National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas 77058

NSTS 07700
VOLUME X – BOOK 1
REVISION M
NOVEMBER 10, 1998

REPLACES
NSTS 07700, VOLUME X
REVISION L

SPACE SHUTTLE

FLIGHT AND GROUND SYSTEM SPECIFICATION

BOOK 1

REQUIREMENTS

PROGRAM DEFINITION AND REQUIREMENTS

REVISION LOG

REV LTR	CHANGE NO	DESCRIPTION	DATE
		BASELINE ISSUE (Reference: Level II PRCBD S00027)	03/20/73
A	13	REVISION A (Reference: Level II PRCBD S00154) Incorporate Changes 1 thru 12 and SRR Category A and B RID'S.	01/02/74
B	27	REVISION B (Reference: Level II PRCBD S02221) Incorporate Changes 14 thru 26.	08/18/75
C	46	REVISION C (Reference: Level II PRCBD S04600) also includes PRCBDs S01245AR1, S02692C, S03325R1, S03517A, S03695B, S04144, S04228A, S04302, S04379, S04488 and Changes 28 thru 45.	04/27/78
D	71	REVISION D (Reference: Level II PRCBD S04600A) also includes PRCBDs S02106VR2, H04354G, S04354H, S10001, S10002, S10007, S10010, S10020, S10021, S10022, S13806HR1, S13807BR1, S13857CR1, S14219B, S14598D, S14770D, S14908C, S15518R2, S15800B, S15816D, S15842R2, H15929C, S16569PR1, S16569VR1, S16569WR1, S20248R3, S20482C, S20652A, H20911C, S20987C, S21300A, S21572, S21742AR1, S21799R1, S22000C, S22000N, S22058, S22106DR1, S22106ER1, S22106KR1, S22106LR1, S22106LR2, S22106NR1, S22106PR1, S22131A, S22131R1, S22200, S22330, S22330R1, S22425, S22425R1, S22449, S22487, S22492, S22599, S22726, S22728, S22882A, S22902, S22917, S23035, S23039, S26569AR1, S26569FR1, S36889CR2, S36889G, S46360A, S46553, S52877H, S52877J, S52877K, S77340, S77340A, S77340B, S787517, S87040 and Changes 47 thru 70.	09/30/83
E	84	REVISION E (Reference: Level II PRCBD S40129, dated 7/23/86) also includes PRCBDs S10230, S32654E, S33496, S33687 and Changes 72 thru 83.	08/21/86

REVISION LOG - Continued

REV LTR	CHANGE NO	DESCRIPTION	DATE
F	85	REVISION F (Reference: Level II PRCBD S04600B, dated 5/28/87) also includes PRCBDs S15795W, S15795Y, S21841AR1, S21841B, S25795R1, S25795R2, S25795B, S30317K, S31073L, S31664AR1, S31664ER1, S33687, S40107AR1, S40107B, S40131, S40166A, S40198, S40201FR1, S40201JR1, S40201KR1, S40201LR1, S40201M, S40201MR1, S40201P, S40201Q, S40201T, S40201VR1, S40201WR1, S40201YR1, S40201ZR1, S40204R1, S40204R2, S40204R3, S40204R5, S40204BR3, S40204CR5, S40204DR1, S40204E, S40207R1, S40207BR1, S40207R2, S40349, S40426, S40431A, S40442A, S40442B, S40445, S40448, S40495, S40522, S50201, S50201A, S50201B, S50201C, S50201D, S50201E, S50201Q, S50201T, S50201U, S60035D and Errata.	06/02/87
G	95	REVISION G (Reference: Level II PRCBD S04600C, dated 7/12/88) also includes S40204L, S40204M, S40210R1, S40210R2, S40210AR1, S40210B, S40535T, S40620G, S40814, S40905B, S40905D, S40905F, S40942A, S40948B, S40948C, S40994E, S40994G, S41106, S50200KR1, S50200VR1, S70200R1, S70200DR1, S70200ER1, S70200FR1, S70200KR1, S70200LR2, S70200P, S70200QR1, S70200VR1, S70200YR1, S93469, S93473, S93479, S93486, S94540 and Changes 86 thru 94.	07/13/88

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REV LTR	CHANGE NO	DESCRIPTION	DATE
H	100	REVISION H (Reference: Level II PRCBD S04600D, dated 12/10/88) also includes PRCBDs S14366A, S15101B, S15404D, S31301K, S36604A, S40202JR3, S40202KR3, S40203YR1, S40203ZR1, S40204T, S40204U, S40204Z, S40210CR1, S40210DR1, S40220R1, S40220PR1, S40220UR2, S40220VR2, S40222AR1, S40224, S40224B, S40224C, S40224, S40224FR1, S40224G, S40224M, S40230JR3, S40230MR1, S40230NR1, S40230PR1, S40230QR1, S40230YR1, S40230ZR1, S40240ER1, S40240JR1, S40240UR1, S40250BR1, S40447R1, S40522U, S40614, S40614C, S40614E, S40674A, S40793B, S40793D, S40994BR1, S41230U, S41230V, S41293, S41331, S41331A, S41365, S41379, S41393, S41417A, S41420, S41443, S41461A, S41473, S41506, S41551, S41552, S52877Q, S54015A, S61526Q, S70200CR1, S70200VR3, S70200YR3, S76134, S76137, S76190R1, S76257, S76261, S76263, S92140A, S92173, S92173F, S93461AR1, S94182, S94193, S94201A, S94510, S94549A, S94554, S94577A, S94586, S94614, S94741A, S94825R1, Changes 96 thru 99 and Errata.	12/28/88
J	131	REVISION J (Reference: Level II PRCBD S004600E, dated 6/5/90) also includes PRCBDs S040227CR1, S040227D, S040234M, S04242HR1, S050250D, S076233HR6, S083284A, S098184U, S098184UR1, Errata and Changes 101 thru 130.	06/14/90
		- - VOLUME X RESTRUCTURE - -	
K	187	REVISION K (Reference: Space Shuttle PRCBD S004600F, dated 10/9/92) also includes PRCBD S052200FR1; SSP DOC-057 and Changes 132 thru 186.	10/09/92
L	194	REVISION L (Reference: SSP DOC-102, dated 5/21/93) also includes PRCBDs S052158AD, S052200FR2, S052849, S052860A, S092140FR1, S093532C, SSP DOC-108 and Changes 188 thru 193.	06/04/93

REVISION LOG - Concluded

REV LTR	CHANGE NO	DESCRIPTION	DATE
M	247	REVISION M (Reference: Space Shuttle PRCBD S004600MR1, dated 11/5/98) also includes S060614BU, S061111, S061114, S061143, S061180, S071024CD, S071024EB, S091357, SSP DOC-271, SSP DOC-307 and Changes 195 thru 246.	11/10/98

CHANGE SHEET

FOR

PROGRAM DEFINITION AND REQUIREMENTS
VOLUME X - Space Shuttle
Flight and Ground System Specification
BOOK 1
REQUIREMENTS

CHANGE NO. 273

Program Requirements Control Board Directive No. S022362W/(1-1), dated 5/11/01 and S071765/(2-1), dated 5/8/01.(2)

June 4, 2001

Robert H. Heselmeyer
Secretary, Program Requirements
Control Board

CHANGE INSTRUCTIONS

1. Remove the following listed pages and replace with the same numbered attached pages:

Page	PRCBD No.
3-3	S022362W
3-4	
3-145	
3-146 - 3-147	S071765
3-148	
3-167	S022362W
3-168	

NOTE: A black bar in the margin indicates the information that was changed.

2. Remove the List of Effective Pages, dated May 11, 2001 and replace with List of Effective Pages, dated June 4, 2001.

3. Sign and date this page in the space provided below to show that the changes have been incorporated and file immediately behind the List of Effective Pages.

_____ _____

Signature of person incorporating changes Date

PROGRAM DEFINITION AND REQUIREMENTS
Volume X - Space Shuttle
Flight and Ground System Specification
BOOK 1
REQUIREMENTS

*Revision M (Reference PRCBD Nos. S004600MR1, dated 11/5/98; S060614BU, dated 8/31/98; S061111, dated 8/17/98; S061114, dated 8/25/98; S061143, dated 9/30/98; S061180, dated 10/9/98; S071024CD, dated 8/25/98; S071024EB, dated 10/28/98; S091357, dated 9/8/98; SSP DOC-271 and SSP DOC-307).

LIST OF EFFECTIVE PAGES

June 4, 2001

The current status of all pages in this document is as shown below:

Page No.	Change No.	PRCBD No.	Date
i - xii	Rev. M	*	November 10, 1998
xiii	255	S052189CT	August 21, 1999
xiv - xvi	Rev. M	*	November 10, 1998
1-1 - 1-6	Rev. M	*	November 10, 1998
2-1	258	S061229	November 9, 1999
2-2 - 2-3	Rev. M	*	November 10, 1998
2-4 - 2-5	270	S061563	March 1, 2001
2-6 - 2-9	257	S061287	October 6, 1999
2-10 - 2-10B	270	S061563	March 1, 2001
2-11	Rev. M	*	November 10, 1998
2-12	260	SSP DOC-444	January 13, 2000
2-13 - 2-14	Rev. M	*	November 10, 1998
2-15	252	S042013AY	May 22, 1999
2-16 - 2-20	271	S061623	April 3, 2001
2-21	271	S061595R1 S061623	March 21, 2001, April 3, 2001
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2-24 - 2-25	258	S061229	November 9, 1999
2-26	270	S061563	March 1, 2001
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2-34	271	S061493A	March 21, 2001
2-35 - 2-36	Rev. M	*	November 10, 1998
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3-3	273	S022362W	May 11, 2001
3-4	271	S061595R1	March 21, 2001
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A-8	Rev. M	*	November 10, 1998

NSTS 07700

VOLUME X - BOOK 1

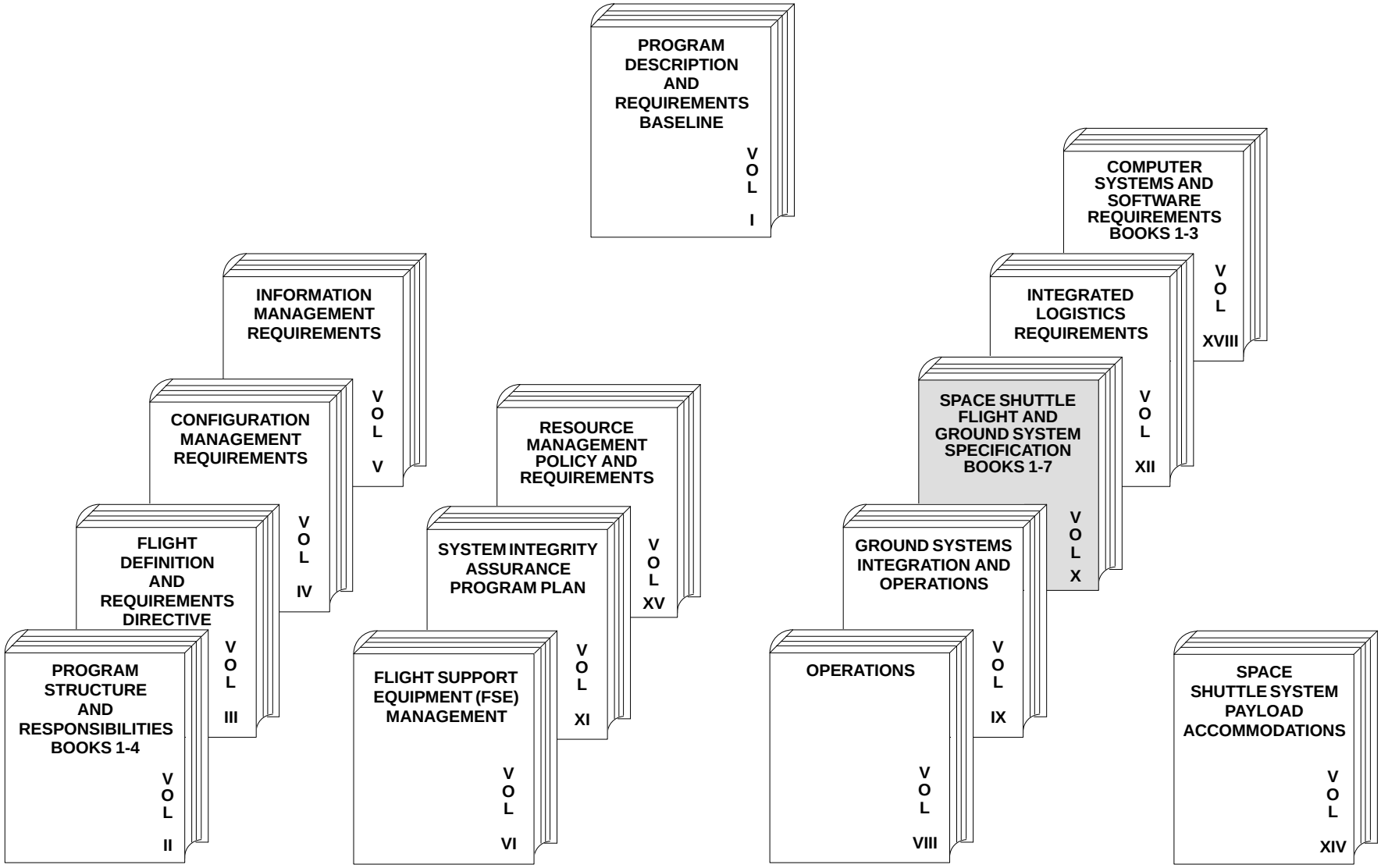
SPACE SHUTTLE

FLIGHT AND GROUND SYSTEM SPECIFICATION

BOOK 1

REQUIREMENTS

SPACE SHUTTLE
PROGRAM DEFINITION AND REQUIREMENTS - NSTS 07700

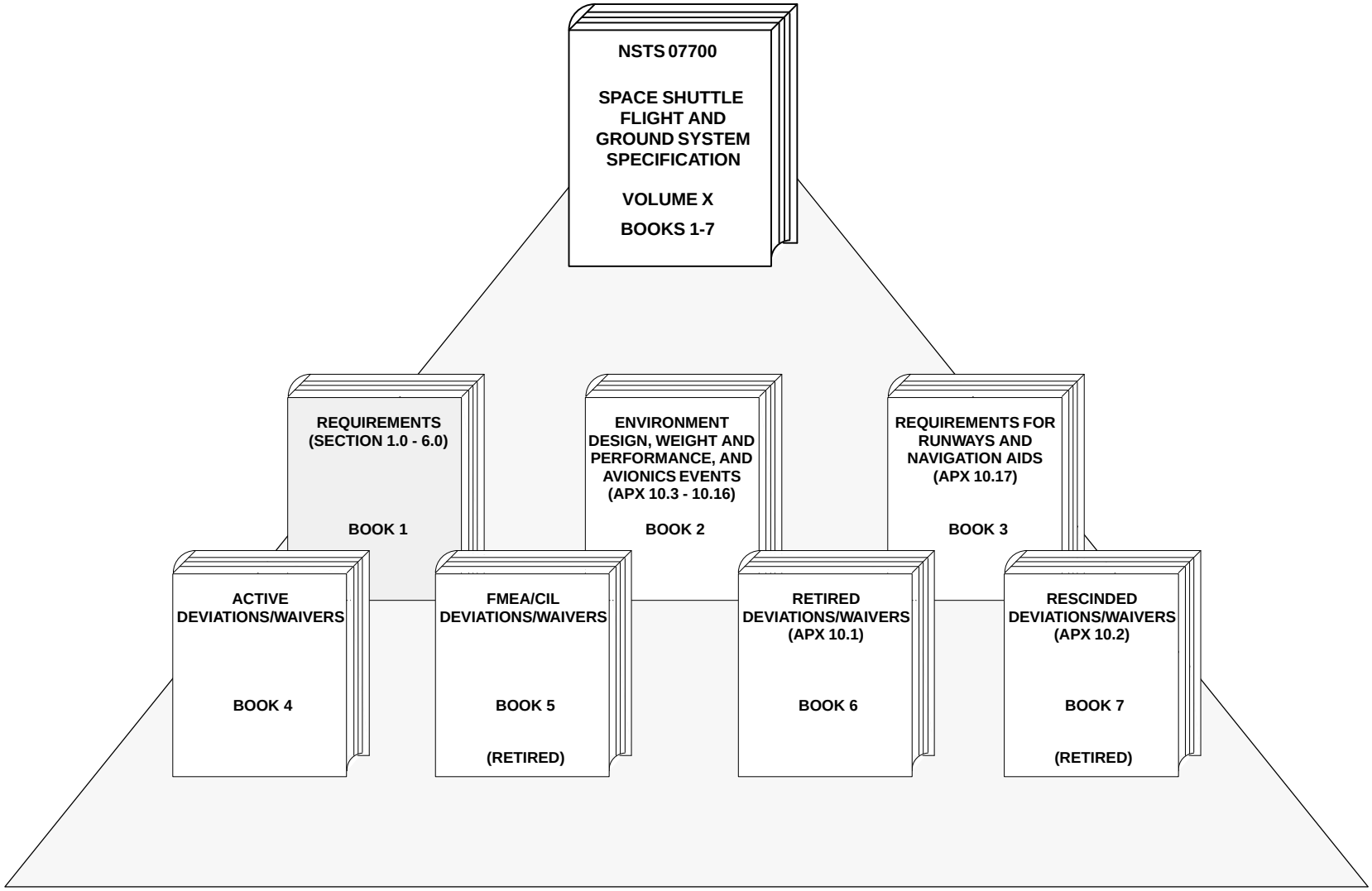


MANAGEMENT REQUIREMENTS

TECHNICAL REQUIREMENTS

NOTE: THE FOLLOWING VOLUME NUMBERS ARE
RESERVED: XVII
RETIRED: II-BKS 1 & 4; VI-BK 2; VII; X-BKS 5 & 7; XIII; XVI

SPACE SHUTTLE
FLIGHT AND GROUND SYSTEM SPECIFICATION
BREAKDOWN STRUCTURE



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FOREWORD

Efficient management of the Space Shuttle Program (SSP) dictates that effective control of program activities be established. Requirements, directives, procedures, interface agreements, and system capabilities shall be documented, baselined, and subsequently controlled by SSP management.

Program requirements, directives, procedures, etc., controlled by the Manager, Space Shuttle Program, are documented in the volumes of this document, NSTS 07700. The accompanying illustration identifies the volumes that make up the Space Shuttle Program Definition and Requirements. Volume I contains overall descriptions of the NSTS 07700 documentation. Requirements to be controlled by the NASA project managers are to be identified, documented, and controlled by the project.

Book 1, Requirements, is one of seven books currently in the NSTS 07700, Volume X structure. This book defines the Space Shuttle Flight and Ground Systems requirements to be used by all NASA and Contractor organizations involved in the design, development, production, test, and operation of Space Shuttle Flight and Ground Systems. All Space Shuttle Flight and Ground Systems shall conform to the requirements contained herein. The Office of Primary Responsibility (OPR) for NSTS 07700, Volume X - Book 1 is the Space Shuttle Systems Integration Office.

All elements of the SSP must adhere to these baselined requirements. When it is considered by the Space Shuttle program element/project managers to be in the best interest of the SSP to change, waive or deviate from these requirements, an SSP Change Request (CR) shall be submitted to the Program Requirements Control Board (PRCB) Secretary. The CR must include a complete description of the change, waiver or deviation and the rationale to justify its consideration. All such requests will be processed in accordance with NSTS 07700, Volume IV - Book 1 and dispositioned by the Manager, Space Shuttle Program, on a Space Shuttle PRCB Directive (PRCBD).

Tommy W. Holloway
Manager, Space Shuttle Program

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1.0 INTRODUCTION

1.1 PURPOSE

This Book 1 defines the Space Shuttle Flight and Ground Systems requirements to be used by all NASA and contractor organizations.

1.2 SCOPE

This specification shall contain the program level technical requirements for the Space Shuttle System (SSS) Design, Development, Test, and Evaluation ([DDT&E] and Operations) and forms the basis for control by the NASA Program Office. The specification defines the performance, operational, design, and verification requirements for the integrated Shuttle System and, in addition, specifies unique requirements and characteristics to which Shuttle System elements shall conform. Program management requirements which include costs, schedules, manning, training, and others are contained in other program documents.

This specification shall be the source for the expanded definition of project-level requirements for all elements of the Shuttle System. Such requirements shall be documented in Contract End Item (CEI) Specifications, and Contractor Procurement Specifications. The CEI Specifications for individual Shuttle elements shall also contain (by reference only) specific requirements allocated from this specification. The order of precedence for these specifications shall be:

a. Shuttle System Specification

b. Space Shuttle Program (SSP) Interface Control Documents (ICDs)

c. CEI Specifications

d. Contractor Procurement Specifications

All program level Flight and Ground System Specification requirements for the SSP are contained herein. In the event of conflicting statements regarding Flight and Ground System Specification requirements between this volume and any other SSP document, the requirement of this document shall take precedence. However, if a Program Directive has been subsequently issued by the Manager, Space Shuttle Program which affects the statement(s) in question, the Program Directive shall take precedence.

1.3 SYSTEM FUNCTIONAL DEFINITION AND END ITEM IDENTIFICATION

1.3.1 Top Level Shuttle System Functions

The top level Functional Flow Diagram (FFD) shown in Figure 1.3.1, depicts the major operations of the SSS. The top level FFD shall be used for developing more detailed

functional requirements and lower levels of functional flow diagrams. These functional requirements are subsequently translated into performance and design requirements for system elements and their subsystems. The FFDs are also used for generating mission timelines, constraints, quantities of support equipment, numbers of operating personnel, etc. The following subparagraphs summarize the scope of activities and events encompassed in each of the top level functions 1.0 through 14.0.

1.3.1.1 Perform Mission Operations (FFD 1.0)

Shall cover all activities from flight vehicle lift-off through boost, staging, orbit insertion, rendezvous, docking, undocking, payload deployment, payload retrieval, landing, landing rollout, and Solid Rocket Booster (SRB) recovery and retrieval.

1.3.1.2 Perform Assembly and Launch (FFD 2.0)

Shall include assembly and checkout of SRBs and External Tank (ET), flight vehicle mating, transport to the pad, payload installation, cryogenic propellant loading, flight personnel loading, final servicing, checkout, launch countdown, ignition, and launch.

1.3.1.3 Perform Turnaround Maintenance Operations (FFD 3.0)

Shall begin with Orbiter activities just after landing rollout and shall include any classified data removal, flight personnel egress and transport to the maintenance checkout area for post-flight safing, deservicing, cargo removal, inspection, post-flight data processing, maintenance, repair, refurbishment, payload installation, vehicle premate checkout, and end with the Orbiter ready for flight vehicle mating. This function also includes SRB retrieval, transport to the refurbishment and checkout area, inspection, repair and refurbishment, and ends with the SRB ready for flight vehicle mating. In addition, this function shall include mission equipment installation, removal, reconfiguration, or maintenance.

1.3.1.4 Provide Mission Operations Support (FFD 4.0)

Shall include the premission, mission, and post mission operations support and shall include but not be limited to:

a. Mission planning

b. Mission profiles

c. Communications and air traffic control

1.3.1.5 Perform Mission Abort Operations (FFD 5.0)

Shall include all flight vehicle abort operations including pad abort and progressing through launch, staging, and on-orbit and entry modes.

1.3.1.6 Perform Ferry Mission (FFD 6.0)

This function encompasses the activities associated with transporting an Orbiter in the ferry configuration from its point of origin, where the Orbiter is mated to the Shuttle Carrier Aircraft (SCA), to its final destination, where the Orbiter is demated from the SCA. It will include the ferry itself and the activities required at intermediate stops in the ferry flight. Abort modes during the ferry will be included.

1.3.1.7 Transport System Elements to Using Site (FFD 7.0)

Shall include the transport of the Shuttle Vehicle elements, support equipments, and supplies from acceptance sites to the using site. This function begins after acceptance of the system elements at the manufacturing acceptance site and ends with delivery of the system elements to the using site. This function will include the initial ferry flight required for delivery of the Orbiters from the manufacturing acceptance site to the launch site.

1.3.1.8 Test and Accept System Elements (FFD 8.0)

Shall include the activities associated with the ground test and acceptance checkout of system elements subsequent to completion of element final assembly. This function begins with the acceptance checkout of the assembled vehicle elements at the manufacturing acceptance site and ends with the element ready for shipment to the using site. For the Orbiter, this shall include the Horizontal Flight Test.

1.3.1.9 Produce System Elements (FFD 9.0)

Shall include the analysis and preparation of system element requirements, analysis and preparation of design solutions, development testing to assess system and subsystem performance, qualification testing, and major ground testing to certify system and subsystem performance, analysis and preparation of tooling drawings, fabrication of tooling, and fabrication and assembly of subsystem and system elements. This function starts at program go-ahead and ends with preparation of assembled system elements for test and acceptance checkout.

1.3.1.10 Provide Support Facilities (FFD 10.0)

Shall include the analysis and preparation of development and operational support facilities requirements, definition of new or existing facilities, modification or construction of facilities, and support site activation. This function starts at program go-ahead and continues throughout site utilization.

1.3.1.11 Train Personnel (FFD 11.0)

Shall include the analysis and identification of training requirements, definition of training equipment (simulators and mockups), training programs and procedures, and

personnel training. This function starts at program go-ahead and continues throughout system operation.

1.3.1.12 Perform Support Equipment and Facility Maintenance (FFD 12.0)

Shall include support equipment installation, operation and maintenance, and facility maintenance functions. This function shall begin with site activation and continues throughout site utilization.

1.3.1.13 Recycle Launch Facility (FFD 13.0)

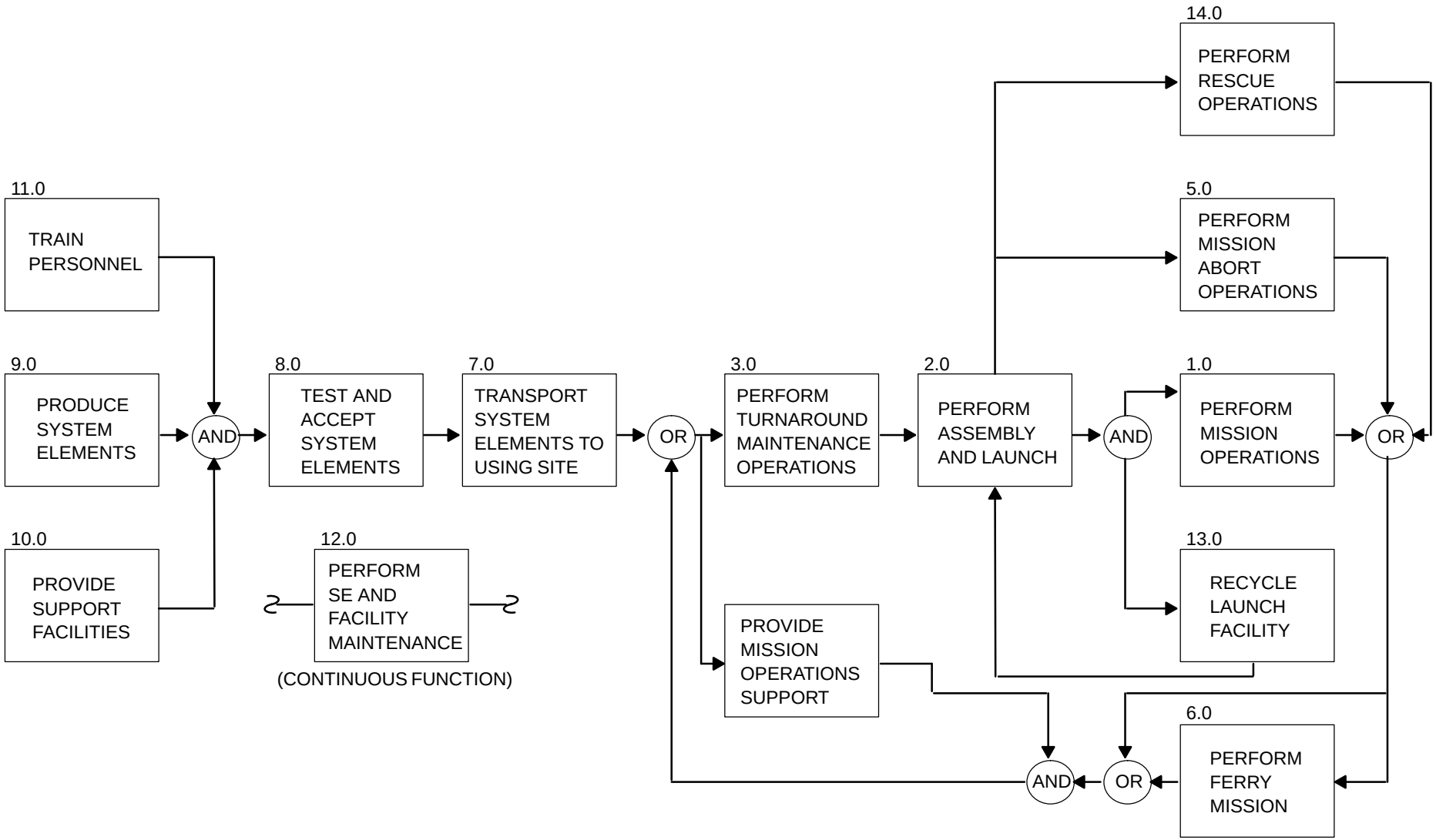
Shall include launch pad/mobile launcher platform facility and GSE servicing, refurbishment, and reverification required to recycle to a launch readiness state.

1.3.1.14 Perform Rescue Operations (FFD 14.0)

Shall include all flight vehicle rescue operations which may occur during regular missions (including on-orbit and post-landing modes) and post-landing modes during ferry missions.

FIGURE 1.3.1

TOP LEVEL FUNCTIONAL FLOW DIAGRAM



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2.0 APPLICABLE DOCUMENTS

The following documents of the date and issue shown form a part of this document to the extent specified herein. "(Current Issue)" is shown in place of a specific date and issue when the document is under Space Shuttle PRCB control. The current status of documents shown with "(Current Issue)" may be determined from NSTS 08102, Program Document Description and Status Report.

For documents not marked "(Current Issue)" the listed issue or a later issue of the same document may be used. When a later issue is used, the project shall assure traceability of the design and certification baselines to the listed issue.

SPECIFICATIONS

Military

MIL-A-8862 May 18, 1960	Airplane Strength and Rigidity Landplane Landing and Ground Handling Loads Ref. Table 3.2.2.1.5.2(G)
MIL-H-5440F January 18, 1972	Hydraulic Systems; Aircraft, Types 1 & 2, Design, Installation, and Data Requirements for Ref. Para. 3.3.1.2.5.2.2, 3.3.2.2.4, 3.3.4.2.2, Table 3.2.2.1.5.2(E)
MIL-H-5606	Hydraulic Fluid, Petroleum Base; Aircraft, Missile and Ordnance Ref. Para. 3.6.12.1
MIL-H-83282	Hydraulic Fluid, Fire Resistant Synthetic Hydrocarbon Base, Aircraft Ref. Para. 3.6.12.1

MIL-I-6870B February 25, 1965	Inspection Requirements, Nondestructive, for Aircraft Materials and Parts Ref. Para. 3.7.1
MIL-I-8835	Indicator, Humidity, Card, Chemically Impregnated Ref. Para. 5.2.2
MIL-I-26860B May 17, 1972	Indicator, Humidity, Plug, Color Change Ref. Para. 5.2.2
MIL-R-398 December 12, 1996	Cyclotrimethylenetrinitramine (RDX) Ref. Para. 3.6.20
MIL-S-7742B Amendment 1 March 15, 1973	Screw Threads, Standard Optimum Selected Series, General Specification for Ref. Para. 3.6.17.2
MIL-S-7742D July 25, 1991	Screw Threads, Standard, Optimum Selected Series: General Specification for Ref. Para. 3.6.17.2
MIL-S-8879A	Screw Threads, Controlled Radius Root with Increased Minor Diameter, General Specification for Ref. Para. 3.6.17.2
MIL-S-8879C July 25, 1991	Screw Threads, Controlled Radius Root with Increased Minor Diameter, General Specification for Ref. Para. 3.6.17.1, 3.6.17.2, Table 3.6.17

MIL-T-5021 January 24, 1978	Test, Aircraft and Missile Welding Operators Qualification Ref. Para. 3.6.2.1
MIL-W-22759	Wire Specification Ref. Table 2.0
MIL-W-81381A November 15, 1972	Wire Electrical Polyimide Insulated Copper or Copper Alloy Ref. Table 2.0

National Aeronautics and Space Administration (NASA)

MSC-SPEC-M-1A June 1967	Identification and Marking Ref. Para. 3.6.8
MSFC-SPEC-250 February 26, 1964	Protective Finishes for Space Vehicle Structures and Associated Flight Equipment, General Specification for Ref. Para. 3.6.5.1.2, 3.6.5.2.1
MSFC-SPEC-445	Requirements for Adhesive Bonding, Process and Inspection Ref. Para. 3.6.24
MSFC-SPEC-522A November 18, 1977	Design Criteria for Controlling Stress Corrosion Cracking Ref. Para. 3.6.5.1.1

MSFC-SPEC-522B July 1, 1987	Design Criteria for Controlling Stress Corrosion Cracking - Electronics Control Unit (ECU) Critical Review (CDR) Ref. Para. 3.6.5.1.1
MSFC-SPEC-2083	Foam, Polyurethane Ref. Para. 3.6.1.1.2
MSFC-SPEC-30A90506C June 17, 1983	Shuttle Range Safety Command Destruct System Specification Ref. Para. 3.5.4.1.12
MSFC-SPEC-40M38298A (without changes) March 17, 1975	Connector, Electrical, Special, Miniature Circular, Environmental Resistant 200°C, Specification for Ref. Para. 3.6.3.1
NSTS 07636 (Current Issue)	Lightning Protection, Test and Analysis Requirements Ref. Para. 3.4.5.1, 3.4.6.2.3, 3.6.14, 3.6.21
NSTS 08060 (Current Issue)	Space Shuttle System Pyrotechnic Specification Ref. Para. 3.6.20, 5.3
NSTS 08318 (Current Issue)	NSTS Hydraulic System Exceptions to MIL-H-5440 Ref. Para. 3.3.1.2.5.2.2, 3.3.2.2.4, 3.3.4.2.2
SE-G-0020B October 20, 1993	Leakage Measurement of Helium and Nitrogen Test Gases Ref. Para. 3.7.3

SE-R-0006 (Current Issue)	General Specification, Space Shuttle System Requirements for Materials and Processes Ref. Para. 3.2.2.1.8, 3.6.2.1, 3.6.5.1.1
SE-S-0073 (Current Issue)	Specification, Fluid Procurement and Use Control Ref. Para. 3.4.6.2.14.2, 3.6.12.1, 3.6.12.1.1.1.1.1, 3.6.12.1.1.3.1, 3.6.12.1.1.6
SL-E-0001 (Current Issue)	Specification, Electromagnetic Compatibility Requirement Ref. Para. 3.6.7
SL-E-0002 (Current Issue)	Specification, Electromagnetic Interference Characteristics, Requirements for Equipment Ref. Para. 3.6.7
SN-C-0005 (Current Issue)	Contamination Control Requirements Ref. Para. 3.4.22.2.1.1, 3.6.12.1, 3.6.12.2.4.1, 5.2.4
SN-P-0006	Printed Wiring Boards, Multilayer, Plated Through Hole, Design Specification for Ref. Para. 3.6.15.2.1
SS-P-0002-150	Computer Program Development Specification Ref. Para. 3.4.16.3
SW-E-0002 (Current Issue or refer to Para. 3.6.16.2)	Space Shuttle Ground Support Equipment General Design Requirements, Book 1, Existing GSE, Book 2, New GSE Ref. Para. 3.2.2.2.2, 3.4.6.2.18, 3.6.12.1.1.2.1.2, 3.6.12.1.1.2.3.2, 3.6.13, 3.6.16.2, 3.6.16.3, 3.6.16.5, 3.6.22

STANDARDS

American National

ANSI/ASQCZ1.4-1993	Sampling Procedures and Tables for Inspection by Attributes Ref. Para. 3.7.2
ANSI/ASQCZ1.9-1993	Sampling Procedures and Tables for Inspection by Variables for Percent Nonconforming Ref. Para. 3.7.2
ANSI/Z136.1-1993	American National Standard for Safe Use of Lasers Ref. Para. 3.5.4.2.9

Federal

FED-STD-H28/2B August 20, 1991	Screw-Thread Standards for Federal Services Section 2 Unified Inch Screw Threads-UN and UNR Thread Forms Ref. Para. 3.6.17.1
FED-STD-H28/20A September 21, 1987	Screw-Thread Standards for Federal Services Section 20 Inspection Methods for Acceptability of UN, UNR, UNJ, M, and MJ Screw Threads Ref. Para. 3.6.17.1, 3.6.17.2
FED-STD-123E February 25, 1986	Marking for Shipment (Civil Agencies) Ref. Para. 3.6.8, 5.2.6
FED-STD-209B April 24, 1973	Clean Room and Work Station Requirements, Controlled Environment Ref. Para. 3.4.19.2.1.1, 3.6.12.2.4.1

Military

MIL-STD-101B December 3, 1970	Color Code for Pipelines and for Compressed Gas Cylinders Ref. Para. 3.6.8
MIL-STD-105D April 29, 1963 Change 1, 11-1-63 Change 2, 3-20-64	Sampling Procedures and Tables for Inspection by Attributes Ref. Para. 3.7.2
MIL-STD-105E May 10, 1989	Sampling Procedures and Tables for Inspection by Attributes Ref. Para. 3.7.2
MIL-STD-129E April 10, 1972	Marking for Shipment and Storage Ref. Para. 3.6.8, 3.6.25.2, 5.2.6
MIL-STD-130	Identification and Marking of U.S. Military Property Ref. Para. 3.6.8
MIL-STD-130D July 30, 1971	Identification and Marking of U.S. Military Property Ref. Para. 3.6.8
MIL-STD-143B November 12, 1969	Standards and Specifications, Order of Precedence for Selection of Ref. Para. 3.6.1
MIL-STD-280A July 7, 1969	Definitions of Item Levels, Item Exchangeability, Models, and Related Terms Ref. Para. 3.6.6

MIL-STD-414 June 11, 1957 Change 1, 5-8-68	Sampling Procedures and Tables for Inspection by Variables for Percent Defective Ref. Para. 3.7.2
MIL-STD-454 December 1, 1971	Standard General Requirements for Electronic Equipment Ref. Para. 3.6.4
MIL-STD-462 July 31, 1967 Notice 1, 8-1-68 Notice 2, 5-1-70	Electromagnetic Interference Characteristics Measurements of Ref. Para. 3.6.7
MIL-STD-463 June 9, 1966	Definitions and System of Units, Electromagnetic Interference Technology Ref. Para. 3.6.7
MIL-STD-794B March 11, 1969	Parts and Equipment, Procedure for Packaging and Packing of Ref. Para. 5.2
MIL-STD-810 September 23, 1973	Material Standards for Environmental Test Methods Ref. Para. 3.6.4
MIL-STD-970 October 1, 1987	Standard and Specifications, Order of Preference for the Selection of Ref. Para. 3.6.1

MIL-STD-1247B December 20, 1968	Markings, Functions and Hazard Designations of Hose, Pipe, and Tube Lines for Aircraft, Missiles and Space Systems Ref. Para. 3.6.8
MIL-STD-1472A May 15, 1970	Human Engineering Design Criteria for Military Systems, Equipment and Facilities Ref. Para. 3.5.5.3
MIL-STD-1542 April 15, 1974	Electromagnetic Compatibility (EMC) and Grounding Requirements for Space System Facility Ref. Para. 3.4.6.2.14.2
MIL-STD-1595 July 26, 1977	Qualifications of Aircraft, Missile and Aerospace Fusion Welders Ref. Para. 3.6.2.1

<u>National Aeronautics and Space Administration (NASA)</u>

KSC-STD-C-0001B July 1987	Protective Coating of Carbon Steel, Stainless Steel and Aluminum on Launch Structures and GSE Ref. Para. 3.6.5.2.1
KSC-STD-E-0011	Electrical Power Receptacle and Plugs Ref. Para. 3.4.6.2.14.2
MSFC-STD-136 June 1971	Parts Mounting Design Requirements for Soldered Printed Wiring Board Assemblies Ref. Para. 3.6.15.2.1
MSFC-STD-154 December 1965	Printing Wiring Boards, (Copper Clad) Design, Documentation, and Fabrication of, Standard for Ref. Para. 3.6.15.2.1

