficient to process a workload that is 200 percent greater than the worst case data access workload for that data transmission medium.

Under the additional workloads specified, any processor, or augmented processor, accessing the data transmission medium, or augmented data transmission medium, shall meet the originally stated functional and performance computational requirements, including timing requirements, allocated to that processor.

3.2.8.1.2.5 Data Processing Subsystems Software/Firmware. The software and firmware in each data processing subsystem of the ground elements shall be designed (e.g., via parameterization, appropriate sizing of data structures, or other methods) so that utilization of the computer performance reserves specified due to additional use of existing functions can be accomplished without changes in the software or firmware logic. Any hardware augmentations necessary to meet the expansion requirements specified shall, where practical, be designed so that the software and firmware in each data processing subsystem of the ground elements is *upward compatible* with the implementation of those augmentations.

3.2.8.2 Nonoperational Computer Resource Reserves

3.2.8.2.1 Computer Software Maintenance Resources: Additional Growth Capability. The computer resources used for computer software maintenance shall be capable of accommodating the specified growth requirements of the operational computer resources without necessitating any major modifications.

3.2.8.2.2 Computer Resources in Trainers: Additional Growth Capability. The trainer shall be capable of accommodating the growth requirements of the operational computational equipment without necessitating major modifications.

3.2.8.2.3 (TBS)

3.2.8.3 Other Flexibility and Expansion Requirements. System flexibility and expansion shall be enhanced by (TBS).

3.2.9 Portability. Not applicable. The only portability requirements for the system are stated in Paragraph 3.3.11 and subparagraphs for computer resources and in Paragraph 3.3.7 and subparagraphs for transportation.

3.3 DESIGN AND CONSTRUCTION

3.3.1 Materials

3.3.1.1 Toxic Products and Formulations. (Not applicable)

3.3.1.2 Materials, Processes, and Parts for Space Vehicle Equipment. Unless otherwise specified in the contract, the parts, materials, and processes shall be selected and controlled in accordance with documented procedures to satisfy the specified requirements. The selection and control procedures shall emphasize quality and reliability to meet the mission requirements and to minimize total life cycle cost for the applicable system. An additional objective in the selection of parts, materials, and processes shall be to minimize the variety of parts, related tools, and test equipment required in the fabrication, installation, and maintenance of the space equipment. However, identical electrical connectors, identical fittings, or other identical parts shall not be used on space equipment where inadvertent interchange of items or interconnections could cause possible malfunction. The parts, materials, and processes selected shall be of sufficient proven quality to allow the space equipment to meet the functional performance, reliability, and strength as required during its life cycle, including all environmental degradation effects.

3.3.1.2.1 Part Selection. Parts for space equipment shall be in accordance with MIL-STD-1547. Care shall be exercised in the selection of materials and processes for the space equipment to avoid stress corrosion cracking in highly stressed parts and to preclude failures induced by hydrogen embrittlement. Parts, materials, and processes shall be selected to ensure that any damage or deterioration from the space environment or the outgassing effects in the space environment will not reduce the performance of the space equipment beyond the specified limits.

3.3.1.2.2 Material Selection. Materials shall be selected that have demonstrated their suitability for the intended application. Where practicable, fungus-inert materials shall be used. Combustible materials or materials that can generate toxic outgassing or toxic products of combustion shall not be used if cost-effective alternatives exist. Materials shall be corrosion resistant or shall be suitably treated to resist corrosion when subjected to the specified environ-ments. Protection of dissimilar metal combinations shall be in accord-ance with MIL-STD-889.

Structural properties of materials for use in space applications shall be taken from MIL-HDBK-5 for metals and from MIL-HDBK-17 for plastics. Properties not listed shall be based upon appropriate material tests. When such data are not available, they shall be determined by approved test methods. A sufficient number of tests to establish values for mechanical properties on a statistical basis shall be performed.

Materials for the space equipment shall be selected for low outgassing in accordance with SP-R-0022 (NASA JSC). The total mass loss shall be less than 1 percent, and the collected volatile condensable material shall be less than 0.1 percent when heated in vacuum to 125 degrees C and collected at 23 degrees C. The hygroscopic nature of many materials such as composites, electroformed nickel, and anodic coatings for aluminum should be recognized, if they are used, since they emit water in a vacuum and therefore may be unsuitable for some applications.

3.3.1.3 **Materials, Processes, and Parts for Ground Equipment**. The selection and control procedures for parts, materials, and processes shall emphasize quality and reliability to meet the mission requirements and to minimize total life cycle cost for the applicable system. An additional objective in the selection of parts, materials, and processes shall be to minimize the variety of parts, related tools, and test equipment required in the fabrication, installation, and maintenance of the equipment.

3.3.1.3.1 **Part Selection**. MIL-STD-1547 shall be used as a guide in the application and selection of parts. In addition, the following part types shall be considered as acceptable for ground equipment:

a. Semiconductor Devices. All Class B or Class S semi-conductor devices selected from the MIL-S-19500 Qualified Parts List (QPL). No germanium device shall be utilized where a silicon counterpart exists.

b. Microelectronics. All Class B or Class S microelectronic devices selected from the MIL-M-38510 QPL. No germanium device shall be utilized where a silicon counterpart exists.

c. Passive Piece Parts. All piece parts, including capacitors, resistors, connectors, and relays, selected as Established Reliability types with at least a P or MIL-SPEC failure rate level, whichever is more reliable.

d. Electrical Connectors. Electrical connectors selected in accordance with MIL-C-38999 and MIL-C-83723 (covering circular connectors), MIL-C-55302 (covering printed circuit board connectors), MIL-C-28748 (covering rectangular rack and panel connectors), and other connector types selected in accordance with Requirement 10 of MIL-STD-454. Electrical connectors requiring potting compound material shall not be used.

3.3.1.3.2 Material Selection. Materials shall be selected that have demonstrated their suitability for the intended application. Where practicable, fungus-inert materials shall be used. Combustible materials or materials that can generate toxic outgassing or toxic products of combustion shall not be used if cost-effective alternatives exist. Materials shall be corrosion resistant or shall be suitably treated to resist corrosion when subjected to the specified environ-ments.

3.3.1.3.3 Resistance to Degradation and Wearout

a. Where dissimilar metals are used and come into contact, MIL-STD-889 and MIL-STD-454, Requirement 16, shall be followed to minimize corrosion effects.

b. Metals used in construction shall be resistant to corrosion. MIL-STD-1568 may be used as a guideline. Ferrous alloys shall be in accordance with MIL-STD-454, Requirement 15.

c. Fabric (textile) or plastic pressure-sensitive (adhesive or friction) tape shall not be used for electrical insulation purposes. Fastener hardware selection and use shall be in accordance with MIL-STD-454, Requirement 12.

d. Materials used for encapsulation and embedment shall be selected for their intended operational environmental conditions. Only those materials which meet or exceed the requirements of MIL-S-8516, MIL-S-23586, or MIL-I-81550 shall be used.

e. All exterior equipment including shelters of all kinds shall be assembled with MIL-S-81733 sealant between all faying surfaces. All fasteners (screws, bolts, rivets, etc.) protruding through the outside surfaces or exposed in any way must be wet-dipped in MIL-S-81733 sealant before being inserted and fastened. All exterior connector bases, access panels, and so forth, must also have MIL-S-81733 sealant applied wet to the faying surface immediately prior to being attached to the exterior surface.

f. Spot welding to fasten exterior equipment panel skins or exterior shells and covers to structural members is not allowed.

g. Fungus resistance must be designed in by using fungus-resistant materials in accordance with MIL-STD-454, Requirement 4.

h. Vinyl or polyvinylchloride materials shall not be used due to their well-known fungus nutrient characteristics and the dangers of outgassing corrosive products during storage.

i. Felt, leather, cork, asbestos, or glycol-impregnated gaskets shall not be used.

j. The design shall use arc-resistant materials in those locations where materials may be degraded by exposure to arcs, corona discharge, or related electrical discharges.

k. Contacts on circuit cards or other removable modules shall be designed to be abrasion and wear resistant, to be resistant to repeated reseating, removal, and reinsertion actions. Sliding surfaces of removable modules shall be suitably treated to prevent galling.

l. Solid film lubricants may be used except where exposure to fuels, hydraulic fluids, solvents, and so forth, occurs.

m. The equipment shall be designed to include adequate drain holes and corrosion protection in those locations where moisture, condensation, or rain can enter or accumulate.

3.3.1.3.4 Structural Properties. Structural properties of materials shall be taken from MIL-HDBK-5 for metals and from MIL-HDBK-17 for plastics. Properties not listed shall be based upon appropriate material tests. When such data are not available, they shall be determined by approved test methods. A sufficient number of tests to establish values for mechanical properties on a statistical basis shall be performed.

3.3.2 Electromagnetic Radiation. Electrical and electronic equipment shall operate independently and in conjunction with other equipment that may be placed nearby. The operation of such equipment shall not be adversely affected by interference voltages and fields reaching it from external sources. In addition, the equipment shall not be a source of interference which might adversely affect the operation of other equipment. The system shall be designed for electromagnetic compatibility in accordance with MIL-STD-1541. The system ground facilities shall be designed for electromagnetic compatibility in accordance with MIL-STD-1542.

3.3.2.1 Electromagnetic Radiation for Space Vehicle Equipment. The space equipment shall be designed for electromagnetic compatibility in accordance with MIL-STD-1541. For Shuttle-launched equipment, the requirements of JSC 07700, Volume XIV also apply.

Emissions of space equipment shall be controlled in accordance with MIL-STD-1541 requirements and, for Shuttle-launched equipment, in accordance with the requirements of JSC 07700, Volume XIV.

3.3.2.2 Electromagnetic Radiation for Ground Equipment. Although ground equipment need not meet the flight electromagnetic compatibility requirements, it is necessary that it not be a source of interference to, or be affected by, flight hardware. Ground equipment which is to be used at the launch site, particularly that for Shuttle-launched space equipment, also shall meet the emission requirements imposed by the launch site.

3.3.2.2.1 Red/Black Interface Control. Equipment layout and electrical interfaces shall be designed in accordance with NACSIM-5203.

3.3.2.2.2 TEMPEST Requirements. The system equipment shall meet TEMPEST requirements specified in NACSIM-5100A. TEMPEST-approved equipment shall be used as required; however, to allow for the use of items for which TEMPEST-approved equipment is not available, physical security shall be implemented. Additionally, other physical measures such as RFI cabinets and screen rooms shall be used if required. Individual equipment need not meet TEMPEST requirements at the unit level, if the design or installation of the system equipment in the facilities enables TEMPEST requirements to be met at the primary control zone of the facility. The specified levels of radiation shall not be exceeded at the secure site perimeter.

3.3.3 Nameplates and Product Marking. The system CIs and each interchangeable subassembly shall be identified by a nameplate. The nameplate identification may be attached to, etched in, or marked directly on the item. The nameplate shall utilize suitable letter size and contrasting colors, contrasting surface finishes, or other techniques to provide identification that is readily legible. The nameplate shall be capable of withstanding cleaning procedures and environmental exposures anticipated during the service life of the item without becoming illegible. Metal foil nameplates may be applied if they can be placed in an area where they cannot interfere with proper operation should they inadvertently become detached. Metal stamping shall not be used. Where practicable, identification nameplates on components and subassemblies shall be in locations which permit observation of the marking at the next higher level of assembly. Nameplates shall contain, as a minimum, the following:

a. Item or CI number

b. Serial number

c. Lot number

d. Manufacturer

e. Contract number

f. Nomenclature

3.3.3.1 Data Cards. When size limitations, cost, or other considerations preclude marking all applicable information on an item, the nameplate may provide a reference key to cards or documents in which the omitted nameplate information may be found. A copy of the referenced nameplate information or card shall accompany the item or assembly containing the item during ground tests and ground operations.

3.3.3.2 Nameplates and Product Marking for Space Vehicle Equipment. The marking of any two or more items intended for space applications with the same item number or identification shall indicate that they may be capable of being changed, one for another, without alteration of the items themselves or of adjoining equipment if the items also meet all other specified requirements (such as acceptable lot date code).

3.3.3.3 *"NOT FOR FLIGHT"* Marking. Space equipment which by intent or by material disposition are not suitable for use in flight, and which could be substituted accidentally for flight or flight spare hardware, shall be red-tagged or striped with red paint, or both, to prevent such substitution. The red tag shall be conspicuous and marked *"NOT FOR FLIGHT."* The red paint shall be material compatible and the stripes unmistakable.

3.3.3.4 Nameplates and Product Marking for Ground Equipment. The marking of any two or more items intended for ground applications with the same item number or identification shall indicate that they possess such functional and physical characteristics as to be equivalent in performance and durability and therefore can be changed, one for another, without alteration of the items themselves or of adjoining items.

Ground equipment, assemblies, and parts shall be marked for identification in accordance with MIL-STD-454, Requirement 67. Nomenclature and reference designations for ground equipment shall meet the requirements of MIL-E-4158.

3.3.3.5 Software Media Marking. Software media marking requirements are stated in the computer resources Paragraph 3.3.11 and subparagraphs.

3.3.4 Workmanship. Equipment shall be manufactured, processed, tested, and handled such that the finished items are of sufficient quality to ensure reliable operation, safety, and service life. The items shall be free of defects that would interfere with operational use such as excessive scratches, nicks, burrs, loose materials, contamination, and corrosion. Workmanship for ground equipment shall be in accordance with the requirements of MIL-STD-454, Requirement 9.

3.3.5 Interchangeability

3.3.5.1 Space Vehicle Equipment Interchangeability. The design of the space elements shall make provisions for the factory replacement of components and subassemblies and for the prelaunch installation or replacement of explosive ordnance devices, batteries, and major space vehicle components.

3.3.5.2 Ground Equipment Interchangeability. To the extent practicable, the design of the ground equipment shall make provisions for modular replacement of components to expedite maintenance and repair. The interchangeability requirements of MIL-STD-454, Requirement 7 shall apply for all ground equipment. To the maximum extent possible, equipment shall be designed as modular plug-in devices and shall be readily replaceable or interchangeable with identical devices. The plug-in devices shall be marked and keyed to preclude insertion or installation in the wrong position or location. All components performing identical functions shall be physically and electrically interchangeable without requiring any preparation other than minor adjustments, such as resetting of external switches, connection of cables, or insertion of plug-in modules. Attention shall be directed toward standardizing form, fit, and function of like equipment modules to ensure interchangeability. This includes the use of standard interequipment communications, man-machine interface, software, and data processing.

3.3.6 Safety. The system design shall be such that hazards to personnel, to the system, and to the associated equipment are either eliminated or controlled throughout all phases of the system life cycle. The safety requirements shall be in accordance with MIL-STD-1574. A safety hazard to personnel and surrounding equipment shall not be created during installation, maintenance, ground test, transportation, and operational use. Safety procedures shall be documented and implemented to assure maximum freedom from accidents attributable to facilities, equipment, and personnel. The safety requirements shall be formulated to achieve an integrated system safety engineering effort. Procedures shall be used and precautions taken to preclude the dropping of tools or other items that might injure personnel or damage sensitive equipment during installation, maintenance, ground test, and transportation. The safety requirements and procedures shall comply with applicable Range Safety manuals.

3.3.6.1 Space Transportation System Payload Safety. For all payloads which are to be launched by the STS, the safety requirements also shall be in accordance with Chapter 2 of NHB 1700.7 (NASA). For these payloads, it is required that the payload must tolerate a minimum number of failures and/or operator errors determined by the consequence of any hazardous functions. For catastrophic hazards or hazards that would result in personnel injury or loss of the Orbiter or STS facilities and equipment, the hazard shall be controlled such that no combination of two failures, operator errors, or radio-frequency signals would unleash the hazard. For critical hazards or hazards that would result in damage to STS equipment or in the use of contingency or emergency procedures, the hazard shall be controlled such that no single failure, or operator error, will unleash the hazard. Hazardous functions are thereby controlled with either two or three inhibits, depending on whether the hazard is critical or catastrophic.

In addition, Chapter 2 of NHB 1700.7 (NASA) defines safety requirements for space equipment structural design, stress corrosion, pressure vessels, sealed containers, hazardous materials, pyrotechnics, destruct subsystems, radiation, electrical subsystems, flammable atmospheres, and reflown hardware.

3.3.6.2 Ground Equipment Safety. The safety requirements for ground equipment shall be in accordance with SAMTO HB S-100 (designated by NASA as KHB 1700.7) and with MIL-STD-454, Requirement 1.

3.3.6.2.1 Electrical. The system design shall incorporate methods to protect personnel from accidental contact with voltages in excess of 30 volts. Appropriate voltage interlocks shall be provided.

3.3.6.2.2 Acoustic Noise. System equipment shall not generate acoustic noise in excess of 70 decibels adjusted (dBa) continuous or 140 dB of impulsive noise. System acoustic noise levels shall not exceed the noise level prescribed in MIL-STD-1472.

3.3.6.2.3 Personnel Safety. Platforms, ladders, access, and task lighting shall be provided for all items requiring inspection, maintenance, service, or replacement.

3.3.7 Human Engineering. Throughout the design and development of the system, the applicable criteria in MIL-STD-1472 shall be judiciously applied to obtain effective, compatible, and safe man-equipment interactions. Provisions such as tabs, shoulders, and different thread sizes shall be employed to prevent incorrect assembly which may impair the intended functions. Human engineering goals shall be for effective use of human resources. The goal shall be to minimize manning, operator error, task complexity, and task time. Throughout the human engineering efforts, particular attention shall be given to equipment and computer programs supporting time-critical functions which require personnel interaction. Displays shall be housed in consoles or equipment racks. The console design shall consider the human engineering aspects of physical dimensions, operating controls, and viewing areas. Visual considerations shall include visual display legibility; size, shape, and spacing of indicators on the display surface; brightness, color, contrast, and blink rate for unique annunciation of events; and ambient lighting and its effect on the display surface and display legibility together with size and coloring of lettering and other markings on the display surfaces. Aural considerations shall include location of audible alarms, tone, pitch, quality, and intensity.

3.3.8 Nuclear Control Requirements. Provisions shall be made in the design for the control of all nuclear material so as to prevent the inadvertent exposure, loss, or detonation of nuclear material. (TBS)

3.3.9 System Security. Ground facilities shall have an identified primary security control zone for each building within a secure site perimeter. (TBS)

3.3.10 Government-Furnished Property Usage

3.3.10.1 Government-Furnished Equipment for Incorporation. The following GFE shall be incorporated into the system as indicated:

a. COMSEC equipment (TBS)

b. Rocket motors (TBS)

c. Explosive ordnance (TBS)

d. Payload equipment (TBS)

e. Other (TBS)

3.3.10.2 Government-Furnished Software for Incorporation. The following government-furnished software shall be incorporated into the system as indicated: (none)

3.3.10.3 Government-Furnished Information for Incorporation. (none)

3.3.11 Computer Resources. Computer resources include all computer software and the associated computational equipment included within the system. Computational equipment is that equipment, including the associated peripheral devices, which is capable of executing machine-readable, symbolically expressed instructions. These computer resources shall be designed and developed in accordance with an integrated plan that minimizes the system life cycle cost. The design shall provide ample memory and processing margins to accommodate contingencies and growth (see Paragraph 3.2.8). A distinction is made between the computer resources required to functionally support operations and computer resources used for nonoperational support. For operational computer resources, a further distinction is made for some features between the requirements for computer resources in space elements and the requirements for computer resources in ground elements of the space system. Nonoperational computer resources are those used for computer software maintenance, those embedded in test equipment, and those included in other functional areas such as in trainers. Requirements for nonoperational computer resources are separated by functional area.

3.3.11.1 Operational Computer Resources. The operational computer resources are those required to function on-line or off-line during one or more phases or modes of the operational service life. The operational computer resources shall be capable of performing the required real-time computational functions in the space system, including the space vehicle, the launch vehicle (STS), and the ground equipment. These real-time functions include data processing, communications, display, and control functions. In addition, the operational computer resources shall perform the required nonreal-time data processing and support functions.

3.3.11.1.1 Operational Computational Equipment. The computational equipment includes processing units; special-purpose computational devices; main storage; peripheral data storage; input and output units such as printers, graphic displays, video display devices; and other associated devices. To the extent practicable, the ground operational computational capability shall be provided by commercially available, general-purpose computer equipment.

3.3.11.1.1.1 Computer Instruction Performance Rate. Within its operating environment, each processing unit shall perform instructions at a rate to support the requirements specified herein. An increased capability in peak real-time functional capability beyond the specific requirements identified shall be provided for future growth as stated in Paragraph 3.2.8.

3.3.11.1.1.2 Data Channel Capacity. The maximum input data-rate capability and the maximum output data-rate capability of each channel, when operating with the operational application computer software, shall support the requirements specified herein. An increased capability in channel buffer capacity and peak data rate beyond the specific requirements identified shall be provided for future growth as stated in Paragraph 3.2.8.

3.3.11.1.1.3 Main Storage (Primary Memory). The capacity of the main storage (primary memory) in operational computers shall support the requirements specified herein. An increased capability in storage capability beyond the specific requirements identified shall be provided for future growth as stated in Paragraph 3.2.8. The main storage in operational ground computers shall be modular in design.

3.3.11.1.1.4 Peripheral Data Storage (Secondary Memory) in Ground Installations. The capacity of the peripheral data storage (secondary memory) in operational computers shall support the requirements specified herein. An increased capability in storage capability beyond the specific requirements identified shall be provided for future growth as stated in Paragraph 3.2.8. The peripheral data storage in operational ground computers shall be modular in design.

3.3.11.1.1.5 Automatic Initialization and Startup. Each computer shall have facilities to establish automatic initialization and startup in response to a single control action. These facilities shall provide for the automatic loading, initialization, and starting of both the operating system and the application computer software.

3.3.11.1.2 Operating Systems Used in Operational Computers. The operating system for each operational computer should be in broad use and should have a demonstrable record of reliable performance. Where applicable, the operating systems shall provide the scheduling, task switching (on a priority basis), input/output control, data management, and memory management capabilities required to support the real-time computational and control functions of the computational components. The operating system shall support memory protection. The operating system shall be capable of exploiting the growth requirements specified for the operational computational equipment without necessitating any modifications (see Paragraph 3.2.8).

Utility libraries which are available to all tasks at link time through the operating system link and load facility are considered part of the operating system itself.

3.3.11.1.3 Operational Application Software

3.3.11.1.3.1 Programming Language. Where practicable, operational application computer software shall be written in Ada per MIL-STD-1815 or in JOVIAL J73 per MIL-STD-1589. Assembly language shall be used only where its use is necessary for the satisfaction of system performance requirements or where its use is cost effective over the life of the system. The term *"assembly language"* includes the use of microcode and microprogramming.

3.3.11.1.3.2 Computer Software Tasks. An executable entity of a computer application program under a modern operating system is defined as a task. (By this definition, the word *"task"* is used only to mean an executable entity of an application program under an operating system, and it does not mean *"something that has to be done"*.)

3.3.11.1.3.3 Computer Software Structure. The structure of application programs shall be organized to preserve the identification of the tasks involved. While the operating system supervises software execution by task and task priorities, tasks are organized for programming and compiling into groups of tasks (packages), single tasks, and computer software units. For formal configuration identification and control, the computer application software and structure shall be identified as Computer Software Configuration Items (CSCIs), Computer Software Components (CSCs), and Computer Software Units.

a. Computer Software Configuration Items. The top-level computer software end item is a CSCI. A CSCI consists of one or more subtier elements. An application CSCI consists of one or more tasks. The subtier elements of a CSCI may be other CSCIs, CSCs, or computer software units.

b. Computer Software Components. A CSC is a subtier element of a CSCI which may be defined to assist in the development or acquisition process. A CSC shall consist of a single task or may be subtier to a task. The subtier elements of a CSC may be one or more computer software units. A CSC shall not consist of units in different tasks. If the identical computer software unit is used in various tasks, it would appear in the various CSCs completely or by reference.

c. Computer Software Units. A computer software unit may provide information or may provide a capability to perform one or more operations, or both. A computer software unit may contain embedded units. Several different types of computer software units may be defined, depending upon the computer language used.

3.3.11.1.3.4 Structure of Modules. Each computer software unit shall be organized into two subparts: an interface and an implementation.

a. The interface part shall characterize the capabilities the computer software unit makes available to other units or to other interfacing system items such as devices or human operators. The interface part shall not exceed 50 lines of source code (excluding comments).

b. The implementation part of each computer software unit shall define how the operations specified in the interface are to be provided. The implementation part shall not exceed 100 lines of source code (excluding comments).

3.3.11.1.3.5 Hierarchical Software Design. Operational computer software shall be designed in a hierarchical manner, and the levels of the hierarchy shall correspond to the levels of abstraction of the tasks performed by the program. A level of abstraction is characterized by:

a. The types of data objects defined to exist on that level.

b. The operations defined to be performed to those data objects.

Each level of the program shall be complete in itself. Provisions for incorporating existing computer software units into the hierarchy shall be made so as to maximize the reuse of previously developed computer software.

3.3.11.1.3.6 Standardized Control Structures. Only closed control structures shall be used in the construction of program computer software units. Closed control structures are structures that have a single entry point and a single exit point. For example, closed control structures include:

a. A simple sequence.

b. A conditional selection.

c. An iteration.

3.3.11.1.3.7 Strong Typing. Explicit declarations shall be provided of the characteristics attributed to computer software elements. No computer software element with a particular collection of declared characteristics shall be treated as if it had some other attributes. A method shall be utilized to constrain data attributes at compile time.

3.3.11.1.3.8 Encapsulation of Representations. Every computer software element which is used to represent some concept other than itself shall be treated as encapsulated within the declaration of the concept represented. Encapsulated means that external to the encapsulating declaration, no operation shall be applied directly to the internal elements. For example, an array may be used to represent a stack. In this case, the array is the representation and the stack is the concept represented. Encapsulation requires that no array operations may be applied to the array by any part of the program other than that part that implements the representation. Other parts of the program may apply only stack operations.

3.3.11.1.3.9 Software Coding Conventions. All computer software shall conform to the following coding conventions:

a. The structure of the source code shall reflect the design of the program.

b. Each line of source code shall contain no more than three statements, i.e., no more than three semicolons in Ada or JOVIAL. Each statement in a line with multiple statements shall have no more than three operations.

c. To the extent practicable, names used in computer software shall be consistent with those used in the system design.

d. Code shall be written such that no code is modified during execution.

3.3.11.1.3.10 Software Comments. Comments shall be incorporated throughout each computer program to self-document the organization and logic of the program. Computer software shall adhere to the following commenting standards:

a. Banners. A banner shall be the first item in each computer software listing. The banner for a CSCI listing shall state the CSCI title, the titles of all subtier CSCIs if any, the title of all tasks, the title of all subtier CSCs, and the title of all subtier com-puter software units not granted the level of a CSC. The banner for a CSC listing shall state the title for the parent CSCI, the title of the parent task, the CSC title, and the title of all computer software units in the CSC. The banner for each of the two parts of a computer software unit listing should state the title for the parent CSCI, the title for the parent CSC, the title for the parent computer software unit (if any), the title of the computer software unit, and whether the part is the interface or the implementation part of the computer software unit.

b. Headers. A header consisting of a consecutive block of comments shall follow the banner in each source code listing to facilitate the understanding and readability of the listing. The header shall provide a prose abstract of the declarations and processing activities to assist in understanding of the program code.

c. Special Comments. Special comments shall be included within the source code listing to assist in reading particularly subtle or confusing code. Special comments may supplement header comments, but they should not replace the header comments. A special comment shall be included for every logic branch and join point to characterize the intended operation of the program to that point.

3.3.11.1.3.11 Message Generation. The ground operational computer software shall generate error messages, diagnostic messages, and alarm messages on-line to facilitate real-time fault isolation required to maintain the system in operational status In addition, these ground operational computer software shall generate off-line error and diagnostic messages for the logging of fault messages onto system files for those categories of faults which require isolation and correction but can be addressed off-line and do not degrade system performance. The required processing time to identify and generate error and diagnostic messages shall not degrade the operational performance of the system. Messages shall conform to the following:

a. With the exception of lengthy diagnostic procedures for use following an abnormal condition, processor message and advisory formats shall not require additional interpretation by the operator. For example, table lookups and references to documentation should not be required.

b. Every message and advisory shall include a unique description of the condition which prompted it.

c. On-line error messages shall contain as a minimum the following information:

(1) Time error was detected

(2) Textual description of error condition

(3) Required operator action where applicable

d. Off-line error messages shall contain as a minimum the following information:

(1) Time error was detected

(2) Textual description of error condition

(3) Required operator action where applicable

(4) Identification of triggering computer software unit

(5) Identification of source program operation being performed at the time of the error

(6) Computer software or system execution status following the error

3.3.11.1.3.12 Character Set Standards. Character sets shall conform to standards in ANSI-STD X 3.4-1968 (FIPS PUB 1).

3.3.11.1.3.13 Growth. The operational application computer software shall satisfy their performance requirements without the implementation of any of the growth provisions identified herein for computational equipment (see Paragraph 3.2.8). However, the application programs should be designed to be capable of easily exploiting any of the identified growth provisions, such as added memory, which may be implemented.

3.3.11.1.4 Operational Firmware. Computer programs and data stored in a class of storage that cannot be modified by the computer during processing shall be considered firmware. Requirements on operational firmware shall be the same as those on operational application computer software.

3.3.11.1.5 Computer Resource Utilization Monitoring. The ground operational computer resources shall provide a capability which can be exercised under operator control to monitor, record, display, and print the utilization of the various computer resources. The computer resource utilization that should be measurable and recordable during real time operations includes:

a. Job timing, that is, overall CPU utilization
b. Task timing, the CPU seconds used by each task
c. Computer main storage (primary memory) utilization
d. Peripheral data storage (secondary memory) utilization
e. A trace of the program execution sequence

The time interval between recording samples shall be variable, and the types of data collected shall be options; both shall be under operator control. Deletion of the options shall remove the execution and storage overhead associated with the options.

3.3.11.2 Computer Software Maintenance Resources

3.3.11.2.1 Computational Equipment for Computer Software Maintenance. The computational equipment for computer software maintenance is that computational equipment required during the operational service life to develop and test changes to the computer software used in operational equipment and in training equipment. To the extent practicable, this computational equipment for computer software maintenance shall be identical to the computational equipment used for computer software development. In other words, the computer software development equipment normally would transition to the computer software maintenance facility. The computer software maintenance equipment shall be capable of accommodating the growth requirements of the operational computational equipment without necessitating any hardware modifications.

3.3.11.2.2 Computer Software for Computer Software Maintenance Computers. The operating system for each computer used in the maintenance of operational computer software shall be capable of exploiting the growth requirements specified for the operational computational equipment without necessitating any major modifications. Maintenance of operational computer software shall be supported by utility programs and other computer software running with the operating system(s) and computer(s) specifically identified for computer software maintenance. The operating system(s) and computer software used for computer software maintenance shall provide as a minimum the following interactive capabilities:

a. Editing

b. Compilation which produces relocatable object code

c. If applicable, an assembly which produces relocatable object code

d. Linker and loader

e. Generation, maintenance, and initialization of storage media for programs and data

f. Diagnostics to support fault isolation

g. Debugging tools

h. Program library facilities for both source and object code

i. Configuration control capability

To the extent practicable, the operating system(s), other computer software, and firmware to be used for computer software maintenance during the operational service life shall be the same as that used for computer software development.