MSFC-STD-506	Material and Process Control Standard Ref. Para. 3.6.2.1, 3.6.5.1.1
NASA-STD-6001	Flammability, Odor, Offgassing, and Compatability Requirements and Test Procedures for Materials in Environments that Support Combustion Ref. Para. 3.6.2.1
NASA-STD-8739.3	Soldered Electrical Connections Ref. Para. 3.6.15.1.1
NSS/GO 1740.9 July 1988	NASA Safety Standard for Lifting Devices and Equipment Ref. Para. 3.2.2.2.1

INTERAGENCY AGREEMENTS

NASA/USAF

September 18, 1979	NASA/USAF Interagency Agreement for STS/COMSEC Ref. Para. 3.2.1.4.2
September 19, 1986	NASA/USAF Interagency Agreement for the Protection of Space Transportation National Security Information Ref. Para. 3.2.1.4.2, 3.3.1.2.3.1.3
December 29, 1986	STS Program Security Management, Supplemental Agreement to NASA/USAF Agreement for the Protection of Space Transportation National Security Information Ref. Para. 3.2.1.4.2

DRAWINGS

MSFC-DWG-10M33107 Revision B August 1975	Design Criteria for Controlling Stress Corrosion Cracking
	Ref. Para. 3.6.5.1.1

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OTHER PUBLICATIONS

Military

AFETRM-127-1 September 1972	Air Force Eastern Test Range Manuel 127-1, Range Safety Manual Ref. Para. 3.5.4.1.12, 3.5.4.2.7
AMRL-TR-70-5 April 1972	Anthropometry of AF Women Ref. Para. 3.5.5.2
ERR 127-1 June 30, 1993	Eastern Range Regulation 127-1, Range Safety Ref. Para. 3.5.4.1.12
ESMCR 127-1 July 30, 1984	Eastern Space and Missile Center Regulation 127-1, Range Safety Ref. Para. 3.5.4.1.12, 3.5.4.2.7
EWR 127-1 March 31, 1995	Eastern and Western Range 127-1, Range Safety Requirements Ref. Para. 3.5.4.1.12, 3.5.4.2.7
FR-19634 January 1993	Space Shuttle Main Engine (SSME) Alternate Turbopump Quality Program Plan Ref. Table 2.0
FR-19793	ATD Fracture Control Plan Ref. Para. 3.2.2.1.8, 3.2.2.1.9

KHB 1700.7	Space Transportation System Payload Ground Safety Handbook Ref. Para. 3.6.8
MIL-HNBK-5B September 1, 1971	Metallic Materials and Elements for Aerospace Vehicle Structures Ref. Para. 3.2.2.1.7
MIL-HNBK-17A January 1971	Plastics for Aerospace Vehicles Ref. Para. 3.2.2.1.7
MIL-HNBK-23A December 30, 1968	Structural Sandwich Composites Ref. Para. 3.2.2.1.7

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ICD 2-0A001	Shuttle System/Launch Platform Stacking and VAB Servicing Interface Control Document Ref. Para. 3.3.1.3.10, 3.3.2.3.3, 3.3.3.3.3, 3.4.5.2.2, 3.4.5.2.4
ICD 2-0A002	Shuttle System Launch Pad and Platform Interface Control Document Ref. Para. 3.2.1.1.16.1, 3.3.1.3.11, 3.3.2.3.6, 3.3.3.2.1.2, 3.3.3.3.5, 3.4.6.2.19, 3.4.6.3

ICD 2-0A003	Flight Vehicle/LPS Computational Systems Interface Control Document Ref. Para. 3.3.1.3.16, 3.3.2.3.9, 3.3.3.3.6, 3.4.16.2.6, 3.4.16.3
ICD 2-0A004	Space Shuttle Systems/KSC RF Communications and Tracking Checkout Interface Control Document Ref. Para. 3.2.5.1
ICD 2-0D003	JSC/USAF Space Shuttle/SCF RF Communications and Tracking Interface Control Document Ref. Para. 3.2.5.1
ICD 2-0D004	JSC/GSFC Space Shuttle RF Communications and Tracking Interface Control Document Ref. Para. 3.2.5.1, 3.3.1.3.14
ICD 2-0H001	Shuttle Vehicle/Ground Range Safety System Interface Control Document Ref. Para. 3.2.5.1.1
ICD 2-1A001	Orbiter/KSC Landing Station Interface Control Document Ref. Para. 3.3.1.3.7, 3.4.1.3
ICD 2-1A002	Orbiter Processing Facility/Orbiter Maintenance Checkout Facility Interface Control Document Ref. Para. 3.3.1.3.8, 3.4.4.3, 3.4.23.3

ICD 2-1A003	Orbiter/Hypergolic Station Interface Control Document Ref. Para. 3.3.1.3.9, 3.4.11.3
ICD 2-1D003	Orbiter Secondary Landing/Safing and Deservicing Stations Interface Control Document Ref. Para. 3.3.1.3.12, 3.4.1.3, 3.4.2.3, 3.4.3.1.3, 3.4.3.2.3, 3.4.3.3.3
ICD 2-1D004	Orbiter and Carrier Aircraft Mate/Demate Interfaces Interface Control Document Ref. Para. 3.3.1.3.15, 3.4.18.3
ICD 2-2A001	External Tank/Receiving, Storage, and Checkout Station Interface Control Document Ref. Para. 3.3.3.3.4, 3.4.7.3
ICD 2-4A001	Solid Rocket Booster/Receiving Processing Station Interface Control Document Ref. Para. 3.3.2.3.4, 3.3.2.3.7, 3.4.8.3, 3.4.17.3
ICD 2-4A002	Solid Rocket Booster/Retrieval Station Interface Control Document Ref. Para. 3.3.2.3.5, 3.4.9.3
ICD 2-00001	Shuttle Moldline and Protuberances Interface Control Document Ref. Para. 3.1.4, 3.3.1.2.1.7, 3.3.2.2.1, 3.3.3.1.1.1
ICD 2-12001	Orbiter Vehicle/External Tank Interface Control Document Ref. Para. 3.3.1.3.1

ICD 2-14001	Orbiter Vehicle/Solid Rocket Booster Interface Control Document Ref. Para. 3.3.1.3.2, 3.3.1.3.3.3.3.2, 3.3.2.2.1.4, 3.3.2.3.1, 3.6.1.1.1
ICD 2-24001	External Tank/Solid Rocket Booster Interface Control Document Ref. Para. 3.3.1.3.2, 3.3.2.3.2
ICD 13M15000	Space Shuttle/Orbiter Vehicle/Main Engine Interface Control Document Ref. Para. 3.3.1.3.4, 3.3.4, Table 3.3.4.1.2
ICD 2-17001	Orbiter/Carrier Aircraft Vehicle Interface Control Document Ref. Para. 3.3.1.3.5
ICD 2-19001	Shuttle Orbiter/Cargo Standard Interfaces Ref. Para. 3.2.1.1.12, 3.3.1.2.1.2.1, 3.3.1.2.1.2.2, 3.3.1.2.1.2.3, 3.3.1.2.1.3.2, 3.3.1.3.3, 3.3.1.3.3.3.3.1, 3.3.1.3.3.6.1.2, 3.3.1.3.3.10, 3.3.1.3.3.13, 3.4.19.2.1, 3.4.19.2.2; Table 3.3.1.2.1.3.10.1
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NSTS 07700, Volume IV (Current Issue)	Configuration Management Requirements Ref. Para. 3.6.10, 3.6.12.1.1.5, 3.6.18, 6.1.28, 6.1.29

NSTS 07700, Volume IV - Book 1 (Current Issue)	Configuration Management Requirements, Requirements Ref. Foreword, Para. 3.2.10.10
NSTS 07700, Volume V (Current Issue)	Information Management Requirements Ref. Para. 3.4.16.3
NSTS 07700, Volume X (Current Issue)	Space Shuttle Flight and Ground System Specification Ref. Para. 3.3.1.2.1.3.14.1, 3.3.1.2.3.1.2, 3.5.1.1.1, 3.5.1.1.2, 3.5.1.1.3, 3.5.1.2.1.1, 3.6.19.1
NSTS 07700, Volume X - Book 2 (Current Issue)	Space Shuttle Flight and Ground System Specification, Environment Design, Weight and Performance, and Avionics Events Ref. Para. 3.2.1.1.9.1.1.3, 3.2.1.2.11, 3.2.2.1.2, 3.2.2.1.2.1, 3.2.2.1.5.2, 3.2.2.1.17.1, 3.2.2.1.17.1.1, 3.2.2.1.17.2, 3.2.2.1.17.2.1, 3.2.2.1.17.2.2, 3.3.1.1.8, 3.3.1.1.9, 3.3.3.2.8.5, 3.4.6.2.17.1, 3.5.4.2.9; Table 3.2.2.1.5.2
NSTS 07700, Volume X - Book 3 (Current Issue)	Space Shuttle Flight and Ground System Specification, Requirements for Runways and Navigation Aids Ref. Para. 3.3.1.1.5, 3.3.5.1.1.1, 3.3.5.1.1.2, 3.4.1.2.1, 3.4.1.2.5, 3.4.1.2.7, 3.4.2.2.1, 3.4.2.2.5, 3.4.2.2.7, 3.4.3.1.2.1, 3.4.3.1.2.2, 3.4.3.1.2.5, 3.4.3.2.2.1, 3.4.3.2.2.2, 3.4.3.2.2.5, 3.4.3.3.2.1

NSTS 07700, Volume XII (Current Issue)	Integrated Logistics Requirements
	Ref. Para. 3.2.3, 3.2.4
NSTS 07700, Volume XIV (Current Issue)	Space Shuttle System Payload Accommodations
	Ref. Para. 3.2.1.1.12, 3.3.1.1.12, 3.3.1.2.1.2.1, 3.3.1.2.1.2.2, 3.3.1.2.1.2.3, 3.3.1.2.1.3.1, 3.3.1.2.1.3.2, 3.3.1.2.1.3.14.1, 3.3.1.2.1.4, 3.3.1.3.3, 3.3.1.3.3.3.3.1, 3.3.1.3.3.10, 3.3.1.3.3.13, 3.4.19.2.1, 3.4.19.2.2, Table 3.3.1.2.1.3.10.1
NSTS 07700, Volume XVIII (Current Issue)	Computer Systems and Software Requirements
	Ref. Para. 3.3.1.2.3.3.1, 3.4.16.3, 3.6.18
NSTS 07700, Volume XVIII - Book 1 (Current Issue)	Computer Systems and Software Requirements, Allocation of Computational Functions
	Ref. Para. 3.4.16.2.13
NSTS 07700, Volume XVIII - Book 2 (Current Issue)	Computer Systems and Software Requirements, Allocation of Simulation Functions
	Ref. Para. 3.4.16.2.13
NSTS 07700-10- MVP-01 (Current Issue)	Shuttle Master Verification Plan, Volume I, General Approach and Guidelines
	Ref. Para. 3.4.16.2.5, 3.6.12.1.1.4, 4.3, 6.1.36

NSTS 07700-10-MVP-02 (Current Issue)	Shuttle Master Verification Plan, Volume II, Combined Element Verification Plan
	Ref. Para. 4.3.1
JSC 07700-10-MVP-03 (Use of Latest Revision is Authorized)	Orbiter Verification Plan, Volume III (MJ072-0004-3)
	Ref. Para. 4.3.2
JSC 07700-10-MVP-04 (Use of Latest Revision is Authorized)	Solid Rocket Booster Verification Plan, Volume IV, Booster Assembly (SE-019-019-2H)
	Ref. Para. 4.3.2
JSC 07700-10-MVP-05 (Use of Latest Revision is Authorized)	External Tank Verification Plan, Volume V, Lightweight (MMC-ET-TM01)
	Ref. Para. 4.3.2
JSC 07700-10-MVP-06 (Use of Latest Revision is Authorized)	Main Engine Verification Plan, Volume VI (RSS-8782)
	Ref. Para. 4.3.2
JSC 07700-10-MVP-08 (Use of Latest Revision is Authorized)	KSC Launch and Landing Site Return to Flight Reverification Plan, Volume VIII (KSC-STSM-09-Volume IV - Supplement)
	Ref. Para. 4.3.2

NSTS 07700-10-MVP-09, Part I (Current Issue)	Shuttle Master Verification Plan, Volume IX, Computer Systems and Software Verification Plan, Part I, Guidelines and Standards Ref. Para. 4.3.3
NSTS 07700-10-MVP-09, Part II (Current Issue)	Shuttle Master Verification Plan, Volume IX, Computer Systems and Software Verification Plan, Part II, Verification Requirements Ref. Para. 4.3.3
NSTS 5300.4(1D-2) (Current Issue)	Safety, Reliability, Maintainability and Quality Provision for the Space Shuttle Program Ref. Para. 3.5.1, 3.5.4, 3.6.15.1, 3.6.15.1.1, 3.7
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NSTS 08117 (Current Issue)	Requirements and Procedures for Certification of Flight Readiness (CoFR) Ref. Para. 3.5.3.2.1.2
NSTS 08123 (Current Issue)	Certification of Flexible Hoses and Bellows for Flow Induced Vibration Ref. Para. 3.2.2.1.18

NSTS 08131 (Current Issue)	Contamination Control Plan Ref. Para. 3.6.12.1
NSTS 08171	Operations and Maintenance Requirements and Specifications Document Ref. Para. 3.2.1.2.7, 3.2.10
NSTS 08171, File I	Operations and Maintenance Requirements and Specifications Document, Introduction Ref. Para. 3.2.10.1, 3.2.10.10
NSTS 08171, File II	Operations and Maintenance Requirements and Specifications Document, Integrated OMRSD Ref. Para. 3.2.1.2.7, 3.2.10.2, 3.5.3.1.1, 3.5.3.2, 3.5.3.2.1.1, 3.5.3.2.1.2, 3.5.3.2.1.3
NSTS 08171, File III	Operations and Maintenance Requirements and Specifications Document, Orbiter and SSME Ref. Para. 3.2.10.3
NSTS 08171, File IV	Operations and Maintenance Requirements and Specifications Document, External Tank Ref. Para. 3.2.10.4
NSTS 08171, File V	Operations and Maintenance Requirements and Specifications Document, Solid Rocket Booster Ref. Para. 3.2.10.5
NSTS 08171, File VI	Operations and Maintenance Requirements and Specifications Document, KSC Ground System Ref. Para. 3.2.10.6

NSTS 08171, File VII	Operations and Maintenance Requirements and Specifications Document, Spacelab Ref. Para. 3.2.10.7
NSTS 08171, File VIII	Operations and Maintenance Requirements and Specifications Document, Payloads and Payload Carriers (Non-Spacelab) Ref. Para. 3.2.10.8
NSTS 08171, File IX	Operations and Maintenance Requirements and Specifications Document, Flight Data Collection and Analysis Requirements Ref. Para. 3.2.10.9
NSTS 08171, File X	Operations and Maintenance Requirements and Specifications Document, International Space Station (ISS) OMRSD Ref. Para. 3.2.10.10
NSTS 08192 (Current Issue)	Math Models of Friction Characteristics for Orbiter Main and Nose Gear Tires Ref. Para. 3.3.1.1.8
NSTS 08209, Volume I (Current Issue)	Shuttle Systems Design Criteria, Shuttle Performance Assessment Databook Ref. Para. 3.1.3.1.2.2.3, 3.1.3.1.2.4.3, 3.1.3.1.2.4.4 3.2.1.1.4, 3.3.2.1.2, 3.3.2.2.1.1, 3.3.3.1.1.1, 3.3.3.1.1.2, 3.3.4.1.3, Table 3.3.4.1.2
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NSTS 08209, Volume IV (Current Issue)	Shuttle Systems Design Criteria, Design Criteria and Constraints Ref. Fig. 3.2.1.1.10.2.4
NSTS 08240 (Current Issue)	Television Plan Ref. Para. 3.4.1.4
NSTS 08242 (Current Issue)	Limitations for Non-flight Materials and Equipment Used in and Around the Space Shuttle Orbiter Vehicles Ref. Para. 3.6.12.1
NSTS 08307 (Current Issue)	Criteria for Preloaded Bolts Ref. Para. 3.2.2.1.24
NSTS 08347	Contingency Abort Data Book Ref. Para. 3.2.1.5.2
NSTS 08399	Space Shuttle Program (SSP) Critical Items List (CIL) Ref. Para. 3.3.1.2.3.1.2, 3.5.1.1.1, 3.5.1.1.2, 3.5.1.1.3, 3.5.1.2.1.1, 3.6.19.1, Table 2.0
JSC 08800 February 1974	JSC Supplement to NHB 5300.4(3A) Requirements for Soldered Electrical Connections Ref. Para. 3.6.15.1.1
NSTS 08934, Volume III	Space Shuttle Operational Data Book, Shuttle Systems Analysis Data Ref. Para. 3.3.4.1.4

NSTS 08934, Volume V	Space Shuttle Operational Data Book, Orbiter Flight Capability Ref. Para. 3.3.1.1.9
NSTS 08934, Volume VII	Space Shuttle Operational Data Book, Orbiter Ascent Structure Envelopes Ref. Para. 3.2.2.1.17.2
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NSTS 14046	Payload Interface Verification Requirements Ref. Para. 4.2
NSTS 16007 (Current Issue)	Shuttle Launch Commit Criteria and Background Document Ref. Para. 3.2.1.2.14, 3.3.3.2.6
NSTS 17462-XX (Applicable Flt)	STS-XX Flight Requirements Document Ref. Para. 3.4.1, 3.4.2

JSC 18206, Volume III	Shuttle Data Integration Plan Ref. Para. 3.2.6.1, 3.3.1.2.3.7
NSTS 21000-IDD-MDK	Shuttle/Payload Interface Definition Document for Middeck Accommodations Ref. Para. 3.3.1.3.3
NSTS 21000-IDD-ISS	Shuttle Orbiter/International Space Station Interface Definition Document Ref. Para. 3.3.1.2.1.3, 3.3.1.2.1.3.2, 3.3.1.2.1.3.11, 3.3.1.2.1.3.12.2, 3.3.1.2.1.3.13, 3.3.1.2.1.4.5
NSTS 21000-IDD-SL	Shuttle Orbiter/Spacelab Module Interface Control Document Ref. Para. 3.3.1.3.3, 3.3.1.3.3.19.1, 3.3.1.3.3.19.2, 3.3.1.3.3.19.3
NSTS 22206 (Current Issue)	Requirements for Preparation and Approval of Failure Modes and Effect Analysis (FMEA) and Critical Items List (CIL) Ref. Para. 3.5.1, 3.5.1.1.3, Table 2.0
NSTS 37330 (Current Issue)	Bonding, Electrical, and Lightning Specifications Ref. Para. 3.6.14
JSCM 08080 February 1, 1976	Manned Spacecraft Design Criteria and Standards (Note: See Applicability of Standards - Table 2.0) Ref. Para. 3.6.19.1

NHB 5300.4(1B) April 1969	Quality Program Provisions for Aeronautical and Space System Contractors Ref. Para. 3.7
NHB 5300.4(3A) May 1968	Requirements for Soldered Electrical Connectors Ref. Para. 3.6.15.1.1
NHB 5300.4(3A-1)	Requirements for Soldered Electrical Connections Ref. Para. 3.6.15.1.1
NHB 5300.4(3G)	Requirements for Interconnecting Cables, Harnesses, and Wiring Ref. Para. 3.6.15.1.2
NHB 5300.4(3H)	Requirements for Crimping and Wire Wrap Ref. Para. 3.6.15.1.3
NHB 5300.4(3I)	Requirements for Printed Wiring Boards Ref. Para. 3.6.15.2.2
NHB 5300.4(3K)	Design Requirements for Rigid Printed Wiring Boards and Assemblies Ref. Para. 3.6.15.2.2
NHB 6000.1(1A) December 1969	Requirements for Packaging, Handling and Transportation for Aeronautical and Space Systems Equipment and Associated Components Ref. Para. 5.2, 5.2.5

NHB 7320.1 January 1971	Facilities Engineering Handbook Ref. Para. 3.2.2.2.1, 3.6.16.1, 6.1.26
NHB 8060.1A February 1974	Flammability, Odor and Offgassing Requirements and Test Procedures for Materials in Environments that Support Combustion Ref. Para. 3.2.2.1.16, 3.6.2.1
TM-82473 June 1982	Terrestrial Environment (Climatic) Criteria Guidelines for Use in Aerospace Vehicle Development, 1982 Revision Ref. Para. 3.6.22
TMX-58153 October 1974 (Formerly JSC 09084)	Coordinate Systems for the Space Shuttle Program Ref. Para. 3.3.2.1.4, 3.6.11
NASA-TN-D-5153 April 1969	The Use of Pilot Ratings in the Evaluation of Aircraft Handling Ref. Para. 3.3.1.2.3.3.5

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SD72-SH-0172C	RI Material Control Plan Ref. Para. 3.6.5.1.1
SD73-SH-0297	Implementation Report for Manned Spacecraft Criteria Ref. Para. 3.6.19.1

TABLE 2.0

APPLICABILITY OF SPACE SHUTTLE MANNED SPACECRAFT CRITERIA AND STANDARDS (NSTS 08080-1)

NO.	ORBITER	ET	SRB	SSME	GROUND OPERATIONS	RSRM
1A	X	X	X	X	X	X
2A	X					
3A (2)	X	X	X	X		X
Deviations/Waivers 361, 444, 455 and 561 are applicable to Standard No. 3A. Refer to Book 4, Active Deviations/Waivers.						
4B (4)	X	X	X		X	X
Deviations/Waivers 638 and 683 are applicable to Standard No. 4B. Refer to Book 4, Active Deviations/ Waivers.						
5	NOT APPLICABLE					
6A	X		X			X
7	X		X	X		X
Deviation/Waiver 456 is applicable to Standard No. 7. Refer to Book 4, Active Deviations/Waivers.						
8A	X		X			X
9	X					
Deviations/Waivers 493 and 629 are applicable to Standard No. 9. Refer to Book 4, Active Deviations/ Waivers.						
10	X					
11A	X				X	
12A	X	X	X	X		X
Deviation/Waiver 494 is applicable to Standard No. 12A. Refer to Book 4, Active Deviations/Waivers.						
13	X	X	X	X	X	X
14A	X	X	X	X		X
15	CANCELLED					
16	X		X			X
17	X					
18	X	X	X	X		X
19	X	X	X	X		X
Deviation/Waiver 335 is applicable to Standard No. 19. Refer to Book 4, Active Deviations/Waivers.						

X = APPLICABLE

TABLE 2.0

APPLICABILITY OF SPACE SHUTTLE MANNED SPACECRAFT CRITERIA AND STANDARDS (NSTS 08080-1) - Continued

NO.	ORBITER	ET	SRB	SSME	GROUND OPERATIONS	RSRM
20A (3)(4)	X	X	X	X	X (1)	X
Deviations/Waivers 358, 360, 495, 639 and 683 are applicable to Standard No. 20A. Refer to Book 4, Active Deviations/Waivers.						
21A	X					
Deviation/Waiver 630 is applicable to Standard No. 21A. Refer to Book 4, Active Deviations/Waivers.						
22A	X					
23	X					
24	X					
25	X	X	X	X		X
26	X	X		X	X	
27	X					
28	X	X	X	X		
29	X	X	X	X		
30	X	X	X	X	X	
31	X	X	X	X	X	X
Deviations/Waivers 355, 485 and 631 are applicable to Standard No. 31. Refer to Book 4, Active Deviations/Waivers.						
32(4)	X	X	X	X		X
33	X					
34	X					
35	X					
36	X	X	X	X		X
Deviation/Waiver 496 is applicable to Standard No. 36. Refer to Book 4, Active Deviations/Waivers.						
37	X	X	X	X		X
38A	X	X	X		X	
Deviation/Waiver 457 is applicable to Standard No. 38A. Refer to Book 4, Active Deviations/Waivers.						
39A	X	X	X		X	X
40	CANCELLED					

X = APPLICABLE

TABLE 2.0

APPLICABILITY OF SPACE SHUTTLE MANNED SPACECRAFT CRITERIA AND STANDARDS (NSTS 08080-1) - Continued

NO.	ORBITER	ET	SRB	SSME	GROUND OPERATIONS	RSRM
41A	X				X	
42	X	X				
43	X				X	
44	NOT APPLICABLE					
45			X			
46	X		X		X	X
47	X	X	X	X		X
48	X			X		
49	X	X	X	X	X	
50A	X	X				
Deviation/Waiver 458 is applicable to Standard No. 50A. Refer to Book 4, Active Deviations/Waivers.						
51	X				X	
52	X	X	X	X	X	
53	DELETED					
54	X					
55	NOT APPLICABLE					
56	X					
57A	X					
58	X					
59	X					
60			X			
61	X					
62	X	X	X	X		X
63	X	X	X	X	X	X
Deviation/Waiver 355 is applicable to Standard No. 63. Refer to Book 4, Active Deviations/Waivers.						
64	X	X	X	X		X
65	X					

X = APPLICABLE

TABLE 2.0

APPLICABILITY OF SPACE SHUTTLE MANNED SPACECRAFT CRITERIA AND STANDARDS (NSTS 08080-1) - Continued

NO.	ORBITER	ET	SRB	SSME	GROUND OPERATIONS	RSRM
66			X			X
67	X	X	X	X	X	
68	X	X	X	X	X	
69 (5)	X (5A)	X (5A)	X (5A)	X	X	X
Deviations/Waivers 679 and 680 are applicable to Standard No. 69. Refer to Book 4, Active Deviations/ Waivers.						
70	NOT APPLICABLE					
71	X	X	X		X	
72	X					
73	X					
74	X					
75	X	X	X	X		
76	X	X	X	X	X	
77	X	X	X	X	X	
78	X	X	X	X	X	
79	X	X	X	X		X
Deviation/Waiver 355 is applicable to Standard No. 79. Refer to Book 4, Active Deviations/Waivers.						
80	X	X	X	X	X	X
81	X	X	X	X		X
82 (6)	X	X	X	X	X	
83	X	X	X	X		X
84A	X	X	X	X	X	X
85A	X	X	X	X	X	X
Deviation/Waiver 632 is applicable to Standard No. 85A. Refer to Book 4, Active Deviations/Waivers.						
86	X	X	X	X	X	X
Deviation/Waiver 355 is applicable to Standard No. 86. Refer to Book 4, Active Deviations/Waivers.						
87A	X	X	X	X	X	

X = APPLICABLE

TABLE 2.0

APPLICABILITY OF SPACE SHUTTLE MANNED SPACECRAFT CRITERIA AND STANDARDS (NSTS 08080-1) - Continued

NO.	ORBITER	ET	SRB	SSME	GROUND OPERATIONS	RSRM
88A	X	X	X	X	X	X
89	X				X	
Deviation/Waiver 355 is applicable to Standard No. 89. Refer to Book 4, Active Deviations/Waivers.						
90B	X		X		X	X
91	X	X	X	X	X	
92	X	X	X	X	X	
93	X (8C)	X	X	X (8C)	X	
94	X	X	X	X	X	
95E	X (8A)(8B)	X	X	X		X (8)
Deviations/Waivers 355, 357, 391, 459, 486 and 534 are applicable to Standard No. 95E. Refer to Book 4, Active Deviations/Waivers.						
96A	X	X	X		X	X
97	X	X	X	X	X	
98	X	X	X	X	X	X
Deviation/Waiver 460 is applicable to Standard No. 98. Refer to Book 4, Active Deviations/Waivers.						
99C (12)	X	X	X	X (7)(7A)	X	X
100	X	X	X	X		X
101	X	X	X	X	X	X
102	X					
103	X	X	X		X	X
104	X	X	X	X		X
105A	X		X		X	
106	CANCELLED					
107	DELETED					
108A	X		X	X		X
109B (11)	X		X	X	X	X
Deviations/Waivers 355 and 460 are applicable to Standard No. 109B. Refer to Book 4, Active Deviations/Waivers.						

X = APPLICABLE

TABLE 2.0

APPLICABILITY OF SPACE SHUTTLE MANNED SPACECRAFT CRITERIA AND STANDARDS (NSTS 08080-1) - Continued

NO.	ORBITER	ET	SRB	SSME	GROUND OPERATIONS	RSRM
110B	X	X	X	X		X
111	X	X	X	X	X	
112	X	X	X	X	X	X
113	CANCELLED					
114A (9)	X	X	X			
115	X	X	X	X	X	X
116 (10)	X	X	X	X	X	X
117	X	X	X	X	X	
118	X	X	X		X	
119	X	X	X	X	X	X
120	X				X	
121	X		X	X	X	X
122	X					
Deviation/Waiver 497 is applicable to Standard No. 122. Refer to Book 4, Active Deviations/Waivers.						
123	X					
124	X		X			
125	X	X	X	X	X	X
126	X					
127	X					
128	X	X	X	X	X	X
129	X	X	X	X		X
130	X					
131	X					
132	X	X	X		X	X
133D	X		X		X	X
Deviation/Waiver 356 is applicable to Standard No. 133D. Refer to Book 4, Active Deviations/Waivers.						

X = APPLICABLE

TABLE 2.0

APPLICABILITY OF SPACE SHUTTLE MANNED SPACECRAFT CRITERIA AND STANDARDS (NSTS 08080-1) - Continued

NO.	ORBITER	ET	SRB	SSME	GROUND OPERATIONS	RSRM
134	X	X	X	X	X	X
Deviations/Waivers 461, 487, 685 and 686 are applicable to Standard No. 134. Refer to Book 4, Active Deviations/Waivers.						
135	X		X			X
136	X					
137	X	X	X		X	X
139	X	X	X		X	X
140	X	X	X			
141A	X					
142	X					
143	X					
144	X					
145A	X					
Deviation/Waiver 628 is applicable to Standard No. 145A. Refer to Book 4, Active Deviations/Waivers.						
146	X	X	X	X	X	X
Deviations/Waivers 489, 490, 491 and 492 are applicable to Standard No. 146. Refer to Book 4, Active Deviations/Waivers.						
147A	X	X	X	X	X	X
148	X	X	X	X	X	X
Deviation/Waiver 498 is applicable to Standard No. 148. Refer to Book 4, Active Deviations/Waivers.						
149	X	X	X			
150	NOT APPLICABLE					
151	NOT APPLICABLE					
152B	X	X	X	X	X	X
Deviation/Waiver 392 is applicable to Standard No. 152B. Refer to Book 4, Active Deviations/Waivers.						
153	X	X	X	X	X	X
154	X					

X = APPLICABLE

TABLE 2.0

APPLICABILITY OF SPACE SHUTTLE MANNED SPACECRAFT CRITERIA AND STANDARDS (NSTS 08080-1) - Continued

NOTES

(1) Applicability is limited to KSC Criticality 1 Ground System.

(2) Connectors on pyrotechnic devices using common pyro initiators may be identical.

(3) Shuttle System electrical interface umbilicals are exempted from compliance with this standard.

(4) Any Deviation/Waiver to requirements for physical separation of Criticality 1R circuits (Standards 4B, 20A and 32 of NSTS 08080-1) shall be processed solely in accordance with NSTS 22206 and documented in NSTS 08399, Space Shuttle Program (SSP) Critical Items List (CIL) located in WebPCASS. For circuits changed each flight or with each payload, the requirements of these standards will be satisfied by preflight checkout requirements and the performance of a hazard analysis.

(5) Each request for a new or increased load across connectors during connect or disconnect operations shall be evaluated on a case by case basis, however, the current across the Orbiter Tail Service Masts (TSM) Takeoff (T-O) umbilical shall not exceed 500MA. Any power loads across this interface shall be diode isolated or deadfaced before lift-off.

(5A) Applicability of this Standard for the following Orbiter/ET/SRB functions is exempted: 1. SRB Bus A,B,C DC Power; 2. ET Tumble Valve Arm Command; 3. ET Tumble Valve Fire Command.

(6) Retrievable documentation of the specified information is an acceptable alternate to the braze joint marking required by Standard No. 82.

(7) Equivalent Rocketdyne Procedures: Specifically, the Configuration Management Plan (Class I), the Quality Assurance Procedure R-4.3 (Class II) and the Quality Assurance Instruction RI-16.1 (Class II) are approved by the SSP for use in lieu of the detailed requirements of Standard No. 99C for identification of equipment restricted to non-flight use only.

(7A) Pratt and Whitney Alternate Turbopump Procedures: Specifically, FR-19634, Space Shuttle Main Engine (SSME) Alternate Turbopump Quality Program Plan, is approved by the SSP for use in lieu of the detailed requirements of Standard No. 99C for identification of Class II and Class III non-flight equipment.

TABLE 2.0

APPLICABILITY OF SPACE SHUTTLE MANNED SPACECRAFT CRITERIA AND STANDARDS (NSTS 08080-1) - Concluded

NOTES - Concluded

(8) The qualification of wire used in Reusable Solid Rocket Motor (RSRM) Safe and Arm (S&A) devices (P/N 1U52295-01), MIL-W-16878 or MIL-W-22759, Wire Specification, may be used in lieu of MIL-W-81381A, Wire Electrical Polyimide Insulated Copper or Copper Alloy.

(8A) Government source inspection is waived for the wire used in the Audio Terminal Unit Interface cables P/N SED18100826-307, S/N 2014-2022.

(8B) Government source inspection is waived for wire P/N 74925 (O5GW50526-1&2) for the ACCU Bypass Module P/N SED1610100-301, S/N 1001-3 and 1005.

(8C) In packaging area a maximum relative humidity of 65% is considered acceptable for ET and SSME components.

(9) For the SRB fuel supply module hydrazine tank (MSFC P/N 13A10009) (USBI P/N 10203-0015), water may be used instead of hydrazine as the qualification medium for satisfying the requirements of NSTS 08080-1, Standard 114A for STS-26 thru STS-999.

(10) Batteries with ZN HGO cells in the crew survival equipment hand held radio PRC 90, 90-1, and 90-2, the firefly rescue lite SDU-5E, and the CD HGO cells in the SSME Block II Controller are exempt from this standard.

(11) The requirement for electrical wire etched prior to potting is waived for Remote Manipulator System (RMS) Special Purpose End Effector (SPEE), P/N 51140F36-3/-5, S/N 201 and 202 (Reference SPAR W0568) for STS-37 and subs.

(12) When Ground Support Equipment (GSE) (Including shipping and handling protective materials) is installed temporarily on a flight system, it shall comply with Standard 99C as specified for non-flight equipment. Each project shall identify and classify GSE and other non-flight equipment that requires serialized red streamers.

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3.0 REQUIREMENTS

3.1 SHUTTLE SYSTEM DEFINITION

3.1.1 Shuttle System Elements

3.1.1.1 Flight Vehicle Elements

The elements of the Shuttle Flight Vehicle shown in Figure 3.1.1.1 shall be:

a. Orbiter Vehicle

b. Solid Rocket Booster (SRB)

c. External Tank (ET)

d. Space Shuttle Main Engine (SSME)

Characteristics of these elements are defined in Paragraphs 3.3.1, 3.3.2, 3.3.3, and 3.3.4, respectively. The Shuttle Flight Vehicle shall consist of a Shuttle Vehicle Booster (reference Paragraph 6.1.10), one ET, and one Orbiter Vehicle with three SSMEs.

3.1.1.2 Ground Operations Systems

The major elements of the Shuttle Ground Operations System and the characteristics of these elements are defined in Paragraph 3.4.

3.1.2 Top Level Schematic Block Diagram

The top level schematic block diagram shown in Figure 3.1.2 identifies the Shuttle System elements and other systems with which the Shuttle System interfaces.

3.1.3 Shuttle System Weight and Performance Control

For all elements, the nominal weights shall be based on inert weights (dry plus closed-loop fluids) and are defined in NSTS 09095, Space Shuttle Systems Weight and Performance. Planning weights for consumables, propellants, personnel, and the payload are specified also in the referenced document.

3.1.3.1 Shuttle Mission and Vehicle Definition for International Space Station

3.1.3.1.1 Mission Definition

The following mission definition supports the generic International Space Station (ISS) Performance Reference Mission (PRM) provided in Paragraph 3.2.1.1.3.8. This configuration is used for performance reporting only and is not intended to represent a

certification case. The manager's reserve requirement is consistent with the requirements defined in NSTS 07700, Volume III, Flight Definition and Requirement Directive, Paragraph 3.1q, Ascent Performance Manager's Reserve Guideline.

Launch Dates	Worst Performance Month (15th day)
Insertion Altitude	173 nmi
Rendezvous Altitude	220 nmi
Inclination	51.6°
Launch Window	5 min
Yaw Steering	First Stage (auto del psi) and Second Stage
SRB Burn Rate	0.3705 ips @ 70°
Ascent Design	DOLILU II High Q, PE Max Alpha
Crew Size	5 Shuttle Crew
Duration	7 Days
Orbiters	103, 104, 105 (OV-103 is used for performance quotes)
SSME	Block II @ 104.5%
Cryo Hardware	4 Tank Sets
Cryo Loading	3 Full Equivalent
RMS	Installed
Rendezvous Day	FD3
Manager's Reserve	2500 pounds
DOL Reserves	700 pounds

The PRM definition also includes the following trajectory performance enhancements:

First Stage Yaw Steering
First and Second Stage Gimbal Changes
Constant Pitch Rate
Second Stage Orbital Maneuvering Subsystem (OMS) Assist
Lower Main Engine Cutoff (MECO) Altitude (52 nmi)
SRB Separation Times Optimization

3.1.3.1.2 Vehicle Definition

The vehicle configuration described in the following paragraphs (except OV-102) supports the generic ISS reference mission provided in Paragraph 3.2.1.1.3.8. This configuration is used for performance reporting only and is not intended to represent a certification case. An overview matrix of the major vehicle components and their respective Design Control Parameters is provided in Table 3.1.3.1.2 (Design Control Parameter - reference Paragraph 6.1.37).

3.1.3.1.2.1 Orbiter Design Control Weights

The OV-102, -103, -104, and -105 nominal design control weights are 160,289 pounds, 155,701 pounds, 154,910 pounds, and 155,707 pounds, respectively. These nominal design control weights include all approved and projected Orbiter modifications, anticipated weight growth projections, and with the exception of OV-102, the weight of the external airlock and Orbiter Docking System (ODS). The allowable flight-to-flight manufacturing variation for each Orbiter is ±550 pounds. The Orbiter maximum design control weight is the nominal design control weight plus the manufacturing variations. The control weight for the Orbiter separation/attach hardware installed on the external tank is 64 pounds. A detailed listing of these modifications and projections is provided in NSTS 09095.

3.1.3.1.2.2 External Tank (ET) and Main Propulsion Subsystem (MPS) Design Control Weights

3.1.3.1.2.2.1 ET Design Control Weight

The Lightweight (LWT) ET nominal design control weight is 65,449 pounds. In order to support the ISS, the Super Lightweight Tank (SLWT) nominal design control weight is 58,505 pounds. The ET maximum design control weight is the nominal design control weight plus the manufacturing variations. These weights specifically exclude Orbiter and SRB separation/attach hardware that is installed on the tank. The allowable flight-to-flight manufacturing variation for each tank is ±511 pounds. This manufacturing variation is for mission planning purposes and shall not be verified.

3.1.3.1.2.2.2 (Deleted)

3.1.3.1.2.2.3 SLWT MPS Design Control Weight

The usable LH_2 and Liquid Oxygen (LOX) minimum design control weights are specified in NSTS 08209, Shuttle Systems Design Criteria, Volume I, Shuttle Performance Assessment Databook, Table 4.5.7.

3.1.3.1.2.2.4 (Deleted)

3.1.3.1.2.3 Solid Rocket Booster (SRB)

3.1.3.1.2.3.1 SRB Design Control Weight

The SRB nominal design control weight is 1,299,550 pounds. This weight consists of 149,360 pounds motor inert weight, 44,060 pounds subsystem inert, and 1,106,130 pounds motor propellant. The allowable flight-to-flight manufacturing variation for each

of these values is ±1,270, ±560, and ±2,323 pounds, respectively. The subsystem and motor inert hardware shall not exceed the nominal design control weight plus the inert manufacturing variations. The motor propellant shall not be less than the nominal design control weight minus the propellant manufacturing variations. The RSRM control weight margin (combined motor inert and propellant) is +10 pounds of equivalent payload. The SRB subsystem inert control weight includes a control weight margin of +50 pounds per SRB (10 pounds of equivalent payload performance weight). The control weight for the SRB separation/attach hardware installed on the ET is 829 pounds.

3.1.3.1.2.3.2 (Deleted)

3.1.3.1.2.3.3 (Deleted)

3.1.3.1.2.3.4 (Deleted)

3.1.3.1.2.4 SSMEs Design Control Weights and Performance Characteristics

3.1.3.1.2.4.1 (Deleted)

3.1.3.1.2.4.2 (Deleted)

3.1.3.1.2.4.3 Block II Design Control Weights and Performance Characteristics

The Block II SSME nominal design control weight is 7,748 pounds. The allowable unit-to-unit manufacturing variation for each SSME is +65/-111 pounds. The SSME maximum design control weight is the nominal design control weight plus the manufacturing variations. The operating characteristics shall be as specified in NSTS 08209, Volume I, Table 5.5.1.