3.3.11.2.3 Computer Resource Utilization Monitoring. The computer resources used for computer software maintenance shall provide a capability to monitor, record, display, and print the simulated utilization of the operational computer resources under simulated operational conditions. The intent of this capability is to provide a means for making measurements that would assure that adequate growth margins can be maintained as changes are incorporated during the operational service life.

3.3.11.2.4 Tools for Computer Software Maintenance. Tools required for the initial development of operational computer software and firmware shall become part of the Computer Software Maintenance Resources. These tools shall be capable of reuse in testing and validating changes to the computer software. These tools include test drivers, simulated data, and other special-purpose devices. For example, if a Microprocessor Development System were used to develop firmware, the Microprocessor Development System and the associated computer software and documentation should be controlled and retained as part of the computer software maintenance resources to support possible change activity during the operational service life of the system.

3.3.11.3 Computer Resources in Test Equipment. Test equipment is that equipment required to support the maintenance, repair, and checkout of the system hardware following system deployment. The computer resources that are embedded in the test equipment shall meet the requirements specified for operational computer resources except for programming language requirements and for growth potential. Computer software for use in automatic test equipment shall be written in ATLAS per ANSI/IEEE 416-1978, where practicable.

3.3.11.4 Computer Resources in Trainers. The trainers are the equipment to be used for the training of system operator personnel. The computer resources in trainers are the computer software and the associated computational equipment, controls, and displays embedded in the trainers. To the extent practicable, the computational equipment in trainers that provides operator displays and controls shall be identical to the corresponding operational computational equipment.

3.3.12 Space Vehicle Design Requirements

3.3.12.1 General Structural Design. The primary support structure for the space equipment shall possess sufficient strength, rigidity, and other characteristics required to survive the critical loading conditions that exist within the envelope of handling and mission requirements. It shall survive those conditions in a manner that assures safety and that does not reduce the mission success probability. The primary support structure of the space equipment shall be electrically conductive to establish a single-point electrical ground. The structure of equipment to be launched in the STS shall be designed to meet the applicable safety requirements of NHB 1700.7.

3.3.12.2 Strength Requirements

3.3.12.2.1 Yield Load. The structure shall be designed to have sufficient strength to withstand simultaneously the yield loads, applied temperature, and other accompanying environmental phenomena for each design condition without experiencing yielding or detrimental deformation.

3.3.12.2.2 Ultimate Load. The structure shall be designed to withstand simultaneously the ultimate loads, applied temperature, and other accompanying environmental phenomena without failure.

3.3.12.3 Stiffness Requirements

3.3.12.3.1 Dynamic Properties. The structural dynamic properties of the equipment shall be such that its interaction with the space vehicle control subsystem does not result in unacceptable degradation of performance.

3.3.12.3.2 Structural Stiffness. Stiffness of the structure and its attachments shall be controlled by the equipment performance requirements and by consideration of the handling, launch, and landing environments. Special stowage provisions shall be used, if required, to prevent excessive dynamic amplification during transient flight events such as launch or landing.

3.3.12.3.3 Component Stiffness. The fundamental resonant frequency of a component weighing 23 kilograms or less shall be 50 Hertz or greater when mounted on its immediate support structure.

3.3.12.4 Structural Factors of Safety. The factor of safety of the structure is the ratio of the limit load to the allowable load.

3.3.12.4.1 Flight Limit Loads. Available options for structural design are listed in Table I. All safety-related structural design requirements shall be met.

TABLE I. Structural Design Factors of Safety.

Design and Test Options	Design Factor of Safety of Limit Loads		
	Yield	Ultimate	
	(FSy)	(FSu) Unmanned Events	(FSu) Manned Events
1. Dedicated Test Article	1.00	1.25	1.40
2. Test One Flight Article	1.25	1.40	1.40
3. Proof Test Each Flight Article	1.10	1.25	1.40
4. No Static Test	1.60	2.00	2.25

3.3.12.4.2 Pressure Loads. Factors of safety for pressure loads shall be determined individually for each pressure vessel, based on tests to establish material characteristics and an analysis of life requirements and other environmental exposure. Proof and burst pressure factors shall be established at levels that ensure structural integrity, structural life, and safety throughout all phases. The values listed in Table II are to be considered as limiting lower bounds.

3.3.12.5 Design Load Conditions. The space vehicle equipment shall be capable of withstanding all design load conditions to which it is exposed in all mission phases, as applicable: ground, prelaunch, erection, post-launch, boost, orbit, reentry, and landing. During the orbit phase, all of the following shall be considered: maneuvering loads, vehicle spin, meteoroid environment, radiation environment, and other environmental factors, such as thermal effects due to internal heating, solar heating, eclipses, and extreme cold due to ambient space environment.

3.3.12.6 Space Vehicle Fluid Subsystems

3.3.12.6.1 Pressurized Components. Fluid subsystems and pressurized components shall be in accordance with MIL-STD-1522 and NHB 1700.7 (NASA). For all space equipment, all safety-related pressurized component design requirements shall be met.

3.3.12.6.2 Tubing. Tubing shall be stainless steel, where practicable. Tubing joints shall be thermal welded butt joints, where practicable. Tubing design shall incorporate provisions for cleaning and to allow proof testing.

3.3.12.6.3 Separable Fittings. Separable fittings shall have redundant sealing surfaces, such as double *"O"* rings, and be of the *"parallel loaded"* type. *"Parallel loaded"* means that the fitting contains a compressed element which exerts outward pressure on the other elements of the fitting such that both seals are maintained even if relaxation occurs. Separable fittings shall have provisions for locking. Separable fittings should be accessible for leak tests and for torque checks. Separable fittings should not be designed or assembled with lubricants or fluids that could cause contamination or could mask leakage of a poor assembly.

3.3.12.7 Moving Mechanical Assemblies. Deployment mechanisms, sensor mechanisms, pointing mechanisms, drive mechanisms, despin mechanisms, separation mechanisms, and other moving mechanical assemblies on space vehicles shall be in accordance with MIL-A-83577.

3.3.12.8 Explosive Ordnance. Explosive ordnance to be installed on a space vehicle shall be in accordance with DOD-E-83578. All safety-related explosive ordnance design requirements shall be met.

3.3.12.9 Wiring Harness. The electrical wiring harnesses between space components shall be in accordance with DOD-W-83575.

3.3.12.10 Electronic Components. Electronic components for space applications shall be in accordance with DOD-E-8983. Electronic parts for space applications shall be in accordance with MIL-STD-1547.

TABLE II. Factors of Safety for Pressurized Components.

Component[a]	Design Ultimate	Acceptance (Proof)	Qualification
Solid Rocket Motor Cases[b]	1.25	1.10[c]	1.25[c]
Pneumatic Vessels[b]	2.00	1.50[c]	2.00[c]
Lines, Fittings, and Hoses			
Less than 3.81 cm diameter[d]	4.00	2.00[c]	4.00[c]
3.81 cm diameter and larger[d]	1.50	1.10[c]	1.50[c]
Other Pressurized Components	2.50	2.00[c]	2.50[c]

Notes:

a. All pressure vessels, sealed containers, lines, fittings, and other pressurized components of equipment to be launched in the STS shall be designed to meet the applicable safety requirements of NHB 1700.7 (NASA) and SAMTO HB S-100 (designated by NASA as KHB 1700.7).

b. Factors of safety shown are minimum values applicable to metallic pressure vessels for which ductile fracture mode is predicted via a combination of stress and fracture mechanics analyses. Design of metallic pressure vessels for which brittle fracture mode is predicted by these analyses shall be in accordance with fracture mechanics methodology wherein the proof factor as well as the design ultimate factor of safety shall be established to provide a minimum of four times the specified service life against mission requirements. In addition, a fracture control program shall be established to prevent structural failure due to the initiation or propagation of flaws or crack-like defects during fabrication, testing, and service life.

c. No yielding is permitted at acceptance (proof) test pressure and no rupture at qualification pressure.

d. 3.81 cm diameter is equivalent to 1.5 inches diameter.

3.3.12.11 Solar Arrays. Solar arrays for space applications shall be in accordance with MIL-S-83576.

3.3.12.12 Embedded Nonoperational Elements. Any non-operational elements of the space system that are embedded in space elements, such as self-test circuitry, computer software, or other features not required during on-orbit operations, shall be designed to the applicable requirements of the operational elements in which they are embedded.

3.3.13 Operational Ground Equipment: General Design Requirements

3.3.13.1 General Structural Design. The primary support structure for the ground equipment shall possess sufficient strength, rigidity, and other characteristics required to survive the critical loading conditions that exist within the envelope of handling and mission requirements. The primary support structure shall survive those conditions in a manner that assures safety for the mobile or fixed stations as applicable and that does not reduce the mission success probability. The primary support structure of the equipment shall be electrically conductive and shall permit the implementation of a single-point electrical ground.

3.3.13.2 Strength Requirements

3.3.13.2.1 Yield Load. The structure shall be designed to have sufficient strength to withstand simultaneously the yield loads, applied temperature, and other accompanying environmental phenomena for each design condition without experiencing yielding or detrimental deformation.

3.3.13.2.2 Ultimate Load. The structure shall be designed to withstand simultaneously the ultimate loads, applied temperature, and other accompanying environmental phenomena without failure.

3.3.13.3 Stiffness Requirements

3.3.13.3.1 Dynamic Properties. The structural dynamic properties of the equipment shall be such that its interaction with the environment does not result in unacceptable degradation of performance.

3.3.13.3.2 Structural Stiffness. Stiffness of the structure and its attachments shall be controlled by the equipment performance requirements and by consideration of the handling, transport, and operational environments. Special stowage and tie-down provisions shall be used, if required, to prevent excessive dynamic amplification during transient events such as installation and transport.

3.3.13.3.3 Component Stiffness. The fundamental resonant frequency of a component weighing 23 kilograms or less shall be 10 Hertz or greater when mounted on its immediate support structure.

3.3.13.4 Structural Factors of Safety. The factor of safety of the structure is the ratio of the limit load to the allowable load.

3.3.13.4.1 Transport Limit Loads. Available options for structural design are listed in Table III. All safety-related structural design requirements shall be met.

TABLE III. Ground Equipment Structural Design Factors of Safety.

Design and Test Options	Deisgn Factor of Safety on Limit Loads	
	Yield	Ultimate
1. Static Proof Test Each Air Transportable Article	1.10	1.40
2. No Static Test (analysis only)	1.60	2.25

3.3.13.4.2 Pressure Loads. Factors of safety for pressure loads shall be determined individually for each pressure vessel, based on tests to establish material characteristics and an analysis of life requirements and other environmental exposure. Proof and burst pressure factors shall be established at levels that ensure structural integrity, structural life, and safety throughout all phases. The values listed in Table IV are to be considered as limiting lower bounds. Federal, State, and local safety regulations shall be met.

TABLE IV
Factors of Safety for Ground Equipment Pressurized Components.

Component[a]	Design Ultimate	Acceptance (Proof)	Qualification
Pneumatic Vessels[a]	2.00	1.50[b]	2.00[b]
Lines, Fittings, and Hoses			
Less than 3.81 cm diameter[c]	4.00	2.00[b]	4.00[b]
3.81 cm diameter and larger[c]	1.50	1.10[b]	1.50[b]
Other Pressurized Components	2.50	2.00[b]	2.50[b]

Notes:

a. Factors of safety shown are minimum values applicable to metallic pressure vessels for which ductile fracture mode is predicted via a combination of stress and fracture mechanics analyses. Design of metallic pressure vessels for which brittle fracture mode is predicted by these analyses shall be in accordance with fracture mechanics methodology wherein the proof factor as well as the design ultimate factor of safety shall be established to provide a minimum of four times the specified service life against mission requirements. In addition, a fracture control program shall be established to prevent structural failure due to the initiation or propagation of flaws or crack-like defects during fabrication, testing, and service life.

b. No yielding is permitted at acceptance (proof) test pressure and no rupture at qualification pressure.

c. 3.81 cm diameter is equivalent to 1.5 inches diameter.

3.3.13.5 Design Load Conditions. The equipment shall be capable of withstanding all design load conditions to which it is exposed.

3.3.13.5.1 Air Transportation Load Factors. The load factors applied to the C-130, C-141, and C-5 air transport environments shall be 1.5.

3.3.13.5.2 Ground Transportation Load Factors. The ground transportation load factors shall be 1.5.

3.3.13.6 Fluid Subsystems

3.3.13.6.1 Pressurized Components. Fluid subsystems and pressurized components shall be in accordance with MIL-STD-1522. For all equipment, all safety-related pressurized component design requirements shall be met.

3.3.13.6.2 Tubing. Tubing shall be stainless steel, where practicable. Tubing joints shall be thermal welded butt joints, where practicable. Tubing design shall incorporate provisions for cleaning and to allow proof testing.

3.3.13.6.3 Separable Fittings. Separable fittings shall have provisions for locking. Separable fittings should be accessible for leak tests and for torque checks. Separable fittings should not be designed or assembled with lubricants or fluids that could cause contamination or could mask leakage of a poor assembly.

3.3.13.7 Electronic Components. Ground electronic equipment shall be in accordance with MIL-E-4158. Electronic components for ground applications shall be in accordance with MIL-STD-1250. The design shall avoid use of incompatible materials such as that given in MIL-STD-1250, Paragraph 5.13, and in MIL-STD-171, Paragraph 4.8.

3.3.14 Nonoperational Ground Equipment: General Design Requirements. Nonoperational ground equipment is ground equipment that is used off line in such areas as training, maintenance, or transportation and is not required during on-orbit operations.

3.3.14.1 Embedded Nonoperational Elements. Any nonoperational ground equipment that is embedded in operational ground equipment, such as self-test circuitry, computer software, or other features not required during on-orbit operations, shall be designed to the applicable requirements of the operational ground equipment in which they are embedded.

3.3.14.2 Other Nonoperational Ground Equipment

3.3.14.2.1 Test Equipment. Test equipment is that equipment required to support the maintenance, repair, and checkout of the system hardware following system deployment. To the extent practicable, test equipment shall be designed using applicable commercial practices. Commercially available modules shall be used to the extent practicable.

3.3.14.2.2 Trainers. The trainers are the equipment to be used for the training of system operator personnel. To the extent practicable, trainers shall be designed using the same interfacing controls, displays, and equipment locations as occurs operationally. Trainers shall be designed using applicable commercial practices.

3.3.15 General Construction Requirements

3.3.15.1 Processes and Controls for Space Vehicle Equipment. Acceptance and flight certification of space equipment is based primarily on an evaluation of data from the manufacturing process. The manufacturing process for space equipment shall be accomplished in accordance with documented procedures and process controls which assure the *reliability* and *quality required for the mission.* These manufacturing procedures and process controls shall be documented to give visibility to the procedures and specifications by which all processes, operations, inspections, and tests are to be accomplished by the supplier. This internal contractor documentation shall include the name of each part or component, each material required, the point it enters the manufacturing flow, and the controlling specification or drawing. The documentation shall indicate required tooling, facilities, and test equipment; the manufacturing check points; the quality assurance verification points; and the verification procedures corresponding to each applicable process or material listed. The specifications, procedures, drawings, and supporting documentation shall reflect the specific revisions in effect at the time the items were produced. These flow charts and the referenced specifications, procedures, drawings, and supporting documentation become the manufacturing process control baseline and shall be retained by the supplier for reference. It is recognized that many factors may warrant making changes to this documented baseline; however, all changes to the baseline processes used, or the baseline documents used, shall be recorded by the supplier following establishment of the manufacturing baseline or following the manufacture of the first item or lot of items. These changes provide the basis for flight accreditation of the items manufactured or of subsequent flight items.