3.1.3.1.2.4.4 Block IIA Design Control Weights and Performance Characteristics

The Block IIA SSME is an interim configuration version of the Block II SSME to be flown until the fleet can be fully implemented with the Block II high pressure fuel turbopumps. The Block IIA SSME nominal design control weight is 7,488 pounds. The allowable unit-to-unit manufacturing variation for each SSME is +65/-111 pounds. The SSME maximum design control weight is the nominal design control weight plus the manufacturing variations. The operating characteristics shall be as specified in NSTS 08209, Volume I, Table 5.5.1.

3.1.3.1.2.5 Cargo Integration Equipment Configuration and Design Control Weight

The total maximum design control weight is 2,267 pounds for the cargo integration equipment (excluding the payload attach hardware) required to support the generic ISS reference mission defined in Paragraph 3.2.1.1.3.8. The weight of all unique cargo integration hardware is chargeable to the payload control weight and is not included in the weights provided in this paragraph. An item by item listing of the generic integration equipment with weights for each item is provided in NSTS 09095.

3.1.3.1.2.6 Crew and Cabin Manifest Equipment Design Control Weight

3.1.3.1.2.6.1 Crew Equipment (Core) Design Control Weight

The core crew equipment maximum design control weight for a 5-crew/7-day Space Shuttle or ISS reference mission is 4,611 pounds. A matrix providing the weights for various combinations of crew size and duration as well as a detailed listing of equipment, provisions, and installations from which these weights are compiled is provided in NSTS 09095, Appendix 2. The weight of all lockers used by the payload (locker shell and contents) is chargeable to the payload control weight and is not included in the weights provided in this paragraph.

3.1.3.1.2.6.2 Cabin Manifest Equipment Design Control Weight

The generic cabin equipment maximum design control weight for the 5-crew/7-day ISS reference mission is 74 pounds. A detailed listing of equipment, provisions, and installations from which this weight is compiled is provided in NSTS 09095, Appendix 2. The weight of all lockers used by the payload (locker shell and contents) is chargeable to the payload control weight and is not included in the weight provided in this paragraph.

3.1.3.1.2.7 Consumables

3.1.3.1.2.7.1 Propulsive Consumables

The maximum design control weight for propellant loadings required to support the generic ISS mission defined in Paragraph 3.2.1.1.3.8 for the OMS, aft Reaction Control Subsystem (RCS), and forward RCS tanks are 22,930 pounds, 4,970 pounds, and 1,912 pounds, respectively. The OMS load includes 4,000 pounds allocated for the OMS assist.

3.1.3.1.2.7.2 Non-Propulsive Consumables (NPC)

The total maximum design control weight is 5,032 pounds for the NPC loading required to support the generic ISS reference mission defined in Paragraph 3.2.1.1.3.8.

3.1.4 Integrated Vehicle Configuration

The integrated Shuttle Vehicle shall conform to the moldline envelope specified in ICD 2-00001, Shuttle Moldline and Protuberances Interface Control Document.

TABLE 3.1.3.1.2

ISS VEHICLE DEFINITION

Item	Paragraph Reference	Design Control Weight
OV-103 OV-104 OV-105	3.1.3.1.2.1 3.1.3.1.2.1 3.1.3.1.2.1	155,701 lbs 154,910 lbs 155,707 lbs
SLWT	3.1.3.1.2.2.1	58,005 lbs
SRB	3.1.3.1.2.3	1,299,550 lbs
Block II SSME (@ 104.5%)	3.1.3.1.2.4.3	7,748 lbs
Cargo Integration Equipment	3.1.3.1.2.5	2,267 lbs
Crew and Cabin Equipment	3.1.3.1.2.6.1 3.1.3.1.2.6.2	4,669 lbs
Propulsive Consumables OMS Aft RCS Forward RCS	3.1.3.1.2.7.1	 22,930 lbs 4,970 lbs 1,912 lbs
Non-propulsive Consumables	3.1.3.1.2.7.2	5,032 lbs

TABLE 3.1.3.1.2.3.4 (DELETED)

TABLE 3.1.3.1.2.4 (DELETED)

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FIGURE 3.1.1.1

SHUTTLE FLIGHT VEHICLE (GENERAL ARRANGEMENT, NOT TO SCALE – REFERENCE PARAGRAPH 3.1.4 REQUIREMENTS)

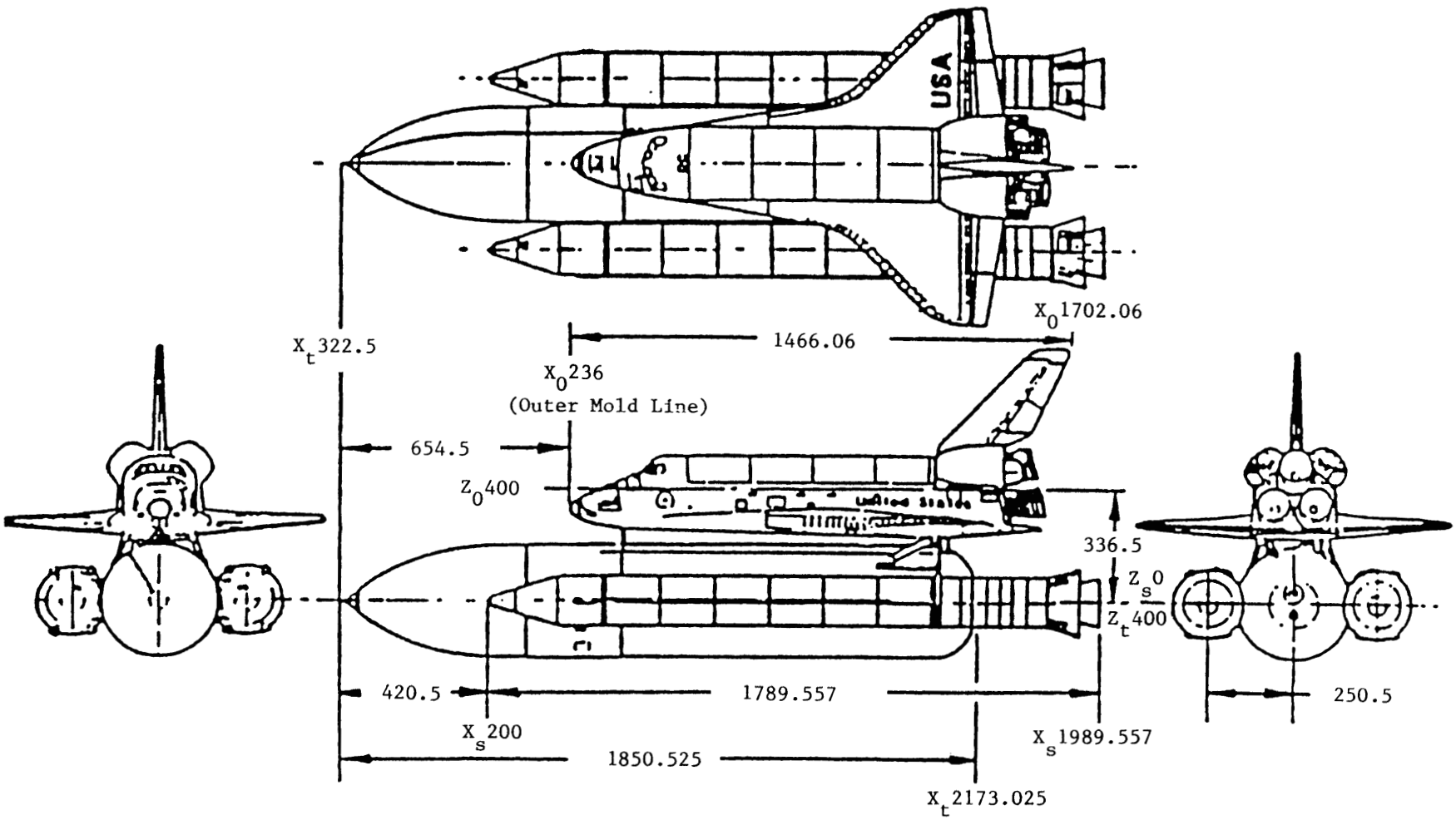

FIGURE 3.1.2

SYSTEM SCHEMATIC BLOCK DIAGRAM

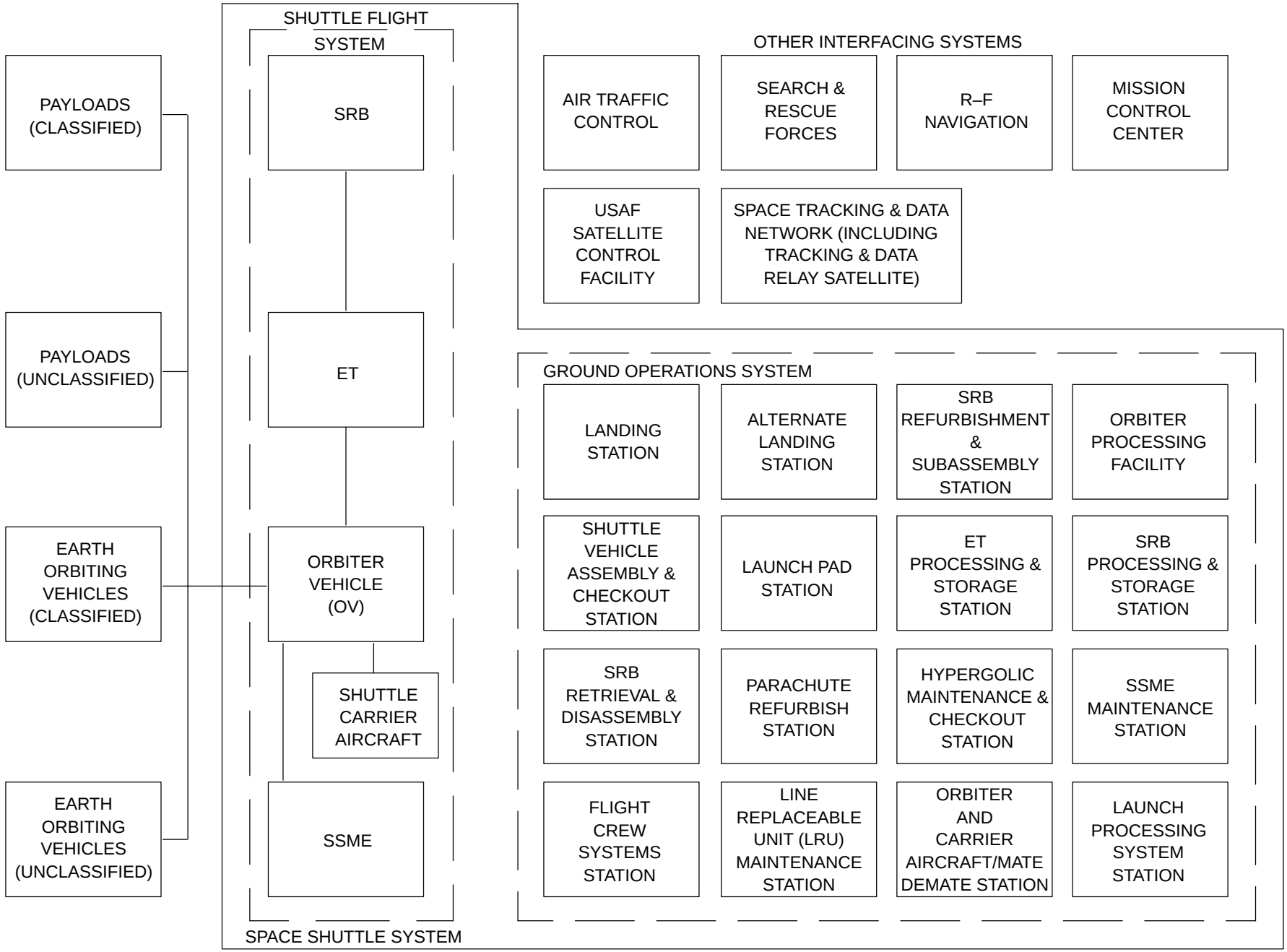

FIGURE 3.1.3.1.2.3.4 (DELETED)

3.2 PERFORMANCE AND DESIGN CHARACTERISTICS

3.2.1 Mission Performance

The following subparagraphs specify the performance requirements categorized by the top level functions depicted in Figure 1.3.1.

3.2.1.1 Mission Operations Functions (FFD 1.0)

3.2.1.1.1 (Deleted)

3.2.1.1.2 Payload Range

The Space Shuttle Flight Vehicle shall be capable of operating within the payload range from zero pounds to the maximum specified in Paragraph 3.2.1.1.3, Reference Missions, with the exception of the vehicle mass constraints for entry and landing as specified in Paragraphs 3.2.1.1.14, Orbiter Direct Entry and 3.3.1.1.9, Payload Weight at Landing.

3.2.1.1.2.1 (Deleted)

3.2.1.1.2.1.1 (Deleted)

3.2.1.1.2.1.2 (Deleted)

3.2.1.1.2.1.3 Extravehicular Activity (EVA)/Intravehicular Activity (IVA) Operations

Equipment, expendables, and accessories to support EVA/IVA operations, including the volume and restraints as required for the Extravehicular Mobility Unit (EMU), to support up to three 2-man EVA/IVA operations, shall be provided by the Orbiter.

The Space Shuttle shall have a crew self-rescue device to be worn by each EVA crew member during all periods when the Orbiter is docked to structure and cannot credibly rescue an inadvertently detached EVA crew member. This self-rescue capability shall not be required on missions in which the ODS-associated contingency EVAs are the only EVAs that will be required during the docked phase of the mission.

One set each of three Pt bulkhead and centerline Payload Bay Door (PLBD) latch tools are to be on all Orbiter flights to support EVA activities to recover from a PLBD failure. This protects for a worst case of two gang failures.

3.2.1.1.2.1.4 (Deleted)

3.2.1.1.2.1.5 (Deleted)

3.2.1.1.2.1.6 (Deleted)

3.2.1.1.2.1.7 (Deleted)

3.2.1.1.2.1.8 (Deleted)

3.2.1.1.2.1.9 (Deleted)

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3.2.1.1.2.1.10 (Deleted)

3.2.1.1.2.1.11 (Deleted)

3.2.1.1.2.1.12 (Deleted)

3.2.1.1.2.1.13 (Deleted)

3.2.1.1.2.1.14 (Deleted)

3.2.1.1.2.1.15 (Deleted)

3.2.1.1.2.1.16 (Deleted)

3.2.1.1.2.1.17 (Deleted)

3.2.1.1.2.1.18 (Deleted)

3.2.1.1.3 Reference Missions

The following reference missions and other functional requirements defined in this specification shall be used to develop the induced environment envelopes for Shuttle Systems certification. These reference missions represent typical operational envelopes but are not constraints on Shuttle operations. Shuttle operations shall be constrained by the certified induced environment capability. Reference Missions 1 and 9 are also used for performance tracking, and Reference Mission 9 is used for launch probability tracking. Payload accommodations beyond those required to accomplish the reference missions reduce the payload capability. The specific payload capability shall be defined in the payload integration process. Reference Missions 1, 2(a), and 9 are launched from KSC and Reference Missions 3(a), 4, and 7 are launched from Vandenberg Air Force Base (VAFB). The reference missions launched from VAFB are included to define induced environment envelopes, but are not intended to be potential missions. Reference Missions 1, 3(a), and 4 are nominal insertion missions in which the boost phase provides an insertion into an orbit with a minimum apogee of 100 nmi. The OMS shall provide the impulse to achieve the reference orbit. Reference Missions 2(a), 7, and 9 are direct insertion missions in which the boost phase provides the operational orbit apogee altitude and the OMS provides the impulse to achieve the desired orbit.

3.2.1.1.3.1 Mission 1

Mission 1 is a payload delivery mission to a 150 nm circular orbit. The mission will be launched due east and require a payload capability of 65,000 pounds. The purpose of

this mission is either the placement in orbit of a 65,000-pound satellite or the placement in orbit of a 65,000-pound satellite and retrieval from orbit of a 32,000-pound satellite. The Orbiter Vehicle on-orbit translational delta V requirements in excess of 50 x 100 nm reference orbit are 650 ft/sec from the OMS and 100 ft/sec from the RCS.

3.2.1.1.3.2 (Deleted)

3.2.1.1.3.3 (Deleted)

3.2.1.1.3.3.1 Mission 3(a)

Mission 3(a) is a 3-day, 2-man payload delivery mission. Its requirements apply only to aeroheating design and certification. This mission is a payload delivery mission to an orbit at 104° inclination and return to the launch site. The boost phase shall provide insertion into an orbit with a minimum apogee of 100 nm, as measured above the Earth's equatorial radius. The Orbiter Vehicle on-orbit translation delta V requirements in excess of a 50 x 100 nm reference orbit are 250 ft/sec from the OMS and 100 ft/sec from the RCS. The ascent payload requirement is 32,000 pounds. For mission performance and consumables analyses, a return payload of 2,500 pounds will be assumed (the 2,500 pounds is included in the 32,000 pounds ascent payload weight).

3.2.1.1.3.3.2 (Deleted)

3.2.1.1.3.4 Mission 4

This mission is a payload delivery and retrieval mission launched from VAFB launch site into a final inclination of 98° in a 150 nm circular orbit as measured above the Earth's equatorial radius. The ascent cargo weighs 32,000 pounds and has a 15-feet diameter x 60 feet long envelope. The mission shall deploy a spacecraft weighing 29,500 pounds within two revolutions after lift-off. Upon subsequent completion of necessary phasing and rendezvous maneuvers, a similar passive-cooperative stabilized spacecraft weighing 22,500 pounds shall be retrieved from a 150 nm orbit and returned to VAFB. The mission duration shall be seven days for mission performance and consumables analysis. A spacecraft cradle weight of 2,500 pounds must be added to the return spacecraft weight. The RCS will be loaded full at lift-off, and the minimum translation delta V from the OMS, including post MECO-insertion burn, is a total of 1,050 ft/sec. Standard provisions shall be included for personnel and stowed equipment, and contingency EVA capability shall be provided.

3.2.1.1.3.5 Mission 2(a)

This is a Direct Insertion Mission. The mission is to deliver a payload launched from KSC into a 285 nm circular orbit inclined at 57°. The ascent cargo weight is to be maximized. The mission duration shall be seven days with a crew size of four. RCS

propellants shall be loaded full. Standard provisions shall be included for personnel and stowed equipment, and contingency EVA capability shall be provided.

3.2.1.1.3.6 Mission 7

This is a Direct Insertion Mission. The mission is a payload delivery and retrieval mission launched from VAFB launch site into a final orbit of 360 nm by 250 nm inclined at 70°. The ascent cargo weighs 25,000 pounds, a payload of 22,500 pounds shall be retrieved from orbit and returned to VAFB. This mission duration shall be seven days with a crew size of five for mission performance. The OMS and RCS propellant shall be loaded full. Standard provisions shall be included for personnel and stowed equipment, and contingency EVA capability shall be provided.

3.2.1.1.3.7 Mission 8

This mission is launched from KSC into either a 140 nm or 150 nm circular orbit inclined at 28.5° using the standard insertion procedure. It is a mission requiring a crew of seven, conducted using an Extended Duration Orbiter (EDO) configured with vehicle modifications and mission kits to support a mission duration of up to 16 +2 contingency days.

3.2.1.1.3.8 Mission 9

This ISS mission is a direct insertion design to 173 nmi with a rendezvous and docking occurring at 220 nmi. The mission is launched from KSC to an inclination of 51.6°. The mission definition and vehicle configuration is defined in Paragraph 3.1.3.1. The total performance requirement is 39,400 pounds. This performance requirement provides 36,200 pounds for ISS cargo.

3.2.1.1.3.8.1 (Deleted)

3.2.1.1.3.8.2 (Deleted)

3.2.1.1.4 Ascent Performance

The flight vehicle ascent performance and payload capability for design reference missions shall be based on the mission and abort requirements specified herein. The nominal specific impulse for OMS is specified in Paragraph 3.3.1.2.2.2.3, the nominal specific impulse for RCS is specified in Paragraph 3.3.1.2.2.3.3, and the nominal specific impulse for SSME is specified in Paragraph 3.3.4. Performance of the SRBs shall be as specified in Paragraph 3.3.2.1.2. One SSME out intact abort capability shall be provided. Flight performance reserves shall be based on ± 3-sigma systems dispersions for normal and Return to Launch Site (RTLS) trajectories. The flight performance

reserves during Abort-Once-Around (AOA)/Abort-to-Orbit (ATO)/Transoceanic Abort Landing (TAL) abort portions of the missions shall be based on ± 2-sigma systems dispersions. For operational mission design, the current capability data for SSMEs and SRBs are specified in NSTS 08209, Volume I.

3.2.1.1.4.1 Yaw Steering

The flight vehicle shall have the capability of yaw steering, first stage flight, to accommodate aerodynamic sideslip angle control to a nominal value of zero in the transonic flight region for a smoothed design wind condition and to provide flexibility in optimizing rendezvous launch windows with respect to ascent performance. Yaw steering during second stage flight shall be provided to afford operational flexibility in accommodating communications constraints, ET disposal constraints, rendezvous launch window, and intact abort to a high cross range target.

3.2.1.1.5 Propellant Dump

During ascent after SSME shutdown and ET separation, the Orbiter shall be capable of dumping propellants remaining trapped in the MPS feedlines and main engine. Dumping through the main engine will be initiated during OMS burn to insertion. Vacuum inerting shall be performed to minimize residual propellant.

3.2.1.1.6 Insertion Accuracy

The guidance and control subsystem in conjunction with the autonomous onboard navigation subsystem shall produce an Orbiter state vector at MECO with 1-sigma dispersions relative to the desired state vector no greater than shown in Table 3.2.1.1.6, for the following conditions:

a. Three (3) Inertial Measurement Unit (IMU) operations - no failures

b. Total time between IMU align complete discrete being set and launch not to exceed 33 minutes

c. No SSME failures within 30 seconds of MECO

d. MECO conditions defined as SSME chamber pressure less than 1% on all engines

3.2.1.1.7 Day and Night Operations

The Shuttle System shall have the capability to launch and land the flight vehicle in daylight or darkness. The Orbiter shall be capable of terminal rendezvous and retrieval of a target, under daylight and darkness conditions. The Shuttle System

shall be capable of supporting EVA operations under daylight and darkness conditions.

3.2.1.1.8 Department of Defense (DOD) Missions

The Shuttle Flight Vehicle shall be capable of performing the DOD missions independent of ground support from ground stations outside the contiguous U.S. for normal operations. It shall contain provisions for the installation of Government Furnished Equipment (GFE) Communications Security (COMSEC) equipment for encryption/decryption/authentication for classified operations.

This does not preclude use of the Air Force Satellite Control Facility (AFSCF) for secure voice transmission for support in the event of an emergency, nor does it preclude use of navigational/communications satellites which simultaneously service multiple users independent of Shuttle operations, nor does it restrict use of ground base terminal landing aids, nor does it preclude the use of launch site tracking.

3.2.1.1.9 Shuttle Vehicle Separation - Nominal Modes

Nominal separation modes are defined as those which occur as planned during ascent without consideration of in-flight contingencies. The separation events are:

a. Separation of the SRBs from the Orbiter/ET at staging (SRB burnout)

b. Separation of the ET from the Orbiter after MECO

The separation subsystem(s) shall provide for Shuttle element separation without damage to or recontact of the elements during or after nominal mode separation. Damage to the SRB/ET connectors on the aft upper struts at the SRB/ET interface during SRB separation after Ascent Thrust Vector Control (ATVC) power is deadfaced is acceptable.

3.2.1.1.9.1 SRB Separation

Separation of the SRBs from the Orbiter/ET shall occur only after SRB burnout.

3.2.1.1.9.1.1 SRB Separation

The SRB separation system shall include:

a. Separation flight control functions

b. Release system

c. Booster Separation Motor (BSM) system

The SRB separation system shall incorporate signal interlocks to prevent SRB release and BSM ignition due to stray signals. The separation system shall not release any debris which could cause damage to any Orbiter/ET system or subsystem during separation under conditions specified in Paragraph 3.2.1.1.9.1.3, Design SRB Staging Conditions.

3.2.1.1.9.1.1.1 Separation Flight Control Functions

Separation flight control functions consist of the Flight Control System (FCS) functions necessary to support the separation sequence specified in Paragraph 3.2.1.1.9.1.2. These shall include:

a. Return of the nozzle of each SRB to a position 0.0 ± 1.0° from the SRB centerline in the vehicle pitch axis and 1.0 ± 0.6° from the SRB centerline, toward the ET, in the vehicle yaw axis. This position shall be maintained for at least five seconds after separation command issuance.

b. Transition of the FCS configuration from that for Orbiter/ET/SRB flight to that for Orbiter/ET flight.

c. Separation-required control of vehicle attitude and/or attitude rate.

3.2.1.1.9.1.1.2 Release System

The release system shall be compatible with the separation sequence specified in Paragraph 3.2.1.1.9.1.2. Any component disconnect or breakwire at release shall not induce an impulse torque in excess of 700 ft/lb/sec about the SRB Center of Gravity (CG) at separation.

3.2.1.1.9.1.1.3 BSM System

Separation motors shall be installed in a forward SRB position (nose cone frustum) and in an aft position (aft skirt). At both the forward and aft locations there shall be a cluster of four BSMs. At both locations, the thrust vector of the BSM cluster shall be parallel ± 4° to a plane containing the SRB centerline which is rotated 20° about the centerline from the SRB +Z axis toward the ET (Figure 3.2.1.1.9.1.1.3). The thrust vector of the forward cluster shall pass within 2.6 inches of the SRB centerline. The thrust vector of the aft cluster shall be offset 1.95 ± 3.9 inches from the SRB centerline toward the ET in a direction normal to the 20° plane. In addition, the thrust vector of each cluster shall be pitched, in the 20° plane, 40 ± 4° from the SRB Y-Z plane; the forward cluster shall be pitched forward and the aft cluster shall be pitched aft.

The BSMs shall be designed to operate over a propellant bulk temperature range of 30° F to 120° F. Each motor shall provide the following vacuum performance over the entire propellant operating temperature range.

a. Average thrust over the Web Action Time (WAT) >/= 18,500 pounds.

b. Neutral or regressive chamber pressure trace.

c. Total impulse over the WAT >/= 14,000 lb/sec.

d. Total impulse over the action time >/= 15,000 lb/sec.

e. Each BSM shall reach 75% of maximum chamber pressure within 30 to 100 milliseconds of the time at which the separation command crosses the Orbiter/SRB interface.

f. The time from BSM ignition start until the chamber pressure during thrust tail-off is one half the chamber Pressure at End of Web Action Time (PEWAT/2) shall not exceed 1,050 milliseconds for each BSM.

g. WAT ≤ 0.805 seconds for each BSM.

h. Maximum thrust ≤ 29,000 pounds.

i. Maximum chamber pressure ≤ 2,220 psia.

The SRB separation system shall be designed to provide a safe separation with a single inoperable BSM on either one of the two SRBs within the design staging conditions specified in Paragraph 3.2.1.1.9.1.3.

The BSMs shall not release any debris which could damage the Orbiter Thermal Protection System (TPS) during separation under conditions specified in Paragraph 3.2.1.1.9.1.3, Design SRB Staging Conditions. The BSM-induced Orbiter/ET thermal environment is shown in NSTS 07700, Volume X - Book 2, Space Shuttle Flight and Ground System Specification, Environment Design, Weight and Performance, and Avionics Events, Appendix 10.11.

3.2.1.1.9.1.2 SRB Separation Sequence

Initiation and control of the SRB separation sequence shall be the responsibility of the Orbiter. The primary cue for initiation of the separation sequence shall be SRB chamber pressure. The backup cue shall be mission elapsed time.

Each SRB shall furnish redundant chamber pressure signals to the Orbiter during SRB thrust tail-off. The separation sequence shall be initiated by the primary cue when the indicated chamber pressure on both SRBs is less than or equal to 50 psia. The chamber pressure measurements shall be accurate to ± 20 psia. The sequence shall be initiated by the backup cue at a time which assures that the chamber pressure of both SRBs is less than or equal to 50 psia.

The following commands shall be issued at a time from sequence initiation which assures that both SRB nozzles are positioned as specified in Paragraph 3.2.1.1.9.1.1.1 at the time of separation command:

a. Null SRB Thrust Vector Control (TVC) actuators

b. Initiate Orbiter/ET FCS configuration

Separation-required control of vehicle attitude and/or attitude rate shall be initiated at a time from sequence initiation which assures its effective operation. It shall be terminated no sooner than 4.0 seconds after separation command issuance.

The SRB separation sequence command shall be issued at a time from sequence initiation which assures that the thrust of each steel case SRB is less than or equal to the values defined in Table 3.2.1.1.1 with the specified SRB separation timers.

TABLE 3.2.1.1.1

MAXIMUM RSRM TAIL-OFF THRUST (Klbs)

SRB Separation Timer RSRM PMBT*	4.48 Sec Hot/Cold	4.96 Sec Hot/Cold	10.08 Sec Hot/Cold
No-Fail (3σ)	73.1/78.7	66.0/71.4	--
Throttle Struck Low (Single APU Failed, 1σ)	52.1/57.8	45.1/50.5	--
One SSME Failed (1σ)	--	--	7.1/8.6

* Linear interpolation shall be used to determine the thrust requirement for RSRM Propellant Mean Bulk Temperatures (PMBTs) between the maximum hot (82°F with a burn rate of 0.373 inches per second) and minimum cold (50°F with a burn rate of 0.363 inches per second) temperature and burn rate.

The SRB separation system shall provide for concurrent initiation of the release and BSM ignition of both SRBs. Release of all structural attachments shall occur within 30 milliseconds.

3.2.1.1.9.1.3 Design SRB Staging Conditions

The SRB separation system shall be designed to provide a safe separation for staging conditions within the specified limits of these parameters:

Separation Envelope Parameter	Flights through STS–84	STS–85 and Subs (Perf Enh Flts)
Body Angular Rates		
Roll rate (deg/sec)	± 2.3	± 3.0
Pitch rate (deg/sec)	± 1.2	± 2.0
Yaw rate (deg/sec)	± 1.0	± 1.5
Maximum Aerodynamic Angles		
Angle of attack (deg)	$-7.0 < \alpha < +5.0$	± 10.0
Angle of sideslip (deg)	$-6.0 < \beta < +6.0$	± 7.0
Maximum Dynamic Pressure (psf)	50	55

3.2.1.1.9.2 Orbiter/ET Separation

Orbiter/ET separation shall include:

a. Fluid line and electrical umbilical disconnect

b. Retraction of Orbiter umbilicals

c. Structural attachment release

d. Maneuvering of the Orbiter away from the ET

e. Closure of the Orbiter aft umbilical doors

Performance and sequencing of these functions shall be initiated and controlled by the Orbiter Vehicle. The release hardware shall be the responsibility of the Orbiter.

3.2.1.1.9.2.1 Orbiter/ET Separation Performance

The Orbiter/ET separation subsystem shall provide safe separation for the conditions specified in Paragraph 3.2.1.1.9.2.3. The separation structural release shall be automatically inhibited if a propellant feed umbilical disconnect valve fails to close or if the body rates exceed those values for which the separation system has the capability to perform a separation without causing damage to or recontact of Shuttle elements. The ability to manually inhibit and subsequently enable release and bypass an automatic structural release inhibit shall be provided. Provisions shall be made to contain all debris caused by pyrotechnic operation at the Orbiter/ET structural attachments which could cause damage to the Orbiter/ET as defined in Paragraph 3.2.1.2.14.

The RCS shall provide a delta V $\geq$4 ft/sec along the -Z axis to the Orbiter for separation. This shall be accomplished using the forward and aft RCS to provide the -Z axis acceleration consistent with safe separation requirements fault tolerant design, and insertion attitude control requirements.

3.2.1.1.9.2.1.1 Separation Flight Control Requirements

Separation flight control functions consist of the FCS functions necessary to support the sequences specified in 3.2.1.1.9.2.2. These shall include:

a. Rate control of the mated Orbiter/ET from separation sequence initiation to structural release within the limits specified in Paragraph 3.2.1.1.9.2.3.

b. Attitude control during the translation maneuver specified in Paragraph 3.2.1.1.9.2.1.

3.2.1.1.9.2.2 Orbiter/ET Separation Sequence

The Orbiter/ET separation sequence is initiated when MECO initiation, automatic or manual, is verified. Following this time, time-sequenced commands are issued to arm all separation subsystem Pyrotechnic Initiator Controllers (PICs) for closure of LH_2/LO_2 disconnect valves, Orbiter/ET electrical deadfacing, umbilical release and retract, and firing of the structural release pyrotechnics. Firing of the RCS-Z jets is initiated in the time period between 160 ms prior to structural release and structural release. Automatic attitude control will be inhibited until sufficient Velocity along the Z-Axis (VZ) is available to ensure separation margins. (Note: Manual override and manual attitude control is available at any time after structural release except during the automatic attitude control inhibit phase). The RCS shall then continue with the - Z axis - attitude hold translation maneuver as specified in Paragraph 3.2.1.1.9.2.1. The separation sequence is terminated after all separation controlled functions have been completed.

Release of all structural attach points shall occur within .020 second. The automatic separation sequence shall incorporate automatic inhibit of structural release as specified in Paragraph 3.2.1.1.9.2.1. Automatic structural release inhibits due to excessive body rates are maintained until the body rates fall within acceptable limits or until manual override of the inhibits is initiated. Automatic inhibits of structural release due to disconnect valve failure must be manually overridden after a procedural delay to allow ET pressure relief.

Manual inhibit of separation shall inhibit all separation functions unless these functions have been commanded prior to initiation of the manual inhibit. Closure of the Orbiter aft umbilical doors shall be initiated manually by the crew for normal missions and most abort situations. Closure of these doors shall be initiated automatically by the guidance system for RTLS aborts.

3.2.1.1.9.2.3 Orbiter/ET Design Staging Conditions

The Orbiter/ET separation system shall be designed to provide a safe separation for staging conditions which comprise any combination of values within the specified limits of the following variables:

a. Pitch rate between –.7°/sec and +.7°/sec

b. Roll rate between –.7°/sec and +.7°/sec

c. Yaw rate between –.7°/sec and +.7°/sec

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3.2.1.1.10 Shuttle Vehicle Separation-Abort Modes

The separation subsystem(s) shall provide for safe separation under intact abort conditions specified in Paragraph 3.2.1.5.1. The related separation modes shall be (a) SRB separation from the Orbiter/ET at burnout under conditions resulting from any of the failures specified in Paragraph 3.2.1.5.1.3, (b) Orbiter/ET separation under conditions corresponding to SSME cutoff for an AOA, (c) Orbiter/ET separation at SSME cutoff for conditions corresponding to a Return To Launch Site (RTLS) abort, and (d) Orbiter/ET separation at SSME cutoff for conditions corresponding to TAL abort.

3.2.1.1.10.1 Abort SRB Separation

Separation of the SRBs from the Orbiter/ET in the event of an abort shall occur only after SRB burnout. If less than three SSMEs are operating at SRB separation, the separation command shall be issued at a time from separation sequence initiation which assures that the thrust of each SRB is less than or equal to the one SSME failed values defined in Table 3.2.1.1.1 with the specified SRB separation timers. For the condition where all three SSMEs are operating at SRB separation but one has a stuck (low) throttle, the separation command shall be issued at a time from separation sequence initiation which assures that the thrust of each SRB is less than or equal to the throttle stuck low (single Auxilliary Power Unit [APU] failure) values defined in Table 3.2.1.1.1 with the specified SRB separation timers. With the exceptions noted above, in an abort, the SRB separation system shall meet all requirements specified in Paragraphs 3.2.1.1.9.1.1 through 3.2.1.1.9.1.3.

3.2.1.1.10.2 Abort Separation of Orbiter/ET

Abort separation of the Orbiter shall include:

a. Fluid line and electrical umbilical disconnect

b. Retraction of Orbiter umbilicals

c. Structural attachment release

d. Maneuvering of the Orbiter away from the ET

Performance and sequencing of these functions shall be initiated and controlled by the Orbiter Vehicle. The release hardware shall be the responsibility of the Orbiter.

3.2.1.1.10.2.1 Orbiter/ET TAL/ATO/AOA Separation

The Orbiter/ET separation for TAL, ATO and AOA shall be as specified in Paragraphs 3.2.1.1.9.2 through 3.2.1.1.9.2.3 except the -Z shall be 11.0 ft/sec for TAL.

3.2.1.1.10.2.2 Orbiter/ET Abort Separation Performance (RTLS)

The Orbiter/ET separation subsystem shall provide safe separation for the conditions specified in Figure 3.2.1.1.10.2.4.

The ability to manually inhibit and subsequently enable release and to bypass an automatic structural release inhibit shall be provided. In addition, the separation sequence shall provide a timed override of automatic inhibits. The operation of the separation subsystem shall not result in the release of any debris.

The Orbiter/ET separation shall be performed with ET usable propellants ranging from zero to a maximum of two percent of propellant loaded at lift-off. The separation shall be accomplished using the forward and aft RCS to provide the maximum -Z axis acceleration consistent with attitude control requirements during a timed separation maneuver. The duration of the translation maneuver shall be such that safe separation can be accomplished for the conditions specified in Paragraph 3.2.1.1.10.2.4.

3.2.1.1.10.2.2.1 Separation Flight Control (RTLS)

Separation flight control functions shall consist of the flight control system functions necessary to support the sequence specified in Paragraph 3.2.1.1.10.2.3. These shall include:

a. Attitude and rate control of the mated Orbiter/ET from separation sequence initiation to structural release within the limits specified in Paragraph 3.2.1.1.10.2.4.

b. Attitude and rate control of the Orbiter during the -Z translation maneuver as specified in Paragraph 3.2.1.1.10.2.4.

3.2.1.1.10.2.3 Orbiter/ET Separation Sequence (RTLS)

The Orbiter/ET separation sequence is initiated when MECO initiation, automatic or manual, is verified. Following this time, time-sequenced commands are issued to arm all separation subsystem PICs, for closure of the LH_2/LO_2 disconnect valves, Orbiter/ET electrical deadfacing umbilical release and retract and firing of the structural release pyrotechnics. The RCS shall then provide a high mode -Z axis translation maneuver, followed by automatically initiated closure of the Orbiter aft umbilical doors. The separation sequence is terminated after all separation controlled functions have been completed.

Release of all structural attach points shall occur within .02 seconds. The translation maneuver shall be initiated no later than .09 seconds following issuance of the structural release command. The automatic separation sequence shall incorporate automatic inhibit of structural release as specified in Paragraph 3.2.1.1.10.2.2. The separation sequence shall incorporate a timed override of automatic inhibits.

3.2.1.1.10.2.4 Orbiter/ET Design Staging Conditions (RTLS)

Orbiter/ET separation subsystem shall be designed to provide safe separation for the range of conditions shown in Figure 3.2.1.1.10.2.4.

3.2.1.1.10.2.5 Orbiter/ET Contingency Abort Separation

A manually initiated fast ET separation sequence shall also be provided in accordance with Paragraph 3.2.1.5.2.3, which will initiate separation in minimum time during first stage flight.

3.2.1.1.11 Flight Personnel Flight Loads

As experienced by the flight personnel, flight vehicle launch trajectory resultant load factors shall not exceed 3 g's and Orbiter Vehicle entry trajectory resultant load factors shall not exceed 3 g's. These load factors are static and do not include dynamic effects. These load factor limits do not apply to abort modes. The product of g forces and time shall not be detrimental to the flight personnel.

Deviation/Waiver 451 is applicable to Paragraph 3.2.1.1.11.
Refer to Book 4, Active Deviations/Waivers.

3.2.1.1.12 Orbiter Vehicle Attitude Constraints

While the Payload Bay Doors (PLBDs) are open, the Orbiter shall have the capability to provide heat removal from the payload up to 29,000 BTU/hr. During on-orbit operations, the Orbiter fixed attitude hold time capability depends on a combination of the following: sun angle relative to the orbit plane (beta angle), Orbiter altitude, Orbiter attitude and previous attitude history, Orbiter and payload heat rejection requirements, water management for heat rejection, and thermal conditioning requirements. Depending on the combination of these factors, the Orbiter allowable hold time capability varies from 5 to 160 hours.