The manufacturing process and control documents for space equipment shall provide a supplier-controlled baseline that assures that any subsequent failure or discrepancy analysis that may be required can identify the specific manufacturing materials and processes that were used for each item. In that way, changes can be incorporated to a known baseline to correct the problems.

3.3.15.1.1 Assembly Lots. To the extent practicable, parts for use in space equipment shall be grouped together in individual assembly lots during the various stages of their manufacture to assure that all devices assembled during the same time period use the same materials, tools, methods, and controls. Parts and devices for space equipment that cannot be tested adequately after assembly without destruction of the item, such as explosive ordnance devices, some propulsion components, and complex electronics, shall have lot controls implemented during their manufacture to assure a uniform quality and reliability level of the entire lot. Each lot shall be manufactured, tested, and stored as a single batch. Sequential lot numbers that indicate the date of manufacture shall be assigned to each lot. (Typically, use three digits for the day of the year and two digits for the year.)

3.3.15.1.2 Contamination

3.3.15.1.2.1 Fabrication and Handling. Fabrication and handling of space equipment shall be accomplished in a clean environment. Attention shall be given to avoiding nonparticulate (chemical) as well as particulate air contamination. To avoid safety and contamination problems, the use of liquids shall be minimized in areas where initiators, explosive bolts, or any loaded explosive devices are exposed.

3.3.15.1.2.2 Device Cleanliness. The particulate cleanliness of internal moving subassemblies shall be maintained to at least level 500 as defined in MIL-STD-1246. External surfaces shall be visibly clean.

3.3.15.1.2.3 Outgassing. Items that might otherwise produce deleterious outgassing while on orbit shall be baked for a sufficient time to drive out all but an acceptable level of outgassing products prior to installation in the experiment or space vehicle. (See Paragraph 6.1.1 herein.) Analytical contamination models shall be used to evaluate performance impacts of outgassing on adjacent critical equipment.

3.3.15.1.3 Electrostatic Discharge. Appropriate provisions stated in DOD-HDBK-263 shall be used to avoid and to protect against the effects of static electricity generation and discharge in areas containing electrostatic sensitive devices such as microcircuits, initiators, explosive bolts, or any loaded explosive device. Both equipment and personnel shall be grounded.

3.3.15.1.4 Mechanical Interfaces. Where practicable, a common interface drill template shall be used to assure correct mechanical mating, particularly for interfaces external to the equipment.

3.3.15.2 Processes and Controls for Ground Equipment. The manufacturing processes and controls for ground equipment shall be selected and documented using the same criteria as used in the manufacture of similar commercial equipment.

3.4 DOCUMENTATION

The design and manufacturing processes for space vehicle equipment shall be documented, and the documents maintained current, to give visibility to the designs, procedures, and specifications by which all processes, operations, inspections, and tests are accomplished. The design documentation shall include specifications, assembly and detailed drawings, part lists, test procedures, operating procedures, maintenance procedures, and supporting documentation. The manufacturing documentation shall include the name of each part or component, each material required, the point it enters the manufacturing flow, the controlling specification or drawing, required tooling, required facilities, required test equipment, the manufacturing check points, the quality assurance verification points, and the verification procedures corresponding to each applicable process or material listed. The design and manufacturing process and control documents for space equipment shall provide a supplier-controlled baseline that assures that any subsequent failure or discrepancy analysis that may be required can identify the specific design and specific manufacturing materials and processes that were used for each item. In that way, changes can be incorporated to a known baseline to correct the problems.

The design of ground equipment shall be documented, and the documents maintained current, to give visibility to the designs and to each of the applicable procedures. The documentation of ground equipment shall include specifications, detailed drawings, assembly drawings, installation drawings, part lists, computer software designs, computer software code, computer software test tools, all test procedures, operating procedures, maintenance procedures, training materials, and other supporting documentation. The documentation for ground equipment shall be in sufficient detail to provide a supplier-controlled baseline that assures reliable operations and timely maintenance of the space system.

3.5 LOGISTICS

Equipment designs shall be based upon minimizing the system life cycle cost, assuming the contractors provide the logistic support for the system for the service life of the system.

3.5.1 Support Concept. Ground equipment designs shall be based on using operator maintenance to the maximum extent practicable. Operator maintenance includes self tests, simple fault diagnosis and fault isolation, and surface cleaning as required by environmental conditions. Ground equipment designs may be based on using organizational level maintenance and intermediate level maintenance for more complex fault diagnosis and fault isolation, for removal and replacement of complete assemblies or line-replaceable units, for preventive maintenance, for corrosion control, for alignment, and for calibration. Depot-level maintenance shall be minimized.

3.5.2 Support Facilities

3.5.2.1 Hardware Support. Ground equipment designs shall be based on using government-furnished facilities for housing hardware spares, test equipment, maintenance equipment, and maintenance personnel doing maintenance or repair tasks.

3.5.2.2 CSCI Support. The Computer Software Maintenance Resources to be developed as required by Paragraph 3.3.11.2 shall be located in a government-furnished facility for computer software maintenance during the operational life of the system. (See Paragraph 3.3.11.2.)

3.5.3 Supply. Ground equipment designs shall be based on using contractor supply support to provide the initial supply of spares and consumable materials, resupply of spares and consumable materials, inventory management, property accountability, and computer data processing spares and consumable materials.

3.6 PERSONNEL AND TRAINING

3.6.1 Personnel. Ground equipment designs shall be based on using a minimum number of operator and maintenance personnel. The initial operators and maintenance personnel shall be professional-level contractor personnel.

3.6.2 Training. Ground equipment designs shall be based on minimizing the special training of operator and maintenance personnel. Training of the initial complement of operators and maintenance personnel shall be accomplished by the contractor by formal classroom instruction covering familiarization with the system, hardware and software subsystems, and real-time operations. Additional on-the-job training for the initial complement of operators and maintenance personnel shall cover all aspects of equipment operations and maintenance. The equipment maintenance training program shall make maximum use of vendor training courses. Training of the initial complement of operators and maintenance personnel shall be used to develop documentation, training aids, and other material that may be of value in training additional complements of operators and maintenance personnel.

3.7 CHARACTERISTICS OF SUBORDINATE ELEMENTS

3.7.1 Requirements Allocated to Subtier Elements

3.7.1.1 Space Vehicle System Segment. (TBS)

3.7.1.2 Ground Terminal System Segment. (TBS)

3.7.1.3 Data Reduction System Segment. (TBS)

3.7.1.4 Other System Segments. (TBS)

3.7.2 Internal Interface Requirements. (TBS)

3.7.2.1 Internal Interface Identification. (TBS)

3.7.2.2 Internal Hardware CI-to-Hardware CI Interfaces. (TBS)

3.7.2.3 Internal Hardware CI-to-Computer Software CI Interfaces. (TBS)

3.7.2.4 Internal Computer Software CI-to-Computer Software CI Interfaces. (TBS)

3.7.3 Requirements Traceability Matrices. (Not applicable.)

[Note: For guidance in tracing the allocation of requirements, the system function(s) performed by each hardware CI and each computer software CI may be summarized in Requirements Traceability Matrices such as shown in Appendix B of this specification. This is an optional requirement as far as the specification is concerned; however, other contract provisions may require the completion of the Requirements Traceability Matrices by the contractor. In that case it could be referenced here. If the Requirements Traceability Matrices is prepared as Document 345X that is referenced here, Document 345X then would be added to the list of references in Section 2. If the contractor is required to prepare or update the matrix, that requirement must be listed in the CDRL.]

3.8 PRECEDENCE

3.8.1 Conflicts. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered the superseding requirements, unless the conflict involves external interface requirements of the system. In the event of a conflict involving the external interface requirements of the system, such as a conflict with equipment external to the system being specified, or in the event of any other unresolved conflict, such as a conflict with government-furnished property, the contracting officer shall be notified, and the order of precedence shall be as directed by the contracting officer.

3.8.2 Requirement Weighting Factors. The requirements stated herein are a composite of the designs, items, and practices found to be cost effective for high-reliability devices used in space systems. Because of the broad scope of these requirements, all requirements stated are not of equal importance or weight. They have been divided into four categories of importance ranging from requirements that are imposed on all applications to examples of acceptable designs, items, and practices. The relative weighting factors for the requirements are incorporated so they can be a consideration in making trade studies of alternatives. The weighting factors that are incorporated in the specification are:

a. Weighting factor *"a"*. *"Shall"* designates the most important weighting level, the mandatory requirements. Unless modified by the contract, the *"shall"* requirements constitute the firm contractual compliance requirements. Any deviations from these contractually imposed mandatory requirements require the approval of the contracting officer.

b. Weighting factor *"b"*. *"Shall, where practicable,"* designates requirements, items, or practices at the second weighting level. Alternative designs, items, or practices may be used for specific applications, when the use of the alternative is substantiated by documented technical trade studies. These trade studies shall be made available for review when requested or provided to the government in accordance with the contract provisions. Unless required by other con-tract provisions, noncompliance with the *"shall, where practicable,"* requirements does not require approval of the contracting officer.

c. Weighting factor *"c"*. *"Preferred"* or *"should"* designates the third weighting level. Unless required by other contract provisions, noncompliance with these preferred requirements does not require approval of the contracting officer and does not require documented technical substantiation.

d. Weighting factor *"d"*. *"May"* designates the lowest weighting level. In some cases, these *"may"* requirements are stated as examples of acceptable designs, items, and practices. Unless required by other contract provisions, noncompliance with the *"may"* requirements does not require approval of the contracting officer and does not require documented technical substantiation.

3.8.3 Life Cycle Cost. System life cycle cost estimates shall be used as an additional engineering tool to establish the order of precedence among alternatives. Although all of the requirements are believed essential, the designs shall consider the relative importance of the requirements to be such that minimizing system life cycle cost is as important as meeting the system performance and physical characteristic requirements stated. All other system requirements shall be considered of less importance than the system life cycle cost, the system performance, and the physical characteristics specified. (TBS)

3.8.4 **Supplementary Specifications and Standards**. If the documents referenced in this specification do not provide the contractually required reliability, quality level, or technical performance, they should be interpreted as being referenced to limit the variety of the physical and functional parameters to the extent practicable. In those cases, the referenced specifications shall be the basis of contractor specifications that would add, delete, or change specific requirements. The use of contractor specifications shall not constitute waiver of government inspection requirements.

3.9 QUALIFICATION

Qualification is required for each space vehicle design, for each space vehicle component design, and for each electronic part type used in the space vehicle design. Qualification also is required for each computer software configuration item. The contracting officer grants qualification status for the items as used in the specific space system based on the results of the qualification tests specified in Section 4. Unless specified, qualification is not required for ground equipment.

3.10 STANDARD SAMPLE (Not applicable)

3.11 PREPRODUCTION SAMPLE, PERIODIC PRODUCTION SAMPLE, PILOT, OR PILOT LOT (Not applicable)

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SECTION 4

QUALITY ASSURANCE PROVISIONS

4.1 RESPONSIBILITY FOR INSPECTION

Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection and test requirements specified herein. The government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

4.1.1 Philosophy of Testing. Because the quality assurance requirements for space systems can have a major cost and schedule impact, considerable detail is provided in this system specification. Because the requirements are different, general boilerplate test and inspection requirements applicable to operational elements of the system are separated from those applicable to nonoperational elements. The identified test and inspection requirements are for the operational elements of the space system unless specifically stated otherwise. The test requirements for the operational elements are separated into those applicable to space elements (space vehicle equipment) and those applicable to nonspace elements (typically ground equipment and computer software). The test requirements for the nonoperational elements of the space system (elements not required for on-orbit support) generally are functional tests conducted after installation to verify performance requirements. Nonoperational elements of the space system that are embedded in operational elements, such as self-test features, shall be designed and tested to the applicable requirements of the operational elements in which they are embedded.

The extremely high cost of an on-orbit space vehicle failure means that all operational elements of the space system must be designed and fabricated to assure high reliability. Testing requirements of the space elements (primarily the space vehicle and its components) are perhaps the most stringent requirements. The specified tests provide general screening checks, but they are necessarily insufficient to absolutely assure the reliability of the space vehicle. In-process screening tests, including stress screening, must be used at the parts, materials, and subassembly levels, and at all subtier levels where appropriate, to assure a reliable space vehicle. The acceptance tests at the space vehicle level provide a final check for any gross errors. In addition, the nonspace elements of the system required to support on-orbit operations (ground equipment and computer software) shall be adequately tested to assure satisfactory support of the space missions. Finally, the prelaunch system-level tests and inspections are conducted to verify at the last opportunity that each critical path in the launch system, in the on-orbit system, and in the reentry system is satisfactory.

In general, the test philosophy for ground equipment and computer software for a space system is the same as for the space equipment, but the details differ. Operational ground equipment and computer software also are tested, starting at the lowest levels of assembly, and progressively tested at each level through to the final system level, as required to assure mission success. However, for ground equipment, the tests generally are not as detailed, and greater emphasis is placed on the system-level tests. The test and inspection requirements applicable to nonoperational elements of the system are even less stringent, typically consisting of functional checks to verify nominal performance after installation.

Proper design requires that items at each level of assembly have broader parameter tolerances and narrower environmental ranges than the subtier items that are used in its fabrication. In that way, manufacturing defects can be screened out at the lowest level of assembly possible, and items that pass subtier screening tests should not be expected to fail during subsequent tests at higher levels of assembly. Also, critical parameters that cannot be measured accurately at higher levels of assembly must be evaluated at lower levels of assembly. This usually means that some form of stress-screening tests are cost effective at subtier levels. For a particular system design or for a particular contractor, the optimum set of quality assurance provisions may differ from those stated herein. A different balance using more subtier testing and less vehicle or system-level testing may be cost effective; however, any reduction in the specified quality assurance provisions requires contracting officer approval.

Note that part screening usually is conducted using the maximum range of design or qualification conditions in the part specifications. Assuming proper applications of the parts, those conditions always would be more severe than the conditions specified for subassembly or component screening. Since the subassembly or component tests do not duplicate the stringent conditions of part-level testing, they should never be viewed as a substitute for part-level screening.

4.1.2 Location of Testing. Except as otherwise specified in the contract or order, tests and evaluations of the space elements may be conducted at in-plant test facilities, which may include subcontractor's facilities, at a government-approved test bed, or at any other appropriate test facility selected by the contractor. The part, material, and software unit development tests and evaluations, Step 1 tests, and Step 2 tests of ground equipment and of computer software also may be conducted at in-plant test facilities, which may include subcontractor's facilities, at a government-approved test bed, or at any other appropriate test facility selected by the contractor. However, when testing is performed at an operational government facility, government-approved formal test plans and procedures may be required.

Where practicable, Step 3 integrated system tests of ground equipment and of computer software shall be performed on integrated CIs installed in an operational system. Whenever possible, these tests shall be conducted at a specified target site with the support of the operational personnel. A development test bed approved by the Acquisition Activity as sufficiently simulating the operational system capability for test purposes may be used for Step 3 integrated system tests, if target sites, operational complexes, or other suitable operational support areas are not available. Step 4 and Step 5 tests shall be performed on an operational system at the specified target site.

Prelaunch system-level inspections and tests shall be conducted on the operational system with the space vehicle mated with the launch vehicle, using operational interfaces to the extent practicable.

4.2 SPECIAL TESTS AND EXAMINATIONS

4.2.1 Classification of Inspections and Tests. The categories listed are intended to encompass all tests and inspections required during the system acquisition. The tests and inspections specified herein are classified as follows:

4.2.1.1 Inspections and Tests of Operational Elements of the On-orbit Space System. (4.2.2)

4.2.1.1.1 Inspections and Tests of Space Elements. (4.2.2.1)

a. Parts, materials, and process controls (4.2.2.1.1)

b. Design verification tests (4.2.2.1.2)

c. Qualification tests (4.2.2.1.3)

d. Acceptance tests (4.2.2.1.4)

e. Service life verification tests (4.2.2.1.5)

4.2.1.1.2 Inspections and Tests of Ground Equipment and Computer Software. (4.2.2.2)

a. Part, Material, and Software Unit Development Tests and Evaluations (4.2.2.2.1)

b. Step 1 - Component Test and Evaluation (Development) (4.2.2.2.2)

c. Step 2 - Configuration Item Compliance Tests (Qualification and Acceptance) (4.2.2.2.3)

Step 2.1 - Single CI or CSCI Compliance Tests (4.2.2.2.3.1)

Step 2.2 - Combined CI/CSCI Compliance Tests (4.2.2.2.3.2)

d. Step 3 - Integrated System Testing (4.2.2.2.4)

e. Step 4 - Initial Operational Test and Evaluation (IOTE) (4.2.2.2.5)

f. Step 5 - Follow-on Operational Test and Evaluation (FOT&E) (4.2.2.2.6)

4.2.1.2 Inspections and Tests of Elements of the On-orbit Space System Not Required for On-orbit Support (Nonoperational Elements). (4.2.3)

4.2.1.3 Prelaunch Validation Tests. (4.2.4)

4.2.2 Inspections and Tests of Operational Elements of the On-orbit Space System

4.2.2.1 Inspections and Tests of the Space Elements

4.2.2.1.1 Space Vehicle Parts, Materials, and Process Controls. Parts, materials, and process controls are to be applied during production of all items to ensure that a reliable system is fabricated. All parts and materials shall be adequately controlled and inspected prior to assembly. During fabrication of the space vehicle and other space equipment, the tools and processes, as well as parts and materials, shall be adequately controlled and inspected to assure compliance with the approved manufacturing processes and controls. Quality assurance requirements included in specifications referenced in Section 3 of this specification are considered incorporated as requirements of this section and should be met for the applicable classes of equipment.

4.2.2.1.1.1 Space Vehicle Records. Records documenting the status of the space vehicle and other space equipment shall be maintained following assignment of serial numbers. Each space item shall have inspection records and test records maintained by serial number to provide traceability from system usage to production lot data for the devices. Complete records shall be maintained for the space items and shall be available for review during the service life of the system. The records shall indicate all relevant test data, all rework or modifications, and all installations and removals for whatever reason. Ground equipment items shall have inspection records and test records maintained by serial number for the service life of the item.

4.2.2.1.1.2 Space Vehicle Manufacturing Screens. Each critical subassembly, component, experiment, and vehicle shall be subjected to in-process manufacturing and assembly screens to assure compliance with the specified requirements to the extent practicable. Compliance with the documented process controls, documented screening requirements, required hardware configuration, and general workmanship requirements shall be verified. At each level of assembly, each completed unit shall be subjected to visual inspection to assure that it is free of obvious defects and is within specified physical limits.

4.2.2.1.1.3 Nonconforming Material. Nonconforming material, components, or assemblies that do not meet the established tolerance limits set for the acceptance limits in the in-process screens shall be rejected for use. Any rejected material, component, or assembly may be reworked and rescreened in accordance with established procedures if system reliability is not jeopardized. Nonconforming material or assembled units in each lot may be reworked and rescreened in accordance with established procedures if the rework is not so extensive as to jeopardize the lot identity of the material or assembled unit. If the reworked material or assembled unit subsequently passes the in-process screens, it again can be considered part of the lot. Reassignment of assembled units to a different lot shall not be made. Nonconforming material or assembled units that do not satisfy these rework criteria shall be considered scrap.

4.2.2.1.2 Space Vehicle Design Verification Tests. Design verification testing shall be performed to demonstrate compliance of new designs or of modified designs with the specified performance margins. Test units shall be sufficiently similar to the final production units so as not to jeopardize the validity of the test results.

4.2.2.1.2.1 Engineering Tests

4.2.2.1.2.1.1 Verification of Nonoperating Constraints. The effects of nonoperational environments on the space equipment may be determined by nonoperating development tests. These tests would be used to identify fabrication, storage, handling, transportation, installation, and launch preparation constraints or controls that might be necessary. Note that approval of the contracting officer is required, if it is necessary to provide special nonoperating environmental controls other than those specified herein.

4.2.2.1.2.1.2 Development Tests. Typically, breadboard or prototype hardware is used for development tests. When cost effective, flight hardware may be utilized for the development test program. The development tests are performed as required to yield information necessary to determine:

a. Design feasibility

b. Adequacy of basic design approaches

c. Functional parameters

d. Thermal and structural data with particular emphasis on deployment, separation, latching mechanisms, clearances, structural dynamic characteristics, and math model verification

e. Mass properties

f. Packaging and fabrication techniques

g. Stabilization performance

h. EMC including TEMPEST

i. Safety

j. Cleanliness requirements and contamination compatibility

4.2.2.1.2.1.3 Modal Survey. Modal survey tests are required for large equipment (see MIL-STD-1540). The flight hard-ware, or dynamically simulated hardware, including attachment and support hardware, is the test article. All natural modes of vibration at frequencies below 50 Hz shall be determined.

4.2.2.1.2.1.4 Static Loads. A static loads test as specified in MIL-STD-1540 shall be performed on each vehicle or experiment.

4.2.2.1.2.1.5 Thermal Balance. The flight vehicle or experiment shall be subjected to a thermal balance test as specified in Paragraph 6.2.8 of MIL-STD-1540. The test shall include both maximum and minimum power dissipation modes. If heat pipes are included, the attitude of the equipment shall be such as to not bias the test measurements. A thermal math model shall be used to correlate pretest temperature predictions with the test data from the thermal balance test. As a goal, correlation of test results to the thermal model predictions shall be within $\pm$ 3 degrees C. The correlated thermal math model then is used to make final temperature predictions for all mission phases and, hence, verify the thermal margins required by MIL-STD-1540.

4.2.2.1.2.1.6 Magnetic Mapping. If applicable, a magnetic mapping on the assembled vehicle or experiment shall be conducted to provide remnant, stray, and induced magnetic field data.

4.2.2.1.2.1.7 Current Margin. Electrical current margins on all electroexplosive ordnance circuits shall be demonstrated. The test shall verify that no less than the minimum recommended firing current (twice all-fire) will be delivered to the electroexplosive devices under worst conditions of minimum voltage and maximum circuit and electroexplosive device resistance. The test also shall verify that the maximum current delivered to the electroexplosive device does not exceed its maximum qualified firing current under worst conditions of maximum voltage and minimum circuit and electroexplosive device resistance.

4.2.2.1.2.1.8 Mechanism Motion Test. The erection, deployment, latching, and jettison features shall be tested to demonstrate adequate functioning under worst case environments.

4.2.2.1.2.1.9 Shock. Equipment susceptible to shock shall be evaluated for bench handling (nonoperating) and, while operating, for possible pyroshock effects.

4.2.2.1.2.1.10 Crash Safety (Nonoperating). Although analysis usually is adequate for Shuttle missions, a demonstration may be used to show that the equipment design complies with the crash safety criteria: i.e., the equipment and its mounting attachments shall not become detached, create a hazard to personnel or to the Shuttle Orbiter, or prevent egress from a crashed vehicle. Operating performance is not required during or after this test, so a nonoperating mass simulator may be used. Compliance to the fracture control plan is required.

4.2.2.1.2.1.11 Outgassing. Outgassing evaluation tests are required for materials, components, and subsystems whose outgassing properties are not known. (See Paragraph 6.1.1 in this specification.)

4.2.2.1.2.2 Preliminary Design Qualification Tests. (TBS)

4.2.2.1.2.3 Reliability Tests. (TBS)

4.2.2.1.2.4 Engineering Critical Item Tests. (TBS)

4.2.2.1.2.5 System Evaluation Tests. (TBS)

4.2.2.1.3 Qualification Tests

4.2.2.1.3.1 Component Level. Qualification tests shall be performed to demonstrate, to the extent it is practicable, that space vehicle components that are manufactured in accordance with the approved processes and controls meet the specified design requirements. Except as specified herein, the first article manufactured of each type shall be acceptance tested and then qualification tested in accordance with the component level tests in MIL-STD-1540. The 6-dB, 10-degree C, or other design factors of safety or margins that are included in the design requirements specified herein include test condition tolerances that are those allowed in MIL-STD-1540. When the actual test tolerances are less than those specified in MIL-STD-1540, the qualification test levels may be reduced appropriately in accordance with provisions specified in MIL-STD-1540. All qualification tests shall be conducted with hardware of the final design that have passed the in-process production screens.

4.2.2.1.3.1.1 Components for STS Usage. For STS usage, it should be demonstrated that the component can operate in an explosive atmosphere. The component should not create an explosion in an explosive atmosphere; it should contain any explosion occurring inside the component; and the temperature of the component case and of all internal parts exposed to the atmosphere shall not exceed 178 degrees C. Upon completion of the qualification test program, the qualification article may be used as a development test article for extended margin evaluation tests and life tests. However, the qualification article test history may be reviewed for excessive test time and potential fatigue-type failures to determine if the unit can be refurbished and used in the qualification vehicle or experiment or as a flight spare in a redun-dant flight set, but it should not otherwise be planned for flight.

4.2.2.1.3.1.2 Reusable Flight Hardware Tests. Some equipment, or portions of the equipment, may be intended for reuse on subsequent missions. Reusable equipment would be subjected to repeated exposure to test, launch, flight, and recovery environments throughout its life. Qualification testing of reusable hardware shall be conducted at environmental levels and durations that provide a sufficiently high margin to assure equipment integrity after the required repeated environmental exposures. Methodology for avoiding fatigue failures is presented in MIL-HDBK-340.

4.2.2.1.3.1.3 Requalification of Existing Designs. Requalification is required for items that incorporate extensive changes in design, manufacturing processing, environmental levels, or performance requirements. However, methodology presented in MIL-HDBK-340 may be used to show that existing designs, or items previously qualified for other applications, have adequately demonstrated compliance to all qualification requirements for the new designs.

Deficiencies in meeting some requirements may be fulfilled by supplementing existing data with new test data. However, qualification by similarity shall be permitted only with the concurrence of the contracting officer. Waiver of qualification or requalification requirements requires the approval of the contracting officer.

4.2.2.1.3.2 Space Vehicle Level Qualification Tests. Qualification tests shall be performed to demonstrate, to the extent it is practicable, that space vehicles that are manufactured in accordance with the approved processes and controls meet the specified design requirements. Except as specified herein, the first vehicle manufactured shall be acceptance tested and then qualification tested in accordance with the vehicle level tests in MIL-STD-1540. The 6-dB, 10-degree C, or other design factors of safety or margins that are included in the design requirements specified herein include test condition tolerances that are those allowed in MIL-STD-1540. When the actual test tolerances are less than those specified in MIL-STD-1540, the qualification test levels may be reduced appropriately in accordance with provisions specified in MIL-STD-1540. All qualification tests shall be conducted with hardware of the final design that have passed the in-process production screens.

4.2.2.1.4 Acceptance Tests. Acceptance tests shall be performed as the basis for acceptance of items manufactured. Acceptance tests, including lot certification testing, is that testing performed to demonstrate confidence that production devices that have passed the in-process production screening also meet the other requirements specified.

4.2.2.1.4.1 Component Level Acceptance Tests. Except as specified herein, space components shall be acceptance tested in accordance with the component level tests in MIL-STD-1540. For space components that cannot be tested adequately after assembly and must rely upon the process controls and in-process production screening to assure satisfactory performance and reliability, appropriate lot certification tests shall be imposed. (TBS)

4.2.2.1.4.2 Lot Certification Tests. Space parts, materials, and components that cannot be tested adequately after assembly, and must rely upon the process controls and in-process screening to assure satisfactory performance and reliability, shall have appropriate lot certification tests imposed prior to assembly. Lot certification testing is that testing performed to demonstrate confidence that a lot of parts, materials, or components that have passed the in-process screening also meets the other quality and performance requirements. All items submitted for lot certification shall have been manufactured using the same supplier-documented processes and controls. Certification of a lot is achieved by the satisfactory completion without failure of the applicable tests. Note that lot certification testing should be performed by the item supplier and need not be repeated by the user.

4.2.2.1.4.3 Space Vehicle Level Acceptance Tests. Except as specified herein, space vehicle acceptance testing shall be in accordance with the vehicle level tests in MIL-STD-1540. (TBS)

4.2.2.1.5 Space Vehicle Service Life Verification Tests. Service life verification tests are defined as those tests conducted on limited life devices to demonstrate that production devices will perform satisfactorily during their specified service life. Explosive ordnance devices and other components whose performance may degrade with time shall have life extensions based upon passing either an aging surveillance test or an accelerated aging test.

4.2.2.1.5.1 Aging Surveillance Tests. (TBS)

4.2.2.1.5.2 Accelerated Aging Tests. (TBS)

4.2.2.2 Inspections and Tests of Ground Equipment and Computer Software. Functional testing of ground equipment CIs and major components shall be conducted to demonstrate compliance with the specified requirements.

4.2.2.2.1 Part, Material, and Software Unit Development Tests and Evaluations. Part, material, and software unit development tests and evaluations shall be conducted as required to demonstrate design feasibility and to assess the design and manufacturing alternatives and tradeoffs to best achieve the development objectives. Development tests may be required to validate hardware and computer program design concepts or to assist in the evolution of designs from the conceptual phase to the operational phase. An objective of these tests shall be to identify hardware and computer program problems early in their design evolution so that any required corrective actions can be taken prior to the start of formal step testing. Development tests may be used to confirm performance margins, manufacturability, testability, maintainability, reliability, life expectancy, and compatibility with system safety. Where practicable, development tests should be conducted over a range of operating conditions that exceed the design limits in order to identify marginal design features.

Internal contractor documentation of development test plans, test procedures, and test results normally are used unless stated otherwise by a contract.

4.2.2.2.1.1 Part and Material Level Development Tests and Evaluations. Part and material development tests and evaluations shall be conducted as required to qualify parts, materials, and processes to assure proper application in the design, to assure adequate performance margins, and to develop acceptance criteria for the items to avoid assembling defective hardware components. The minimum required development tests and evaluations include qualification of new types of parts, materials, and processes to assure proper application in the design, and to develop acceptance criteria for the items to avoid assembling defective hardware components. For each part or material tested or evaluated, the test procedures, test results, and deficiencies or problems encountered and resolutions shall be documented in an informal hardware development file (HDF) maintained by the development contractor. The intent is to make the HDF the source for design data for the parts and materials used.

4.2.2.2.1.2 Subassembly Level Development Tests and In-process Tests and Inspections. Subassemblies shall be subjected to development tests and evaluations as may be required to demonstrate feasibility, to minimize design risk, and to assess the design and manufacturing alternatives and tradeoffs required to best achieve the development objectives. Tests shall be conducted as required to develop in-process manufacturing tests, inspections, and acceptance criteria for the items to avoid assembling defective hardware items.

4.2.2.2.1.3 Computer Software Unit Tests. The earliest development tests and evaluations of software are performed on computer software units (CSUs) which are the smallest software element of a computer software component that is separately testable. As a minimum, each CSU shall be tested to ensure that the algorithms and logic employed are correct and that the CSU satisfies its specified requirements. For each CSU or logically related group of CSUs, the test procedures, design code, test results, and deficiencies or problems encountered and resolutions shall be documented in a software development file (SDF) maintained by the development contractor. Whenever the design or coding are changed, the CSU shall be retested, as necessary, and all documentation pertinent to the changes shall be revised and updated.