Orbiter pre-entry thermal conditioning attitude may require up to 12 hours of duration depending on the thermal state of the Orbiter prior to the pre-entry attitude initiation. Also the Orbiter Active Thermal Control Subsystem (ATCS) radiators will normally be cold soaked for a minimum of one hour in tail to the sun attitude or equivalent prior to closing the PLBDs for entry.

Specific Orbiter Vehicle attitude constraints are defined in NSTS 07700, Volume XIV, Space Shuttle System Payload Accommodations, Attachment 1 (ICD 2-19001, Shuttle Orbiter/Cargo Standard Interfaces, Paragraph 6).

3.2.1.1.13 On-Orbit Rescue Operations

The design shall provide the capability to perform on-orbit rescue operations.

3.2.1.1.14 Orbiter Direct Entry

The Orbiter shall have the capability for deorbit and entry from the reference missions specified in Paragraph 3.2.1.1.3, Reference Missions, with the exception of vehicle mass constraints consistent with the landing weights specified in Paragraph 3.3.1.1.9, Payload Weight at Landing. The crossrange associated with entry shall be as specified in Paragraph 3.3.1.1.5, Ranging Requirements.

3.2.1.1.15 Post-Landing Thermal Conditioning

The Orbiter thermal control design shall be based on GSE ground thermal conditioning (purge) available within 45 minutes after touchdown for vehicle structural cavities and 45 minutes for the ATCS with a pre-entry radiator cold soak. For return without radiator cold soak, the vehicle power shall be managed to allow for minimum safing of the vehicle with vehicle power terminated at the end of the on-board cooling capability. For these conditions, the absence of post-entry/landing GSE cooling will not preclude reuse of the Orbiter Vehicle; however, some resulting degradation in vehicle subsystems' useful life shall be acceptable. Any hazardous condition (i.e., possible venting OMS/RCS propellants, cabin overtemperatures, etc.) which results from the absence of ground cooling shall be identified. Requirements shall be developed to monitor critical areas of the Orbiter for accumulation of hazardous gases after landing. Payloads shall be analyzed to identify hazards which may result from the absence of cooling or purge.

3.2.1.1.16 Flight Vehicle Lift-off Clearances and Launch CG

3.2.1.1.16.1 Lift-off Clearances

Positive clearances shall exist between the Space Shuttle launch vehicles and all ground launch facility hard points from SRB ignition through tower clearance for both nominal and intact abort modes. Vehicle drift during lift-off shall be as specified in ICD-2-0A002, Shuttle System Launch Pad and Platform Interface Control Document.

3.2.1.1.16.2 Space Shuttle Vehicle (SSV) CG Constraint for Ascent

The CG of the SSV, crew and provisions, and payload shall be constrained to provide positive control margin from lift-off to external tank separation. For analysis purposes, an uncertainty of ± .5-degree Orbiter thrust misalignment, ± 1.5 inches vertical CG uncertainty, ± 3.0 inches longitudinal CG uncertainty shall be assumed. The maximum vertical CG is constrained by configurations consistent with the earliest Press to MECO call up to and including the first guided cutoff and requires a quarter degree of static

control margin. The maximum vertical CG constraint specified in the Orbiter coordinate system is described by:

$$Z_{max} = 342.64 - \left[1468.17 - \left(X_{cg} - \Delta X_{cg_{1\sigma}}\right) * \right] \tan(1.54) - \Delta Z_{cg_{1\sigma}}$$

where : X_{cg} = CG of the integrated vehicle

$\Delta X_{cg_{1\sigma}}$ = 3.0 inches

$\Delta Z_{cg_{1\sigma}}$ = 1.5 inches

3.2.1.1.17 ET Disposal

3.2.1.1.17.1 (Deleted)

3.2.1.1.17.2 ET Disposal (ET 54 thru ET-999)

For all missions launched from KSC between inclinations of 57° N and 28.5° N, including the reference missions as defined in Paragraph 3.2.1.1.3, the SSME cutoff targeting shall be selected such that the nominal ET impact will be in a preselected impact area. The ET impact area is driven by the mission's apogee altitude, type of orbit insertion (standard or direct) and footprint size, which are all a function of the MECO target. The footprint size is also dependent on the type of tank rupture and breakup (violent or benign) upon reentry into the atmosphere. For nominal missions, the ET impact footprint shall fall in the Indian or Pacific Oceans. The preselected impact location, defined by the ET footprint, shall adhere to the following constraints:

a. For nominal missions, the ET impact footprint shall be no closer than 200 nm from foreign land masses (except the French-held Polynesian Islands, where the State Department has approved a 60 nm limit when dictated by mission objectives), 25 nm from U.S. territories and Continental United States (CONUS) (only when mission objectives and performance dictates) and 25 nm from the permanent ice pack of Antarctica, and

b. For planned guided MECO abort missions, the ET impact footprint shall not impact land masses. For MECO underspeeds, land impacts shall be minimized.

The above constraints shall be achieved by trajectory shaping.

3.2.1.1.18 EVA Operations

The Shuttle System shall provide the capability for EVA by two crewmen for three periods of up to six hours each outside the vehicle.

Two EVAs are available to payloads, with one EVA always reserved for Orbiter contingency use. The Manned Maneuvering Unit (MMU) shall be available for operational

missions when required to support payload operations. The MMU will be stowed in the payload bay for all flights which require it.

3.2.1.1.19 (Deleted)

3.2.1.1.19.1 (Deleted)

3.2.1.1.19.2 (Deleted)

3.2.1.2 Assembly and Launch Functions (FFD 2.0)

3.2.1.2.1 (Deleted)

3.2.1.2.2 Launch and Recycle

The SSS design shall be capable of achieving on-time launch readiness and of launching any time with a continuous 1-hour launch window. It shall be capable of launching within a 3-hour launch window with minor interruptions for guidance system alignments. It shall be capable of recycling for a launch capability within approximately 24 hours. For planetary flights, it may be necessary to conduct two recycles back-to-back to support a 3-day launch period.

3.2.1.2.3 Cryo Loading

The Shuttle System shall be capable of loading ascent cryogenic propellants within the constraints specified in Paragraph 3.2.1.2.2. The design shall not preclude main propellant drain and subsequent reload with no manual operations on the launch pad.

3.2.1.2.3.1 Cryo Loading Monitor and Control

The Shuttle Ground System shall be capable of monitoring and remotely controlling flight vehicle functions and parameters critical to propellant loading or draining.

3.2.1.2.3.2 Hold After Cryo Loading

With due consideration to internal subsystems management, the Shuttle System shall be capable, without recycle, of holding after MPS propellant loading for at least seven hours prior to the initiation of LO_2 drainback. Subsequent to the initiation of LO_2 drainback, a 2-minute hold capability, with reduction of vehicle performance capability shall exist until T-31 seconds.

3.2.1.2.4 Payload Changeout

The Shuttle System shall be capable of performing on-pad payload changeout as specified in Paragraph 3.3.1.1.6. The specified environmental contamination control requirements in Paragraph 3.6.12.2 and DOD control requirements shall be maintained during the exchange of a payload assembly at the launch pad.

3.2.1.2.5 On-time Launch

From initiation of launch activities (beginning of standby through lift-off or from the beginning of the countdown through lift-off), the Shuttle System shall be capable of achieving a lift-off with ± two seconds of the target lift-off time Greenwich Mean Time (GMT). The 2-second tolerance shall apply to flight vehicle subsystems only. The ground systems functional reliability shall be in accordance with Paragraph 3.5.1.2.

3.2.1.2.6 Vehicle Launch Orientation

The Shuttle Flight Vehicle shall be in a tail south orientation for launch at KSC. The vehicle shall be oriented tail west for determining induced environments from the VAFB reference missions.

3.2.1.2.7 Propellant Fill

The Shuttle Vehicle shall be capable of accepting ET propellants at the maximum rates of 5,000 GPM LO_2 and 12,000 GPM LH_2 after completing chilldown. The ground facility shall be capable of loading ET propellants at the maximum rates specified below. The ET shall be capable of simultaneous and/or sequential LO_2 and LH_2 loading and/or draining provided that pressure and/or fill levels are maintained in each tank as specified in NSTS 08171, Operations and Maintenance Requirements and Specifications Document, Integrated OMRSD, File II, to ensure the required structural factors of safety are met.

	KSC	Other Sites
Max LO_2 Fill Rate	1,500 GPM	5,000 GPM
Max LH_2 Fill Rate	10,000 GPM	12,000 GPM

3.2.1.2.7.1 RCS Propellant Fill

The RCS tanks will be loaded full. The ground systems will provide the capability to vacuum (less than one psia) fill the RCS manifold.

In addition, the forward RCS tankage shall also have the capability to be off-loaded, using the Pressure, Volume, and Temperature (PVT) method, to a minimum 60% (lb wt) of maximum rated loading for specific selected missions as deemed necessary. (Effectivity STS-7, or the first operational flight).

3.2.1.2.7.2 Electrical Power Subsystem (EPS) Cryogenic Reactant Fill

The SSS shall be capable of off-loading EPS cryogenic reactants for specific selected missions, as deemed necessary. (Effectivity STS-7, or the first operational flight).

3.2.1.2.8 Prelaunch Purge

All Shuttle elements shall utilize GSE and facilities to meet all compartment/cavity purge requirements during prelaunch phase.

3.2.1.2.9 On-Pad Abort

The SSS shall be capable of recycling for a launch attempt within approximately 24 hours of the initial launch window for a launch scrub prior to SSME ignition. In case of an on-pad abort following SSME ignition, the Shuttle System shall be capable of recycling for the launch without rollback to the Vehicle Assembly Building (VAB).

3.2.1.2.10 (Deleted)

3.2.1.2.11 Pad Stay Time

The SSS shall accommodate the mated vehicle on the launch pad for durations up to 180 days. Exposure to natural and induced environments for the pad stay time duration shall not invalidate the design performance or operational capability of the flight vehicle. Operational procedures shall be used to supplement element design capability, as necessary, to meet the natural and induced environments defined in Book 2 (Appendices 10.10 and 10.11). Suitable instrumentation will be required during ground operations to monitor conditions that exceed the natural environments criteria of Book 2 (Appendix 10.10) to determine the extent of potential damage to critical components.

3.2.1.2.12 Emergency Egress

The SSS shall provide for emergency egress of the flight crew and closeout crew from the Orbiter Access Arm (OAA) on the launch pad to a safe area. Unaided egress to a safe area shall require a maximum of five minutes from flight crew ingress into the cabin until SRB ignition. Emergency breathing air shall be available during this evacuation.

3.2.1.2.12.1 Emergency Egress Fire Water Protection

As part of the launch pad fire water protection system (reference Paragraph 3.4.6.2.17), there shall be a water spray system on the Fire Suppression System (FSS) 195-foot level and the OAA to provide fire protection for emergency egress.

3.2.1.2.13 Cabin Pressure Integrity Verification

The SSS shall be capable of pressurizing the crew module up to two psid through the cabin hatch and venting the crew module through onboard valves while on the launch pad and after crew ingress and cabin hatch closeout.

3.2.1.2.14 Debris Prevention

The SSS, including the ground systems, shall be designed to preclude the shedding of ice and/or other debris from the Shuttle elements during prelaunch and flight operations that would jeopardize the flight crew, vehicle, mission success, or would adversely impact turnaround operations.

a. Debris is defined as broken and/or scattered remains emanating from the element(s) of any flight or ground systems.

b. Ice is defined as frozen water of 18 lbs/cubic foot or greater density formed on the outside exposed surface(s) of any element. Frost is defined as frozen water of less than 18 lbs/cubic foot.

c. NSTS 16007, Shuttle Launch Commit Criteria and Background Document, Appendix F, contains the specific locations where the presence of ice is unacceptable for launch or flight, as well as other locations where limited amounts of ice/debris are acceptable.

Deviation/Waiver 675 is applicable to Paragraph 3.2.1.2.14.
Refer to Book 4, Active Deviations/Waivers.

3.2.1.2.14.1

The SSS shall be designed so that “Launch Holds” due to ice formation shall not occur more than 5% of the time on an annual basis based on atmospheric conditions at the launch pad in the proximity of applicable launch vehicle surfaces.

Deviation/Waiver 682 is applicable to Paragraph 3.2.1.2.14.1.
Refer to Book 4, Active Deviations/Waivers.

3.2.1.2.14.2 (Deleted)

3.2.1.2.14.3 SRB Debris Allowances

The SRB design shall be allowed to produce debris, which does not jeopardize flight safety for specified SRB items, and to use materials where potential debris generation may occur during ignition, ascent, and separation.

The sources of the debris are as follows:

a. Nozzle Plug (1U51711)

Size	- 63.45 inches diameter, 6.5 inches thick (breaks into random sizes at ignition)
Material	- Polyurethane foam and RTV
Weight	- 84 - 90 pounds (Foam, 2.8 - 3.2 lbs/cubic foot)
Location	- Station 1856.284 (plug centerline) (the plug is expelled at ignition into the SRB flame deflector)

b. Rain Shield Attachment

Size	- Aft skirt attachment, 650-inch circumference, six inches wide; nozzle attachment, 400-inch circumference, six inches wide
Material	- Laminated vinyl-nylon and velcro loop
Weight	- 0.25 pounds per foot (this is burned away by SSME heating in very light particles)
Location	- Aft skirt attachment - Station 1927; nozzle attachment - Station 1942
Time	- At SRB ignition and ascent

c.

Material	- Steel
Size	- 3/8 by 3/8-inch hollow cylinder
Weight	- 1/2 gram, maximum
Location	- SRB/ET aft upper strut
Time	- At separation

d.

Material	- Bakelite-type material [used as electrical insulators for NASA Standard Initiator (NSI) connector sockets]
Size	- 3/8 by 3/8-inch cylinder - crumbled
Weight	- 3/4 gram maximum
Location	- SRB/ET aft upper strut
Time	- At separation

e.

Material	- Phenolic glass
Size	- Variable - from small particles to full panel size (up to three square feet by .010 to .015 inch thick)
Weight	- .235 grams/square inch
Location	- Station 1837
Time	- 105 seconds to separation

f.

Material	- Steel
Size	- Connector ramp nut and smaller items
Weight	- Largest item, 120 grams; total, approximately 240 grams
Location	- SRB/ET aft upper strut
Time	- At separation, if a compressive load condition exists in the strut

g.

Material	- Aluminum
Size	- Largest particle approximately one square centimeter
Weight	- Approximately .05 gram/particle; five grams total
Location	- Forward SRB/ET fitting and all strut separation joints
Time	- At separation

h. Material - Frangible nut and associated hardware
Size - See note below
Weight - See note below
Location - SRB/Launch Pad separation
Time - Lift-off

i. Material - K5NA
Size - .0065 in^3
Weight - .06 grams
Location - All areas
Time - 95 seconds to separate

j. Material - MCC-1
Size - .0065 in^3
Weight - .06 grams
Location - All areas
Time - 95 seconds to separate

k. Material - BTA
Size - .0065 in^3
Weight - .06 grams
Location - All areas
Time - 95 seconds to separate

NOTE: Nut fractures into two major pieces which are retained. Smaller fragments of random size may become debris and will be minimized to the extent practicable by the debris containment system.

3.2.1.2.14.4 ET Debris Allowances

The ET design shall be allowed to produce debris which does not jeopardize flight safety for specified ET items during ascent.

The sources, areas, and debris materials are as follows:

a. Forward Face of LH_2 Recirculation Line Bellows Shield (2)
   Material - SLA-561
   Size - 2.1″ x 6.0″ x 0.3″ Thick, Normal/AOA, TAL
   - 0.9″ x 6.0″ x 0.3″ Thick, RTLS
   Density - 17 lbm/ft^3
   Location
   Lower Shield - ^{X}T 2105, ^{Z}T 551, ^{Y}T -52.5 (θ_T=337.5′)
   Upper Shield - ^{X}T 2090, ^{Z}T 588, ^{Y}T -66.0 (θ_T=337.5′)
   Flight Mode - Normal/AOA, TAL, RTLS
   Time - 363 seconds to MECO for Normal/AOA, TAL
   - 612 seconds to MECO for RTLS

b. Aft Face of LH_2 Recirculation Line Bellows Shield (2)
   Material - SLA-561
   Size - 0.9″ x 6.0″ x 0.3″ Thick, Normal/AOA, TAL
   - 1.2″ x 6.0″ x 0.3″ Thick, RTLS
   Density - 17 lbm/ft^3
   Location
   Lower Shield - ^{X}T 2105, ^{Z}T 551, ^{Y}T -52.5 (θ_T=337.5′)
   Upper Shield - ^{X}T 2090, ^{Z}T 588, ^{Y}T -66.0 (θ_T=337.5′)
   Flight Mode - Normal/AOA, TAL, RTLS
   Time - 116 seconds to MECO for Normal/AOA, TAL
   - 118 seconds to MECO for RTLS

c. Forward Face of LH_2 Feedline Bellows Shield
   Material - SLA-561
   Size - 1.0″ x 18.0″ x 0.7″ Thick
   Density - 17 lbm/ft^3
   Location - ^{X}T 2064, ^{Z}T 564, ^{Y}T -62.5 (θ_T=337.5′)
   Flight Mode - Normal/AOA, TAL, RTLS
   Time - 118 seconds to MECO

d. Aft Face of LH_2 Feedline Bellows Shield
   Material - SLA-561
   Size - 1.0″ x 18.0″ x 0.7″ Thick
   Density - 17 lbm/ft^3
   Location - ^{X}T 2088, ^{Z}T 564, ^{Y}T -62.5 (θ_T=337.5′)
   Flight Mode - Normal/AOA, TAL, RTLS
   Time - 118 seconds to MECO

e. LO_2 Cable Tray Fairing

Material	- Foam
Size	
Cover	- 4.0″ x 5.0″ x 0.5″ Thick
Side	- 2.0″ x 9.0″ x 0.35″ Thick
Density	- 2.4 lbm/ft^3
Location	- ^{X}T 906, ^{Z}T 534, ^{Y}T -94.5 (θ_T=3.5″)
Flight Mode	- RTLS
Time	- 460 seconds to MECO

f. (Deleted)

3.2.1.2.15 (Deleted)

3.2.1.2.16 (Deleted)

3.2.1.2.17 Secure Communications

The SSS shall be capable of providing communications security between the Orbiter and the Launch Control Center (LCC) and between the Orbiter and the Mission Control Center (MCC). The primary means of providing this capability shall be through the use of encryption and command time authentication techniques. One of two modes of operation shall be employed as follows:

3.2.1.2.17.1 NASA Communications Security Mode

For operations not requiring the protection of DOD classified information, the operational forward link shall be protected through the use of encryption and command authentication whenever the operational forward link is active and the vehicle is configured such that a false Radio Frequency (RF) command could result in vehicle damage or personnel injury. In the absence of an encryption/authentication capability, the forward link shall be protected through the selective use of a command inhibit function capable of blocking the command link at the Orbiter. For ground test operations, the use of encryption/authentication is not required provided that procedural safeguards are in place which would preclude vehicle damage or personnel injury.

3.2.1.2.17.2 DOD Communications Security Mode

For operations requiring the protection of DOD classified information, the operational forward link shall be protected in the same manner as described in Paragraph 3.2.1.2.17.1 with the additional requirement that the operational return link shall also be protected via encryption. Voice and data circuits interfacing to the vehicle during

ground operations shall be protected using methods which are consistent with the physical characteristics of the communications system and with the level of protection required by the DOD.

3.2.1.2.18 (Deleted)

3.2.1.3 Turnaround Maintenance Operations Functions (FFD 3.0)

3.2.1.3.1 (Deleted)

3.2.1.4 Mission Operations Support Functions (FFD 4.0)

3.2.1.4.1 Natural Environment Data Requirements

3.2.1.4.1.1 Meteorological Data

The following meteorological data will be required to support Shuttle operations:

a. Surface and upper air wind profiles

b. Ceiling and cloud cover

c. Visibility

d. Vertical temperature profiles

e. Humidity

f. Pressure

g. Density

h. Precipitation

i. Lightning potential

j. Turbulence

k. Storm location, intensity, movement

l. Sea state

m. Particles (hail, blowing dust/sand)

3.2.1.4.1.1.1 (Deleted)

3.2.1.4.1.2 Space Environment Data

The following space environment data will be required to support Shuttle operations. This data will be derived from established solar observatories, operating satellites, and various other environmental and solar observing facilities.

3.2.1.4.1.2.1 Conventional Space Environment Data

a. Solar Observation

1. Solar flare reports (size, location, time, region behavior, etc.)

2. Solar flare data (RF and X-ray background peak fluxes, times, etc.)

b. Geophysical and Interplanetary

1. Energetic particle reports

2. Artificial event reports

3.2.1.4.2 DOD Security

The SSS shall have the capability to process and secure classified STS mission data during any phase of operation, including mission planning, launch, flight, landing, post-landing and turn-around. This includes STS mission data loaded into, or residing in the Orbiter, simulators, and related ground equipment and facilities. The Orbiter onboard computers shall be capable of being declassified by using approved memory overwrite or erase procedures. Roles and responsibilities for DOD security are as specified in the NASA/USAF Interagency Agreement for the Protection of Space Transportation National Security Information, September 19, 1986, and the generic security requirements contained in its supplement, STS Program Security Management, December 29, 1986. These requirements shall be adapted to the unique environment of the flight vehicle elements. Communications security measures shall conform to the NASA/USAF Interagency Agreement for STS COMSEC, September 18, 1979.

3.2.1.4.3 Landing Site Support

The Orbiter Vehicle shall have the capability and ground support for safe landing from orbit in daytime or darkness at the primary or secondary landing site. In addition, a number of augmented and emergency landing sites will be available throughout the Space Shuttle Program as needed to support quick returns from orbit. In order to open the payload bay doors or remove “payload bay” payloads at the landing sites other than KSC, special GSE and enclosures are required.

3.2.1.4.3.1 Payload Landing Site Support

a. Primary Landing Site (KSC) - Within 45 minutes after landing at the Shuttle Landing Facility (SLF), for nominal (no safety concerns) conditions, a conditioned GSE purge will be provided to the payload bay. Ground freon cooling will be applied to the Orbiter and vehicle power will remain on thru jacking and

leveling. The Orbiter is towed to the Orbiter Processing Facility (OPF) where it is jacked and leveled followed by safing/deservicing operations. After jacking and leveling and prior to safing and deservicing operations, mid-deck experiments that have early removal requirements will be removed from the Orbiter and transported to the appropriate facility for deintegration.

b. Primary Landing Site Edwards Air Force Base (EAFB) - Within 45 minutes after landing, for nominal (no safety concerns) conditions, a conditioned GSE purge will be provided to the payload bay. Ground freon cooling will be applied to the Orbiter and vehicle power will remain thru jacking and leveling. The Orbiter is towed to the mate/demate facility where it is jacked and leveled followed by safing/deservicing operations. After jacking and leveling and prior to safing and deservicing operations, mid-deck experiments that are time critical will be removed from the Orbiter and released to the experimenter at the landing site or returned to the launch site. Remaining payloads/mid-deck experiments will normally remain aboard the Orbiter for ferry to the launch site via the SCA. After the Orbiter has been returned to the OPF, the remaining payloads/mid-deck experiments are removed and transported to the appropriate facility for deintegration.

c. Secondary Landing Site - Within 90 minutes after landing, for nominal (no safety concerns) conditions, a conditioned GSE purge will be provided to the payload bay. If the secondary landing site is KSC Shuttle Landing Facility (SLF), the payload/mid-deck experiments will be removed as described in step “A”. At other secondary landing sites, the mid-deck experiments will be removed and returned to the launch site or experimenter and the remaining payloads will normally remain aboard the Orbiter for ferry to launch site via the SCA. Once the Orbiter has been returned to the OPF, the remaining payloads/experiments are removed and transported to the appropriate facility for deintegration.

d. TAL and Emergency Landing Sites - Should a mission end at a TAL or Emergency Landing Site (ELS), the Orbiter mid-deck experiments and equipment will be removed and returned to the launch site or experimenter. Due to weight, CG, and safety considerations, the payloads may be removed from the Orbiter payload bay and placed horizontally in a shipping container and transported by SSP transportation to the primary launch site for return to the customer as a standard service. NASA will provide, on a space available basis, transportation of payload GSE and personnel to and from the landing site.

After payload removal from the Orbiter and prior to shipping, all payload unique operations (data removal, safing, preps for shipping and etc.) and personnel to conduct these operations are the responsibility of payloads.

e. Purge Availability at TAL Site or at ELS - Specific requirements for purge will be defined on a case-by-case basis and incorporated into the individual Flight Requirements Document (FRD).

3.2.1.5 Mission Abort Operations Functions (FFD 5.0)

3.2.1.5.1 Safe Mission Termination

The Shuttle System shall provide, by intact abort, the safe return of personnel, payload, and Orbiter. Intact abort consists of safe separation of the Orbiter from other vehicle elements and the safe landing of personnel, payload, and Orbiter on a runway.

3.2.1.5.1.1 Intact Abort

In addition to the requirements established in other sections of this document, the following requirements shall apply for intact abort.

a. The Shuttle System shall provide the capability for intact abort through all mission phases with payload range from zero pounds to the maximum specified in Paragraph 3.2.1.1.3, Reference Missions, with the exception of vehicle mass constraints as specified in Paragraph 3.3.1.1.9, Payload Weight at Landing.

b. The redundancy requirements for an abort are specified in Paragraph 3.5.1.1.1, Flight Vehicle Subsystem Reliability.

c. Higher TPS bondline temperatures following landing which may decrease the useful life of the vehicle shall be acceptable.

d. Secondary and contingency landing sites may be considered for Orbiter and personnel recovery. Secondary and primary contingency landing sites will include, as a minimum, GSE to ensure crew, vehicle and payload safety.

e. TAL sites will include, as a minimum, GSE to ensure crew and vehicle securing. ELSs will not have prelaunch deployed ground support and will await arrival of the rapid response teams for vehicle towing/safing and payload securing.

f. The payload shall not jeopardize the capability of the Orbiter to perform intact abort.

g. During an abort (during ascent or from on-orbit), provisions must be made to get the combined vehicle (Orbiter plus payload) CG within the entry and landing limits stated in Paragraph 3.3.1.2.1.5 prior to the start of atmospheric flight (i.e., dynamic pressure greater than two psf).

h. The Orbiter Vehicle shall have the capability of mission termination after orbit insertion and return to the launch or secondary/contingency landing site.

i. The Backup Flight System (BFS) shall support all intact abort modes (RTLS, TAL, AOA and ATO) whether the abort mode is selected prior to or subsequent to BFS engagement. The BFS shall not be required to be fault tolerant.

j. The Shuttle shall have the capability to withstand plume heating effects incurred while flying backwards during RTLS abort at free-stream pitot pressures that do not exceed four psf. RTLS trajectories shall be designed to keep pitot pressures within this limit.

k. OMS Engines and Aft RCS engines, if required, shall be used in parallel with the SSME engines during RTLS, TAL, and AOA for performance and Orbiter weight and CG control.

l. OMS engines and RCS engines can be used in parallel post MECO during RTLS, TAL, and AOA for Orbiter weight and CG control.

m. The ATO abort mode shall extend from the earliest ATO capability until nominal MECO. The earliest ATO shall be based on a minimum perigee altitude orbit with Day 1 return to shallow entry targets (90° targeted entry pre-bank). The ATO shall assume payload return. Operational techniques such as on-orbit thermal conditioning may be used to help stay within Orbiter EOM thermal criteria.

3.2.1.5.1.2 Intact Abort Modes

The following intact abort modes shall be utilized in the event one of the failures listed in Paragraph 3.2.1.5.1.3 occurs and may be used for other reasons than the intact abort failures listed in Paragraph 3.2.1.5.1.3.

a. The Shuttle Flight Vehicle shall have the capability to continue ascent from SRB ignition through SRB separation.

b. The Shuttle Flight Vehicle shall have continuous intact abort capability during ascent provided by RTLS, TAL, ATO, or an AOA capabilities.

c. The TAL abort mode will provide an intact landing capability to TAL primary and TAL alternate landing sites from earliest TAL capability to earliest ATO and/or AOA capability. The capability to reselect to the alternate sites shall be provided preflight and during powered ascent or abort operations.

d. (Deleted)

3.2.1.5.1.3 Intact Abort Failures

Intact abort shall be provided for the following subsystems or systems failures. These failures shall be considered singly without combinations.

a. Complete or partial loss of thrust from one Orbiter main engine

b. (Deleted)

3.2.1.5.2 Contingency Aborts

Aborts caused by failures not included in the intact abort category shall be classified as a contingency abort. Intact abort capability is not required throughout the mission phases for this class of abort. Contingency abort analyses software changes, and procedures are documented in the NSTS 08347, Contingency Abort Data Book.

3.2.1.5.2.1 Contingency Abort Criteria

The following criteria shall apply for contingency abort:

a. Contingency aborts will not be used to determine hardware design criteria.

b. The Orbiter's and SSMEs usable lifetime may be degraded.

c. Software and hardware impact may be allowed where feasible and cost effective, with specific approval.

3.2.1.5.2.2 Contingency Abort Failures

The following conditions constitute the contingency abort failures:

a. Loss of thrust from two or three SSME

b. SSME TVC Failure(s)

c. SRB TVC Failure(s)

d. Premature Orbiter separation

e. Failure to separate SRB from Orbiter/ET

f. Any failure/failures which require the initiation of a system abort

3.2.1.5.2.3 Contingency Abort Requirements

For possible use in contingency situations where mission completion or intact abort modes are not applicable, the Orbiter shall provide the capability to:

a. Manually initiate MECO at any time.

b. Manually initiate ET mechanical separation sequence at any time.

c. Provide an abort downmoding capability (from ATO to AOA) to be effective post-MECO, for sequential multiple-SSMEs out.

d. Provide a manual single engine control capability (utilizing RCS augmentation and OMS propellant), for two SSMEs out.

Deviation/Waiver 399 is applicable to Paragraph 3.2.1.5.2.3d.
Refer to Book 4, Active Deviations/Waivers.

e. Provide a second stage trajectory shaping capability, for 3-SSME out entry (i.e., retain abort MECO data slots).

f. Provide a direct transfer capability to “alpha recovery and load relief” immediately following an exoatmospheric-type Orbiter/ET separation, for multiple-SSMEs-out downrange ditching (i.e., direct transfer from MM104 to MM602).

g. Provide a manually initiated and terminated OMS/RCS propellant maximum rate depletion capability during powered flight (normal ascent, RTLS, TAL, AOA, ATO) and immediately following Orbiter/ET separation (allowing for control and utilizing existing propulsion systems), for multiple-SSMEs out CG control.

h. Provide an MPS propellant exoatmospheric dump capability in RTLS and TAL immediately following Orbiter/ET separation (utilizing the existing “on-orbit MPS LOX dump”), for sequential multiple-SSMEs-out CG control.

i. Execute the Orbiter/ET contingency abort separation sequence in accordance with Paragraph 3.2.1.1.10.2.5 in both the primary and BFSs.

3.2.1.5.2.4 Contingency Abort Modes

Within the criteria established in Paragraph 3.2.1.5.2.1, the following abort modes shall be utilized:

a. During First Stage Flight: Fast ET separation followed by ditching or continuation of ascent through SRB staging.

b. During Second Stage Flight: Termination of main propulsion, ET separation, descent and downrange ditching or landing.

3.2.1.5.3 Loss of Critical Function

A failure in a system or subsystem, required for intact abort or for the initiation of contingency abort procedures, through the loss of a “critical function”, shall be minimized by including in the design appropriate safety margins and/or redundancy levels.

3.2.1.5.3.1 Loss of Critical Function Failures

Critical function failures include the following:

a. ET Rupture/Explosion

b. SRB burnthrough

c. Major structural failure

d. Complete loss of guidance and/or control

e. Failure to ignite one SRB

f. Loss of thrust from one SRB

g. SSME or SRB TVC hardover

h. Failure to separate Orbiter from ET

i. Nozzle failure

j. Premature SRB separation

k. Premature closure of either or both LO_2 or LH_2 17-inch ET/Orbiter disconnects

l. SRB/Mobile Launch Platform (MLP) frangible nut non-release on command

3.2.1.5.4 Range Safety Flight Termination System

The Shuttle Vehicle shall have a range safety flight termination system for all orbital flight tests and operational missions as required.

3.2.1.5.5 Emergency Bailout

The Orbiter shall provide an emergency bailout system for use during controlled gliding flight. The flight condition during bailout shall be selected to maximize crew escape probability and shall be initiated at an altitude to permit all crew members as specified in Paragraph 3.3.1.2.1.1 to escape.

Crew equipment for bailout and survival shall be provided as specified in Paragraph 3.3.1.2.4.4d.

Cabin depressurization shall start at an altitude of approximately 40,000 feet. Side hatch shall be jettisoned between 20,000 and 30,000 feet assuming no forward hatch thruster failures.

For an emergency bailout condition, the Orbiter, crew equipment, and mid-deck payload systems located in the cabin must be compatible with depressurization and crew bailout procedures.

3.2.1.6 Ferry Mission Functions (FFD 6.0)

3.2.1.6.1 Ferry

The program shall provide for the transporting of an Orbiter Vehicle, by use of a SCA, to/from specified sites to/from the launch site, as defined in Paragraph 3.3.5 of this document. Payloads may be ferried to the launch site in the Orbiter payload bay, taking into account weight, CG, safety, and security.

3.2.1.6.2

Total weight and CG of the Orbiter (with payloads) in the ferry configuration shall be within the limits specified in Figure 3.2.1.6.2.

3.2.1.6.3 (Deleted)

3.2.1.7 Transport System Element Functions (FFD 7.0)

3.2.1.7.1 Delivery of System Elements to Using Site

The capability shall be provided to transport Shuttle Vehicle elements and related support equipment from the site of manufacture to the launch and landing site. Such capability shall include initial Orbiter delivery by ferry flight.

3.2.1.8 Recycle Launch Facility Functions (FFD 13.0)

3.2.1.8.1 Launch Facility Turnaround Support

The launch complex, including support equipment and facilities, shall be refurbished and revalidated following each launch of a Shuttle Vehicle. Turnaround operations shall support flight vehicle preparation and subsequent launch activities in a time frame compatible with the traffic model.

3.2.1.9 Perform Rescue Operations Functions (FFD 14.0)

3.2.1.9.1 Prelaunch

An emergency response capability shall be provided to assist the flight crew in case of a contingency, including assistance to incapacitated crew or aided emergency egress.

The emergency response team shall be capable of reaching the flight crew in the Orbiter within eight minutes of notification during the period from flight crew ingress to SRB ignition.

3.2.1.9.2 On-orbit

TBD.

3.2.1.9.3 Post-landing

3.2.1.9.3.1 Primary, Alternate, and Secondary Landing Stations

Emergency vehicles with conventional aircraft fire fighting crew rescue capability and emergency medical support shall be provided to assist the crew in the event of an emergency. Capability to detect hazardous gases in the vicinity of the Orbiter Vehicle shall be provided.

For cases in which the Orbiter comes to a stop on the runway, the emergency vehicles shall be capable of reaching the flight crew within five minutes after landing rollout. For cases in which the Orbiter comes to a stop off the runway, rescue helicopters with rescue personnel and emergency medical support shall be provided.

3.2.1.9.3.2 Transoceanic, Contingency Landing Stations

Existing capabilities available at the facility will be utilized. Supplemental capabilities will be provided, as appropriate, to provide basic fire and rescue capability.

3.2.1.9.3.3 Bailout or Downed Orbiter

For contingency cases in which the Orbiter or flight crew are down in a remote area, conventional search and rescue capabilities will be utilized, as available.

TABLE 3.2.1.1.6

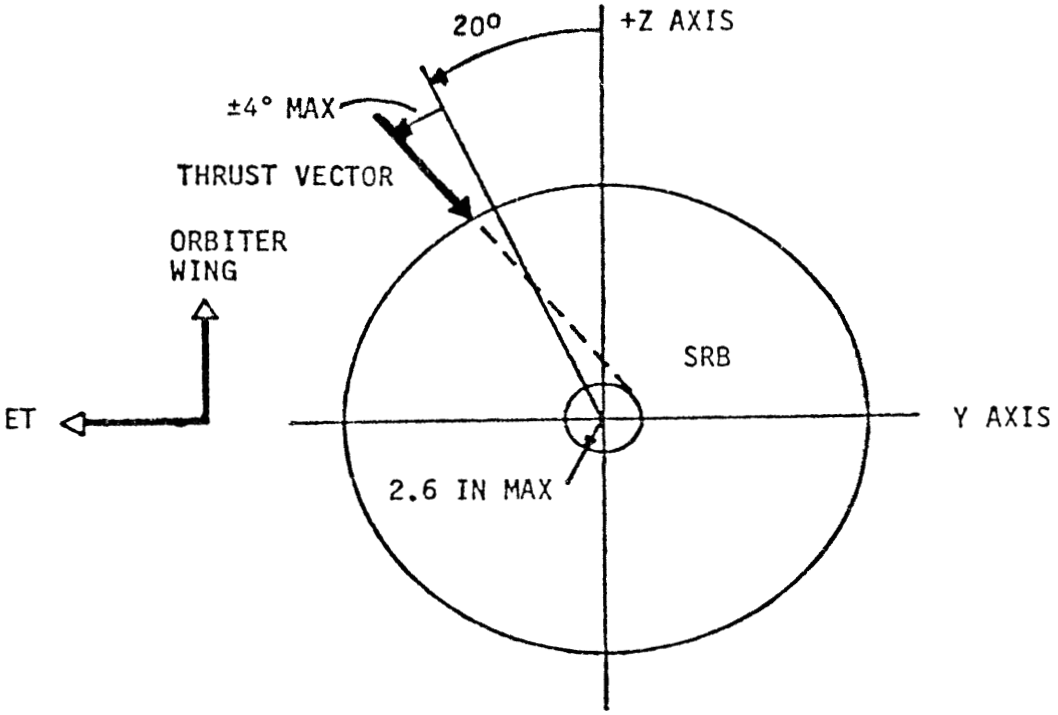
INSERTION ACCURACY

Maximum Allowable 1-Sigma Dispersion of Actual State Vector at MECO

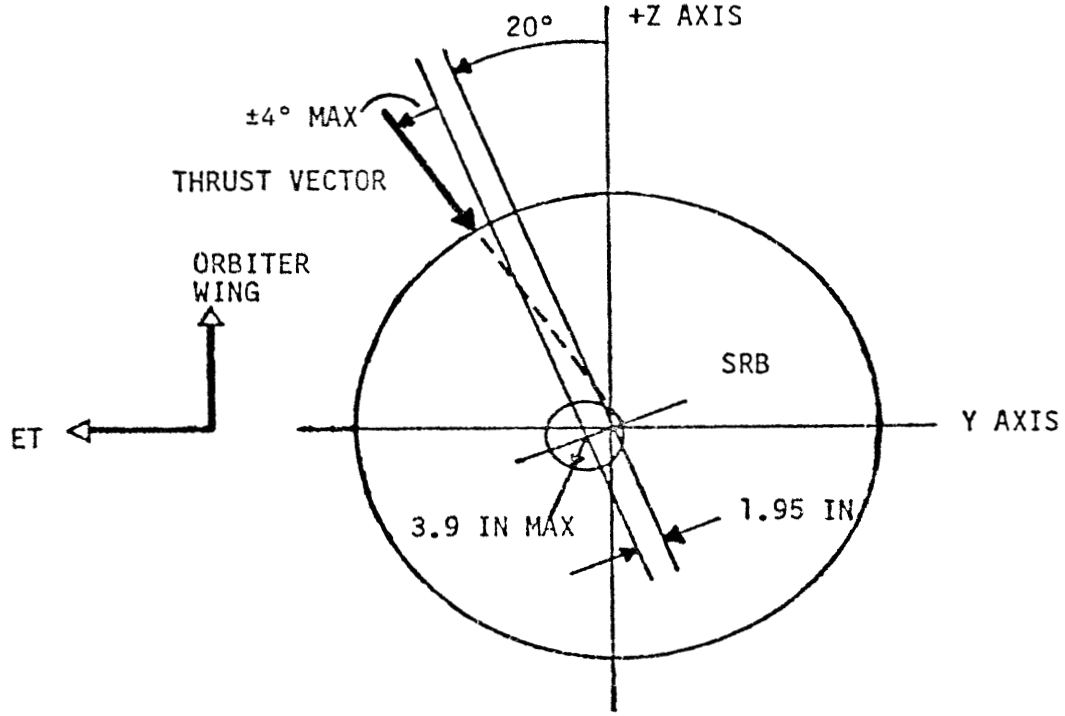
State	Position NM	Velocity ft/sec
Downrange	0.1	4.0
Crossrange	0.4	10.5
Vertical	0.15	4.5

FIGURE 3.2.1.1.9.1.1.3

BSM CLUSTER THRUST VECTOR ORIENTATION TOLERANCES



FORWARD BSM CLUSTER



AFT BSM CLUSTER

FIGURE 3.2.1.1.10.2.4

ORBITER/ET RETURN TO LAUNCH SITE ABORT DESIGN STAGING CONDITIONS

Parameter/Event	MECO	Structure Release	Separation Termination
Angle of Attack-Deg	-3.0 ± 1.5	-2.5 ± 1	> 10
Roll Angle-Deg	0 ± 2	0 ± 20	0 ± 30
Sideslip Angle-Deg	0 ± 2	0 ± 2.0	0 ± 3
Yaw Rate-°/Sec	0 ± .5	0 ± .5	0 ± 1
Roll Rate-°/Sec	0 ± .5	0 ± 2.0	0 ± 2
Pitch Rate-°/Sec	-.25 ± .5	-.25 ± .5	2.5 ± 2.5
Dynamic Pressure* Lb/Ft^2		$6 \leq q \leq 9.5$	

*<u>DYNAMIC PRESSURE</u>

The undispersed engine-out ET structural release Qbar target zone of 6 to 9.5 psf is based on range reference atmosphere. These dynamic pressure limits represent the undispersed engine-out variation target zone to which the RTLS ET sep Qbar designs were assessed and must adhere. Details on the application of these limits to the I-Load design process are presented in NSTS 08209, Volume IV, Shuttle Systems Design Criteria, Design Criteria and Constraints, Paragraph 3.3.2.3, RTLS ET Separation Conditions. Dynamic pressure limits are based on simulated environments (not flight software derived). Limits for all the other parameters (alpha, beta, roll and body rates) are flight software derived.

3.2.2 Design Characteristics

3.2.2.1 Flight Systems Design

The Shuttle System flight hardware shall consist of a reusable manned Orbiter Vehicle including installed SSMEs, an expendable ET, and reusable solid rocket boosters which burn in parallel with the Orbiter SSMEs. The Orbiter Vehicle shall be capable of cross-range (reference Paragraph 6.1.6) maneuvering during entry and aerodynamic flight when returning from orbit.

3.2.2.1.1 (Deleted)

3.2.2.1.2 Mated Ascent Guidance, Navigation, and Control (GN&C)

The Shuttle Flight Vehicle ascent GN&C function shall be accomplished in accordance with Paragraph 3.3.1.3.2.1. The Orbiter Vehicle shall provide control to the Shuttle Vehicle during mated ascent by throttling the MPS to limit resulting rigid body, longitudinal acceleration as specified in Paragraph 3.2.1.1.11. Aerodynamic, inertial, and thrust loads shall be limited by trajectory shaping and control, including throttling of the MPS, yaw steering, and elevon position changes for the following conditions:

a. Design winds, shears, and gusts are as specified in NSTS 07700, Volume X - Book 2, Appendix 10.10, applied with no SSME total thrust failures.

b. Design winds as specified in NSTS 07700, Volume X - Book 2, Appendix 10.10, applied in conjunction with a total thrust loss from a SSME. The dynamic effects due to gust penetrations and SSME thrust loss shall not be superimposed within five (5) seconds before or two (2) seconds after the failure occurs.

The ascent flight control system shall provide the capability to parallel the SSMEs in the pitch and yaw axes during acceptable flight regions to enhance performance capability. The ascent flight control system shall provide also the capability to unparallel the SSMEs to improve control authority and prevent engine collision, as required.

The definition and application of system and environmental dispersions for use in flight system design and certification, are defined in NSTS 08209, Volume III, Shuttle Systems Design Criteria, Systems and Environmental Dispersions.

Powered Explicit Guidance (PEG) shall provide capability for optimum steering profiles from SRB separation to MECO.

PEG shall also provide the capability for variable Iy targeting. Variable Iy is an ascent trajectory design method which provides for equal main propellant margin for the nominal mission, the earliest AOA and the latest RTLS trajectories.

3.2.2.1.2.1 Shuttle Systems Avionics Terminal Events, Timing Constraints

The Shuttle System avionics terminal events times are contained in Book 2 (Appendix 10.14). The terminal event times are for (1) SSME start command to SRB ignition command (2) SRB ignition command to SRB ignition PIC fire output command (3) the SRB ignition command to SRB Holddown PIC fire output command, and (4), the SRB ignition command to T-0 umbilical retract PIC Fire output command. System timing includes both serial time delays required for the initiation of a single event and the skew time between initiation of two events.

3.2.2.1.2.2 Shuttle Systems Avionics Main Engine Shutdown Events, Timing Constraints

The Shuttle Systems avionics timing constraints for Orbiter LO_2 prevalve close commands as referenced to either premature engine shutdown or MECO shutdown commands at the SSME controller interface are contained in Figure 3.2.2.1.2.2.

Deviation/Waiver 475 is applicable to Paragraph 3.2.2.1.2.2.
Refer to Book 4, Active Deviations/Waivers.

3.2.2.1.2.3 Lift-off Flight Control and Sequence

The ascent flight control system shall initiate and execute the lift-off sequence and provide guidance and control to ensure that recontact between the mated vehicle and the launch facility is prohibited.

3.2.2.1.3 Aeroelasticity

Static and dynamic structural deformations and responses including the effects of aeroelasticity under all limit conditions and environments shall be accounted for in the structural design and shall not cause a system malfunction, preclude the stable control of the vehicle or cause unintentional contact between adjacent bodies.

3.2.2.1.3.1 Static Aeroelasticity

The lifting surfaces shall be free from “divergence” and the aerodynamic control surfaces shall not exhibit “reversal” at dynamic pressures up to 1.32 times the maximum dynamic pressures, at the appropriate mach number, or boost, abort, entry, and aerodynamic-flight envelopes.

3.2.2.1.3.2 Dynamic Aeroelasticity

The Shuttle Vehicle shall be free from classical flutter, stall flutter, and control surface buzz at dynamic pressures up to 1.32 times the maximum dynamic pressure expected

during flight. External panels shall be free of panel flutter at 1.5 times the local dynamic pressure at the appropriate temperature and mach number for all flight regimes including aborts.

Maximum nominal dynamic pressure for environmental and systems dispersions shall not exceed ascent structural design requirements of 819 psf dispersed dynamic pressure nor ascent stability constraints.

3.2.2.1.4 POGO

The SSV, in all mated and unmated configurations, shall be free of instabilities resulting from dynamic coupling of the structure, propulsion, and flight control subsystems during all phases of powered flight with all payload variations. Stability margins shall be determined by a closed-loop stability analysis which shall consider, but not be limited to, interaction of the vehicle structural modes of vibration, propellant tank and feedline hydroelastic modes, POGO suppression device (if required), OMS and main engine dynamic characteristics, the vehicle flight control subsystem, and appropriate parameter variations of these interacting subsystems. The total coupled system shall be stable for any allowable combination of system parameter variations.

3.2.2.1.4.1 POGO Suppressor Requirements

A POGO suppressor shall be provided on each SSME. The effective point of application of the suppressor shall be located on the SSME low pressure oxidizer turbopump discharge duct within 13 inches of the inlet flange of the high pressure oxidizer turbopump.

3.2.2.1.4.1.1 Compliance

The suppressor shall provide a minimum effective compliance of 0.045 in^2 at the maximum operating pressure of the suppressor (equivalent to a helium gas volume of 0.6 ft^3 at 568 psia). Capability to modify the design to provide a minimum compliance of 0.12 in^2 shall be maintained (equivalent to a helium gas volume of 1.6 ft^3 at 568 psia).

3.2.2.1.4.1.2 Inertance

The suppressor inertance shall not exceed 1.1×10^{-3} sec^2/in^2.

3.2.2.1.4.1.3 Helium and Electrical Power Consumption

The suppressor design and operations shall minimize helium and electrical power consumption which will be supplied by the Orbiter.

3.2.2.1.5 Structure

The Shuttle Vehicle structure, including pressure vessels and mechanical systems, shall have adequate strength and stiffness, at the design temperature, to withstand limit

loads and pressures without loss of operational capability for the life of the vehicle and to withstand ultimate loads and pressures at design temperature without failure. The structure shall not be designed to withstand loads, pressures, or temperatures arising from malfunctions that prevent a successful abort. Major structural elements shall not be designed by non-flight conditions, i.e., conditions other than prelaunch (vehicle mating) through landing except for SRB water recovery. Structure and pressure vessels shall be designed to withstand the effect of a failure of a MPS oxygen or hydrogen ullage pressure flow control valve during nominal ascent. An intact abort combined with the failure of an MPS oxygen or hydrogen ullage pressure flow control valve is not a design requirement for primary structure and pressure vessels.

Deviations/Waivers 387, 440, 448 and 449 are applicable to Paragraph 3.2.2.1.5. Refer to Book 4, Active Deviations/Waivers.

3.2.2.1.5.1 Definitions

For the purpose of interpretation of this section, the following definitions will apply:

a. Limit Load - The maximum load expected on the structure during mission operation including intact abort.

b. Ultimate Factor of Safety - The factor by which the limit load is multiplied to obtain the ultimate load.

c. Ultimate Load - The product of the limit load multiplied by the ultimate factor of safety.

d. Allowable Load - The maximum load which the structure can withstand without rupture or collapse.

e. Maximum Operating Pressure - The maximum pressure applied to the pressure vessel by the pressurizing system with the pressure regulators and relief valves at their upper limit, with the maximum regulator fluid flow rate, and including the effects of system environment such as vehicle acceleration and pressure transients.

f. Proof Pressure - The pressure to which production pressure vessels are subjected to fulfill the acceptance requirements of the customer, in order to give evidence of satisfactory workmanship and material quality. Proof pressure is the product of maximum operating pressure times the proof factor.

g. Margin of Safety - The ratio of allowable load to ultimate load minus one.

h. Safe-life - A design criteria under which failure will not occur because of undetected flaws or damage during the specified service life of the vehicle; also, the period of time for which the integrity of the structure can be ensured in the expected operating environments.

3.2.2.1.5.2 Ultimate Factors of Safety

The ultimate factors of safety given in Table 3.2.2.1.5.2 shall be used for the Shuttle Vehicle structure. The following specific conditions are allowed:

a. The ultimate factors of safety for LO_2 tank buckling shall not be less than 1.25 prior to initiation of prepressurization.

b. A safety factor of 1.491 for Power Reactant Storage Assembly is acceptable for Power Reactant Supply and Distribution (PRSD) tank unit-part No. MC282-0063-0100 S/N SX T0010.

c. The ultimate factor of safety for the SSME spark igniter casings shall not be less than 1.25.

d. The ultimate factors of safety for the following SSME pressurized lines and fittings of less than 1.5 inch diameter shall be greater than or equal to 1.5:

Part Number	Description
RS007049	Rigid Oxidizer Tank Pressurant Duct
RS007083	Heat Exchanger Inlet Line
RS007186	Oxidizer Preburner, Aerodynamic Sensitive Item (ASI) Oxidizer Line
RS007187	Fuel Preburner, ASI Oxidizer Line
RS007363	Tap B06A-To-Transducer Line
R0019585	Fuel System Drying Purge Line
R0011053	Fuel Preburner, ASI Oxidizer Inlet Line
RS009525	Fuel Preburner, ASI Fuel Inlet Tube
R0011052	Oxidizer Preburner, ASI Oxidizer Inlet Tube
RS009524	Oxidizer Preburner, ASI Fuel Inlet Tube
RS007083	Heat Exchanger Inlet Line
R0018051	Fuel Preburner, ASI Oxidizer Line
R0018052	Fuel Preburner, ASI Fuel Line
RS009035	Preburner ASI Oxidizer Inlet
RS009016	Preburner ASI Fuel Inlet
RS009086	Preburner ASI Oxidizer Inlet Flange
R0010751	Oxidizer P/B ASI Fuel Supply Line

R0010752	Fuel P/B ASI Fuel Supply Line
R0010758	Preburner Fuel Supply Line
RS009168	Nozzle, High-Pressure Oxidizer Turbopump (HPOTP) Purge Line
RES1001	Hydraulic Supply Flexhose
RS007119	Main Oxidizer Valve (MOV) Hydraulic Supply Manifold
RS007120	MFVA Hydraulic Supply Manifold
RS007212	MOVA Hydraulic Supply Manifold

NOTE: The RS007083, Heat Exchanger Inlet Line, has been identified twice in the SSME Pressurized lines listing.

e. The RSRM aft stiffener segment shall maintain a factor of safety greater than or equal to 1.4 with respect to case buckling for the induced environments resulting from the prelaunch surface winds specified below.

Wind Direction	Volume X Requirement	Allowable Wind Speed
91 - 100	34 Knots	34 Knots*
101 - 110	34 Knots	31 Knots
111 - 120	34 Knots	30 Knots
121 - 134	34 Knots	29 Knots
135 - 140	31 Knots (@ 140 deg)	28 Knots
141 - 150	27 Knots (@ 150 deg)	27 Knots*

* Indicates no change to NSTS 07700, Volume X - Book 2, Appendix 10.10 requirements.

NOTE: This is applicable to Bolck II engines.

f. The ultimate factor of safety of 1.50 against ICD max pressure conditions is acceptable for ET intertank and nose cone purge systems.

MMC has performed a stress analysis for the purge system components for maximum operating and relief pressure conditions with the results as follows:

1. All components satisfy ET-EIS requirements for max ICD operating pressure

2. All components have factors of safety (F.S.) ≥ 1.0 for relief pressure

3. All components have adequate proof factors for both pressure conditions

EXCEPTION: For ET-66 and ET-71 thru ET-75, the ultimate factor of safety of 1.5 may be excepted to allow flight use of ET nose cone purge line 1/4 inch tubing which has demonstrated an ultimate factor of safety of 1.37.

g. For the operating SSME nozzle, the ultimate factor of safety shall not be less than 1.4 for the normal (no-fail) ascent design conditions and shall not be less than 1.25 for the ascent intact aborts design conditions.

NOTE: The non-operating SSME nozzle is not required to be reusable but it shall not be a hazard to flight safety.

h. The ultimate factor of safety of 1.5 x Maximum Operating Pressure (MOP) is acceptable for the crew escape oxygen supply hoses and Quick Don Mask Assembly.

i. The SRB aft skirt holddown stud shall maintain a factor of safety greater than or equal to 1.4 for the induced environments specified in NSTS 07700, Volume X - Book 2, Appendix 10.11, and a minimum Orbiter lift-off weight of 235,000 pounds.

3.2.2.1.5.3 Design Thickness

Stress calculations of structural members, critical for stability, shall use the mean drawing thickness or 1.05 times the minimum drawing thickness, whichever is less. Structural members, critical for strength, shall use the mean drawing thickness or 1.10 times the minimum drawing thickness, whichever is less.

3.2.2.1.6 Ultimate Combined Loads

The mechanical external, thermally induced, and internal pressure loads shall be combined in a rational manner according to the equation given below to determine the design loads. Any other loads induced in the structure, e.g., during manufacturing, shall be combined in a rational manner. In no case shall the ratio of the allowable load to the combined limit loads be less than the factor in Paragraph 3.2.2.1.5.2.

Ultimate loads = $K_1 L_{external} + K_2 L_{thermal} + K_2 L_{pressure}$

Where: K_1 = The appropriate design factor of safety in Table 3.2.2.1.5.2 when the term is additive to the algebraic sum

K_2 = The appropriate design factor of safety in Table 3.2.2.1.5.2 for all pressure vessels when the term is additive to the algebraic sum

K_1, K_2 = 1.0 when the term is subtractive to the algebraic sum

$L_{External}$ = Mechanical externally applied loads, e.g., internal loads, aerodynamic pressures

$L_{Thermal}$ = Thermally induced loads

$L_{Pressure}$ = Maximum relief valve setting (except ET) where additive to algebraic sum

= Maximum regulated pressure (for ET only) where additive to algebraic sum

= 0 to minimum regulated pressure when subtractive to algebraic sum

3.2.2.1.7 Allowable Mechanical Properties

Values for allowable mechanical properties of structural materials in their design environment; e.g., subjected to single or combined stresses, shall be taken from MIL-HNBK-5B, Metallic Materials and Elements for Aerospace Vehicle Structures, MIL-HNBK-17A, Plastics for Aerospace Vehicles, MIL-HNBK-23A, Structural Sandwich Composites, or other sources approved by NASA. Where values for mechanical properties of new materials or joints or existing materials or joints in new environments are not available, they shall be determined by analytical or test method approved by NASA. Complete documentation of testing and analyses used to establish material properties and design allowables shall be maintained by the contractor, and the documentation

shall be made available to the procuring agency on request. When using MIL-HNBK-5B, material “A” allowable values shall be used in all applications where failure of a single load path would result in loss of vehicle structural integrity. Material “B” allowable values may be used in redundant structure in which the failure of a component would result in a safe redistribution of applied loads to other load-carrying members.

3.2.2.1.8 Fracture Control

In addition to the ultimate factors of safety presented in Paragraph 3.2.2.1.5.2, designs for primary structure, windows, glass components of other subsystems, and tanks shall consider the presence of sharp cracks, crack-like flaws, or other stress concentrations in determining the life of the structure for sustained loads and cyclic loads coupled with environmental effects. Parts (other than SSME) determined to be fracture critical shall be controlled in design, fabrication, test, and operation by a formal, NASA-approved fracture control plan as specified in SE-R-0006, General Specification, Space Shuttle System Requirements for Materials and Processes. SSME parts determined to be fracture critical shall be subjected to fracture mechanics analysis as specified in RSS-8589. Where analysis does not demonstrate that the detectable flaw size will not grow to critical size during the service life, a risk assessment will be made to determine the acceptability of the part for flight and the conditions for this use. Alternate turbopump fracture critical parts shall meet the requirements of FR-19793, ATD Fracture Control Plan. If the fracture life requirements of FR-19793 cannot be met, alternate turbopump fracture critical parts shall be inspected at 25% of the demonstrated safe life (see Paragraph 6.1.32) until a defect is detected. When a crack-like defect is detected, the life analysis shall be performed using upper bound fatigue crack growth rate properties. The part shall be inspected at intervals of one-eighth of the demonstrated safe life, until flaw growth is detected.

Deviation/Waiver 512 is applicable to Paragraph 3.2.2.1.8.
Refer to Book 4, Active Deviations/Waivers.

3.2.2.1.9 Fatigue

Safe life design shall be adopted for all major load-carrying structures. These structures shall be capable of surviving without failure a total number of mission cycles that is a minimum of four times greater than the total number of mission cycles expected in service (shown by analysis or by test through a rationally derived cyclic loading and temperature spectrum). This does not preclude fail safe structural features.

Orbiter structure may be subjected to a durability analysis in lieu of a fatigue analysis. When using a durability analysis, the total number of mission cycles the structure shall be capable of surviving without failure shall be a minimum of two times the mission cycles expected during the design life specified in Paragraph 3.5.3.1.1.

SSME structures which are shown by analysis or test to have a life less than four times the total number of mission cycles expected in service but meet one of the criteria listed below may operate up to a limit of 50% of the demonstrated safe life limit (see Paragraph 6.1.32).

EXCEPTIONS:

1. The high pressure fuel turbopump main housing, Part Number RS007577, shall be unacceptable for continued use for units having “Y” and/or intersecting “Y” cracks in and/or flight adjacent to the inner ring bolt hole threads greater than the equivalent of seven full threads in axial height (7 full threads = 0.25 inches).

2. For the high pressure fuel turbopump first and second stage turbine blades, Part Numbers RS007520 and RD0019821, these blades must have a remaining life that is not less than mission duration. In the event of an abort, exceedance of the 4,300-second service life limit is an acceptable condition. The statistical method used to establish the life limit differs from that in Paragraph 3.2.2.1.9 and is not contained in one of the alternate criteria listed. Specifically, the blade failure distribution is assumed to be weibull with the distribution parameter estimates based on the first and second stage blade data and the limit life is calculated to ensure that the combined reliabilities of the first and second stages of three pumps is at least 0.999 for the entire service life of 4,300 seconds. For an abort, the combined reliabilities of the first and second stages of the three pumps with a failure on its last mission is at least 0.9987 for their extended service life of 4,534 seconds.

3. The High Pressure Fuel Turbopump/Alternate Turbopump (HPFTP/AT) turbine first stage vane cluster, Part Number PW-4701351, has a life limit of 3,040 seconds (this allows four 520 second nominal mission hotfires plus one 754 second RTLS abort scenario). Limit is based on one fourth of fleet leader (unit 8012: 12,161 seconds).

4. The HPFTP/AT first and second stage turbine blades, Part Numbers PW-4701471 and PW-4701502/PW-4702002, have a life limit of 3,354 seconds (this allows for five 520 second nominal mission hotfires plus one 754 second RTLS abort scenario). A statistical rank regression weibull

approach was utilized to determine the life interval to provide a 99.9% predicted blade set fatigue reliability.

a. Life Based on Operating History With No Failures - The allowable life limit must be statistically justified using the single flight reliability method (see Paragraph 6.1.33) with a demonstrated reliability statement of 0.995 reliability/0.90 confidence for the last mission of the calculated life, and additionally constrained by requiring six similar structures to each have demonstrated life equal to or greater than the allowable life limit.

b. High Cycle Fatigue Life Based on Analysis and Test Data - The allowable life limit may be up to 50% of the demonstrated safe life limit for high cycle fatigue if test data from at least nine tests (a minimum of two tests per engine and three engines) correlated to 0.99 reliability and one-sided 0.95 confidence, in conjunction with expected minimum material properties (a minimum of ten high cycle fatigue tests with a maximum of two run-outs, at temperature and environment of interest) and a life factor of 2 are used to establish the allowable life limit. In addition, periodic inspection must be performed at up to 25% demonstrated safe life limit exposure, and/or health monitoring performed.

c. Life Based on Demonstrated Safe Life Limit - The allowable life limit may be up to 50% of the demonstrated safe life limit, if there are six similar structures each with demonstrated life equal to or greater than the allowable life limit and periodic inspection is performed at up to 25% demonstrated safe life limit exposure, and/or health monitoring performed.

EXCEPTIONS:

1. For the low pressure oxidizer turbopump stator, Part No. RS007808, the periodic inspection requirement for abort mission durations is extended from 25% (factor of 4) to 26% (factor of 3.8) of demonstrated safe life.

2. For the high pressure oxidizer turbopump preburner pump end bearings, Part No. RS007958, the allowable life limit for abort mission durations is extended from 50% (factor of 2) to 56% (factor of 1.8) of demonstrated safe life.

3. For the high pressure fuel turbopump bearings, Part No. RS007502, the allowable life limit for abort mission durations is extended from 50% (factor of 2) to 56% (factor of 1.8) of demonstrated safe life.

4. For the high pressure turbopump jet ring, Part No. RS007757, the allowable life limit of 2,465 seconds is extended beyond the 50% of the cracked jet ring, 4,930

seconds total, based on dye penetrant inspection performed at up to 25% of the cracked jet ring, 1,230 seconds, prior to each flight thereafter.

5. For Weld 118 on the high pressure fuel turbopump turbine bearing supports with the Electronic Discharge Machine (EDM) inlet sheet metal, Part Number RS007524-211, four similar structures that have demonstrated life equal to or greater than the allowable life limit shall be permitted, when structural analysis indicates Configuration End Item (CEI) safety factors and life requirements are maintained.

d. Fatigue Life Based on Fracture Mechanics (alternate turbopump only) - Fracture critical parts meeting the requirements of FR-19793, and whose critical initial flaw size (see Paragraph 6.1.38) is greater than 1/32 inch, shall be inspected at one-half of the total number of mission cycles expected in service. When the detectable flaw results in a life less than required, inspection shall be performed at intervals of one-eighth of the demonstrated safe life until a crack-like flaw is detected.

3.2.2.1.10 Creep

The design shall preclude cumulative creep strain leading to rupture, detrimental deformation, or creep buckling of compression members during their service life. Analysis shall be supplemented by test to verify the creep characteristics for the critical combination of loads and temperatures.

3.2.2.1.11 Flight Vehicle Main Propulsion Propellants

The flight vehicle shall provide a nominal storage capacity of 52,526 cubic feet for the liquid hydrogen and 19,486 cubic feet for the liquid oxygen of the main propulsion system at the 100% sensor in a vented cryogenic condition.

3.2.2.1.12 Tank/Liquid/Flight Control Coupling

Tanks containing liquid and the flight control system shall be designed jointly to prevent or suppress coupling between the slosh of the liquid, the vehicle structure, and the flight control system.

3.2.2.1.13 Propellant Loading Accuracies

The root sum square overall system loading accuracy to the 100% mass load level of the SSS shall be $\pm$ 0.43% for LO_2 and $\pm$ 0.37% for LH_2. The allocation of uncertainties between the vehicle and ground system are given in Table 3.2.2.1.13.

3.2.2.1.14 LO_2 Geyser Suppression

The ET LO_2 fill, drain and engine feed design shall include provisions to suppress geysering to preclude damaging the ET, Orbiter, and SSME.

3.2.2.1.15 ET Venting

3.2.2.1.15.1 O_2 Venting

The O_2 vent system shall not interface with the Orbiter but shall vent directly to atmosphere via a facility vent line. In addition to providing ET relief protection, the vent valves shall be capable of being actuated open, prior to launch, by ground command. The electrical command and pneumatic supply will be provided by GSE. Capability shall be provided to monitor the main propulsion LOX system pressure when either vehicle or ground power is applied to the flight instruments.

3.2.2.1.15.2 H_2 Vent

The H_2 vent system shall be capable of venting the maximum steady state boil-off from the H_2 ET to limit the tank pressure to 16.0 psia maximum (including facility back pressure) at a maximum sea level ambient pressure of 15 psia during the replenish mode of the tanking operation. On the launch pad, the H_2 vent system shall be connected to a facility line for safe disposal. Facility back pressure at the facility/ET interface shall not exceed 0.5 psig maximum at a boil-off rate of 2.9 lbs/sec. The H_2 vent system shall not interface with the Orbiter but shall vent directly to atmosphere in flight. In addition to providing ET relief protection, the vent valves shall be capable of being actuated open, prior to launch, by ground command. The electrical command and pneumatic supply will be provided by GSE. Capability shall be provided to monitor the main propulsion LH_2 system pressure when either vehicle or ground power is applied to the flight instruments.

3.2.2.1.16 Oxygen Compatibility

Materials used internally in the Space Shuttle main propulsion oxygen subsystems shall be oxygen compatible as determined by NHB 8060.1A, Flammability, Odor and Offgassing Requirements and Test Procedures for Materials in Environments that Support Combustion.

3.2.2.1.17 Design Environments

3.2.2.1.17.1 Natural Environment

The Shuttle Flight Vehicle design shall satisfy the natural environment design requirements specified in NSTS 07700, Volume X - Book 2, Appendix 10.10. An exception

shall be permitted for flight hardware design capability that does not satisfy NSTS 07700, Volume X - Book 2, Appendix 10.10, natural environments derived for a maximum pad stay time (reference Paragraph 3.2.1.2.11) and operational procedures shall be used to supplement element design capability to satisfy these environments.

3.2.2.1.17.1.1 Resistance to the Effects of Radiation

Shuttle avionics shall meet performance and operability requirements while operating within the natural radiation environment, as specified in NSTS 07700, Volume X - Book 2, Appendix 10.10, of ascent, entry, and on-orbit flight phases. All radiation effects, such as, Single Event Upset (SEU), latchup, and burnout shall be considered. This paragraph shall apply to new designs with an Authority to Proceed (ATP) after November 4, 1992. This requirement shall be considered for hardware modifications that increase the susceptibility to radiation.

3.2.2.1.17.2 Induced Environment

Each element of the Space Shuttle and its structural interfaces shall be capable of withstanding the incurred environment imposed during transportation, ground operation, and flight operation as defined in NSTS 07700, Volume X - Book 2, Appendix 10.11, except for the as-built Orbiter, which will be operationally constrained to the capabilities defined in NSTS 08934, Space Shuttle Operational Data Book, Volume VII, Orbiter Ascent Structure Envelopes. Operational procedures may be used to supplement element design capability to satisfy environments derived for a maximum pad stay time (reference Paragraph 3.2.1.2.11).

3.2.2.1.17.2.1 Ascent Heating Design Criteria

In general, all elements of the SSS shall be designed to withstand limiting induced ascent aerodynamic and plume heating environments, encompassing all baseline reference missions. The Orbiter Vehicle for which limit ascent aerodynamic heating environments coupled with reuse criteria would result in unnecessary weight and cost penalties, shall be designed to meet reuse requirements considering the frequency of occurrence of the ascent heating environments resulting from statistical treatment of the baseline reference missions and shall be shown to have single-mission survivability for limit ascent aerodynamic heating case encountered on any mission during the lifetime of the vehicle. The applicable environments are defined in NSTS 07700, Volume X - Book 2, Appendix 10.11.

3.2.2.1.17.2.2 ET Entry Heating (ET-71 thru ET-999)

To ensure safe disposal of the ET and a safe separation distance between the Orbiter and ET, the ET shall be designed to meet the requirements outlined in Paragraph

3.3.3.2.8 for the normal and intact abort ascent and entry heating. The heating environments are defined in NSTS 07700, Volume X - Book 2, Appendix 10.11.

3.2.2.1.17.3 TPS Absorption

All TPS material and installation design shall minimize absorption and entrapment of liquids or gases which would degrade thermal or physical performance or present a fire hazard (wicking), and shall not require draining, drying or any dedicated purge system from refurbishment through launch, except for the inadvertent exposure to rain after flight and before rewaterproofing.

3.2.2.1.18 Flow Induced Vibration

All metal flexhoses and bellows shall be designed and certified to exclude or minimize flow induced vibrations in accordance with the requirements in NSTS 08123, Certification of Flexible Hoses and Bellows for Flow Induced Vibration. The OMS low pressure solenoid valve is excluded from this requirement.

3.2.2.1.19 Cross Contamination

Cross contamination of SSS elements, such as SRB jettisoning engine plume impingement on the Orbiter, shall be minimized.

3.2.2.1.20 Flight Element Mating Design Characteristics

3.2.2.1.20.1 ET/SRB Joints

The joint concept for ET/SRB utilization shall be capable of:

a. Assembly without internal access to ET.

b. Assembly with access sufficient to:

   1. Easily verify alignment of mating interface

   2. Easily join (with positive engagement) the mating joint

c. Assembly without requirement for makeup of explosive devices during mating.

d. Assembly allowing use of a nominal “0” moment joint in the ET interstage.

e. Assembly allowing unrestrained rotation in the Orbiter/ET plane.

f. Assembly within the operational timeline.

g. Accommodating shrinkable induced loads caused by ET cryogen loading and SRB expansion.

h. Restricting SRB pitch misalignments, both SRBs deflected symmetrically, to ± 0.25° maximum during launch and boost in flight, for aerodynamic performance and flight control considerations.

i. Restricting SRB yaw misalignments to ± 0.25° maximum during launch and boost in flight, for aerodynamic performance and flight control considerations.

3.2.2.1.20.2 Orbiter/ET Joints

The joint concept for Orbiter/ET utilization shall be capable of:

a. Restricting Orbiter pitch misalignments to ± 0.25° maximum during launch and mated flight operations, for aerodynamic performance and flight control considerations.

b. Restricting Orbiter yaw misalignments to ± 0.25° maximum during launch and mated flight operations, for aerodynamic performance and flight control considerations.

3.2.2.1.21 Instrumentation Calibration Data

The flight system instrumentation shall condition signal output data to follow specified theoretical or model characteristic curves. The output signal shall be within a specified error band of the characteristic curve. Deviation from this standard shall be allowed only where necessary to meet instrumentation accuracy requirements.

3.2.2.1.22 Flight Termination System Design

A ground-commanded flight termination system shall be provided on the SRBs to destruct the SRBs. There is no risk to the public if ET propellants are not dispersed for all inclinations (28.5 - 57 degrees) after SRB separation. SRB system components shall be reusable where cost savings will result. The ET design shall provide for flexibility, by add-on or removal of components, where possible. The system shall not require any action by the crew to operate.

3.2.2.1.22.1 (Deleted)

3.2.2.1.22.2 Destruct Safing

The SRB destruct systems shall be safed electronically and mechanically prior to normal SRB separation by an automatic signal from the Orbiter so that destruct action cannot occur and the SRBs are safe for recovery/retrieval operations. The mechanical safing shall provide a physical interruption of the ordnance train.

3.2.2.1.22.3 Command System

The flight termination system radio command system shall utilize a separate, secure flight code for each arm and fire command so configured that continuous transmission of unauthorized command messages for 30 minutes would allow not more than one chance in one million of a valid command being accepted. The operational ground and flight codes shall be classified and preflight testing shall be accomplished without radiating the operational codes.

3.2.2.1.22.4 Range Safety Abort Light

Receipt of an “arm” command by the range safety flight termination system shall illuminate an Orbiter display light to warn the crew.

3.2.2.1.22.5 Realtime Telemetry

The Orbiter shall provide realtime RF transmission of range safety system telemetry parameters through ascent.

3.2.2.1.23 Critical Speeds

Rotating machinery essential to crew or vehicle survival shall be free from dynamic divergence. Hardware with a ratio of shaft horsepower to shaft weight less than 50 horsepower per pound, or operating below 100 Hz are exempt. Effects of temperature, fluids, shaft load, imbalance, support stiffness, and load factor shall be considered in critical speed assessments. Each project element shall determine margin at steady operating speed.

3.2.2.1.24 Preloaded Bolts

Preloaded bolted joints designed after September 1, 1989, shall be in accordance with NSTS 08307, Criteria for Preloaded Bolts. Designs in progress prior to the effective date have the option of using these criteria.

3.2.2.2 Ground System Design

The ground system shall be designed to withstand or be protected from the effects of the natural environments defined in NSTS 07700, Volume X - Book 2, Appendix 10.10, in addition to the requirements outlined in the following paragraphs.

3.2.2.2.1 Ground Facilities

New ground facilities (after July, 1989) shall be designed in accordance with NHB 7320.1, Facilities Engineering Handbook.

Facility cranes, hoists and lifting devices shall be designed in accordance with applicable American National Standards Institute (ANSI) and Occupational Safety and Health Administration (OSHA) standards. In addition, the design of cranes, hoists and lifting devices shall be in accordance with NSS/GO 1740.9, NASA Safety Standard for Lifting Devices and Equipment.

Deviation/Waiver 580 is applicable to Paragraph 3.2.2.2.1.
Refer to Book 4, Active Deviations/Waivers.

3.2.2.2.2 Ground Support Equipment (GSE)

GSE required by the Shuttle Ground Operations Systems shall be designed in accordance with SW-E-0002, Space Shuttle Ground Support Equipment General Design Requirements.

Deviation/Waiver 654 is applicable to Paragraph 3.2.2.2.2.
Refer to Book 4, Active Deviations/Waivers.

3.2.2.2.3 (Deleted)

3.2.2.2.4 (Deleted)

3.2.2.2.5 (Deleted)

3.2.2.2.6 GSE Control and Monitoring

When hazardous operations or safety dictates, servicing equipment and GSE used during test and launch operations shall interface with ground stations to provide for control and status monitoring.

TABLE 3.2.2.1.5.2

ULTIMATE FACTORS OF SAFETY

Components	Factors of Safety Ultimate	
General structure and main propellant tanks	≥ 1.40	(A) (G) (H) (I) (J) (L) (M) (N)
Pressurized windows		(B)
A. Annealed panes		
Initial F. S.	≥ 2.0	
Final F. S.	≥ 1.0	
B. Tempered panes		
Initial F. S.	≥ 2.0	
Final F. S.	≥ 2.0	
Pressurized manned compartments	≥ 1.5	
Pressure alone	≥ 1.5	
Main propellant tanks ET and SRB (pressure alone)	- - -	(C) (H)
Pressure vessels (other than main propellant tanks)	≥ 1.5	(A) (B) (K)
Pressurized lines and fittings		
Less than 1.5 in. diameter	≥ 4.0	(E) (F)
1.5 in. diameter or greater	≥ 1.5	

(A) Reference Paragraph 3.2.2.1.6.

(B) Reference Paragraph 3.2.2.1.8.

(C) Factor of safety specified in element Contract End Item (CEI) and as determined by Paragraph 3.2.2.1.8.

(D) (Deleted).

(E) Design of hydraulic systems shall be in accordance with MIL-H-5440F.

(F) Lines and fittings of less than 1.5 in. diameter may be designed to a minimum factor of safety of 1.5, where advantageous to the Shuttle Vehicle, providing the rigor of design analysis and verification testing performed is equivalent to that applied to other critical systems/components. Whenever the exception allowed by this paragraph is utilized by an element, the affected system/components shall be identified along with a brief description of the analysis and testing applied in order to justify adequacy and acceptability of the lower factor of safety. All exceptions must be approved by the Manager, Space Shuttle Program.

TABLE 3.2.2.1.5.2

ULTIMATE FACTORS OF SAFETY - Continued

(G) The design of the landing gear system shall be in compliance with the following structural loads design criteria:

*

Loading Condition	Loads Definition	Factor of Safety	Material Allowable
Landing Touchdown Loads	Design	1.0	Yield
Rollout and Ground Handling	Limit	≥ 1.4	Ultimate

* From MIL-A-8862, Airplane Strength and Rigidity Landplane Landing and Ground Handling Loads, Paragraph 3.1.3

(H) SRB general structure and SRB case - before separation and during BSM firing, the ultimate factor of safety shall be equal to or greater than 1.4, except reused stiffener segment stubs which are certified safe for flight by proof testing. After BSM firing, the ultimate factor of safety shall be equal to or greater than 1.25.

(I) For the ET the factor of safety for highly predictable quasi-static loads shall be equal to or greater than 1.25. Examples of such loads are steady thrust, inertial loads from steady acceleration, and weight. Thus the combined factor of safety requirement for ET structure subjected to quasi-static and not quasi-static loads is determined by:

TABLE 3.2.2.1.5.2

ULTIMATE FACTORS OF SAFETY - Concluded

$$FOS = \frac{(\%\ QUASI\text{-}STATIC)}{100\%} \times (1.25) + \frac{(\%\ NOT\ QUASI\text{-}STATIC)}{100\%} \times (1.4)$$

For ascent, the combined factor of safety shall be limited to a quasi-static load range of 75% to 100%. For quasi-static loads less than 75%, the factor of safety shall be 1.4. Therefore, the combined factor of safety can range from 1.25 to 1.29 for quasi-static loads ranging from 100% to 75% and is 1.4 for quasi-static loads ranging from 74% to 0. The factor of safety requirement may be determined individually for each hardware component.

(J) For the induced environments specified in NSTS 07700, Volume X - Book 2, Appendix 10.11, a factor of safety greater than or equal to 1.35 shall be acceptable for the ET/SRB forward separation bolt.

(K) This includes any component which is required by design intent to function as a pressure container following a failure in a primary pressure barrier.

(L) For preload operations, the ultimate factor of safety of the SRB holddown stud shall be equal to or greater than 1.25, based on an ultimate strength of 180,000 pounds per square inch. The factor of safety on yield shall be equal to or greater than 1.10 during preloading based on a yield strength of 150,000 pounds per square inch. Each SRB holddown stud shall be load tested to at least 1,218,000 pounds but no more than 1,228,000 pounds and not experience detrimental yielding. (Effective for STS-37, STS-39, STS-40, STS-42, and subsequent missions.)

(M) The ultimate factor of safety of the GH_2 vent separator bolt shall be greater than or equal to 1.30. The 1.30 factor of safety is based on a minimum separator bolt break force of 7,500 pounds at ambient temperature.

(N) The ET LH_2 aft dome shall be designed for stability using $K_1 = K_2 = 1.25$.

Deviation/Waiver 662 is applicable to Table 3.2.2.1.5.2.
Refer to Book 4, Active Deviations/Waivers.