4.2.2.2.2 Step 1: Component Tests and Evaluation (Development)

4.2.2.2.2.1 Step 1: Hardware Components. Hardware components shall be subjected to tests and evaluations as may be required to qualify the components to assure proper application in the design, to assure adequate performance margins, and to develop acceptance criteria for the components to avoid assembling defective hardware. Component tests and evaluations also may be required to demonstrate manufacturing feasibility and to assess the design and manufacturing alternatives and tradeoffs required to best achieve the development objectives.

4.2.2.2.2.2 Step 1: Software Components. The CSUs forming a software component with specific functions constitute a CSC. The CSC tests shall be conducted to assure that all algorithms and logic used in each CSC are correct and satisfy their allocated requirements. The tests also shall evaluate any design alternatives or tradeoffs, demonstrate the feasibility of the CSC design, and assure that design risks are minimized.

4.2.2.2.3 Step 2: Configuration Item Compliance Tests (Qualification and Acceptance). Step 2 tests are the qualification and acceptance tests of a CI, either a hardware configuration item (HWCI), a CSCI, or a CI consisting of both hardware and software. The Step 2 tests include qualification and acceptance tests of combined CIs. All Step 2 tests shall be conducted using prequalified test tools and test procedures designed to attain the test objectives in the approved test plans. When included within the scope of the contract, the completion of these tests may be made contingent on the satisfactory completion of subsequent integrated system tests. A Functional Configuration Audit and a Physical Configuration Audit normally are conducted in accordance with contract requirements following the completion of Step 2.2 tests.

4.2.2.2.3.1 Step 2.1: Single CI Compliance Tests

4.2.2.2.3.1.1 Step 2.1: Hardware CI Qualification. Each HWCI type shall be formally qualified. The qualification tests shall verify that the CI meets the specified system design requirements allocated to the CI, including external interfaces. The qualification tests shall verify the performance margins by evaluating the functional performance of the CI in an environment that simulates the operational environments associated with the CI.

4.2.2.2.3.1.2 Step 2.1: Hardware CI Acceptance. The qualification tests on the first production item of each type serve as the acceptance test for that item. Subsequent production items of each type shall be formally acceptance tested as required. The acceptance tests of the subsequent production items may be a subset of the qualification tests.

4.2.2.2.3.1.3 Step 2.1: Computer Software CI Qualification. Functional or logically distinct CSCs are organized or grouped into CSCIs. Each CSCI performs or executes a set of functions or tasks. Formal qualification tests shall be conducted on each CSCI to verify CSCI compliance with design or specified requirements, i.e., stressing the CSCIs to the limits of their specified requirements. Step 2.1 tests associated with software maintenance shall be conducted on the CSCI as required to verify that the deficiency documented in the problem description has been corrected.

4.2.2.2.3.2 Step 2.2: Combined CI Compliance Tests. A series of compliance test Steps shall be conducted on expanding strings of CIs. Typically, a HWCI is combined with other HWCIs and the combination tested, a CSCI is combined with other CSCIs and the combination tested, and then the various CIs are combined until the final end item ground equipment to be delivered, including the interfaces. The actual combination of CIs to be tested, and the particular test sequence to follow, depend on the complexity of the development, criticality of the functions, and on the external interfaces involved. The tests shall be designed to confirm functional compatibility among the mechanical, electrical, and computer software interfaces. Step 2.2 tests shall demonstrate that the end item functions resulting at each test sequence of combined CIs meet the performance requirements and system specifications. To show the planned sequence for the Step 2.2 tests, the detailed tests should be identified further as Step 2.2.1 tests, Step 2.2.2 tests, Step 2.2.3 tests, Step 2.2.4 tests, and so forth for the expanding strings of configuration items.

4.2.2.2.3.3 Commercial Off-the-shelf or Government-Furnished Equipment Testing. Commercial off-the-shelf (COTS) items that are not developed specifically for acquisition or modification often are included in the system design. Also, GFE may be included in the system design. The COTS or GFE items may be either hardware, software, or a combination of the two. If incorporated in the system design, the COTS and GFE testing shall be included in the testing baseline, that is, as incorporated in the configuration tested for compliance. Individual tests shall be conducted on COTS and GFE prior to incorporation in the configuration or assembly, as specified in the applicable acquisition contract. The test shall be conducted at the level of detail necessary to determine whether the COTS and GFE perform satisfactorily, are documented adequately for the application, and satisfy the system requirements allocated to them.

4.2.2.2.3.4 Computer Resources Reserves Verification. The space system computer resources reserves specified in Paragraph 3.2.8, and its subparagraphs, shall be verified through incremental testing, the final increment being conducted as part of the system-level testing for the particular element of the space system involved [e.g., operational (ground), operational (space), maintenance, test, trainers, etc.]. The tests shall be conducted to demonstrate that the worst case throughput requirements specified in government-approved load scenarios have been met. At least four incremental tests shall be conducted per identified system element or subsystem:

a. Isolated subsystem/first software version

b. Isolated subsystem/last pre-baseline software version

c. Combined subsystems/last pre-baseline software versions, (optional as required)

d. Baselined full element or subsystem

Each test increment shall establish that the throughput reserve remains available under the worst case space system test scenarios.

4.2.2.2.4 Step 3: Integrated System Testing. Integrated system tests shall be designed to exercise, as near as practical and possible, the total system. The intent is to ensure that the products, which may be from multiple contractors, are integrated, that interfaces are verified, and that all higher-level operational requirements or specifications are met. Where practicable, integrated system tests shall be performed on integrated CIs installed in an operational system. Whenever possible, these tests shall be conducted at the target site with the support of the operational personnel. A development test bed approved by the Acquisition Activity as sufficiently simulating the operational system capability for test purposes may be used for Step 3 integrated system tests if target sites, operational complexes, or other suitable operational support areas are not available. The Step 3 integrated system tests shall incorporate tests of the affected interfaces of the ground equipment and software with other elements of the operational system. The Step 3 tests shall be structured as appropriate to demonstrate design requirements of the system related to such items as performance, electromagnetic compatibility, reliability, maintainability, system safety (hazardous noise, radiation hazards, pressure vessels), logistics supportability, operational procedures, and personnel performance.

Step 3 tests shall be conducted to demonstrate, as applicable to the system design (or modification), that:

a. Reliable operation is achieved at specified design limits.

b. Specified system functional and performance requirements are met.

c. The system can recover from hardware or software malfunctions within a reasonable or specified time without loss of data or control.

d. Performance requirements are met under all required logical or physical device assignment combinations.

e. The software and hardware modifications or upgrades have not degraded the capability of the system's baseline or of other operational systems, unless specifically designed to do so.

f. Security mechanisms are in place or incorporated to protect resources from unauthorized access or break-in from illicit users.

Tests shall be focused on the external interfaces involved, the use of operational databases and operational scenarios, and the system requirements from a mission operations perspective.

The Step 3 tests also shall include other applicable tests, such as a reliability demonstration; a maintainability demonstration; system safety tests, inspections, and evaluations in such areas as hardware inspections for electrical and mechanical hazard, including caution labeling; evaluation of the fire suppression system; evaluation of emergency systems; use of any hazardous materials; possibility of personnel exposure to any equipment and ambient noise levels considered hazardous; RF radiation testing to determine actual levels of radiation to which personnel may be exposed and to evaluate the accuracy of the mathematical predictions of radiation levels; proper functioning of any radiation warning systems; and proper procedures for inspection, operation, and maintenance of pressure vessels.

Step 3 integrated system tests shall be conducted by an independent test organization approved by the acquisition activity. This test organization shall be responsible for the development of test plans, test tools, and test procedures and the conduct of the test. Development contractors provide support for the Step 3 tests and the resolution of deficiencies only within the scope of the applicable contract provisions and as directed by the acquisition activity.

4.2.2.2.5 Step 4: Initial Operational Test and Evaluation. Initial operational tests and evaluations (IOT&E) are conducted with the equipment in its operational configuration, in an operational environment, by the operating personnel. These Step 4 tests are conducted in an environment that is as operationally realistic as possible and practical in order to test and evaluate the effectiveness and suitability of the hardware and software in meeting operational requirements. Step 4 tests emphasize reliability, maintainability, supportability, and logistics. Satisfactory completion of the Step 4 tests is the milestone for the initial operational capability.

4.2.2.2.6 Step 5: Follow-on Operational Test and Evaluation. Follow-on operational tests and evaluations (FOT&E) are conducted with the equipment in its operational location by the operating personnel assigned. The Step 5 tests demonstrate and verify the continued capability of the system, with the modification or upgrade incorporated, to support ongoing missions. The FOT&E are conducted to refine estimates made during IOT&E and to identify operational system deficiencies.

4.2.3 Inspections and Tests of Elements of the On-orbit Space System Not Required for On-orbit Support (Nonoperational Elements). (TBS)

4.2.3.1 Test Equipment. Test equipment is that equipment required to support the maintenance, repair, and checkout of the system hardware following system deployment. To the extent practicable, test equipment shall be designed using applicable commercial practices. Commercially available modules shall be used to the extent practicable.

4.2.3.2 Trainers. The trainers are the equipment to be used for the training of system operator personnel. To the extent practicable, trainers shall be designed using the same interfacing controls, displays, and equipment locations as occur operationally. Trainers shall be designed using applicable commercial practices.

4.2.3.3 Computer Software Maintenance Resources. (TBD)

4.2.4 Prelaunch Validation Tests. Prelaunch validation tests of the first operational space vehicle usually is conducted as part of the Step 4 testing. All subsequent operational space vehicles shall be subjected to prelaunch validation tests to assure that there are no out-of-tolerance conditions or anomalous behavior. To the extent practicable, prelaunch system-level inspections and tests shall be conducted to verify by end-to-end testing that each critical path in the launch system, the on-orbit system, and the reentry system is satis-factory. Duplication of the factory acceptance functional tests in subsequent tests also is intended to provide data for trend analysis that might provide evidence of a potential problem, even though all current measurements were within tolerances. Whether electrical, mechanical, or both, all critical paths or circuits shall be verified from the application of the initiating signal through completion of each event. This testing is intended to verify that an event command or signal was generated properly and sent on time, that it arrived at its correct destination, that no other function was performed, and that the signal was not present other than when programmed. Once success-fully accomplished, that particular critical path or circuit is considered validated. Not all end-to-end tests can be performed with only flight hardware, as in the case in which an explosive event is involved. In cases in which end-to-end testing cannot be performed with the flight hardware and software, appropriate simulation devices should be used to exercise the flight hardware and software to the maximum extent possible. Simulation devices should be controlled carefully and should be permitted only when there is no feasible alternative for conducting the test. All of the events that occur during the mission profile should be tested in the flight sequence to the extent that is practical. Redundant components and subsystems also should be validated in the same manner.

4.2.4.1 Space Vehicle Prelaunch Validation Tests. Prelaunch validation tests shall be conducted on space equipment in accordance with the applicable requirements of MIL-STD-1540. The space vehicle shall be operated through a simulated sequence of ascent phase, separation and engine ignition phase, orbital injection, on-orbit operation and, if applicable, recovery phase. These integrated system tests shall include all tests designed to verify system performance.

4.2.4.1.1 Functional Integration. End-to-end integration tests shall be conducted to assure an orderly buildup and verify proper subsystem operation.

4.2.4.1.2 Alignment Checks. Alignment checks shall be conducted as required to verify alignments of specific equipment.

4.2.4.1.3 Integrated System Tests. Integrated system tests are system-level functional tests conducted in accordance with the applicable paragraphs of MIL-STD-1540. Integrated system tests provide baseline performance data and follow-up comparison data to verify factory tests and assure that no degradation results from the individual environmental tests, transportation, storage, and preceding flights. Integrated system tests shall include a *"typical"* flight simulation encompassing prelaunch, launch, and orbital modes of operation.

4.2.4.1.4 Mass Properties. Actual weight and center-of-gravity (cg) measurements are required at the component and at each higher level of assembly to verify predictions and to ensure that the installed equipment meets final weight and cg requirements.

4.2.4.1.5 High Pressure. Tests of all pressure subsystems of the integrated equipment shall be performed in accordance with MIL-STD-1540 (Paragraph 6.2.6), NHB 1700.7 (NASA), and SAMTO HB S-100 (designated by NASA as KHB 1700.7).

4.2.4.2 Launch System Prelaunch Validation Tests. Prelaunch validation tests shall be conducted on the launch vehicle in accordance with the applicable requirements. These integrated system tests include all tests designed to verify system and launch conductor performance. (TBD)

4.2.4.3 <u>On-orbit System Prelaunch Validation Tests</u>. Prelaunch validation tests shall be conducted on the on-orbit system in accordance with the applicable requirements. These integrated system tests include all tests designed to verify system and operator performance. (TBD)

4.2.4.4 <u>Certification for Flight</u>. Upon completion of the integrated system tests, the test history of the integrated equipment shall be reviewed to determine its acceptability for flight. The concept of product flight accreditation is used to assure that the critical components satisfy all requirements that have been found necessary for successful space missions. Note that items furnished by other GFE may require additional testing or controls to satisfy the flight accreditation requirements. Flight accreditation is a process in which the status of each item is under continuing evaluation from program inception to final accreditation for flight. The extent of reviews required is dependent upon the specific qualification and production status of the experiment to be flown and the suitability of its as-qualified design for the intended mission application. Unless specifically excluded, flight accreditation should incorporate all technical assessment activity from inception of the program through manufacturing, qualification, transportation, handling, storage, and post-delivery operations leading to final installation and checkout prior to flight. The assessment activity involves incremental reviews and culminates in documentation that all accreditation requirements have been met. After completion of the final review for each item, the acceptability or nonacceptability for flight is documented.

Items are considered to be flight accredited if the items satisfy all of the following conditions or the conditions have been waived by the contracting officer:

a. The items have passed the specified design verification tests.

b. The items have passed the qualification or protoflight test requirements.

c. The items that require lot certification are from a lot that passed the specified lot certification tests. Government-furnished items are not exempt from this requirement. If prior lot certification testing has not met the requirements contained herein, testing should be conducted to demonstrate compliance.

d. The items have been transported and stored within the specified environmental limits for the device.

e. The items are from a lot that has an adequate service life for the scheduled operational use.

4.3 REQUIREMENTS CROSS REFERENCE

For guidance in correlating the Section 4 requirements with the Section 3 and Section 5 requirements, and for use in developing test plans, a requirements cross reference matrix is provided in Appendix C (or Document 456X). (Note that if a separate Document 456X is used instead of Appendix C, Document 456X is added to the list of references in Section 2. If the contractor is required to prepare or update the matrix, that requirement must be listed in the CDRL.

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SECTION 5

PREPARATION FOR DELIVERY

(Not applicable)

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SECTION 6

NOTES

6.1 INTENDED USE

The space system covered by this specification is intended for use in the (insert nomenclature) space program. (TBS)

6.1.1 Missions. (See 3.1.4.3)

6.1.2 Threat. (See 3.1.4.4)

6.2 ORDERING DATA

6.2.1 Precedence Requirements. For precedence requirements, see Subsection 3.8.

6.2.2 Trade Studies. If there are particular trade studies that are critical to the development process, they should be specifically identified and required by the SOW. *In addition, the system life cycle* cost model to be used for trade studies of various alternatives may be critical to the acquisition process, particularly in the early phases. For that reason, the model may be GFE or it may require government approval. If the system life cycle cost model is developed by the contractor(s), the government may want to require delivery in a usable form to assure its availability for subsequent phases or for use by other contractors.

6.2.3 Technical Review. The government plans for conducting technical reviews and audits should be clearly stated in the contract. In particular, the use of weighting factors in the specification is intended to help identify design review items that should be addressed in the contract SOW or in the Program Management Plan. For example, if the contractor does not follow a *"preferred"* requirement, what level of justification, if any, is expected at a design review? If the contractor's design does comply with a *"preferred"* requirement, would a justification of that decision be required at the design review?