TABLE 3.2.2.1.13

PROPELLANT LOADING ACCURACIES

	LO_2	LH_2
Level Control	± 0.09%	± 0.22%
Tank Volume	± 0.30%	± 0.18%
Propellant Density	± 0.28%	± 0.22%
Sensor Location	± 0.01%	± 0.01%
Wave Action and Surface Perturbations	± 0.07%	± 0.08%
Total RSS	± 0.43%	± 0.37%

FIGURE 3.2.1.6.2

ORBITER WEIGHT AND CENTER-OF-GRAVITY DESIGN ENVELOPE - FERRY

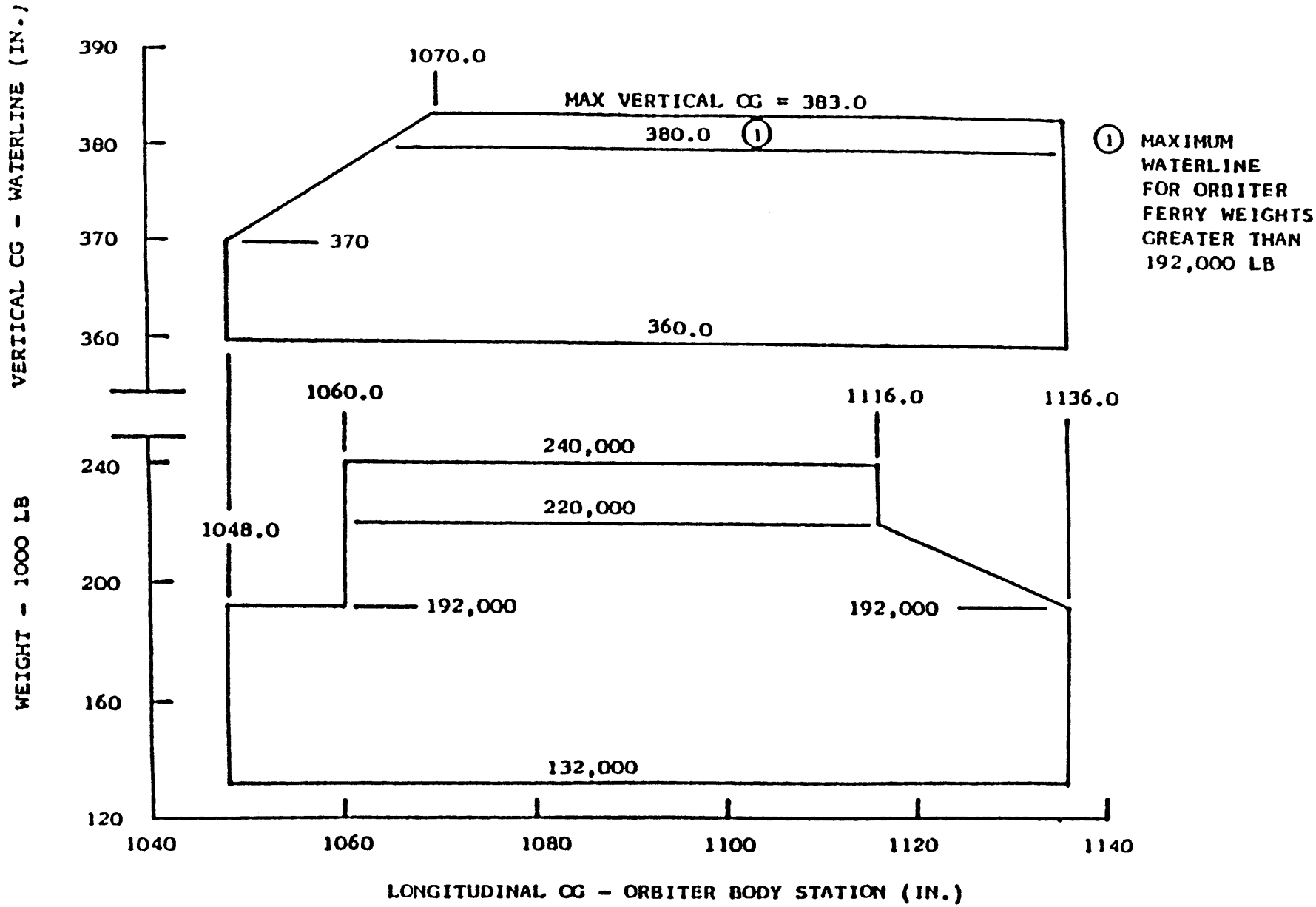
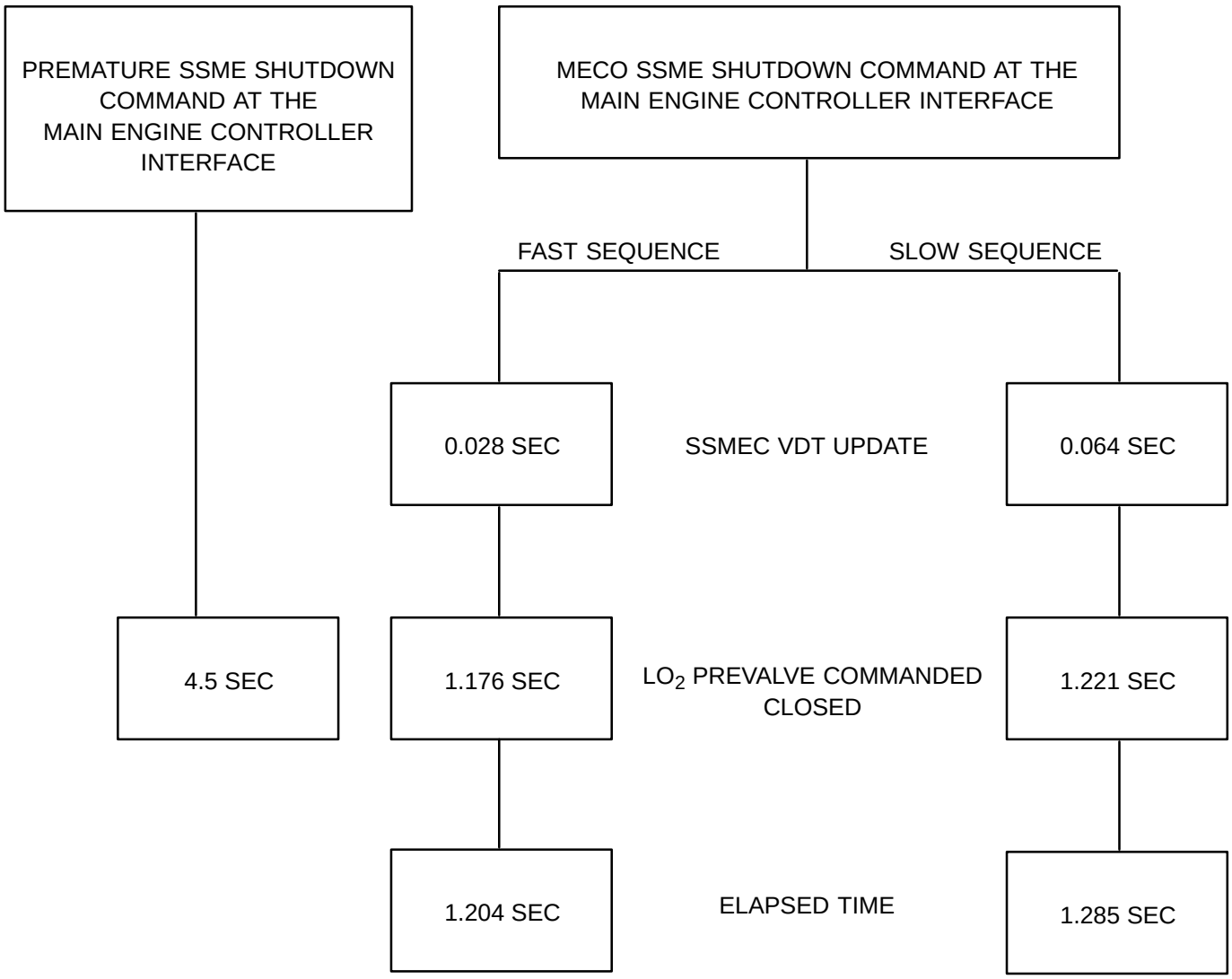


FIGURE 3.2.2.1.2.2

SHUTTLE SYSTEMS AVIONICS MAIN ENGINE SHUTDOWN EVENTS, TIMING CONSTRAINTS



3.2.3 Logistics

Shuttle System logistics requirements are specified in NSTS 07700, Volume XII, Integrated Logistics Requirements.

3.2.4 Personnel and Training

Shuttle System personnel and training requirements are specified in NSTS 07700, Volume XII.

3.2.5 Shuttle System Interface Characteristics

3.2.5.1 Shuttle System Interface with Communications and Tracking Functions

The Shuttle System shall interface with the communications and tracking functions as defined in the following ICDs:

a. ICD 2-0A004, Space Shuttle Systems/KSC RF Communications and Tracking Interface Control Document

b. ICD 2-0D003, JSC/USAF Space Shuttle/SCF RF Communications and Tracking Interface Control Document

c. ICD 2-0D004, JSC/GSFC Space Shuttle RF Communications and Tracking Interface Control Document

3.2.5.1.1 Range Safety Realtime Data

Specific telemetered Shuttle position data and systems measurements will be provided to the Eastern Space and Missile Center (ESMC) range safety officer's facility in realtime from prelaunch through ascent. The Shuttle Vehicle-to-ground Range Safety System interface is defined by ICD 2-0H001, Shuttle Vehicle/Ground Range Safety System Interface Control Document.

3.2.6 Shuttle System Measurement Requirements

3.2.6.1 Master Measurement List for the Space Transportation System

The Master Measurement List for the Space Transportation System is a product of MAST II. The MAST II data deliverable products are defined in JSC 18206, Shuttle Data Integration Plan, Volume III.

3.2.6.1.1 (Deleted)

3.2.6.2 (Deleted)

3.2.7 (Deleted)

3.2.7.1 (Deleted)

3.2.8 (Deleted)

3.2.8.1 (Deleted)

3.2.9 (Deleted)

3.2.9.1 (Deleted)

3.2.10 Operations and Maintenance Requirements and Specifications (OMRS)

All preflight, flight and post-flight assembly level maintenance, servicing, inspection, time/age/cycle, performance analysis, trending, and functional validation and checkout requirements for flight elements, payloads, and ground systems shall be defined in NSTS 08171, Operations and Maintenance Requirements and Specifications Documents (OMRSD). Requirements for design, construction, assembly and installation shall be defined by released engineering and not within the OMRSD.

3.2.10.1 File I - Introduction OMRSD

This file contains the purpose, scope, and policy of the OMRS. It includes descriptions of the document structures, contents, numbering system format, change procedure, and groundrules for the content and its changes.

3.2.10.2 File II - STS Integrated OMRSD

This file contains all the requirements which cross flight element (Orbiter, ET, SSME, SRB, Payloads/Shuttle experiments) interfaces for mechanical, fluid, electrical and functional verification, closed-loop control system test, integrated vehicle tests, cargo integration test equipment interface verification and special payload/Shuttle equipment requirements. Also included are the requirements for NASA provided mission kits and services which interface with or provide support to payloads. This file also contains the requirements for limited life/time/cycle for Orbiter, ET, SSME, and SRB elements. Mid-deck payloads/Shuttle experiments Time-critical Ground Handling Requirements (TGHRs) shall be defined in the TGHR table and not within the OMRSD.

3.2.10.3 File III - Orbiter OMRSD

This file contains all ground operation requirements for Orbiter systems including SSME and for Orbiter-to-ground interfaces. Also included are requirements for Orbiter (non-payload) mission kits and Orbiter experiments.

3.2.10.4 File IV - External Tank OMRSD

This file contains all ground operation requirements for ET systems and for ET-to-ground Interfaces.

3.2.10.5 File V - Solid Rocket Booster OMRSD

This file contains all ground operation requirements for SRB systems and for SRB-to-ground interfaces. Also included are requirements for retrieval and disassembly operations.

3.2.10.6 File VI - Ground System OMRSD at KSC

This file contains the requirements to verify and maintain support equipment/facility ground systems at KSC.

3.2.10.7 File VII - Spacelab OMRSD

This file contains all stand-alone requirements to verify Spacelab Systems and Spacelab System-to-ground interfaces.

3.2.10.8 File VIII - Shuttle Payloads and Payload Carriers (Non-Spacelab) OMRSD

This file contains all stand-alone requirements for all payloads and payload carriers, except Spacelab, to verify systems within and Systems-to-ground interfaces.

3.2.10.9 File IX - Data Collection and Analysis OMRSD

This file contains the Space Shuttle elements data collection and analysis requirements for in-flight checkout verification, engineering photography analysis and introduction/ guidelines for File IX requirements buildup.

NOTE: In-flight checkout verification requirements are performed in lieu of the systems ground turnaround checkout requirements to reduce ground turnaround operations.

3.2.10.10 File X - International Space Station (ISS) OMRSD

This file contains the stand-alone requirements for the ISS to verify systems within and systems-to-ground interfaces.

NOTE: The structure of this file will be controlled through NSTS 08171, OMRSD, File I, with approval in accordance with NSTS 07700, Volume IV - Book 1, Configuration Management Requirements, Requirements, Paragraph 4.3.2.1.1d.

Approval authority for requirement changes within NSTS 08171, OMRSD, File X, will be controlled through ISS program documentation.

3.2.11 (Deleted)

3.2.11.1 (Deleted)

3.2.12 (Deleted)

3.2.12.1 (Deleted)

3.2.13 (Deleted)

3.2.13.1 (Deleted)

3.2.14 (Deleted)

3.2.14.1 (Deleted)

3.2.15 (Deleted)

3.2.15.1 (Deleted)

3.2.16 (Deleted)

3.2.16.1 (Deleted)

3.2.17 (Deleted)

3.2.17.1 (Deleted)

3.2.18 (Deleted)

3.2.18.1 (Deleted)

3.2.19 (Deleted)

3.2.19.1 (Deleted)

3.2.20 (Deleted)

3.2.20.1 (Deleted)

3.3 SHUTTLE VEHICLE END ITEM PERFORMANCE AND DESIGN CHARACTERISTICS

3.3.1 Orbiter Vehicle Characteristics

3.3.1.1 Orbiter Performance Characteristics

3.3.1.1.1 Pointing Accuracy

For payload pointing purposes, the Orbiter Vehicle shall be capable of attaining and maintaining any desired inertial, local vertical, earth surface pointing, or orbital object pointing attitude within the thermal constraints defined in Paragraph 3.2.1.1.12. The GN&C shall have the capability to point any vector defined in the IMU navigation base axis system to within ± 0.5° of the desired attitude, other than for orbital object pointing. For payload pointing utilizing the vernier RCS, the Orbiter FCS shall provide a stability (deadband) of ± 0.1 deg/axis and a stability rate (maximum limit cycle rate) of ± 0.01 deg/sec/axis when no vernier RCS thrusters are failed. When using the large RCS thrusters, the Orbiter FCS shall be capable of providing a stability of ± 0.1 deg/axis and a stability rate of ± 0.2 deg/sec/axis.

3.3.1.1.2 (Deleted)

3.3.1.1.3 Rendezvous with Passive Target

The Orbiter Vehicle, by using ephemeris data from ground facilities and onboard sensors and computation, shall be capable of rendezvous with a passive, stabilized orbiting element. Onboard RF tracking sensor information shall be provided for ranges equal to or less than 19 km for a target whose effective RF cross-sectional area is one square meter. The passive target sensor weight shall be a part of the Orbiter and shall assess no weight or volume penalty to the payload.

3.3.1.1.4 Crew Controlled Docking

The Orbiter Vehicle shall have a crew controlled capability to rendezvous, dock, and undock with stabilized orbiting element during daylight and eclipse portions of the orbit. In order to perform these Orbiter operations, the Orbiter crew shall have realtime insight into the status and health of the target vehicle. This realtime information shall be provided to the Orbiter crew via ground controllers, via crew members onboard the target vehicle, or via a direct telemetry link between the Orbiter and target vehicle. The Orbiter crew, target vehicle crew, and/or ground controllers shall have the capability to command functions on the target vehicle necessary to safely accomplish docking and subsequent undocking. Docking contact conditions are specified in Table 3.3.1.1.4.

3.3.1.1.5 Ranging Requirements

The Orbiter Vehicle shall have the crossrange (see Paragraph 6.1.6) capability to return to any premission selected nominal, alternate, or intact abort landing site supported by

NSTS 07700, Volume X - Book 3, Space Shuttle Flight and Ground System Specification, Requirements for Runways and Navigation Aids, Appendix 10.17, Requirements for Runways and Navigation Aids, for orbital inclinations from 28.5 to 104°, inclusive. Provision shall be made for downrange maneuver capability accounting for the effects of deorbit, entry guidance and entry dispersions, including navigation, aerodynamic, atmospheric, and weight uncertainties. The capability shall be consistent with that which is achievable from the program baselined entry Angle of Attack (AOA) profile of 40.0° from any orbit.

3.3.1.1.6 Orbiter Payload Integration

The SSS shall provide for payload removal or installation including replacement of removed payloads by identical payloads with the Orbiter Vehicle in the vertical position on the launch pad. At all other locations, payloads shall be installed and removed with the Orbiter Vehicle in the horizontal position. Both of the installation operations (horizontal or vertical) shall be considered baseline and each consistent with the current timeline allocations. Payloads will have a standard ground handling interface.

3.3.1.1.7 Payload Bay/Payload Access

a. Physical Access in OPF Station - The Orbiter Vehicle and ground system facility shall provide access to the payload bay and the payload through the Orbiter crew compartment and by opening the PLBD.

b. Physical Access in VAB Integration Cell Station - The Orbiter Vehicle and ground system facility shall provide access to the payload bay and the payload through the Orbiter crew compartment. Any special provisions for personnel access in the payload bay shall be provided by payloads.

c. Physical Access at Launch Pad Station:

   1. Horizontally Installed Payloads - Launch pad access to horizontally installed payloads is not normally planned, however, the Orbiter Vehicle and ground facilities shall provide contingency access capability to the payload through the PLBDs.

   2. Vertically Installed Payloads - The Orbiter Vehicle and ground facility shall provide access to the payload through the PLBDs until start of PLBD closing.

   3. Late Access to Payload Bay - Late access for unique servicing and adjustment of payload elements is possible through the PLBDs. Payload bay doors must be closed prior to the beginning of countdown operation.

   4. Mid-deck Payloads - The Orbiter Vehicle shall provide access to the mid-deck payloads through the Orbiter crew compartment hatch.

5. Equipment used for access or servicing through the PLBD shall be designed to facilitate a PLBD closure within four hours for severe weather condition predictions and safing.

d. Physical Access at EOM Landing Sites - The Orbiter Vehicle and ground system facility shall provide access to the payload bay through the crew compartment at the prime landing site and secondary landing site, if required, at landing plus four hours.

3.3.1.1.8 Orbiter Landing

For Orbiter return, the Orbiter Vehicle shall be capable of operating into airfields that have runways equivalent to 12,500 feet long and 150 feet wide at sea level on a hot day (103°F). The Orbiter Vehicle shall be designed to land on such runways, allowing for hot temperatures, damp surfaces with no standing water, and the wind conditions specified in NSTS 07700, Volume X - Book 2, Appendix 10.10. NSTS 08192, Math Models of Friction Characteristics for Orbiter Main and Nose Gear Tires, defines the math model of friction characteristics for Orbiter main and nose gear tires. The Orbiter shall also have the capability to land under manual control.

3.3.1.1.9 Orbiter Vehicle Landing Weight

The Orbiter Vehicle shall be capable of landing without exceeding limit capability as defined in NSTS 08934, Space Shuttle Operational Data Book, Volume V, Orbiter Flight Capability, for the environmental conditions specified in NSTS 07700, Volume X - Book 2, Appendix 10.10, and the following maximum conditions.

Flight Phase	Inclination			
	28.5 deg	39.0 deg	51.6 deg	57.0 deg
RTLS	248k lbs	248k lbs	245k lbs	242k lbs
TAL	248k lbs	248k lbs	244k lbs	241k lbs
AOA/ATO	248k lbs	248k lbs	242k lbs	239k lbs
EOM	233k lbs	233k lbs	233k lbs	233k lbs

In addition to the weight limitations listed above, the Orbiter Vehicle shall be capable of landing without exceeding the following maximum conditions which are not inclination or phase dependent:

Vehicle Weight at Landing (k pounds)	Main Gear Sink Rate (ft/sec) for 0 kts Crosswind	Main Gear Sink Rate (ft/sec) for 20 kts Crosswind	TAEM Maneuver
Wt ≤ 211	9.6	6.0	2.5 G
211 < Wt < 240	linear function of wt	linear function of wt	linear function of wt
Wt ≥ 240	6.0	5.0	2.1 G

In the event that a payload is not deployed as planned, the Orbiter shall be capable of returning the payload from orbit. These Unplanned Payload Return (UPR) aborts do not require immediate deorbit, but may prevent the completion of mission objectives. Operational techniques will be employed to minimize descent thermal effects for UPR aborts which exceed the nominal EOM thermal limits. These techniques will be defined and prioritized in mission specific flight rules. A waiver is not required for UPR down weight exceedances.

3.3.1.1.10 Extended Missions

The basic Orbiter Vehicle design shall not preclude the capability to extend the orbital stay time up to a total of 20 days. This requirement shall not affect the cabin size. Provisions shall be made to configure the Orbiter that, with the appropriate mission kits, will be capable of performing an extended mission for 18 days + 2 days wave off. For all extended missions (greater than 10 days) with no additional habitable volume, the impact of crew size, shift, and payload operations, on available stowage and habitable volume will be a consideration in the mission integration process.

3.3.1.1.11 Passive Control Mode

For those payload experiment operations requiring essentially zero g translational accelerations with no attendant pointing requirements, the Orbiter shall be capable of operating in a passive (free drift with jets inhibited) control mode within the Orbiter thermal constraints defined in Paragraph 3.2.1.1.12.

3.3.1.1.12 Payload Deployment Operations

During payload deployment operations, the payload will be capable of sustaining loads imposed by the Shuttle as a result of RCS attitude control. However, options shall be provided to inhibit RCS under certain payload deployment operations requirements. The definition of the FCS for RCS attitude control including any restrictions or inhibits

will be contained within the appropriate Payload Integration Plan (PIP). Reference NSTS 07700, Volume XIV, Paragraph 8.1.1 for RMS requirements.

3.3.1.2 Orbiter Design Characteristics

3.3.1.2.1 Structure and Mechanical Subsystems

3.3.1.2.1.1 Cabin Size

The cabin shall be designed to accommodate a total crew of seven. The design shall not preclude installation of crew support equipment for a total of 10 crew members as would be required to implement an Orbiter-to-Orbiter rescue. Shuttle System weight and performance control shall be per Paragraph 3.1.3.

3.3.1.2.1.2 Payload Accommodations

3.3.1.2.1.2.1 Payload Envelope

A 15-foot diameter and 60-foot long payload envelope shall be provided in the Orbiter payload bay. For flight events, this payload envelope distorts due to Orbiter thermal and dynamic deflections. The resulting payload envelope is a 15-foot diameter circle at each Orbiter XO station with the center of the circular envelope located at the distorted Orbiter centerline. This distorted Orbiter centerline is defined by displacing the undistorted centerline by the average motion of the right and left Orbiter longerons for each XO station. Payload thermal and dynamic deflections and all payload protrusions, except the payload attachment fittings, shall be contained within the payload envelope. Payload attachment fittings, shall extend beyond the payload envelope in order to mate with the Orbiter attachment fittings which are outside of the payload envelope. Umbilicals required to interface the payloads to the Orbiter or to GSE while the payload is in the payload bay may also penetrate the payload envelope. Any exceptions to the payload envelope will be documented in NSTS 07700, Volume XIV, Attachment 1 (ICD 2-19001).

3.3.1.2.1.2.1.1 Payload Bay Clearance

The clearance between the payload envelope and the Orbiter Vehicle structure and subsystems shall be provided by the Orbiter. This clearance will prevent interference between the payload and Orbiter due to Orbiter deflection caused by the induced environment and during payload deployment. Payloads are constrained to the payload envelope, when subjected to the induced environment during the complete mission, beginning with payload installation and ending with payload deployment or removal.

3.3.1.2.1.2.1.2 Payload Viewing

The Orbiter shall have the capability of exposing the entire length and the full width of the payload bay. With the PLBD(s) and radiator(s) open, an unobstructed 180° lateral field of view shall be available above the payload bay door frame and associated mechanism.

3.3.1.2.1.2.2 CG Envelopes for Total Cargo

The Shuttle Vehicle aerodynamic stability requirements constrain the vehicle CG to remain within the limits established in Paragraph 3.3.1.2.1.5 of this document. The total cargo CG must therefore be constrained to ensure the vehicle CG limits are not violated. The allowable total cargo CG envelopes are defined in NSTS 07700, Volume XIV, Attachment I (ICD 2-19001, Paragraph 4.1.4, Mass Properties Characteristics of Total Cargo).

3.3.1.2.1.2.3 Payload/Vehicle Dynamic Interfaces

Payload/vehicle dynamic interactions shall be minimized through proper design procedures. The Orbiter/payload combination shall be based on the payload frequency constraints contained in NSTS 07700, Volume XIV, Attachment 1 (ICD 2-19001).

3.3.1.2.1.2.4 Ku-Band Radiation Environment

The maximum Orbiter generated RF field intensity incident on payloads in the cargo bay during orbital operations shall not exceed 10 volts/meter. The Orbiter shall provide software controlled limits on the Ku-Band antenna to preclude the irradiation of payloads in the cargo bay in excess of this field intensity. An override capability will be provided for missions with payloads which have maximum power density limitation (greater than 301 volts per meter). During deployment and retrieval, operational procedures will be used to ensure the RF field intensity limit is not exceeded. Payloads which cannot tolerate 10 volts/meter will require special provisions.

3.3.1.2.1.3 Mating System

The Orbiter Vehicle shall include a mating system, when required, for mating to International Space Station Alpha (ISSA) or other compatible spacecraft. The mating system shall be defined as the equipment required to be added to the basic Orbiter Vehicle to accomplish mating/demating and post-mating IVA crew and resource transfer and includes the on-orbit mating half of the vehicle. SSP mating system design and provisioning responsibilities with regard to specific programs and spacecraft shall be as defined in the following sub-paragraph(s):

a. International Space Station Alpha (ISSA). The SSP shall provide to the ISSA as GFE all mating system interface hardware to be mounted on the U.S. provided ISSA elements. Interface requirements for these hardware items shall be specified in NSTS 21000-IDD-ISS, Shuttle Orbiter/International Space Station Interface Definition Document.

3.3.1.2.1.3.1 Mating/Demating Methods

The mating system shall be the nominal means of Orbiter mating/demating to/from all compatible ISSA configurations having pressurized, habitable elements. The mating system shall be compatible with Solid Rocket Motors (SRMs) berthing/unberthing requirements as defined in NSTS 07700, Volume XIV.

3.3.1.2.1.3.1.1 (Deleted)

3.3.1.2.1.3.1.2 (Deleted)

3.3.1.2.1.3.2 General Design Requirements

Mating system equipment shall be designed to be installed and operated in conjunction with an airlock outside the crew module. The mating system equipment shall be designed to permit IVA crew transfer from the Orbiter to the mated spacecraft through the airlock. Mating system equipment shall be designed as a mission kit to permit installation and removal, as required, to meet mating mission objectives while minimizing weight impacts to non-mating missions. Mating system equipment shall only be required to be installed, checked out, and removed with the Orbiter in a horizontal position. The combined external airlock/mating system shall not extend aft of XO 701 under static conditions. Refer to NSTS 07700, Volume XIV, Attachment 1 (ICD 2-19001), and NSTS 21000-IDD-ISS for forward cargo envelope limits with the external airlock/mating system installed.

3.3.1.2.1.3.2.1 Lifetime and Maintainability Design Requirements

The Orbiter installed mating system equipment shall be designed for a 100-mission cycle life. Service and storage with normal preventative maintenance, repair, replacement or upgrading of components is allowable.

The ISSA installed mating system equipment supporting nominal mission docking operations shall be designed for a 100-mission cycle life and a 15-year life with no planned maintenance. All ISSA mating system components required only for contingency docking operations shall be designed for 20 mating cycles and a 15-year life with no planned maintenance.

Mating system equipment shall have a documented design-life extension certification program as defined in Paragraph 3.5.3.2. The Pressurized Mating Adapter will be designed as a returnable element to allow ground maintenance on the ISSA side in support of life extension requirements.

A mission cycle is defined as all ODS operations associated with one Orbiter launch to the next successful launch, consisting of the ground checkout, ascent, on-orbit operation, de-orbit, entry, landing, and post-landing Orbiter processing.

3.3.1.2.1.3.2.2 (Deleted)

3.3.1.2.1.3.2.3 (Deleted)

3.3.1.2.1.3.2.4 (Deleted)

3.3.1.2.1.3.3 Mating System Services and Resource Requirements

Payload integration and/or Orbiter services and resources for power and command/data may be used for mating system operation.

3.3.1.2.1.3.4 (Deleted)

3.3.1.2.1.3.5 Control and Monitoring

Mating system operations shall be controlled and monitored from the aft flight deck on-orbit station.

3.3.1.2.1.3.6 Termination of Operations

The mating system shall be designed to allow the Orbiter crew to safely terminate and/or reverse nominal mating/demating operations at any point during those operations, in a manner that will not preclude subsequent mating or demating.

3.3.1.2.1.3.7 EVA Egress and Ingress

Mating system design and operations shall provide the capability for EVA egress and ingress between the Orbiter airlock and the payload bay. The external airlock aft opening (with a 3.04 inch adapter installed and exclusive of the thermal hatch) shall extend no further aft than X_O=685.04 inches in the payload bay to provide an egress path.

3.3.1.2.1.3.8 Rendezvous and Proximity Operations Compatibility

Mating system design and operations shall be compatible with standard Orbiter rendezvous and proximity operations trajectories and procedures.

3.3.1.2.1.3.9 Visual Cues

The Orbiter crew shall be provided with a means of determining relative Orbiter/target vehicle mating system lateral and angular misalignments. Lateral cues shall be available from the beginning of the approach corridor until docking capture and angular cues shall be available from a minimum mating system separation range of 30 feet until docking capture.

Alignment reference targets for Orbiter-mounted sensor system(s) shall be provided for use on the target vehicle. Any Orbiter-mounted video cameras providing a Zo-axis line of sight for docking alignment shall be located such that the line of sight if within a 48-inch radius centered on the Orbiter docking system Xo-Yo centerline. Alignment of Orbiter-mounted docking alignment sensors and corresponding targets/markings on the target vehicle shall be as necessary to ensure the Orbiter crew can achieve the docking contact conditions specified in Table 3.3.1.1.4.

3.3.1.2.1.3.9.1 Contact Indication

Positive initial contact docking/undocking/failed docking indicators and/or visual cues shall be provided to Orbiter pilots for all mating/demating operations in both day and night conditions.

3.3.1.2.1.3.10 Mating and Demating Functional Requirements

The mating system shall provide the capability to mate the Orbiter to compatible spacecraft so as to establish structural, IVA crew transfer, and resource transfer connections. The first and second means of separation will not compromise the operational capability of the interface on the ISSA side. All mating system mate/demate functions shall be commandable from the Orbiter. Nominal mate/demate systems/equipment shall be located on the Orbiter. The ISSA mating system structural latches may be used for mating in a contingency after a single fault on the Orbiter.

3.3.1.2.1.3.10.1 Functional Performance Parameters

The mating system shall be capable of mating/demating the Orbiter having mass properties as defined in Table 3.3.1.2.1.3.10.1a to/from spacecraft having mass properties as defined in Table 3.3.1.2.1.3.10.1b. Interface contact conditions for mating capture and load attenuation equipment design shall be as specified in Table 3.3.1.1.4. The mating system shall be designed to limit the loads and moments imparted at the mating/demating interfaces, and limit the relative dynamic rotations to the values specified in Table 3.3.1.2.1.3.10.1, during all mating operations prior to structural latching and all demating operations following structural unlatching. Upon contact with ISSA, the Orbiter shall be in free drift. The Orbiter Primary RCS thrusters can be used to assist

capture. The ISSA shall be in attitude hold control mode until capture is complete. The Orbiter and ISSA shall be in free drift from capture complete until completion of structural mating operations. The Orbiter and ISSA shall also be in free drift during demating operations.

3.3.1.2.1.3.10.2 Clearances

The mating system equipment and operations shall be designed to provide the following minimum clearance between the Orbiter and the mating/demating spacecraft exclusive of mating system components designed to come into contact:

a. Prior to mating interface capture:
   - mating spacecraft to Orbiter Vehicle structure and/or subsystems: 24 inches

b. Following mating interface capture and prior to release:
   - mating spacecraft to Orbiter Vehicle structure and/or subsystems: 12 inches

c. During all demating operations following mating interface release:
   - mating spacecraft to Orbiter Vehicle structure and/or subsystems: 24 inches

Deviation/Waiver 688 is applicable to Paragraph 3.3.1.2.1.3.10.2.
Refer to Book 4, Active Deviations/Waivers.

3.3.1.2.1.3.10.3 Fault Tolerance

The mating system shall be single fault tolerant at a minimum to accomplish mating. EVA shall not be considered as a means of meeting this requirement. The mating system shall be dual fault tolerant at a minimum to accomplish demating (and allow subsequent Orbiter payload bay door closure) through the provision of at least two independent (no common cause failure mode) methods. EVA may be used as the third means of demating, but shall only be used after two failures have occurred.

Deviations/Waivers 636 and 673 are applicable to Paragraph 3.3.1.2.1.3.10.3.
Refer to Book 4, Active Deviations/Waivers.

3.3.1.2.1.3.10.4 (Deleted)

3.3.1.2.1.3.11 Mated Structural Requirements

In the fully mated configuration, the mating system components shall be designed to safely react planned combinations of the applied loads environments including, but not limited to, those listed below. Specific loads values for design purposes are defined in NSTS 21000-IDD-ISS.

a. IVA transfer pathway pressurization/depressurization

b. ISSA-controlled attitude control maneuvers

c. ISSA-controlled reboost and collision avoidance maneuvers
d. Shuttle Payload Deployment and Retrieval System (PDRS) operations
e. ISSA SS RMS and mobile transporter operations
f. Shuttle and ISSA EVA and IVA crew operations
g. Shuttle controlled attitude maneuvers
h. Other vehicle induced loads transmitted by docking at other ISSA docking locations

3.3.1.2.1.3.12 IVA Crew Transfer Capability

The mating system shall provide accommodations for post-structural-mating IVA (shirt-sleeve environment) transfer of crew and equipment between the Orbiter crew cabin and compatible mated spacecraft.

3.3.1.2.1.3.12.1 IVA Crew Transfer Pathway

The IVA crew transfer pathway shall be defined as consisting of all elements through which a crewperson must pass to move from the Orbiter crew cabin to the ISSA pressurized mating adapter/habitable element interface. The mating system elements, which form parts of the pathway, shall be configured to permit passage of IVA crew and shall meet the following requirements: minimum size for hatchways shall be the standard Orbiter D-shaped hatch opening (40 inch diameter by 36 inches across flat), minimum internal pathway diameter shall be 40 inches for translation through areas not requiring mobility aids (such as handrails), and 43 inches in areas requiring mobility aids. Exceptions shall be made for the forward external airlock adapter where electrical cables will restrict the available envelope to a minimum clearance of 34 inches diameter, for the forward tunnel where a fan muffler will restrict the available envelope to a minimum clearance of 32 inches diameter and for the APAS, which shall have a clear minimum internal diameter of 29.5 inches.

3.3.1.2.1.3.12.2 Transfer Pathway Environmental Control

The Orbiter shall provide all capabilities required to pressurize/depressurize evacuated portions of the pathway (including the Orbiter external airlock and the Pressurized Mating Adapter). Capability to verify pressure integrity and pressure equalization across hatches before opening shall be provided. The Spacecraft mated to the Orbiter shall provide backup or contingency capability to perform the above listed function. Either vehicle shall be capable of providing air flow across the SSP/ISSA interface within the transfer pathway. These air transfer quantities and conditions are defined in NSTS 21000-IDD-ISS. The transfer pathway atmosphere shall be maintained per the habitable atmosphere requirements of the spacecraft providing pressurization and/or air

circulation. The Orbiter crew module and mated spacecraft hatches at each end of the pathway shall both nominally be open during all IVA transfer operations. Drag-through air ducts which would require Orbiter airlock hatches to remain open may be utilized for transfer pathway environmental control. Redundant means shall be provided to remove drag-through ducts from hatchways. Specific details on transfer pathway environmental control interfaces with the ISSA are defined in NSTS 21000-IDD-ISS.

3.3.1.2.1.3.12.3 Transfer Pathway Element Survival and Operating Pressure

The mating system elements constituting the IVA crew transfer pathway shall be designed to survive and operate, as required, with on-orbit internal pathway pressures between 0 and 14.9 psia.

3.3.1.2.1.3.12.4 Pressure Vessel Design

Mating system transfer pathway pressure vessel elements shall be designed to an on-orbit limit pressure of 16.0 psia.

3.3.1.2.1.3.12.5 Safe Atmosphere Verification

Capability shall be provided for the Orbiter crew to extract and test an air sample from the non-airlock portion(s) of the transfer pathway using a GFE ACM, to verify that the atmosphere is safe for IVA ingress prior to opening Orbiter hatches between the airlock and the remainder of the pathway.

3.3.1.2.1.3.13 Post-Mating Resource Transfer

The mating system design shall provide accommodations for the post-mating transfer of electrical power (Orbiter-to-ISSA), two-way data, commands, (Orbiter-to-ISSA), two-way voice communication, two-way video, gaseous nitrogen and oxygen, air, and potable water between the Orbiter and compatible spacecraft. All electrical power transfer connectors and cables shall be located external to the mating system IVA crew transfer pathway. Command/data/voice/video communication umbilicals shall be automatically connected during the docking sequence. Manual IVA hookup of water lines within the IVA crew pathway may be utilized. N_2/O_2 transfers must be fail-safe and operationally confirmable as such, and all lines must comply with clear path requirements. Specific details on Orbiter-to-ISSA resource transfer items and interfaces are defined in NSTS 21000-IDD-ISS.

3.3.1.2.1.3.14 SSP-to-ISSA GFE Requirements

3.3.1.2.1.3.14.1 Design Environments

The mating system elements shall be designed to meet the natural and induced environments for ground operations, ascent/entry, and pre-ISSA installed on-orbit activities

as defined in NSTS 07700, Volume X, Space Shuttle Flight and Ground System Verification, for the Shuttle, NSTS 07700, Volume XIV, for the cargo elements, and Table 3.3.1.2.1.3.14.1, for the mating system post-ISSA installation.

3.3.1.2.1.3.14.2 (Deleted)

3.3.1.2.1.3.14.3 (Deleted)

3.3.1.2.1.3.15 (Deleted)

3.3.1.2.1.3.15.1 (Deleted)

3.3.1.2.1.3.15.2 (Deleted)

3.3.1.2.1.3.16 (Deleted)

3.3.1.2.1.3.16.1 (Deleted)

3.3.1.2.1.3.16.2 (Deleted)

3.3.1.2.1.3.16.3 (Deleted)

3.3.1.2.1.3.16.4 (Deleted)

3.3.1.2.1.3.17 (Deleted)

3.3.1.2.1.4 Payload Deployment and Retrieval Mechanism

The Orbiter Vehicle shall provide a payload deployment and retrieval mechanism which shall be stowed outside the 60-foot length by 15-foot diameter payload envelope.

Further information on the PDRS is available in NSTS 07700, Volume XIV.

3.3.1.2.1.4.1 Multiple Payload Deployment and Retrieval

Within the reach limits of the deployment/retrieval mechanism, the Orbiter Vehicle shall have the capability to deploy and retrieve single or multiple ($_5$) payload elements on-orbit during a single mission, including placement or docking of payloads to a stabilized body. In applying this requirement, payload attachment schemes shall be compatible with Orbiter capability for operating a minimum of 15 and a maximum of 29 active retention mechanism latches.

3.3.1.2.1.4.2 Payload Retention

An active retention and release mechanism for the payload shall be provided.

3.3.1.2.1.4.3 (Deleted)

3.3.1.2.1.4.4 Payload Contingency Retrieval

The payload deployment and retrieval mechanism shall have the capability to retrieve deployed/detached payloads, in a non time-constrained manner, weighing up to 65,000 pounds (29,484 Kg) and suitably configured for berthing into the Orbiter cargo bay.

3.3.1.2.1.4.5 ISSA Berthing/Unberthing

To support ISSA assembly operations, the payload deployment and retrieval mechanism shall be capable of berthing/unberthing the Orbiter to/from the ISSA having a mass up to 250,000 pounds with a center of mass offset of up to 47 feet from the grapple fixture to the center of mass of the element being manipulated. Specific requirements for interfaces and operations for these berthing/unberthing operations are defined in NSTS 21000-IDD-ISS and the mission-specific Mission Integration Plans for ISSA assembly flights.