6.2.4 Data Items. The requirements for the delivery of data items believed critical to understanding the acquisition status should be clearly stated in the CDRL. Usually the contract will include a line item to provide for the delivery, on request, of any internally generated contractor document listed on the data accession list.

6.3 DEFINITIONS

(TBS)

6.4 ABBREVIATIONS AND ACRONYMS

(TBS)

6.5 GUIDANCE DOCUMENTS

The following documents provide information and data that may be useful in the allocation of the stated requirements to lower levels of assembly or in the preparation of more detailed documentation required by the acquisition process:

(TBS)

(Copies of these publications may be obtained from the contracting office or as directed by the contracting officer.)

6.6 TAILORED APPLICATIONS

It is intended that the requirements in documents referenced in this specification are referenced in ways that properly tailor the requirement for each application. Nevertheless, all requirements of this specification, including referenced requirements, should be evaluated for each application, and those that are inappropriate, or that seem to increase system life cycle cost, should be identified and reviewed. The stated order of precedence of requirements, including the use of the weighting factors in the specification, is intended to assist contractors in the design process, trade studies, and in the allocation of requirements to specific applications. Contractors are encouraged to identify to the contracting officer, for program office review and consideration, any requirements imposed by this specification that are believed excessive or conflicting. However, contractors are reminded that deviations from contractually imposed requirements can be granted only by the contracting officer.

6.7 REVISION MARKING

Symbols are not used in this revision to identify changes with respect to the previous issue, due to the extensiveness of the changes.

[Note that if the changes are not extensive, the following statement may be used in Subsection 6.6 instead:

> The margins of this specification are marked with a vertical bar (or symbol) to indicate where changes (additions, modifications, corrections, deletions) from the previous issue were made. This was done as a convenience only, and the government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notation and relationship to the last previous issue.

Note that if the specification is the initial issue, this subparagraph would not be included.]

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APPENDIX A

10. THREAT ENVIRONMENT

This appendix is a mandatory part of the specification.

10.1 SCOPE

This appendix sets forth the threat environment for the (insert nomenclature) system.

10.2 APPLICABLE DOCUMENTS

(TBS)

10.3 REQUIREMENTS

10.3.1 Ground Tracking Stations. Perimeter fences around ground tracking stations that are located in tropical areas may be attacked by (TBS).

10.3.2 Space Vehicles. (TBS)

10.3.3 (TBS)

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APPENDIX B

20. REQUIREMENTS TRACEABILITY MATRIX

This appendix is not a mandatory part of the specification.

20.1 SCOPE

This appendix outlines a Requirements Traceability Matrix for the correlation of the Section 3 requirements with each hardware CI and each software CI.

20.2 APPLICABLE DOCUMENTS

(Not applicable)

20.3 REQUIREMENTS

The correlation of each hardware CI and each software CI with the Section 3 requirements is shown in Table B-I.

Table B-I. Requirements Traceability Matrix.

SECTION 3 PARAGRAPH	REQUIREMENT NAME	REQUIREMENT NUMBER	HARDWARE CIa ... CIz	HARDWARE CIa ... CIz
. . . .		1	....	....
. . . .			....	....
3.2.5.1	Reliability a	58	X ... X..-	-X...-X
3.2.5.1	Reliability b	59	X ... X..-	-X...-X
3.2.5.1	Reliability c	60	X ... X..-	-X...-X
3.3.12.9	Wiring Harness a	113	XXXXX---	---------
2.2.12.9	Wiring Harness b	114	XXXXX---	---------
. . . .			....	....
. . . .			....	
3.8.1	Conflicts	---	---------	---------
. . . .			....	....
. . . .			....	....

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APPENDIX C

30. REQUIREMENTS CROSS REFERENCE MATRIX

This appendix is not a mandatory part of the specification.

30.1 SCOPE

This appendix outlines a requirements cross-reference matrix for the correlation of the Section 3 requirements with the Section 4 quality assurance provisions.

30.2 APPLICABLE DOCUMENTS

(Not applicable)

30.3 REQUIREMENTS

The correlation of the Section 4 quality assurance provisions with the Section 3 requirements is shown in Table C-I. The verification methods are described in the following paragraphs.

30.3.1 Inspection. Inspection may be used for the visual determination of an item's qualitative or quantitative properties such as tolerances, finishes, and identification.

30.3.2 Analysis. Analysis may be used for determination of qualitative and quantitative properties and performance of an item by study calculations and modeling. Similarity analysis may be used in lieu of tests when it can be shown that an item is similar or identical in design to another item that has been certified previously to equivalent or more stringent criteria.

30.3.3 Demonstration. Demonstration may be used for determination of qualitative and quantitative properties and performance of an item and is accomplished by example. Verification of an item by this method would be by using it for its designed purpose and would require no special test for final proof of performance.

30.3.4 __Test__. Tests may be used for the determination of qualitative and quantitative properties and performance of an item by technical means, which requires the use of external resources such as volt meters, recorders, and any test equipment necessary for measuring performance.

Table C-I. Requirements Cross Reference Matrix.

SECTION 3 PARAGRAPH NUMBER	REQUIREMENT NAME	REQUIREMENT NUMBER	VERIFICATION METHOD[1]	ASSEMBLY LEVEL[2]	SECTION 4 TEST PARAGRAPH
...	Reliability a	58	A	1	4.2.2.1
3.2.5.1	Reliability b	59	T	2	4.2.2.2
3.2.5.1	Reliability c	60	T	3	4.2.2.3
...					
3.3.12.9	Wiring Harness a	113	T	2	4.2.2.3
3.3.12.9	Wiring Harness b	114	T	3	4.2.2.4
...					
3.8.1	Conflicts	---	N/A	-	-

[1]VERIFICATION METHOD
- A - ANALYSIS
- D - DEMONSTRATION
- I - INSPECTION
- T - TEST
- N/A - NOT APPLICABLE

[2]LEVEL OF ASSEMBLY
- 1 - PART OR MATERIAL
- 2 - COMPONENT
- 3 - VEHICLE LEVEL
- 4 - SYSTEM LEVEL

TEST CATEGORY LEGEND:
- A - Design Verification Test
- B - Qualification Test
- C - Acceptance Test
- D - Service Life Verification Test
- E - Prelaunch Validation Test
- F - Operational Test
- G - Step 1: Component Tests and Evaluation (Development)
- H - Step 2: CI/CSCI Compliance Tests (Qualification and Acceptance)
- I - Step 2.1: Single CI OR CSCI Compliance Tests
- J - Step 2.2: Combined CI/CSCI Compliance Tests
- K - Step 2.3: Combined CI/CSCI Compliance Tests
- L - Step 2.4: Combined CI/CSCI Compliance Tests
- M - Step 3: Integrated System Testing
- N - Step 3.1: Preliminary Integrated System Tests
- O - Step 3.2: Final Development Test and Evaluation (FDT&E)
- P - Step 4: Initial Operational Test and Evaluation (IOTE)
- Q - Step 5: Follow-on Operational Test and Evaluation (FOT&E)

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SPEC NUMBER SS-01
15 OCT 91

APPENDIX B

DI-CMAU-80008A

SYSTEM/SEGMENT SPECIFICATION

DATA ITEM DESCRIPTION

Form Approved OMB No. 0704-0188

1. TITLE	2. IDENTIFICATION NUMBER
SYSTEM/SEGMENT SPECIFICATION	DI-CMAN-80008A

3. DESCRIPTION/PURPOSE

3.1 The System/Segment Specification (SSS) specifies the requirements for a system or a segment of a system. Upon Government approval and authentication, the SSS becomes the Functional Baseline for the system or segment.

(continued on page 2)

4. APPROVAL DATE (YYMMDD)	5. OFFICE OF PRIMARY RESPONSIBILITY (OPR)	6a. DTIC APPLICABLE	6b. GIDEP APPLICABLE
880229	AF-10		

7. APPLICATION/INTERRELATIONSHIP

7.1 This Data Item Description (DID) contains the format and content preparation instructions for data generated under the work tasks described by paragraph 3.1.3.1 of MIL-STD-490.

7.2 The Contract Data Requirements List should specify whether this document is to be prepared and delivered on bound 8 1/2 by 11 inch bond paper or electronic media. If electronic media is selected, the precise format must be specified.

(continued on page 2)

8. APPROVAL LIMITATION	9a. APPLICABLE FORMS	9b. AMSC NUMBER
		F4328

10. PREPARATION INSTRUCTIONS

10.1 **Content and format instructions.** Production of this specification using automated techniques is encouraged. Specific content and format instructions for this specification are identified below.

a. Response to tailoring instructions. In the event that a paragraph or subparagraph has been tailored out, a statement to that effect shall be added directly following the heading of each such (sub)paragraph. If a paragraph and all of its subparagraphs are tailored out, only the highest level paragraph heading need be included.

b. Use of alternate presentation styles. Charts, tables, matrices, or other presentation styles are acceptable when the information required by the paragraphs and subparagraphs of this DID can be made more readable.

c. Page numbering. Each page prior to Section 1 shall be numbered in lower-case roman numerals beginning with page ii for the Table of Contents. Each page starting from Section 1 to the beginning of the appendixes shall be consecutively numbered in arabic numerals. If the document is divided into volumes, each such volume shall restart the page numbering sequence.

(continued on page 2)

11. DISTRIBUTION STATEMENT

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

3. DESCRIPTION/PURPOSE (continued)

3.2 The SSS provides a general overview of the system or segment that may be used by training personnel, support personnel, or users of the system.

---

7. APPLICATION/INTERRELATIONSHIP (continued)

7.3 The word "system" is used generically in this DID to mean either a system or a segment, as applicable.

7.4 System division into segments normally occurs if parts of the system are:

a. Assigned to different contractors or government organizations
b. Intended to be added in an evolutionary or incremental manner
c. Planned for major modification.

7.5 This DID supersedes DI-CMAN-80008 dated 4 June 1985.

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10. PREPARATION INSTRUCTIONS (continued)

d. Document control numbers. For hardcopy formats, this document may be printed on one or both sides of each page (single-sided or double-sided). All printed pages shall contain the document control number and the date of the document centered at the top of the page. Document control numbers shall include revision and volume identification, as applicable.

e. Multiple (sub)paragraphs. All paragraphs and subparagraphs starting with the phrase "This (sub)paragraph shall..." may be written as multiple subparagraphs to enhance readability. These subparagraphs shall be numbered sequentially.

f. Identifiers. The letters "X", "Y", and "Z" serve as identifiers for a series of descriptions. For example, the subparagraphs of 10.1.5.2.1.1 shall be structured as follows:

3.2.1.1 (First system state name)
  3.2.1.1.1 (System mode I)
    3.2.1.1.1.1 (System capability A)
    3.2.1.1.1.2 (System capability B)
    3.2.1.1.1.3 (System capability C)
  3.2.1.1.2 (System mode J)
    3.2.1.1.2.1 (System capability W)
    3.2.1.1.2.2 (System capability X)
  etc.
3.2.1.2 (Second system state name)
  etc.

DI-CMAN-80008A

10. PREPARATION INSTRUCTIONS (continued)

g. Document structure. This specification shall consist of the following:

(1) Cover
(2) Title page
(3) Table of contents
(4) Scope
(5) Applicable documents
(6) System requirements
(7) Quality assurance provisions
(8) Preparation for delivery
(9) Notes
(10) Appendixes.

10.1.1 Title page. The title page shall contain the information identified below in the indicated format:

[Document control number end date: Volume x of y (if multi-volume)]

[Rev. indicator: date of Rev.]

SYSTEM SPECIFICATION
(OR SEGMENT SPECIFICATION)

FOR THE

[*SYSTEM NAME*]

CONTRACT NO. [*contract number*]

CDRL SEQUENCE NO. [*CDRL number*]

Prepared for:

[*Contracting Agency Name, department code*]

Prepared by:

[*contractor name end address*]

Authenticated by ______________________ (Contracting agency)

Approved by ______________________ (Contractor)

Date ______________________

Date ______________________

10. PREPARATION INSTRUCTIONS (continued)

10.1.2 **Table of contents.** This specification shall contain a table of contents listing the title and page number of each titled paragraph and subparagraph. The table of contents shall then list the title and page number of each figure, table, and appendix, in that order.

10.1.3 **Scope.** This section shall be numbered 1 and shall be divided into the following paragraphs.

10.1.3.1 **Identification.** This paragraph shall be numbered 1.1 and shall contain the approved identification number, title, and abbreviation, if applicable, of the system to which this SSS applies.

10.1.3.2 **System overview.** This paragraph shall be numbered 1.2 and shall briefly state the purpose of the system to which this SSS applies.

10.1.3.3 **Document overview.** This paragraph shall be numbered 1.3 and shall summarize the purpose and contents of this document.

10.1.4 **Applicable documents.** This section shall be numbered 2 and shall be divided into the following paragraphs.

10.1.4.1 **Government documents.** This paragraph shall be numbered 2.1. This paragraph shall begin with one of the following two paragraphs, as applicable: (1) "The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement." (2) "The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement, except for specification (enter number of next higher-tiered specification) listed below." The following paragraph shall appear at the conclusion of the list of documents: "Copies of specifications, standards, drawings, and publications required by suppliers in connection with specified procurement functions should be obtained from the contracting agency or as directed by the contracting officer." Government documents shall be listed by document number and title in the following order:

SPECIFICATIONS:

Federal
Military
Other Government Agency

STANDARDS:

Federal
Military
Other Government Agency

DRAWINGS:

(Where detailed drawings referred to in a specification are listed on an assembly drawing, it is only necessary to list the assembly drawing.)

10. PREPARATION INSTRUCTIONS (continued)

OTHER PUBLICATIONS:

Manuals
Regulations
Handbooks
Bulletins
etc.

10.1.4.2 **Non-Government documents.** This paragraph shall be numbered 2.2 and shall begin with the following paragraph: "The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement." The source for all documents not available through normal Government stocking activities shall be listed. The following paragraph shall be placed at the conclusion of the list when applicable: "Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal Agencies." Non-Government documents shall be listed by document number and title in the following order:

SPECIFICATIONS:
STANDARDS:
DRAWINGS:
OTHER PUBLICATIONS:

10.1.5 **System requirements.** This section shall be numbered 3 and shall be divided into the following paragraphs and subparagraphs to specify the requirements for the system to which this specification applies.

10.1.5.1 **Definition.** This paragraph shall be numbered 3.1 and shall provide a brief description of the system. This description shall address pertinent operational, and logistical considerations and concepts. A system diagram shall be provided.

10.1.5.2 **Characteristics.** This paragraph shall be numbered 3.2 and shall be divided into the following subparagraphs to describe the requirements for system performance and physical characteristics.

10.1.5.2.1 **Performance characteristics.** This subparagraph shall be numbered 3.2.1 and shall be divided into the following subparagraphs to specify the system's capabilities in the context of the states in which the system can exist and the modes of operation within each state. Each capability of the system shall be specified in a uniquely identified subparagraph in order to provide for objective qualification.

10.1.5.2.1.1 **(State name).** This subparagraph shall be numbered 3.2.1.X (beginning with 3.2.1.1) and shall identify and provide a brief description of a state in which the system can exist (e.g., weapon idle, weapon ready, weapon deployed).

10.1.5.2.1.1.1 **(Mode name).** This subparagraph shall be numbered 3.2.1.X.Y (beginning with 3.2.1.1.1). This subparagraph shall identify and provide a brief description of a mode of operation (e.g., surveillance, threat evaluation, weapon assignment, target designation and acquisition, fire control resolution) within the system state identified above.