3.3.1.2.1.5 Orbiter CG Limits

The Orbiter design control weights are specified in Paragraph 3.1.3.1.2.1 (Design Control Parameter - reference Paragraph 6.1.37). The nominal, mission specific Orbiter inert weight is specified in NSTS 09095. The longitudinal CG of the operational Orbiter Vehicle (Main Engines included), crew and provisions, and payload for entry initiation (MM-304 or MM-602) through landing shall be within the limits of 1075.2″ to 1109.0″ using Orbiter coordinates (64.88% to 67.5% of the Orbiter body length) for nominal EOM, ATO, AOA and contingency payload return and 1076.7″ to 1109.0″ (65% to 67.5%) for TAL and RTLS. However, the longitudinal CG for RTLS abort must be within the limits of 1079.0″ and 1109.0″ (65.18 and 67.5% of the Orbiter body length) between entry phase initiation (MM-602) and the point in the entry trajectory where the AOA is less than or equal to 30° (approximately Mach = 5.0).

In addition, the longitudinal and vertical CG of the operational Orbiter Vehicle (Main Engines included), crew and provisions, and payload at ET separation shall be within the limits defined in Tables 3.3.1.2.1.5.1, 3.3.1.2.1.5.2 and Figure 3.3.1.2.1.5.1. Table 3.3.1.2.1.5.1 shows the longitudinal and vertical CG limits for RTLS and TAL. Figure 3.3.1.2.1.5.1 depicts the No-Fail, AOA/ATO ET separation longitudinal and vertical CG constraints. The coordinates of the points which define this constraint are shown in Table 3.3.1.2.1.5.2. The vertical CG is constrained by Paragraph 3.2.1.1.16.2.

The Orbiter lateral CG variation shall be ± 1.5″ maximum for X CGs equal to or aft of 1076.7″ and will be restricted to ± 1.0″ maximum for X CGs forward of 1076.7″. The

Orbiter vertical CG shall be between waterline stations 360.0 and 384.5 (Orbiter coordinates) upon entry. For analysis purposes, an uncertainty of ± .5 inch in the lateral CG and ± 1 inch in the longitudinal and vertical CG shall be assumed.

3.3.1.2.1.6 TPS Design

The TPS shall be designed to accomplish the reference missions in Paragraph 3.2.1.1.3. On-orbit thermal conditioning for up to 12 hours prior to entry shall be accommodated for missions where the TPS temperatures exceed the design values associated with the one revolution missions. For emergency entry, where preentry thermal conditioning cannot be performed, structure over temperature from design values is allowed with the resulting degradation in vehicle service life.

3.3.1.2.1.7 Orbiter External Configuration

The Orbiter shall conform to the moldline envelope specified in ICD 2-00001.

3.3.1.2.1.8 Airlock

An airlock shall be provided to accommodate 2-man EVA operations without the necessity for crew cabin decompression, or decompression of an attached, manned payload or spacecraft. All Orbiter configurations shall accommodate any of the following airlock configurations:

a. Inside the crew module.

b. Inside the crew module with tunnel adapter in series.

c. Outside the crew module, with or without mating system equipment (Paragraph 3.3.1.2.1.3) installed.

d. Outside the crew module with tunnel adapter or spacelab tunnel in series, without mating system equipment (Paragraph 3.3.1.2.1.3) installed.

e. Both inside and outside the crew module, in series, with mating system equipment (Paragraph 3.3.1.2.1.3) installed on the outside airlock.

f. (Deleted).

An outside airlock shall only be required to be installed or removed with the Orbiter in a horizontal position. The outside airlock, Orbiter Vehicle, and applicable GSE shall be designed/modified such that the outside airlock does not have to be removed to perform OPF servicing operations as defined in Paragraph 3.4.4.1. When located outside the crew module with mating system equipment installed, the airlock shall be configured for IVA transfer through a top hatch, and the airlock/mating system combination shall be

capable of safely reacting all load environments as specified in Paragraphs 3.3.1.2.1.3.10.1, Functional Performance Parameters (for the mating system) and 3.3.1.2.1.3.11, Mated Structural Requirements.

3.3.1.2.1.9 Tunnel Adapter

A removable tunnel adapter with capability for attachment of an outside airlock shall be provided to accommodate continuous crew cabin to manned payload access during EVA. The tunnel adapter design shall allow an EVA crewman to access a depressurized Spacelab without the necessity of crew cabin depressurization.

3.3.1.2.2 Propulsion

3.3.1.2.2.1 Main Propulsion Subsystem (MPS)

The Orbiter Vehicle Main Propulsion Subsystem assisted by two SRBs during the initial phase of the ascent trajectory shall provide the velocity increment and thrust vector control from lift-off to main engine shutdown with a maximum SSME gimbal deflection of ± 11° in pitch and ±9° in yaw.

3.3.1.2.2.2 Orbital Maneuvering Subsystem (OMS)

An OMS shall provide the propulsive thrust to perform orbit insertion, orbit circularization, orbit transfer, rendezvous and deorbit.

3.3.1.2.2.2.1 OMS Burn Sequence

The OMS shall be capable of burning all of its allocated propellant in either a single long burn or a series of multiple burns spaced over the mission duration.

3.3.1.2.2.2.2 OMS Tank Sizing

The integral OMS pressurant/propellant tankage shall be sized for an impulse capability of 7.6 million lbs/sec.

Provisions shall be made to incorporate additional tankage capacity to achieve an overall propellant capacity of 2.5 times that of the integral tankage. The additional capacity shall be provided by supplementary propellant supply kits located in the payload bay clear volume and will be payload volume and weight chargeable items. The auxiliary tankage kits shall be designed such that either one, two, or three kits may be installed, as required.

3.3.1.2.2.2.3 OMS Crossfeed

The OMS shall provide crossfeed capability. In the event of losing the operation of an OMS engine, the propellant remaining shall be usable by transfer to the remaining operable engine.

3.3.1.2.2.2.4 OMS/RCS Interconnect

The OMS/RCS interconnect operation will normally be utilized (if required) on-orbit only. For aborts, pre-MECO use of the OMS/RCS interconnect is permissible. Implementation of the interconnect requires eight seconds.

3.3.1.2.2.3 Reaction Control Subsystem (RCS)

The RCS shall provide three-axis angular control and three-axis translation. The RCS shall provide translational delta V for Orbiter/ET separation, and rendezvous and docking, as defined in Paragraph 3.2.1.1.3. Vernier RCS thrusters shall be provided for use in angular control modes for low stability rates.

3.3.1.2.2.3.1 RCS Thrusters Installation

The RCS thrusters installation shall be such as to minimize angular crosscoupling during all RCS operations, and to minimize translational accelerations during rotational maneuvers, and rotational accelerations during translational maneuvers.

3.3.1.2.2.3.2 RCS Tank Sizing

The RCS tankage shall be sized to provide the RCS translational delta V requirements for accomplishing the missions specified in Paragraph 3.2.1.1.3 and attitude control from main engine shutdown to initiation of OMS burn, the pointing accuracies specified in Paragraph 3.3.1.1.1; and the attitude control on-orbit and during entry. Mission requirements that exceed the maximum feasible size of the RCS tanks may be accommodated by loading and using propellant in the OMS tanks.

The aft RCS tankage will be loaded full. The forward RCS tankage will be partially loaded to a minimum 60% of design load up to full load for selected missions as deemed necessary. Partially filled loads will be checked using the PVT method.

3.3.1.2.2.3.3 RCS Crossfeed

An RCS crossfeed will be available for on-orbit operations.

3.3.1.2.3 Avionics

3.3.1.2.3.1 General Requirements

3.3.1.2.3.1.1 Auto Landing

The avionics subsystems shall provide automatic landing capability (following acquisition of terminal area RF landing aid signals) through rollout for orbital missions with the

Orbiter Vehicle configured for non-propulsive atmospheric flight. The auto landing capability shall provide the control to:

a. Maintain the Orbiter on the proper glide slope during the landing approach phase,

b. Maintain the directional control necessary to bring the Orbiter to touchdown on the runway,

c. Perform the final touchdown maneuver,

d. Maintain the Orbiter's heading on the runway in a safe orientation through rollout.

Rollout is defined as the portion of the landing from touchdown to the point where the Orbiter is brought to a full stop or can be manually turned off the runway onto a taxiway. The automatic landing capability shall incorporate rudder control, nose wheel steering, and/or differential braking to provide directional control. Deployment of landing gear and application of braking device shall be manual. Redundancy requirements shall be provided as specified in Paragraph 3.3.1.2.3.1.2.

3.3.1.2.3.1.2 Redundancy

The avionics subsystem shall have sufficient redundancy capabilities, using the flight crew as necessary (with provisions for periods of simultaneous sleep), to provide mission completion after any single failure. After the minimum required time has elapsed to achieve the selected post-failure configuration by automatic or manual means (whichever is used for the given failure), the same subsystem shall have the ability to sustain any second failure and terminate the mission safely. The BFS shall not be required to be fault tolerant.

The redundancy requirements for an intact abort are specified in Paragraph 3.5.1.1.1.

The avionics subsystem shall not preclude the capability for abort specified in Paragraph 3.2.1.5.1 herein.

Deviations/Waivers 527 and 529 are applicable to Paragraph 3.3.1.2.3.1.2.
Refer to Book 4, Active Deviations/Waivers.

NOTE: Waivers of the Reliability and Redundancy requirements Paragraphs 3.3.1.2.3.1.2, 3.5.1.1.1, 3.5.1.1.2 and 3.5.1.1.3 are documented in NSTS 08399, SSP CIL located in WebPCASS, and are no longer documented in NSTS 07700, Volume X, as authorized by Space Shuttle PRCBD S004600G, dated 6/23/93.

3.3.1.2.3.1.3 COMSEC/TEMPEST Requirements for DOD

The TEMPEST requirements will be as specified in classified technical direction in accordance with existing NASA/USAF Interagency Agreement for the Protection of Space Transportation National Security Information, September 19, 1986, and applicable supplements. An RF Orbiter TEMPEST Evaluation will be performed by a USAF team with NASA support.

3.3.1.2.3.2 Communications and Tracking Subsystem (C&TSS)

The C&TSS shall provide for:

a. Reception, transmission and distribution of Orbiter, ground, EVA, and attached payload voice. EVA communications will be provided by Extravehicular Communicator. All external voice interfaces with the Orbiter shall be a nominal ODBM signal level, 300 to 3000 Hz pass band and a nominal 600 ohm balanced impedance.

b. Transmission of realtime and stored operational Pulse Code Modulator (PCM) Data and SRB realtime operational instrumentation data, from launch to separation, as required, for SRB flight evaluation and performance assessment.

c. Reception of payload PCM telemetry in Non-Return-to-Zero (NRZ) - L, M or S or Bi-Phase L, M, or S codes.

d. Transmission of payload commands in NRZ - L, M or S codes.

e. Receiving and decoding of ground-to-Orbiter commands and reception of Orbiter forward data (i.e., text and graphics or teleprinter).

f. Landing and atmospheric navigation RF aids, and on-orbit tracking to include Ground Space Flight Tracking and Data Network ranging.

g. Generation, transmission and distribution of Television (TV) signals.

h. Tracking targets.

i. Decryption and time authentication of the operational forward link and encryption of the operational return link.

j. Transmission of main engine PCM data.

k. Reception of EVA data.

l. Reception and re-transmission of payload data (including the handling of encrypted data and non-standard payload data) to the ground via either the

S-Band Phase Modulated (PM) downlink or the Ku-Band downlink operational data channel (selectable). Time correlation between Orbiter data and payload data shall be provided.

The C&TSS shall provide the capability to transmit and receive between the Orbiter and the following, subject to the compatibility requirements of the applicable ICDs.

a. Other space vehicles

b. Payloads

c. Extravehicular astronauts

d. Prelaunch checkout facilities

e. Air traffic control facilities

f. Space Tracking and Data Network (STDN)

g. Tracking and Data Relay Satellite (TDRS)

h. Air Force Satellite Control Facility (AFSCF)

i. Orbiter Vehicle landing site facilities

j. Ground navaids and facilities

The C&TSS shall provide the capability of performing the following on-orbit functions simultaneously.

a. Two-way phase coherent S-Band PM communication with either TDRS or a STDN ground station or an AFSCF ground station.

b. S-Band FM transmission of TV or wideband data to either a STDN or an AFSCF ground station.

c. Two-way S-Band communication with one detached NASA or USAF payload.

d. The Ku-Band communications through Tracking and Data Relay Satellite System (TDRSS) or Ku-Band rendezvous radar (time-shared).

The S-Band PM links transfer single digital data streams which combine voice and telemetry for the downlink and combine voice and command for the uplink. The resulting Time Division Multiplexed data streams shall be identical for the TDRS, STDN, and AFSCF links, although further processing shall be applied for transmission compatibility.

The Ku-Band forward link shall simultaneously transfer command data, two voice channels and wideband data (for direct routing to the attached payload interface or to the

text and graphics interface) to the Orbiter. The Ku-Band return link shall transmit data at maximum rate of 50 mbps; the actual data rate chosen will depend on the Bit Error Rate (BER) requirements of the payload(s). The Effective Isotropic Radiated Power (EIRP) of the Orbiter Ku-Band return link shall be >48.8 dBW. The Ku-Band error rate between the Orbiter antenna and TDRSS ground station antenna shall be no greater than a one bit error in every 100,000 bits transmitted (maximum BER of 1×10^{-5}). Ku-Band shall have the capability to relay to the ground (in a bent-pipe mode) data from attached or detached payloads.

The Ku-Band return link shall operate in either of two selectable modes; one offering simultaneous transmission of three channels.

Utilization of the various channels will be on a time-shared basis. The information to be transmitted via Ku-Band shall consist of various combinations of the following signals:

a. Realtime operational data

b. Uplink text and graphics data (128 Kbps forward link)

c. Recorder dumps

d. Wideband digital data (up to 50 mbps max.)

e. Payload Standard TV

f. Orbiter TV

g. Wideband analog data (including non-standard TV)

3.3.1.2.3.2.1 S-Band PM RF Link

The S-Band PM system shall provide Orbiter S-Band TDRS performance as follows:

a. EIRP 17.7 dBW

b. Antenna Gain (G/T): -27.8 dB/deg K system temperature

3.3.1.2.3.2.2

S-Band Antennas shall be provided for use with STDN, TDRS, Payload, and AFSCF links. Each antenna shall be adequate to enable the subsystem to meet the required G/T (for receive) and the required EIRP (for transmit) over the specified angular coverage.

a. S-Band PM Link Antennas. The antenna subsystem for the STDN, TDRS, and AFSCF links shall consist of four antennas located around the periphery of the

Orbiter Vehicle. Each antenna shall provide coverage of a sector elliptical in shape. The PM antenna subsystem shall cover the frequency ranges of 1750-1850 MHz and 2000-2300 MHz. The antenna subsystem shall provide for a minimum of 80% average spherical coverage for the four antennas and four frequencies of operation in the 2000-2300 MHz band. The gain shall be such as to provide the EIRP and G/T specified in Paragraph 3.3.1.2.3.2.1 for the coverage including antenna ellipticity. Antenna polarization shall be right hand circular polarized. As a design goal, these antennas shall not impose attitude constraints.

3.3.1.2.3.3 GN&C Subsystem

The GN&C subsystem in conjunction with supporting subsystems shall be capable of providing GN&C for the flight vehicle through all phases of flight from launch through landing and for aircraft aerodynamic flight modes. The control system shall have capability to provide modal suppression and/or attenuation as required for dynamic stability. Modal suppression for control of dynamic loads (if necessary) shall be accomplished within the constraints of hardware and stability requirements.

3.3.1.2.3.3.1 GN&C Ground Support

The GN&C subsystem shall provide the capability for processing uplinked and downlinked parameters as specified in NSTS 07700, Volume XVIII, Computer Systems and Software Requirements.

3.3.1.2.3.3.2 Manual Control

A digitally processed manual control capability shall be provided for all flight control functions for all Orbiter alone flight phases. During launch and ascent of the mated vehicle (Orbiter/ET/SRB and Orbiter/ET) the capability to digitally process manual main engine throttle commands shall be provided. Manual throttle and manual guidance (auto guidance command incremented or replaced by stick command) capability shall be provided during mated vehicle flight phases for contingency situations. If manual guidance is selected, there is no requirement for return to automatic operation during ascent.

3.3.1.2.3.3.3 Orbiter Elevon and Body Flap Limits

During Orbiter entry flight for a normal Eastern Test Range (ETR) mission, the dispersed (± 3-sigma) elevon and body flap deflections (transient and steady state) shall remain within the cross hatched regions of Figure 3.3.1.2.3.3.3 for the applicable dynamic pressure range.

3.3.1.2.3.3.4 Orbiter AOA Reference Profile

For Orbiter normal end of mission entry flight the reference AOA profile and command limits shall be as specified in Figure 3.3.1.2.3.3.4.

3.3.1.2.3.3.5 Flying Qualities

During the Orbiter-alone atmospheric flight, the Cooper Harper ratings as specified in NASA-TN-D-5153, The Use of Pilot Ratings in the Evaluation of Aircraft Handling, shall meet Level I handling qualities and shall not degrade below Level II during landings in turbulent conditions or with a crosswind.

3.3.1.2.3.4 Display and Controls (D&C) Subsystem

The D&C subsystem shall provide the crew with the following basic capabilities during all normal and contingency operations:

a. The means to monitor and command vehicle rotation, translation, and flight path

b. The means to monitor and command onboard subsystems

c. The means to monitor and command critical attached payload functions

d. The means to detect and safe hazardous conditions

In addition, the D&C shall provide all crew compartment interior and integral lighting.

3.3.1.2.3.4.1 Abort Commands

The Orbiter Vehicle shall be the command center for all abort commands. The Orbiter shall monitor critical vehicle subsystems to identify failures, generate automatic and/or manual abort signals, display abort signals, display abort conditions, and control automatic abort initiations commands.

3.3.1.2.3.5 Data Processing and Software (DPS) Subsystem

The airborne DPS subsystem shall provide computational capabilities for GN&C; subsystems performance monitoring and display; payload checkout, monitoring, caution and warning, display, discrete commanding and command loading; and the capability to work in conjunction with the ground system for performing ground functions.

Use of dynamic restringing of the data processing computer configuration allowed by the Program Requirements Control Board (PRCB) approved flight rules as defined below is considered to be a contingency operation and does not require verification/certification (reference Table 4.1, Verification Responsibility Matrix).

a. Pre-MECO: To regain uphill capability.

b. Post-MECO/Pre-ET sep: To regain sufficient RCS jets to perform ET sep.

c. Post-ET sep:

   1. To maintain single fault tolerance.

   2. To regain insight into an unrelated critical system failure.

   3. To obtain two OMS engines for a massive underspeed condition.

d. Entry to Pre-Entry Interface (EI): To regain full fault tolerance

e. Post-EI:

   1. For abort landings or leaking tire cases to regain nosewheel steering.

   2. To maintain two flight control system channels.

   3. To regain vent door command capability.

Deviation/Waiver 430 is applicable to Paragraph 3.3.1.2.3.5.
Refer to Book 4, Active Deviations/Waivers.

3.3.1.2.3.6 Electrical Power Distribution and Control (EPD&C) Subsystem

The EPD&C subsystem shall provide conditioning, conversion, control, and distribution of electrical power supplied by the electrical power generation subsystem. The EPD&C subsystem shall also provide all Orbiter Vehicle lighting external to the crew compartment.

3.3.1.2.3.7 Instrumentation Subsystem

An instrumentation subsystem shall be provided for sampling, conditioning, storing, and distributing of data adequate to determine vehicle status. The vehicle instrumentation requirements required to determine vehicle status are defined in mission-specific telemetry occurrence recon data Change Requests (CRs), the mission occurence data CRs, and in the appropriate Master Measurements List, a product of the Mast II Data Management System (reference JSC 18206, Volume III). Provisions shall be made for generation and distribution of timing or synchronization signals to other Orbiter subsystems, and for determination of time base skew (plus/minus three milliseconds for development flight instrumentation systems) between Orbiter and each SRB instrumentation system.

3.3.1.2.3.8 Performance Monitor

A performance monitor function shall be provided utilizing elements of the instrumentation, D&C, and DPS subsystems. This function shall provide to the flight crew information concerning health status, configuration status, and fault detection and isolation status for flight vehicle subsystems. This function shall also support redundancy

management to the level required in flight; onboard fault detection, isolation and anomaly recording; management of Orbiter data recording; and, monitoring and management of certain other in-flight functions. An interface shall be provided for use of the onboard capabilities in support of ground operations.

3.3.1.2.3.9 Closed Circuit TV Subsystem

A closed circuit TV subsystem shall be provided that consists of a Video Control Unit (VCU) (remote control unit plus video switching unit), two cabin Closed Circuit Television (CCTV) monitors, and wiring, mounts, and controls to support the following TV camera services:

a. Two color cameras in cabin.

b. Four cameras for payload bay bulkheads, with pan and tilt and remote control functions (two cameras on each payload bay bulkhead).

c. Two cameras on each RMS arm, with remote control function capability and with pan and tilt capability for the elbow location.

d. Payload bay-mounted camera(s) to aid in “x” coordinate alignment when using the RMS.

e. On-orbit replaceable centerline camera mounted to align with the center of the Orbiter docking mechanism and parallel with the docking mechanism Z axis to aid with lateral and angular alignments during docking.

f. Single camera mounted exterior to the docking mechanism and aligned parallel with the docking mechanism Z axis to aid operations with the centerline camera.

The Video Control Unit shall support split screen capability on the CCTV monitors plus other locations including payload and downlink. The VCU shall also support CCTV uplink command capability.

Provisions shall be made to accommodate secure Orbiter CCTV in the Mission Station.

3.3.1.2.3.10 Biomedical Monitoring

Capability shall be provided such that any two crew positions can be monitored simultaneously for physiological monitoring during planned investigations for all flight phases and on-orbit and during re-entry in the event of a medical contingency. Capability shall be provided to monitor Electrocardiogram activity on two crew members simultaneously engaged in EVA.

3.3.1.2.3.11 Uplink Text and Graphics Subsystem

The capability shall exist in the Orbiter to receive text and graphics data which has been transmitted from the MCC - Houston via the TDRSS and produce a hard copy for use by the flight crew. The uplink text and graphics subsystem shall receive data from the Ku-Band subsystem. Text and graphics data shall comprise 128 Kbps of the Ku-Band 216 Kbps uplink. The 128 Kbps data stream shall be transmitted to the Orbiter/Payload Station interface as well as to the Orbiter uplink text and graphics interface. The uplink text and graphics subsystem shall, as a minimum, satisfy the following resolution and gray level requirements:

Mode 1 - 125 lines/inch resolution and two linear grey levels

Mode 2 - 200 lines/inch resolution and 64 linear grey levels

3.3.1.2.3.12 Proximity Operations Sensor Requirement

The Orbiter shall have redundant prox ops sensors to provide the crew with Orbiter-to-target vehicle range, range rate, and a field of view which allows the sensor to track the target between 2,500 feet and contact in support of approach, docking, and separation. These performance requirements shall apply for target vehicles with compatible passive reflector devices installed.

3.3.1.2.4 Environmental Control and Life Support Subsystem (ECLSS)

The ECLSS shall provide the life support for the flight personnel as specified in Paragraph 3.3.1.2.1.1 and environmental control for the Orbiter Vehicle during all mission phases. The ECLSS shall provide the life support environment required to provide a shirtsleeve environment for the crew. The ECLSS shall perform the major functions of atmosphere revitalization, active thermal control, water, waste and food management, smoke detection, and fire suppression within pressurized cabin and avionics bays. Provisions shall also be made for support to EVA/IVA.

3.3.1.2.4.1 Crew Compartment Atmosphere

3.3.1.2.4.1.1 Total Pressure

The total pressure shall be 14.7 ± 0.2 psia using a two-gas system composed of nitrogen and oxygen. The Orbiter shall have the capability during on-orbit EVA operations to operate in either of two modes:

a. <u>Reduced cabin pressure procedure</u> - The total pressure control range shall be 10.2 ± 0.2 psia with caution and warning limits set at no lower than 10.0 and no

higher than 10.6 psia. The % oxygen shall not exceed 30% (including sensor errors). The Pressure Control System (PCS) shall be manually controlled during this procedure.

b. Insuit Prebreathe Procedure - The total pressure shall be maintained at 14.7 ± 0.2 psia except during airlock repressurization, when the total pressure shall be allowed to drop to 13.7 psia minimum. The total time for this pressure excursion below 14.5 psia shall be limited to 30 minutes.

NOTE: All payload hardware located in the Orbiter crew cabin shall be certified safe in all of the above environments.

3.3.1.2.4.1.2 Oxygen Partial Pressure

The partial pressure of oxygen shall be 3.2 ± 0.25 psia at a total pressure of 14.7 ± 0.2 psia. The Orbiter shall have the capability during on-orbit EVA operations to operate in either of two modes:

a. Reduced Cabin Pressure Procedure - The oxygen partial pressure control range shall be from 2.55 to 2.8 psia and shall be constrained by caution and warning limits set at no lower than 2.55 and no higher than 2.9 psia at a total pressure of 10.2 +.4, -.2 psia. The % oxygen shall not exceed 30% (including sensor errors). The PCS shall be manually controlled during this procedure.

b. Insuit Prebreathe Procedure - The partial pressure of oxygen shall be maintained at 3.2 ± 0.25 psia except during airlock repressurization, when the oxygen partial pressure shall be allowed to drop to 2.7 psia minimum. The total time for this pressure excursion below 2.95 psia shall be limited to 30 minutes.

NOTE: All payload hardware located in the Orbiter crew cabin shall be certified safe in all of the above environments.

3.3.1.2.4.1.3 Carbon Dioxide Partial Pressure

The carbon dioxide partial pressure shall be:

Nominal:	5.0 mmHg
Range:	0 - 7.6 mmHg
Emergency Limit:	15.0 mmHg

3.3.1.2.4.1.4 Cabin Temperature

The cabin air temperature shall be 65° - 80°F during all mission modes except entry to egress (assuming 15 minutes maximum after touchdown) when it shall not exceed 90°F.

3.3.1.2.4.2 Crew Exposure (Max Temperature)

The crewmen shall not be exposed to direct contact temperatures greater than 120°F on equipment or structure normally touched. This excludes such items as windows and certain structure during entry through rollout, that are accessible to the crew, but should not normally be touched.

Deviation/Waiver 479 is applicable to Paragraph 3.3.1.2.4.2.
Refer to Book 4, Active Deviations/Waivers.

3.3.1.2.4.3 ECLSS for Ferry

Provisions shall be made for the necessary ECLSS functions to support ferry operations to ensure that Orbiter water systems do not freeze.

3.3.1.2.4.4 Emergency Conditions

Provisions shall be made for the following emergency conditions:

a. Cabin emergency repressurization from space vacuum

b. Cabin emergency pressure maintenance

c. In-orbit survival

d. Emergency bailout mode

The baseline contingency expendables shall be sufficient to support the worst of any one of these contingencies (i.e., contingencies are not additive).

3.3.1.2.4.4.1 Cabin Emergency Repressurization from Space Vacuum

Provisions shall be made for one cabin repressurization in the event of an emergency which required depressurization of the cabin to facilitate crew rescue. The flowrate shall be such as to repressurize the cabin in approximately one hour. The ECLSS baseline does not include a dedicated means of crew life support or support of other cabin located subsystems equipment while the cabin is depressurized.

3.3.1.2.4.4.2 Cabin Emergency Pressure Maintenance

Provisions shall be made for maintaining a cabin pressure of 8.0 ± 0.2 psia with an oxygen partial pressure of 2.2 ± 0.25 psia, a flowrate equivalent to the leakage of a 0.45 inch diameter hole for a return time, from orbit, of 165 minutes. Expendables provisioning shall be sufficient to support a maximum crew of seven during this contingency. System design shall accommodate a crew up to 10. These conditions will not be used to establish materials flammability requirements.

3.3.1.2.4.4.3 Crew Survival, In-Orbit

The Orbiter Vehicle expendables design shall be capable of supporting on-orbit operations for a minimum of 27 hours after any on-orbit contingency other than one similar to that defined in Paragraph 3.3.1.2.4.4.2, for the purpose of enabling vehicle safety, stowage, entry and landing at a planned landing site.

3.3.1.2.4.4.4 Emergency Bailout Mode

Provisions shall be made for all crew members to safely escape from an orbiter during controlled subsonic gliding flight conditions. Protective survival equipment shall be provided to sustain the crew below 70,000 feet altitude and for 24 hours after a water landing.

3.3.1.2.4.5 Waste Management

The waste and trash management provisions shall be a permanent installation in the Orbiter utilizing the same equipment for all Orbiters except those modified for the 16 to 28-day duration missions and shall accommodate both male and female personnel. Elements of the waste management system may be removable for cleaning. All solid waste shall be stored for return to earth for the seven day (42 man-days) design mission and on selected vehicles for the 16-day (112 man-days) and 28-day (196 man-days) extended missions. Urine and condensate waste water shall be stored in one waste tank with managed waste water dumps to reduce experiment contamination and to provide emergency flash evaporator capabilities.

3.3.1.2.4.6 EVA/IVA Operations Support

Two EMUs (composed of space suits and life support systems) to support unscheduled or contingency EVA/IVA operation shall be provided for all missions. For any mission that has an EVA, an adequate EMU redundancy will be carried on board the Orbiter. Applicable design requirements for EVA/IVA operations support are as follows:

a. An EVA Service and Recharge Station to support, recharge, checkout, and for donning of EVA equipment shall be provided by the Orbiter. When an airlock is installed outside the crew module in series with an airlock inside the crew module, the service and recharge station shall be installed in the inside airlock.

b. ECLSS expendables shall be provided by the Orbiter for:

    1. Three airlock pressurizations except when the Spacelab tunnel adapter is used in series with the airlock for EVA; then two airlock/tunnel adapter pressurizations shall be required.

2. Required prebreathe operations

3. Three two-man EVA equipment recharges. (Equipment may be precharged before installation to provide for a total of three, two-man EVAs). Expendables for one, two-man EVA, operation must be reserved for any contingency Orbiter operation; i.e., external inspection, repair or rescue as required for safe return of crews. The time duration for each EVA/IVA shall be six hours maximum. System Design shall allow for .5 hour for egress and ingress and .5 hour reserve in addition to the six hour EVA.

3.3.1.2.4.7 Emergency Oxygen

Provisions shall be made for connecting oxygen mask assemblies for EVA/IVA oxygen prebreathing and emergency conditions.

3.3.1.2.4.8 Water Management

The water management system shall be a permanent installation in the Orbiter (four supply tanks) which provides potable water for drinking, food preparation, EVA recharge, and for heat rejection evaporant. The water management system shall have a minimum storage management capability of 12 hours and 18 Kw power level of fuel cell generated water between overboard nozzle dumps in orbit. Excess water shall be periodically dumped via direct dump through heated nozzles. On missions utilizing the mating system, capability to transfer iodinated fuel cell water to the mated spacecraft shall be provided.

3.3.1.2.4.9 Total Iodine Consumption

The total iodine consumption by each crewmember shall be planned for less than 1.0 mg/day from water and food consumption. The potable water iodine level shall be equal to or less than 0.35 mg/liter based on the average crew water intake of two liters of water per day, and average iodine content in the food of 0.26 mg/day.

3.3.1.2.5 Power

3.3.1.2.5.1 Electrical Power Subsystem (EPS)

The EPS shall generate the electrical power required for all Orbiter Vehicle and payload subsystems. It shall also satisfy power requirements for:

a. The full duration 7-day (3528 kwH) orbital mission and on selected vehicles, the 16-day (7296 kwH) and 28-day (12,096 kwH) extended missions.

b. Emergency restart or reset of the prime power components.

c. Four-day survival period after an on-orbit contingency that occurs at the end of the Design Reference Mission.

d. The ET and the SRB (see Paragraph 6.1.10) from prelaunch to separation.

e. Orbiter landing station power until connection to the fixed facility power supply. Usage of the contingency cryo reserve, as available, shall satisfy this requirement. In the event of contingency cryo depletion, contingency ground power will be provided by the Orbiter landing station.

3.3.1.2.5.1.1 EPS Cryo Loading

The Orbiter EPS shall be compatible with the cryo loading requirements of Paragraph 3.2.1.2.7.2.

3.3.1.2.5.2 Hydraulic Subsystem

The hydraulic subsystem, consisting of hydraulic pumps, actuators, fluid distribution lines, and heating and cooling provisions, shall provide power to all hydraulic users.

3.3.1.2.5.2.1 Hydraulic Power

Hydraulic power, provided by the APU subsystem shall satisfy power requirements for:

a. The full duration 7-day orbital mission and, on selected vehicles, the extended duration missions

b. Integrated system checkout and prelaunch activity

c. Post-landing activities as required

3.3.1.2.5.2.2 Hydraulic Subsystem Design

Hydraulic subsystem design and installation, shall be in accordance with MIL-H-5440F, Hydraulic Systems; Aircraft, Types 1 & 2, Design, Installation, and Data Requirements for, amended by NSTS 08318, NSTS Hydraulic System Exceptions to MIL-H-5440. This specification (MIL-H-5440F, amended) shall take precedence over safety factors stated in Paragraph 3.2.2.1.5.2.

3.3.1.2.5.3 APU Subsystem

The APU subsystem consisting of APUs, APU controllers, fuel tanks, fuel distribution system, exhaust ducts, and thermal control system, shall provide power necessary for the hydraulic subsystem during the following mission phases:

a. Prelaunch

b. Ascent

c. MPS Purge

d. Orbit Checkout

e. Entry

f. Landing

3.3.1.2.5.3.1 APU Subsystem Propellant Off-Loading

The SSS shall be capable of off-loading APU subsystem propellant for specific selected missions, as necessary.

3.3.1.2.6 Crew Provisions

3.3.1.2.6.1 Emergency Egress

The Orbiter shall provide for emergency egress of the flight crew on the launch pad as specified in Paragraph 3.2.1.2.12. After landing, the Orbiter shall provide for unaided emergency egress of the flight crew within one minute after landing rollout. The Orbiter shall incorporate onboard provisions to place the Orbiter in a safe condition following landing and permit ingress by ground emergency crews within two minutes, without flight crew assistance.

An alternate escape path shall be provided in case the primary path is blocked or inoperative. Egress time using the alternate path may exceed one minute.

3.3.1.2.6.2 Crew and Cargo Transfer

The Orbiter Vehicle shall provide shirtsleeve access to pressurized payload modules and direct pressure suit access (via airlock) to the unpressurized payload bay in flight. The Orbiter shall provide handholes and handrails to allow crewmen to translate from EVA exit(s) to EVA work areas. Also, the Orbiter will provide attach points for tethers, umbilicals, and other EVA aids.

3.3.1.2.6.3 Normal Ingress/Egress

The Orbiter cabin arrangement shall provide for crew and passenger ingress and egress with the Orbiter in the vertical position on the launch pad during normal operations. With the Orbiter in the horizontal position, the cabin arrangement shall provide

for normal crew and passenger ingress and unaided egress via ground supplied equipment.

3.3.1.2.6.4 (Deleted)

3.3.1.2.6.5 Crew Rotation

The Orbiter shall provide provisionings for the transport and return of up to three space station crew members. These provisionings shall include recumbent seating for the returning crew and support equipment related to crew rotation.

3.3.1.2.7 Cabin Arrangement

3.3.1.2.7.1 Flight Station

A flight station shall be provided for the commander and pilot.

3.3.1.2.7.1.1 Single Crewman Control

The flight station shall be arranged to allow a crewman, flying from either seat, to return the Orbiter Vehicle to earth. For operational flights, the design shall allow for the elimination of “single crewman control” capability from one of the seats.

3.3.1.2.7.2 (Deleted)

3.3.1.2.7.3 On-Orbit Station

An on-orbit station shall be provided to accommodate attitude and translation control of the Orbiter while maintaining direct visual viewing of other orbital elements. The on-orbit station shall also accommodate control and monitoring of docking/undocking operations using the mating system, operation of the RMS, and provide for simultaneous direct and/or remote viewing (CCTV) of the manipulator payload handling, and payload experiment operations. The on-orbit station shall also provide the following:

a. Capability for controlling of PLBDs with sufficient direct visibility of the doors to ensure proper operation.

b. Capability to support dual (side-by-side) operators.

c. Capability for some dedicated payload D&C space and payload-associated equipment volume, plus capability to support mission/payload functions by accommodating ground changeout of mission-unique equipment (such as manipulator D&C) to payload-unique equipment.

3.3.1.2.7.4 Mission Station

A mission station shall be provided to accommodate monitoring and managing of selected Orbiter systems, and monitoring managing and sending commands to attached and detached payload support systems, and conducting some payload operations. The mission station shall also provide the following:

a. Standard mission capabilities to support Orbiter and payload operations such as communications, electrical power, and consumables management.

b. Monitor critical functions (including Caution and Warning [C&W]) of attached payloads and issue of appropriate safing commands.

c. On-orbit work surface area, which includes some temporary on-orbit stowage capability.

d. Accommodations for CCTV in the secure mode.

3.3.1.2.7.5 Payload Station

A payload station shall be provided to accommodate management of payload operations. The payload station shall also provide the following capabilities:

a. Interfaces necessary for supporting payload supplied D&C and equipment.

b. Capability to support single operator and restricted dual (side-by-side) operators.

c. On-orbit work surface area which includes some temporary on-orbit stowage capability.

3.3.1.2.7.6 Changeout of Aft Crew Station Equipment

The cabin aft crew stations (mission station, payload station, and on-orbit station) will be designed as appropriate to facilitate changeout and installation of Orbiter and payload supplied D&C panels and equipment.

3.3.1.2.7.7 Photographic Stations

Photographic stations shall be provided with provisions for electrical power and structural attach points for the GFE camera bracket. Photographic stations shall be located in the following areas with the indicted capabilities:

a. Flight Deck Pilot Station - Attach points for forward looking camera and crew observation cameras. Attach points should support cameras during dynamic mission phases, i.e., launch and reentry.

b. Flight Deck Aft Crew Station - Attach points for overhead and cargo bay window to support on-orbit camera installation.

c. Mid-deck General Interior - Attach points for documenting crew habitation at two locations. These stations support on-orbit camera installation.

d. High Optical Quality Scientific Photo Station - A high optical quality window shall be provided in the side hatch of the crew module.

3.3.1.3 Orbiter Interface Characteristics

3.3.1.3.1 Orbiter Interface with ET

The Orbiter Vehicle shall interface with the ET as defined in ICD 2-12001, Orbiter Vehicle/External Tank Interface Control Document.

3.3.1.3.1.1 Orbiter/ET Release

The Orbiter Vehicle shall provide Orbiter/ET attachment and release. The release mechanism shall be retained with the Orbiter.

3.3.1.3.1.2 Orbiter/ET Umbilical

3.3.1.3.1.2.1 Conductive Signal Path Umbilical

A conductive signal path umbilical shall be provided between the Orbiter Vehicle and ET for the following functions:

a. ET Status Monitor

b. Sequence Commands to ET

3.3.1.3.1.2.2 Fluid Umbilicals

Fluid umbilicals shall be provided between the Orbiter Vehicle and ET for the following MPS interface functions:

a. LO_2 and LH_2 feed, fill and drain

b. LH_2 recirculation

c. Pressurization for LH_2 tank

d. Pressurization for LO_2 tank

3.3.1.3.1.3 Interface Access

Routine ground service operations at the Orbiter/ET interface shall not be required after rollout.

3.3.1.3.2 Orbiter Interface with Solid Rocket Booster (SRB)

The Orbiter/SRB functional and performance interface requirements are stated in ICD 2-14001, Orbiter Vehicle/Solid Rocket Booster Interface Control Document.

3.3.1.3.2.1 Ascent Guidance and Control

All navigation and guidance functions for the mated flight configuration shall be performed by the Orbiter Vehicle. Flight control shall be performed jointly by the Orbiter Vehicle and the SRBs from lift-off to staging. The Orbiter shall provide steering commands to the SRB TVC.

3.3.1.3.2.2 SRB Power Bus Redundancy

No single failure of an active component on the Orbiter shall result in the permanent loss of a SRB power bus.

3.3.1.3.3 Orbiter Interface with Payload

The Orbiter interfaces with payloads shall be defined in accordance with the provisions of NSTS 07700, Volume XIV, Attachment 1 (ICD 2-19001), NSTS 21000-IDD-MDK, Shuttle/Payload Interface Definition Document for Middeck Accommodations, and NSTS 21000-IDD-SL, Shuttle Orbiter/Spacelab Module Interface Control Document.

3.3.1.3.3.1 Payload Carriers

The Orbiter Vehicle shall interface with a series of standard GFE payload carriers, such as the spacelab/airlocks/pallets, mounting platforms, propulsion systems, and free flying systems. Standard carriers shall be designed to be compatible with the Orbiter Vehicle.

3.3.1.3.3.1.1 Payload Structural Attachment

The Orbiter Vehicle structure shall provide multiple sets of mounting points. Payload attachment schemes must be compatible with the structural and mechanical capability of the Orbiter attach points for all combinations of deflections and loads.