10. PREPARATION INSTRUCTIONS (continued)

10.1.5.2.1.1.1.1 **(System capability name and project unique identifier).** This subparagraph shall be numbered 3.2.1.X.Y.Z (beginning with 3.2.1.1.1.1), shall specify a capability of the system by name and project unique identifier, and shall describe its purpose. This subparagraph shall also identify the applicable parameters associated with the capability and shall express them in measurable terms. If a capability of a mode has been previously defined, this subparag aph shall reference rather than duplicate that information.

10.1.5.2.2 **System capability relationships.** This subparagraph shall be numbered 3.2.2 and shall summarize the relationships between system capabilities and the states and modes of the system.

10.1.5.2.3 **External interface requirements.** This paragraph shall be numbered 3.2.3 and shall be divided into the following subparagraphs to describe requirements for interfaces with other systems. Detailed quantitative interface requirements may be defined in separate specifications or Interface Control Documents (ICDs) and referenced herein. All referenced ICDs are considered part of this specification.

10.1.5.2.3.1 **(System name) external interface description.** This subparagraph shall be numbered 3.2.3.X (beginning with 3.2.3.1) and shall identify an external system with which this system interfaces. This subparagraph shall describe the interfaces to the external system. This subparagraph shall identify the purpose of each interface and shall describe the relationship between each interface and the states and modes of the system. When possible, each interface shall be specified in detailed, quantitative terms (e.g., dimensions, tolerances, loads, speeds, communications protocol).

10.1.5.2.4 **Physical characteristics.** This subparagraph shall be numbered 3.2.4 and shall specify the requirements for the physical characteristics (e.g., weight limits, dimensional limits) of the system. Additional considerations for determining physical requirements include:

a. Transportation and storage
b. Security
c. Durability
d. Safety
e. Vulnerability
f. Color

10.1.5.2.4.1 **Protective coatings.** This subparagraph shall be numbered 3.2.4.1 and shall specify, if applicable, protective coating requirements to assure protection from corrosion, abrasion, or other deleterious action.

10.1.5.2.5 **System quality factors.** This paragraph shall be numbered 3.2.5 and shall be divided into the following subparagraphs to specify the applicable requirements pertaining to system quality factors.

10.1.5.2.5.1 **Reliability.** This subparagraph shall be numbered 3.2.5.1, shall specify reliability requirements in quantitative terms, and shall define the conditions under which the reliability requirements are to be met. This subparagraph may include a reliability apportionment model to support apportionment of reliability values assigned to system capabilities for their share in achieving desired system reliability.

10.1.5.2.5.2 **Maintainability.** This subparagraph shall be numbered 3.2.5.2 and shall specify quantitative maintainability requirements. The requirements shall apply to maintenance in the planned maintenance and support environment and shall be stated in quantitative terms. Examples are:

10. PREPARATION INSTRUCTIONS (continued)

a. Mean and maximum down time, reaction time, turnaround time, mean and maximum times to repair, mean time between maintenance actions.
b. Maximum effort required to locate and fix an error.
c. Maintenance man-hours per flying hour, maintenance man-hours per specific maintenance action, operational ready rate, maintenance hours per operating hour, frequency of preventative maintenance.
d. Number of people and skill levels, variety of support equipment.
e. Maintenance costs per operating hour, man-hours per overhaul.

10.1.5.2.5.3 **Availability.** This subparagraph shall be numbered 3.2.5.3 and shall specify the degree to which the system shall be in an operable and committable state at the start of the mission(s), where the mission(s) is called for at an unknown (random) point in time.

10.1.5.2.5.4 **Additional quality factors.** This subparagraph shall be numbered 3.2.5.4 and shall specify system quality requirements not defined in the above subparagraphs (e.g., integrity, efficiency, or correctness requirements of the system).

10.1.5.2.6 **Environmental conditions.** This paragraph shall be numbered 3.2.6 and shall specify the environmental conditions that the system must withstand during transportation, storage, and operation, such as:

a. Natural environment (e.g., wind, rain, temperature, geographic location)
b. Induced environment (e.g., motion, shock, noise, electromagnetic radiation)
c. Environments due to enemy action (e.g., over-pressure, explosions, radiation).

10.1.5.2.7 **Transportability.** This subparagraph shall be numbered 3.2.7 and shall specify any special requirements for transportation and materials handling. In addition, all system elements that, due to operational or functional characteristics, will be unsuitable for normal transportation methods shall be identified.

10.1.5.2.8 **Flexibility and expansion.** This subparagraph shall be numbered 3.2.8 and shall specify areas of growth which require planning for system flexibility and expansion. In addition, this subparagraph shall specify specific system elements which require spare capacity to support flexibility and expansion.

10.1.5.2.9 **Portability.** This subparagraph shall be numbered 3.2.9 and shall specify requirements for portability which are applicable to the system to permit employment, deployment, and logistic support.

10.1.5.3 **Design and construction.** This paragraph shall be numbered 3.3 and shall be divided into subparagraphs that specify minimum system design and construction standards which have general applicability to system equipment and are applicable to major classes of equipment (e.g., aerospace vehicle equipment, and support equipment) or are applicable to particular design standards. To the maximum extent possible, these requirements shall be specified by incorporation of the established military standards and specifications. Requirements which add to, but do not conflict with, requirements specified herein may be included in individual configuration item specifications. In addition, this paragraph shall specify criteria for the selection and imposition of Federal, military, and contractor specifications and standards.

10.1.5.3.1 **Materials.** This subparagraph shall be numbered 3.3.1 and shall specify those system-peculiar requirements governing use of materials, parts, and processes in the design of system equipment. Special attention shall be directed to prevent unnecessary use of strategic or critical materials. (A strategic and critical materials list may be obtained from the contracting agency.) In addition, requirements for the

10. PREPARATION INSTRUCTIONS (continued)

use of standard and commercial parts and parts for which qualified products lists have been established shall be specified in this paragraph.

10.1.5.3.1.1 **Toxic products and formulations.** This subparagraph shall be numbered 3.3.1.1 and shall specify requirements for the control of toxic products or formulations to be used in the system or to be generated by the system.

10.1.5.3.2 **Electromagnetic radiation.** This subparagraph shall be numbered 3.3.2 and shall contain requirements pertaining to limits on the electromagnetic radiation which the system is permitted to generate.

10.1.5.3.3 **Nameplates and product marking.** This subparagraph shall be numbered 3.3.3 and shall contain requirements for nameplates, part marking, serial and lot number marking, software media marking, and other identifying markings required for the system. Reference may be made to existing standards on the content and application of markings.

10.1.5.3.4 **Workmanship.** This subparagraph shall be numbered 3.3.4 and shall specify workmanship requirements for equipment to be produced during system development and requirements for manufacture by production techniques.

10.1.5.3.5 **Interchangeability.** This subparagraph shall be numbered 3.3.5 and shall specify the requirements for system equipment to be interchangeable and replaceable. Entries in this paragraph are for the purpose of establishing a condition for design and are not to define the conditions of interchangeability required by the assignment of a part number.

10.1.5.3.6 **Safety.** This subparagraph shall be numbered 3.3.6 and shall specify those safety requirements which are basic to the design of the system, with respect to equipment characteristics, methods of operation, and environmental influences. This paragraph shall also specify those safety requirements which prevent personnel injury and equipment degradation without degrading operational capability (e.g., restricting the use of dangerous materials where possible, classifying explosives for purposes of shipping, handling and storing, abort/escape provisions from enclosures, gas detection and warning devices, grounding of electrical system, cleanliness and decontamination, explosion proofing).

10.1.5.3.7 **Human engineering.** This subparagraph shall be numbered 3.3.7 and shall specify human engineering requirements for the system or for specific configuration items. This paragraph shall reference applicable documents (e.g., MIL-STD-1472) and specify any special or unique requirements (e.g., constraints on allocation of capabilities to personnel and communications, and personnel/equipment interactions). This paragraph shall include those specific areas, stations, or equipment which would require concentrated human engineering attention due to the sensitivity of the operation or criticality of the task; i.e., those areas where the effects of human error would be particularly serious.

10.1.5.3.8 **Nuclear control.** This subparagraph shall be numbered 3.3.8 and shall specify system requirements for nuclear components, such as:

a. Component design
b. In-flight control
c. Prevention of inadvertent detonation
d. Nuclear safety rules.

10.1.5.3.9 **System security.** This subparagraph shall be numbered 3.3.9 and shall specify security requirements that are basic to the design of the system with respect to the operational environment of

10. PREPARATION INSTRUCTIONS (continued)

the system. This subparagraph shall also specify those security requirements necessary to prevent compromise of sensitive information or materials.

10.1.5.3.10 **Government furnished property usage.** This subparagraph shall be numbered 3.3.10 and shall specify any Government Furnished Equipment (GFE) to be incorporated into the system design. In addition, this paragraph shall specify any Government Furnished Information (GFI) and Government Furnished Software (GFS) to be incorporated into the system. This list shall identify the Government furnished property by reference to its nomenclature, specification number, and/or part number. If the list is extensive, it may be included as an appendix to this specification and referenced in this paragraph.

10.1.5.3.11 **Computer resource reserve capacity.** This subparagraph shall be numbered 3.3.11 and shall specify the required computer resource reserve capacity (e.g. memory, timing, etc.).

10.1.5.4 **Documentation.** This paragraph shall be numbered 3.4 and shall specify the requirements for system documentation such as specifications, drawings, technical manuals, test plans and procedures, and installation instruction data.

10.1.5.5 **Logistics.** This paragraph shall be numbered 3.5 and shall specify logistic considerations and conditions that apply to the operational requirements. These considerations and conditions may include:

a. Maintenance
b. Transportation modes
c. Supply-system requirements
d. Impact on existing facilities
e. Impact on existing equipment.

10.1.5.6 **Personnel and training.** This paragraph shall be numbered 3.6 and be divided into the following subparagraphs to specify the requirements for personnel and training.

10.1.5.6.1 **Personnel.** This subparagraph shall be numbered 3.6.1 and shall specify personnel requirements which must be integrated into system design. These requirements shall be stated in terms of numbers plus tolerance and shall be the basis for contractor design and development decisions. Requirements stated in this paragraph shall be the basis for determination of system personnel training, training equipment, and training facility requirements. Personnel requirements shall include:

a. Numbers and skills of support personnel for each operational deployment mode and the intended duty cycle, both normal and emergency.

b. Skills and numbers of personnel that shall be allocated to the operation, maintenance, and control of the system.

10.1.5.6.2 **Training.** This subparagraph shall be numbered 3.6.2 and shall include the following training requirements:

a. Contractor and Government responsibility for training. This subparagraph shall also specify the concept of how training shall be accomplished (e.g., school, contractor training).
b. Equipment that will be required for training purposes.

c. Training devices to be developed, characteristics of the training devices, and training and skills to be developed through the use of training devices.

10. PREPARATION INSTRUCTIONS (continued)

d. Training time and locations available for a training program.
e. Source material and training aids to support the specified training.

10.1.5.7 **Characteristics of subordinate elements.** This paragraph shall be numbered 3.7 and shall be divided into the following subparagraphs to identify and describe each segment of the system. This subparagraph shall describe the relationships between the segments.

10.1.5.7.1 **(Segment name and project unique identifier).** This subparagraph shall be numbered 3.7.X (beginning with 3.7.1) and shall provide the following information for the segment:

a. State the purpose of the segment
b. Provide a brief description of the segment
c. Identify the system capabilities the segment performs.

10.1.5.8 **Precedence.** This paragraph shall be numbered 3.8 and shall either specify the order of precedence of the requirements or assign weights to indicate the relative importance of the requirements.

10.1.5.9 **Qualification.** This paragraph shall be numbered 3.9 and shall state the requirements for verification or validation, as applicable, of capabilities in a specific application. Each qualification test shall be identified in a separate subparagraph and the specific application shall be described. Requirements shall be included for the conditions of testing, the time (program phase) of testing, period of testing, number of items to be to be tested, and any other pertinent qualification requirements.

10.1.5.10 **Standard sample.** This paragraph shall be numbered 3.10 and, if applicable, shall describe requirements for the production of one or more standard samples. Standard samples shall be limited to the illustration of qualities and characteristics that cannot be described using detailed test procedures or design data or that cannot be definitively expressed.

10.1.5.11 **Preproduction sample, periodic production sample, pilot, or pilot lot.** This paragraph shall be numbered 3.11 and, if applicable, shall describe requirements for producing a preproduction or periodic production sample, a pilot model, or a pilot lot.

10.1.6 **Quality assurance provisions.** This section shall be numbered 4 and shall be divided into the following paragraphs to specify the requirements to show how the requirements of sections 3 and 5 shall be satisfied.

10.1.6.1 **Responsibility for Inspection.** This paragraph shall be numbered 4.1 and shall assign responsibilities for performance of inspections of delivered products, materials, or services for determining compliance with all specified requirements.

10.1.6.2 **Special tests and examinations.** This paragraph shall be numbered 4.2 and shall specify any special tests and examinations required for sampling, lot formation, qualification evaluation, and any other tests or examinations as necessary. Each test and examination shall be described in a separate subparagraph.

10.1.6.3 **Requirements cross reference.** This paragraph shall be numbered 4.3 and shall correlate each system requirement in sections 3 and 5 to the quality assurance provisions specified in section 4. This paragraph may reference a requirements cross reference table which may be provided as an appendix to this specification.

10. PREPARATION INSTRUCTIONS (continued)

10.1.7 **Preparation for delivery.** This section shall be numbered 5 and shall specify requirements for the preparation of the system and all its components for delivery, including packaging and handling. This section shall include requirements to document any non-standard practices in appropriate system end item specifications. This section may impose requirements to comply with standard practice by referencing appropriate military specifications and standards to be used as the basis for preparing Section 5 of each specification for system end items.

10.1.8 **Notes.** This section shall be numbered 6 and shall contain any general information that aids in understanding this document (e.g., background information, glossary). This section shall contain an alphabetical listing of all acronyms, abbreviations, and their meanings as used in this document.

10.1.8.1 **Intended use.** This paragraph shall be numbered 6.1 and shall briefly state the purpose of the system to which the SSS applies in terms of the mission and threat addressed by the system.

10.1.8.1.1 **Missions.** This subparagraph shall be numbered 6.1.1 and shall describe the missions of the system to the extent that such missions affect design requirements. This description shall include operational information, such as tactics, system deployment, operating locations, and facilities.

10.1.8.1.2 **Threat.** This subparagraph shall be numbered 6.1.2 and shall describe the characteristics of potential targets, the characteristics of current and potential enemy weapon capabilities relevant to the system, and any additional threat considerations that affect the system design. This information may be contained in a separate document and referenced in this subparagraph if it is classified.

10.1.9 **Appendixes.** Appendixes may be used to provide information published separately for convenience in document maintenance (e.g., charts, classified data). As applicable, each appendix shall be referenced in the main body of the document where the data would normally have been provided. Appendixes may be bound as separate documents for ease in handling. Appendixes shall be lettered alphabetically (A, B, etc.), and the paragraphs within each appendix be numbered as multiples of 10 (e.g., Appendix A, paragraph 10, 10.1, 10.2, 20, 20.1, 20.2, etc.). Pages within each appendix shall be numbered alpha-numerically as follows: Appendix A pages shall be numbered A-1, A-2, A-3, etc. Appendix B pages shall be numbered B-1, B-2, B-3, etc.

APPENDIX C

Diskette copies of Appendix A, *the Model system specification*, are included with this document. At the end of this report, two diskettes are provided in IBM Word Perfect 5.1 and one diskette in Macintosh Microsoft Word 4.0H. The diskettes may be used as the starting baseline for any new system specification being prepared. Should the diskettes be lost or not included with the copy of the document you receive, please contact the document distribution center at The Aerospace Corporation Library, Distribution and Control, to obtain a copy:

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