A statically determinate attachment system is required for X direction (longitudinal) load paths.

3.3.1.3.3.2 Fluid System Interfaces

The payload propellant systems or other flammable fluid systems shall be serviced before installing the payload in the Orbiter and further, should be serviced prior to arriving at the launch pad.

3.3.1.3.3.3 Electrical Interfaces

3.3.1.3.3.3.1 Electrical Power Interfaces

The Orbiter/payload power transfer circuits shall have power handling capabilities as listed below. More than one feeder may be used simultaneously by the payload to receive power, but power feeders from separate Orbiter sources will not be tied together directly by the payload. The two auxiliary feeders at the mid payload bay, however shall be so mechanized that they may be tied together in the payload without additional circuitry in the payload.

a. Mid Payload Bay Power Interface - One interface at main DC distribution assembly No. 3 shall be capable of delivering up to 12 kw from shared Orbiter busses in the bus-tie mode or up to 7 kw from Main DC Bus B. This power shall be transferred to an interface near station Xo = 645 on the starboard side of the payload bay by a harness, which is part of the Orbiter. Provisions shall be made to allow the installation of a kit to route 7 kw from Main DC Bus B directly to another interface near station Xo = 645. If this kit, which is not now baselined, is installed, the power from Main DC Bus B will no longer be available through the 12 kw feeder. All power levels are as measured at the fuel cell terminals.

b. Auxiliary Power Interface - Two feeders capable of being tied together directly by the payload shall be provided on separate connectors near the power interface at station Xo = 645. Each feeder shall be capable of providing 20 amps from separate Orbiter sources, and the two feeders, when connected in parallel, shall have a total capacity of 20 amps.

c. Aft Payload Bay Interface - Two 2 kw feeders shall provide power from separate Orbiter sources near Station Xo = 1307, one on each side of the bay. In addition, ground power will be available through the right hand T-0/Xo 1307 bulkhead payload interface panel.

3.3.1.3.3.3.1.1 Aft Crew Station Payload Unique Equipment

Redundant Orbiter sources shall provide electrical power to payload equipment in the aft crew station.

3.3.1.3.3.3.1.2 Orbiter Emergency Minimum Power Condition

During Orbiter emergency conditions, power will be provided temporarily to payloads for payload safing, if necessary. Subsequent to payload safing, power may not be available to payloads.

3.3.1.3.3.3.2 Electrical Signal Interface

The Orbiter Vehicle shall provide the electrical signal wiring interface at the forward cargo bay bulkhead to accommodate payload supplied mission equipment mounted in the Orbiter cabin, primary command, systems management and telemetry, C&W, GN&C, timing, data recording, audio, closed circuit TV, S-Band FM, and Ku-Band. A patch distributor shall be located in the Orbiter Aft Cabin to provide flexibility for mission unique equipments and minimize wiring changes during turnaround. The Orbiter shall provide a signal wire interface between the aft bay bulkhead and the T-0 umbilical which accommodates command, telemetry, safing, C&W, and status data from the payload independent of the Orbiter avionics subsystem. In addition, the Orbiter shall make provisions for routing payload signal wire harnesses through the central portion of the payload bay wire trays (port or starboard) with provision for removal and installation independent of Orbiter wiring and without uncovering the Orbiter wiring. The above provisions are Orbiter weight chargeable. Kits required to interface the payload with the forward and aft cargo bay bulkheads are payload provided and weight chargeable.

3.3.1.3.3.3.3 Power Allocation

The Orbiter shall allocate power to the payload as stated below, but usage is constrained by heat removal capacity as specified, in Paragraph 3.3.1.3.3.6.1.

3.3.1.3.3.3.3.1 Ground Operation (GSE Power)

The Orbiter shall provide power through the mid payload bay power interface for use by the payload during checkout and prelaunch at the levels and times noted below:

a. Before the Orbiter is transferred to internal power, it shall provide 3 kw of GSE power to the payload from an Orbiter main bus which is supplying as much as 9 kw to Orbiter loads. Both the primary and backup payload power circuits shall be capable of supporting this requirement. Reference NSTS 07700, Volume XIV, Attachment 1 (ICD 2-19001) Table 7.3.2.2-1.

b. The Orbiter shall provide on-orbit power levels (approximately 12 kw peak) through the primary power circuit or contingency power levels (7 kw peak) through the backup power circuit. This power shall be time-shared with the Orbiter.

3.3.1.3.3.3.3.2 Prelaunch, Ascent, Descent, and Post-Landing (All internal Orbiter power source)

The Orbiter shall provide up to 400 watts to the aft flight deck for payload unique operation functions equipment and up to 400 watts to the Orbiter crew compartment mid-deck

payloads (the combined total shall not exceed 600 watts). The Orbiter shall also provide 2600 watts maximum to the Orbiter/payload bay electrical interface (midbay). Additional payload power may be provided as a function of fuel cell performance and Shuttle Systems power utilization. The mission-specific available payload power shall be limited to assure compliance with the Orbiter/SRB electrical interface requirements as specified in ICD 2-14001 for all nominal and single power source failure conditions.

3.3.1.3.3.3.3.3 On-orbit

The Orbiter shall provide up to 1000 watts to the aft flight deck and up to 1800 watts to the crew compartment mid-deck (the combined total not to exceed 2100 watts and subject to the limitations of Paragraph 3.3.1.3.3.6.1.6) for payload unique operation functions equipment, and:

a. Up to 8000 watts maximum except for peaks up to 12,000 watts (for a maximum of 15 minutes to occur no more often than once in a 3.0 hour period) at the mid payload bay electrical interface, or

b. Up to 7000 watts maximum at the fuel cell can be delivered to the mid payload bay electrical interface via the Bus B backup power circuit, and

c. Up to 1500 watts maximum, except for peaks up to 2000 watts (for a maximum of 15 minutes to occur no more often than once in a 3.0 hour period) from each of the two feeders at the aft payload bay electrical interface.

The total power available to payloads, from all sources in all locations (including AC power) shall not exceed 8000 watts maximum, 12000 watts peak (for a maximum of 15 minutes to occur no more often than once in a 3.0 hour period).

3.3.1.3.3.3.3.4 Electrical Energy

The Orbiter EPS shall provide two reactant storage tank sets. An additional two reactant storage kits shall be installed outside of the payload envelope as the nominal Orbiter configuration. Additionally, volume for a third reactant storage kit shall be provided outside the payload envelope. Each kit shall be capable of providing approximately 840 kwH of additional energy. On selected vehicles used for extended duration missions, additional oxygen/hydrogen tank sets will be installed on a pallet in the aft payload bay of the vehicle. These tank sets will be capable of providing electrical energy for the extended duration missions as specified in Paragraph 3.3.1.2.5.1.

3.3.1.3.3.3.3.5 Operating Voltage and Ripple Voltage

During flight, power shall be provided to the payload from a nominal 28 Volts, Direct Current (VDC) system.

a. Aft Flight Deck - 24.0 to 32.0 volts DC with peak-to-peak narrowband (30 Hz to 7 kHz) not to exceed 0.9 volts falling 10 dB per decade to 0.28 volts peak-to-peak at 70 kHz, thereafter remaining constant to 400 MHz. The momentary coincidence of two or more signals at any one frequency shall not exceed the envelope defined as 1.6 volts peak-to-peak (30 Hz to 7 kHz), falling to 10 dB per decade at 0.5 volts peak-to-peak at 70 kHz, thereafter remaining constant to 400 MHz.

b. Mid Payload Bay - 27.2 to 32.0 volts DC with peak-to-peak narrowband (30 Hz to 7 kHz) not to exceed 0.9 volts falling 10 dB per decade to 0.28 volts peak-to-peak at 70 kHz, thereafter remaining constant to 400 MHz. The momentary coincidence of two or more signals at any one frequency shall not exceed the envelope defined as 1.6 volts peak-to-peak (30 Hz to 7 kHz) falling 10 dB per decade to 0.5 volts peak-to-peak at 70 kHz, thereafter remaining constant to 400 MHz.

c. Aft Payload Bay - Same as that of aft flight deck.

3.3.1.3.3.3.3.6 AC Power to Payloads

The Orbiter shall provide redundant AC power to the payload and mission stations in the aft flight deck and in the cargo bay station X0603 (patched through from AC2 and AC3) at 400 Hz, 115 ± 5 volts RMS, 3-phase, 4-wire wye connection.

a. On-Orbit - 690 VA max total combined, 1000 VA peak for two minutes/three hours.

b. Descent and Post-Landing - 350 VA max total combined, 420 VA peak for two minutes/three hours.

AC power not available during prelaunch and ascent phases. Total combined DC and AC power to the aft flight deck and payload bay shall not exceed the values specified in Paragraph 3.3.1.3.3.3.3.3.

3.3.1.3.3.3.4 Power Transition

a. After Ascent - The Orbiter shall provide the capability for the payload to begin the transition from ascent power level to the on-orbit power level at the OMS-2 burn time plus 30 minutes. (The OMS-2 maneuver time is dependent upon orbital parameters and will vary between 34 and 57 minutes after launch.) The payload power increase may then proceed at a rate determined by the normal

power-up procedures applicable for specific payload if the Orbiter has been appropriately powered down.

b. Prior to Deorbit - The transition from on-orbit power levels to entry power levels shall occur at the beginning of deorbit preparation (depending upon PLBD closure).

3.3.1.3.3.4 Communications Interfaces

3.3.1.3.3.4.1 Voice

The Orbiter shall provide to an attached payload duplex voice service of up to six separate channels, three of which are relayable to the ground (Air to Ground [A/G] 1, A/G 2, Air-to-Air [A/A]), while three are used for payload-Orbiter communications (ICOM A, ICOM B, paging).

NOTE: A/A external to Orbiter is RF simplex.

3.3.1.3.3.4.2 Commands and Update

The Orbiter Vehicle shall have the capability to initiate and transmit up to 2 Kbps of commands or data to an attached or released payload. The Orbiter shall provide the capability to issue commands via the Payload Signal Processor to up to five attached payloads. In addition, the capability to command one detached payload shall be provided during that period of time that PLBDs are open. The Orbiter shall have the capability to relay up to 2 Kbps ground initiated commands or data to attached or released payloads. This communication link shall include a command confirmation capability that the command was received by the Orbiter.

3.3.1.3.3.4.3 Digital Data

Digital data shall be transferred from the payload to the ground via the Orbiter Vehicle as follows:

a. Attached Payload - Up to five payload elements shall provide a single time division multiplexed data stream to the Orbiter Payload Data Interleaver (PDI) at a minimum of 10 bps and not to exceed 64 Kbps.

b. Released Payload - Up to 16 Kbps of digital data shall be relayed to the ground via Orbiter.

3.3.1.3.3.4.4 TV Video and Wideband Data

A hardwired input to the Orbiter Vehicle wideband transmitter carrier shall be provided for attached payloads. For analog data, the payload shall provide commutation and

subcarrier oscillators compatible with the Orbiter transmitter circuitry. For digital data, the payload shall provide the required encoding for compatibility with the Orbiter transmitter. This transmitter shall be time shared among Orbiter downlink TV, payload analog data, or payload digital data. The Orbiter shall provide the cargo complement one Orbiter CCTV video output and sync lines. The Orbiter CCTV system shall receive from the cargo complement up to three separate video inputs. These resources must be shared by the payloads which comprise the cargo complement.

3.3.1.3.3.4.5 Encryption Requirements

Provisions to provide encryption/decryption/authentication for DOD data to be exchanged by RF between DOD spacecraft and the Shuttle Flight Vehicle will be internal to the DOD provided Communications Interface Unit (CIU). A single switch shall be provided to “zeroize” all encryption/decryption devices (KGX-60 plus KGT-60 and KGR-60 in the Payload station) during emergency situations.

3.3.1.3.3.4.6 Standardized Communications Interface

A standardized interface shall be provided by the Orbiter Vehicle for communications between the Orbiter Vehicle and payloads. The following functions shall be accommodated by standardized hardwire interfaces for attached payloads:

a. Wideband information (analog or digital data, or TV video) to the wideband transmission system

b. Digital data to the Orbiter telemetry system

c. Duplex voice to the Orbiter audio system

The following functions, as required, shall be accommodated by standardized RF interfaces for released payloads:

a. Command or data transmission to the payload

b. Data transmission from the payload to the Orbiter

c. Tracking of the payload

3.3.1.3.3.4.7 Non-Standardized Communications Interface

A non-standardized interface shall be accommodated by the Orbiter to relay to the ground (in a bent-pipe mode) data from payloads.

3.3.1.3.3.5 Support Requirements

3.3.1.3.3.5.1 Payload Monitor Subsystem Interface

Connectors shall provide a serial, digital data interface for payload performance monitoring and predeployment checkout. If command/stimulus functions are required to

perform predeployment checkout, the payload system shall provide this capability via a serial, digital command link addressable by the payload monitor subsystem.

3.3.1.3.3.5.2 GN&C Data Interfaces

An interface between the payload and Orbiter Vehicle GN&C shall be capable of providing transfer of payload initializing data, vehicle state vector, attitude, and attitude rate. In addition, GMT, mission elapsed time, and other timing data shall be available from the Master Timing Unit.

3.3.1.3.3.5.3 Displays and Controls Interfaces

The Orbiter shall provide the following displays and controls to support payload operations:

3.3.1.3.3.5.3.1 On-orbit Station

The On-orbit Station shall contain D&C required to execute attitude/translation and maneuver sequences for rendezvous and docking, and deploying and retrieving payloads. This station shall also provide space and installation provisions for payload supplied equipment for conduct of payload operations.

3.3.1.3.3.5.3.2 Payload Station

The Payload Station shall contain space and installation provisions for payload and/or Space Shuttle supplied displays and controls which are used for management of payload operations.

3.3.1.3.3.5.3.3 Mission Station

The Mission Station shall contain displays and controls for management of Orbiter/payload interfaces, and shall provide accommodations for payload supplied displays and controls for payload support systems and for experiment operations as appropriate.

3.3.1.3.3.5.3.4 Payload Operations Monitoring and Control

The Orbiter shall provide the capability to support control of payload operations simultaneously with direct and/or remote viewing of selected payload components in the payload bay and/or the remote manipulator and its attachment points with payloads in the vicinity of the payload bay. The Orbiter shall provide the capability for simultaneous direct payload bay viewing and control of CCTV and appropriate interior/exterior lighting.

3.3.1.3.3.5.4 Orbiter/Payload Electrical Interfaces

The following electrical interfaces shall be provided between the Orbiter crew compartment and payloads:

a. Connections to interface Orbiter avionics subsystem and payload supplied equipments to the payloads

b. Connections to interface payload data and communications with the Orbiter Vehicle or aft flight deck

c. Connections to interface wideband data from the payload with a payload supplied recorder located in the Orbiter cabin, or Orbiter avionics system

d. Electrical power from the electrical power subsystem to the aft flight deck, middeck and the payloads

3.3.1.3.3.5.5 Payload Data Processing

The Orbiter shall have the capability to checkout, monitor, and command payloads. The Orbiter must be capable of performing the checkout, monitor, and command functions at all times on-orbit. A limited capability for payload monitoring and command shall be provided for all flight phases and ground operations. Payload C&W signals shall be displayed to the flight crew and at the mission station. The capability shall be provided to display payload parameters in realtime to the mission station.

3.3.1.3.3.5.6 Recorder Interface

The Orbiter Vehicle shall provide for the onboard recording of selected analog (such as IRIG frequency division multiplex) and digital payload data.

3.3.1.3.3.6 Payload Thermal Control and Atmospheric Revitalization

3.3.1.3.3.6.1 Thermal Control

The Orbiter Vehicle shall provide a heat sink during all mission phases for the payload waste heat.

3.3.1.3.3.6.1.1 Payload Bay Doors Closed

During ascent (above approximately 100,000-foot altitude), entry (including Post-landing Thermal Conditions as specified in Paragraph 3.2.1.1.15) and on-orbit with PLBDs closed, the heat removal capability from payload shall be 5,200 BTU/hr with coolant temperatures of 45°F maximum to the payload and 100°F returned from the payload.

3.3.1.3.3.6.1.2 Payload Bay Doors Open

During orbital operations with the PLBDs open, the ATCS will provide heat removal capability from the payload of up to 29,000 BTU/hr. Actual heat removal capability will depend on the coolant flow variables defined in the ICD-2-19001.

3.3.1.3.3.6.1.3 (Deleted)

3.3.1.3.3.6.1.4 Interface Heat Exchanger

A single payload heat exchanger will be provided for the Orbiter to remove heat from the payloads. The heat exchanger will be sized to meet the 29,000 BTU/hr requirements of Paragraph 3.3.1.3.3.6.1.2.

3.3.1.3.3.6.1.5 Payload Coolant Fluid

The payload heat exchanger shall be designed so that any of the following can be selected (by the payloads) as a payload fluid: water, Freon 21, and Freon 114.

3.3.1.3.3.6.1.6 Cabin Located Equipment

A payload may be cooled with (active) or without (passive) payload provided capability to internally circulate cabin air. The total cabin payload heat load (active and passive combined) shall not cause the cabin air temperature to exceed the temperatures given below:

Mission Phase	Max Cabin Temperatures	Conditions
Prelaunch/Ascent	75 + 5 deg F 75 deg F	with TELCG* without TELCG*
On-orbit	80 deg F	14.7 psi and 10.2 psi
Descent/Landing, Post-landing	75 deg F	with or without TELCG*

*TELCG - Thermo-Electric Liquid Cooling Garment (worn by crew)

The payload integration process determines the payload cooling capability for each mission phase. It is analyzed on a flight-by-flight basis and is a function of launch date and time, crew size, on-orbit attitude and configuration, and crew cooling. The above values (cabin temperatures) represent maximum limits for preflight planning and verification. Any exceedances to the above values during flight will be managed realtime through operational flight rules and will not require waivers to this requirement.

The total amount of passive cooling allowable in the crew cabin, via direct radiation and/or convection to the cabin air can range from 0 watts to 2150 watts. The maximum

cabin temperature limit for each mission phase will determine the actual passive cooling allowable.

The Orbiter can provide forced air (active cooling) of up to 700 watts for Aft Flight Deck (AFD) payloads equipment, 400 watts (36 Cubic Feet per Minute [CFM]) for mid-deck Bay 1 payloads, 200 watts (18 CFM) for Bay 2 payloads, and 1000 watts (180 CFM) for mid-deck Bay 3A payloads. Forced air cooling is not provided on OV-102 mid-deck lockers. Mid-deck payloads requiring active cooling shall interface with the Orbiter soft plenum cooling interface located behind the locker.

3.3.1.3.3.6.2 Atmospheric Revitalization

The Orbiter Vehicle shall provide for atmospheric revitalization of habitable payload modules by providing accommodations for ducting for circulation of conditioned cabin air to the payload for use of up to four crewmen. The Orbiter ducting kit will provide this ducting. Adequate air recirculation between the Orbiter cabin and the payload will be accomplished by a fan, sized and supplied as a part of and by the payload. The Orbiter shall also control and maintain module internal pressure. The Orbiter shall provide the capability for payloads to obtain oxygen from the Orbiter cryogenic oxygen tankage. To accomplish this, a regulated oxygen line shall be provided in the payload bay near the Orbiter aft cabin bulkhead.

3.3.1.3.3.7 Illumination

The Orbiter Vehicle shall provide a lighting subsystem for illumination to support Orbiter docking/berthing operations with other spacecraft and Orbiter/payload operations external to the Orbiter Vehicle and inside the payload bay.

3.3.1.3.3.8 (Deleted)

3.3.1.3.3.9 Payload Conditioning Control

Capability for purging and atmospheric control of the payload bay, independent of the Orbiter Vehicle internal structure, shall be provided by GSE while on the launch pad with the PLBDs opened or closed. The Orbiter shall be designed for payload thermal conditioning and bay purging using conditioned purge gas. Air shall be used as the purge gas with the PLBDs open and either air or GN_2 with the doors closed. Connectors and internal plumbing for payload conditioning and bay purging and atmospheric control, located outside of the payload volume, shall be provided by the Orbiter.

3.3.1.3.3.10 Payload Bay Acoustics

The Orbiter Vehicle payload bay interior sound pressure level shall not exceed a maximum overall of 138 dB (re. 20 N/m^2) for the spectral frequency distribution shown in

NSTS 07700, Volume XIV, Attachment 1 (ICD 2-19001). The overall level of the space averaged sound pressure in the payload bay (without payload) shall not exceed 145 dB with a spectral frequency distribution as follows:

Octave Band Center Freq. (H_z)	Sound Pressure Level (dB)
31.5	124.5
65	130.5
125	137
250	140
500	139.5
1000	134
2000	128
4000	122

3.3.1.3.3.11 Pressure

The Orbiter Vehicle payload bay shall be vented during launch and entry and shall operate unpressurized during the orbital phase of the mission. Venting and repressurization of the payload bay shall be separate from the rest of the vehicle vent/repressurization system.

3.3.1.3.3.12 Payload Bay Wall Temperatures

The internal wall temperatures for the payload bay is dependent on cargo element energy sources and sinks, cargo element configuration, and specific mission attitude timeline. Realistic payload bay environments require a detailed integrated Orbiter/cargo element thermal analysis.

3.3.1.3.3.13 Payload Bay Vibration

The Orbiter Vehicle payload bay attachment vibration environments shall not exceed those shown in NSTS 07700, Volume XIV, Attachment 1 (ICD 2-19001).

3.3.1.3.3.14 (Deleted)

3.3.1.3.3.15 (Deleted)

3.3.1.3.3.16 Attachments for Payload Deployment/Retrival

The Orbiter manipulator(s) shall interface with payload provided attach points for payload deployment and retrieval.

3.3.1.3.3.17 Orbiter/Payload Interface Connectors

The Orbiter Vehicle shall provide standard connectors for electrical power, electrical signals, and fluid interfaces in the payload bay and crew compartment.

3.3.1.3.3.18 Payload Heat Rejection Kit Mounting and Venting Interfaces

The Orbiter Vehicle shall provide mounting capability and necessary vents for a payload supplied heat removal kit having the capacity to remove 48,000 BTU/hr.

3.3.1.3.3.19 Orbiter Interface with Spacelab

The Orbiter shall interface with the Spacelab as defined in the following ICDs.

3.3.1.3.3.19.1

Structural/Mechanical Interfaces are defined in NSTS 21000-IDD-SL.

3.3.1.3.3.19.2

ECS/Thermal Interfaces are defined in NSTS 21000-IDD-SL.

3.3.1.3.3.19.3

Avionics Interfaces are defined in NSTS 21000-IDD-SL.

3.3.1.3.4 Orbiter Vehicle Interface with Main Engine

The Orbiter Vehicle shall interface with the main engines as defined in ICD 13M15000, Space Shuttle Orbiter Vehicle/Main Engine Interface Control Document.

3.3.1.3.5 Orbiter Vehicle Interface with Carrier Aircraft

The Orbiter Vehicle shall interface with the carrier aircraft as defined in ICD 2-17001, Orbiter/Carrier Aircraft Vehicle Interface Control Document.

3.3.1.3.6 (Deleted)

3.3.1.3.7 Orbiter Vehicle Interface with KSC Landing Station

The Orbiter Vehicle shall interface with the KSC Landing Station as defined in ICD 2-1A001, Orbiter/KSC Landing Station Interface Control Document.

3.3.1.3.8 Orbiter Vehicle Interface with Orbiter Processing Facility

The Orbiter shall interface with the Orbiter processing facility as defined in ICD 2-1A002, Orbiter Processing Facility/Orbiter Maintenance Checkout Facility Interface Control Document.

3.3.1.3.9 Orbiter Vehicle Interface with Hypergolic Maintenance Facility

The Vehicle System, Orbiter Aft Propulsion System (APS) and Forward Reaction Control System, shall interface with the hypergolic maintenance facility as defined in Orbiter/Hypergolic Station ICD 2-1A003, Orbiter/Hypergolic Station.

3.3.1.3.10 Orbiter Vehicle Interface with Shuttle Vehicle Assembly and Checkout Station

The Orbiter shall interface with the Shuttle Vehicle Assembly and Checkout Station in the VAB as defined in ICD 2-0A001, Shuttle System/Launch Platform Stacking and VAB Servicing Interface Control Document.

3.3.1.3.11 Orbiter Vehicle Interface with Launch Pad Station

The Orbiter shall interface with the launch pad station as defined in ICD 2-0A002.

3.3.1.3.12 Orbiter Vehicle Interface with All Orbiter Landing Stations Except KSC

The Orbiter shall interface with all Orbiter landing stations except KSC as defined in ICD 2-1D003, Orbiter Secondary Landing/Safing and Deservicing Stations Interface Control Document.

3.3.1.3.13 (Deleted)

3.3.1.3.14 Orbiter Vehicle Interface with Communications and Tracking Functions (DFRC)

The Orbiter shall interface with the communications and tracking functions at DFRC as defined in ICD 2-0D004.

3.3.1.3.15 Orbiter and Carrier Aircraft Interface with the Mate Demate Device

The Orbiter and Carrier Aircraft shall interface with the mate demate device as defined in ICD 2-1D004, Orbiter and Carrier Aircraft Mate/Demate Interfaces Interface Control Document.

3.3.1.3.16 Orbiter Vehicle Interface with Launch Processing System (LPS) Computational System

The Orbiter shall interface with the LPS computational system as defined in ICD 2-0A003, Flight Vehicle/LPS Computational Systems Interface Control Document.

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TABLE 3.3.1.1.4

ORBITER-TARGET SPACECRAFT DOCKING CONTACT CONDITION LIMITS (1) (3)

Parameter	Value
Axial Closing Velocity (ft/sec)	0.00 to 0.20
Lateral Velocity (radial, ft/sec)	0 +/- 0.15
Lateral Misalignment (radial, ft)	0.35
Angular Velocity (each axis, deg/sec)	0 +/- 0.20
Angular Misalignment (each axis, deg)	0 +/- 4.00 (2)

NOTES:

(1) The contact conditions specified in this table are the Orbiter mating interface-to-target spacecraft mating interface relative state contact limits, referenced to the geometric center of the Orbiter mating interface. For design purposes, all of the listed parameters and associated maximum values shall be considered to be concurrent at the time of contact.

(2) Four degrees about Orbiter Z axis. Vector sum of four degrees about Orbiter X and Y axes.

(3) Orbiter RCS may be used to assist capture.

TABLE 3.3.1.2.1.2.2

CARGO X CG ENVELOPE

Cargo Weight	Distance from Forward End of Payload Bay Envelope Xo = 582.0 (Inches)	
Lbs X 1000	Fwd Limit	Aft Limit
2.0	-	698.76
3.5	-	625.13
5.0	-	595.68
6.5	-	579.82
8.0	32.44*	569.91
9.5	105.43	563.12
11.0	158.51	558.19
12.5	198.35	554.44
14.0	230.55	551.50
15.5	256.11	549.12
17.0	277.16	547.17
18.5	294.80	545.53
20.0	309.79	544.13
21.5	322.69	542.94
23.0	333.91	541.89
24.5	343.75	540.98
26.0	352.46	540.17
27.5	360.22	539.45
29.0	367.18	538.80
30.5	373.45	538.22
32.0	379.13	537.69
33.5	384.31	537.21
35.0	389.04	536.77
36.5	393.38	536.37
38.0	397.38	536.00
39.5	401.07	535.65
41.0	404.50	535.33
42.5	407.68	535.04
44.0	410.65	534.76
45.5	413.42	534.51
47.0	416.01	534.26
48.5	418.45	534.04
50.0	420.73	533.83
51.5	422.89	533.63
53.0	424.92	533.44
54.5	426.84	533.26
56.0	428.66	533.09
57.5	430.38	532.93
59.0	432.02	532.78
60.5	433.57	532.63
62.0	435.05	532.50
63.5	436.46	532.36
65.0	437.80	532.24

*Fwd limit is zero at 7475.4 lb

TABLE 3.3.1.2.1.2.2a

CARGO Y CG ENVELOPE

Cargo Weight Lbs X 1000	Distance from Payload Bay C Yo = 0 (Inches)
2	±32.82
4	±17.16
6	±11.94
8	± 9.33
10	± 7.76
12	± 6.72
14	± 5.97
16	± 5.42
18	± 4.98
20	± 4.63
22	± 4.35
24	± 4.11
26	± 3.91
28	± 3.74
30	± 3.59
32	± 3.46
34	± 3.34
36	± 3.24
38	± 3.15
40	± 3.07
42	± 2.99
44	± 2.92
46	± 2.86
48	± 2.81
50	± 2.75
52	± 2.70
54	± 2.66
56	± 2.62
58	± 2.58
60	± 2.54
62	± 2.51
64	± 2.48
65	± 2.46

TABLE 3.3.1.2.1.2.2b

CARGO Z CG ENVELOPE

Cargo Weight Lbs X 1000	Distance from Payload Bay Centerline Zo = 400 (Inches)			
	Cargo Upper Limit	Upper Limit for Payload Mounted on Payload Bay Attachments	Lower Limit for Payload Mounted on Payload Bay Attachments	Cargo Lower Limit
2	90.00	90.00	-90.00	-90.00
3	90.00	90.00	-90.00	-90.00
4	90.00	90.00	-45.00	-90.00
5	90.00	45.00	-45.00	-90.00
6	90.00	45.00	-45.00	-90.00
8	90.00	45.00	-45.00	-90.00
10	90.00	45.00	-45.00	-90.00
12	90.00	45.00	-45.00	-90.00
14	79.59(1)	45.00	-45.00	-90.00
16	67.70	45.00	-45.00	-90.00
18	58.46	45.00	-45.00	-90.00
20	51.06	45.00	-45.00	-90.00
22	45.01	45.00	-45.00	-90.00
24	39.97	39.97(3)	-45.00	-90.00
26	35.70	35.70	-45.00	-90.00
28	32.04	32.04	-45.00	-90.00
30	28.87	28.87	-45.00	-90.00
32	26.10	26.10	-45.00	-88.94(2)
34	23.65	23.65	-43.48	-86.06
36	21.48	21.48	-41.97	-83.50
38	19.53	19.53	-40.45	-81.22
40	17.78	17.78	-38.94	-79.15
42	16.20	16.20	-37.42	-77.29
44	14.76	14.58(4)	-35.91	-75.59
46	13.44	12.48	-34.39	-74.05
48	12.23	10.59	-32.88	-72.63
50	11.12	8.91	-31.36	-71.32
52	10.10	7.44	-29.85	-70.12
54	9.15	6.18	-28.33	-69.00
56	8.27	5.13	-26.82	-67.97
58	7.45	4.29	-25.30	-67.00
60	6.69	3.66	-23.79	-66.10
62	5.97	3.24	-22.27	-65.26
64	5.30	3.03	-20.76	-64.47
65	4.98	3.00	-20.00	-64.09

(1)Cargo CG reaches upper cargo envelope limit of 90 in. at 12,618.4 lb
(2)Cargo CG reaches lower cargo envelope limit of -90 in. at 31,323.4 lb
(3)Cargo CG intersects upper control limit line at 22004.0 lb
(4)Cargo CG intersects upper control limit line at 43571.8 lb

TABLE 3.3.1.2.1.3.10.1

MATING/DEMATING OPERATION LOAD AND MOMENT LIMITS

1	
Loads (Kgf)	
Tension	250 + (750 Dynamic ≤ 0.1 sec)
Compression	250 + (750 Dynamic ≤ 0.1 sec)
Shear	500
1	
Moments (Kgf-m)	
Torsion	± 300
Bending	± 500
2	
Relative Dynamic Rotation Limits (deg)	
$\Theta x,y$	13
Θz	13

NOTES:

1. For design purposes, the load and moment limits listed shall apply concurrently. The parameters listed are referenced to the Orbiter coordinate system as defined in NSTS 07700, Volume XIV, Attachment 1, Paragraph 3.1.1.1.

2. For design, dynamic rotation shall apply simultaneously, $\Theta x,y$ is a vector sum.

TABLE 3.3.1.2.1.3.10.1a

ORBITER MASS PROPERTIES AT ISSA CONTACT

	Mass (lbs)	CG (in)			Inertia (slug-ft^2)			Inertia (slug-ft^2)		
		X	Y	Z	Ixx	Iyy	Izz	Pxy	Pyz	Pxz
Heavy	246600	1087	-0.2	376	942200	7401700	7722900	6600	242700	1360
Light	208000	1100	-0.2	373	932100	7298600	7621800	6580	254200	1400
AFT CG	236000	1110	-1.0	375	944500	7189300	7515500	6920	257000	3060

TABLE 3.3.1.2.1.3.10.1b

ISSA MASS PROPERTIES AND ORBITER/ISSA ORIENTATION AT ORBITER CONTACT

(ISSA ASSEMBLY SEQUENCE BASELINED ON JULY 12, 1994)

	Stage 4 Flight 3A Arrival	Stage 17 Flight 11A Arrival	Stage 41 @ Flight 17A Departure	
Weight (lbs)	146457	427557	1051798	
CG (in)				
X	-811.32	-450.48	-113.36	
Y	0.12	53.28	-6.84	
Z	-189	146.52	267.72	
Moment of Inertia (slug-ft^2)				
Ixx	256159	7379696	98850752	
Iyy	6849649	35106668	114540632	
Izz	6751809	33545084	161699168	
Products of Inertia (slug-ft^2)				
Pxy	807	1515612	-1132262	
Pyz	-150	-255458	-219642	
Pxz	340307	-3635142	14289403	
Docking Interface Location (in)				
X	-153.54	542.52	542.52	
Y	0	0	0	
Z	363.36	218.9	218.9	
Relative Alignment in Orbiter Structural Axis	Space Station Axis of Alignment			
X	Neg Z	Pos Z	Pos Z	
Y	Neg Y	Pos Y	Pos Y	
Z	Neg X	Neg X	Neg X	

Coordinates are in the ISSA coordinate system i.e., the positive X-axis is perpendicular to the longitudinal axis of the integrated truss and in the nominal LVLH flight direction.
The positive Y axis is in the longitudinal axis of the integrated truss and is toward starboard.
The positive Z axis is toward nadir and completes the right-handed system.
All Mass properties were obtained from JSC 26557, Revision B, August 1994.

TABLE 3.3.1.2.1.3.14.1

SPECIFICATIONS AND STANDARDS

GOVERNMENT DOCUMENTS

SSP 30243 Rev C	Space Station Systems Requirements for Electromagnetic Compatibility
SSP 30420 Rev B (June 18, 1993)	Space Station Electromagnetic, Ionizing Radiation, and Plasma Environment Definition and Design Requirements
SSP 30425 Rev B	Space Station Program Natural Environment Definition for Design
SSP 30426 Rev D	Space Station External Contamination Control Requirements
SSP 30512 Rev C	Space Station Ionizing Radiation Design Environment
SSP 41000 Rev A (March 31, 1994)	System Specification for the International Space Station Alpha, Paragraphs 3.2, 3.3, and 4.3

NON-GOVERNMENT DOCUMENTS

D684-10019-1 Rev Basic	Structural Loads Control Plan
EG3-9311-160 Rev Update Version 2.0	Reaction Control System (RCS) Plume Model (RPM) Update, Version 2.0
EG3/9401-06 (January 24, 1994)	Application of Plume Impingement Uncertainties for the Reaction Control System (RCS) Plume Model (RPM), Version 2.0
EG3/9401-09 (January 31, 1994)	Plume Characterization Models of the Attitude Control System Rocket Exhaust for Three Russian Vehicles: 1) Soyuz, 2) Mir, 3) FGB (Tug)
EG4/93-33 Rev Draft (January 27, 1994)	Delivery of the Shuttle Trajectory and Firing History Database for Station SDR
ES42-124 (February 1, 1994)	Space Station SRR Docking Criteria Transmittal
SSD 930311	Rockwell Memorandum for Orbiter Flexible Model

TABLE 3.3.1.2.1.5.1

ORBITER LONGITUDINAL AND VERTICAL CG CONSTRAINTS AT ET SEPARATION FOR RTLS AND TAL (ORBITER COORDINATES)

	Xcg (inches)		Zcg (inches)	
	Fwd (min)	Aft (max)	Bottom (min)	Top (max)
TAL	1075.2	1125.0	360.0	388.0
RTLS	1081.1	1111.0	360.0	384.5

TABLE 3.3.1.2.1.5.2

ORBITER LONGITUDINAL AND VERTICAL CG CONSTRAINT COORDINATES AT ET SEPARATION FOR NO-FAIL, AOA/ATO ASCENT (ORBITER COORDINATES)

Xcg (inches)	Zcg (inches)
1075.2	360.0
1075.2	384.5
1101.5	394.4
1136.4	394.4
1137.5	383.5
1134.7	371.0
1111.0	360.0

FIGURE 3.3.1.2.1.2.2

PAYLOAD CG LIMITS, (ALONG X-AXIS)

NASA-S-74-7344 C

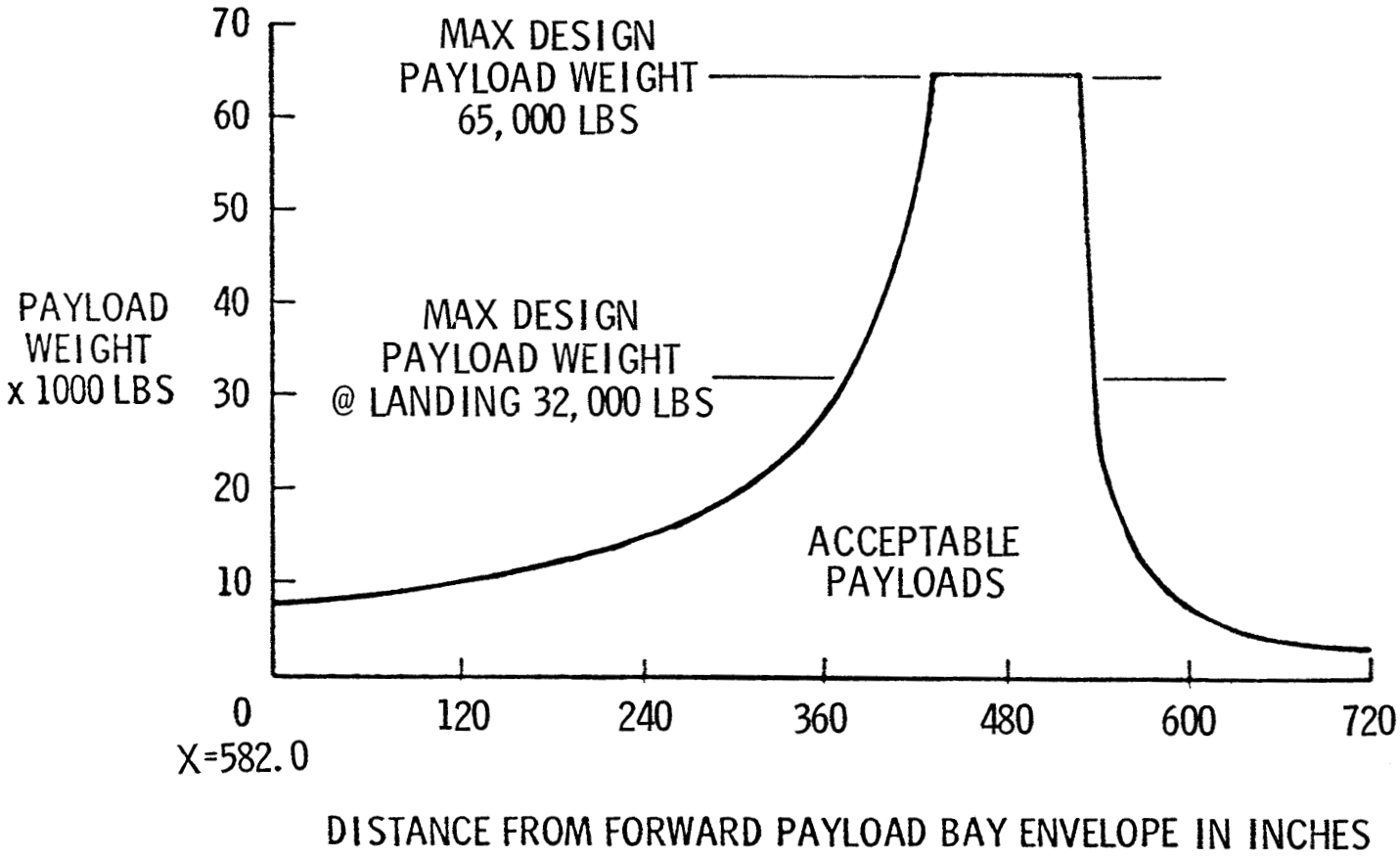


FIGURE 3.3.1.2.1.2.2a

PAYLOAD CG LIMITS, (ALONG Y-AXIS)

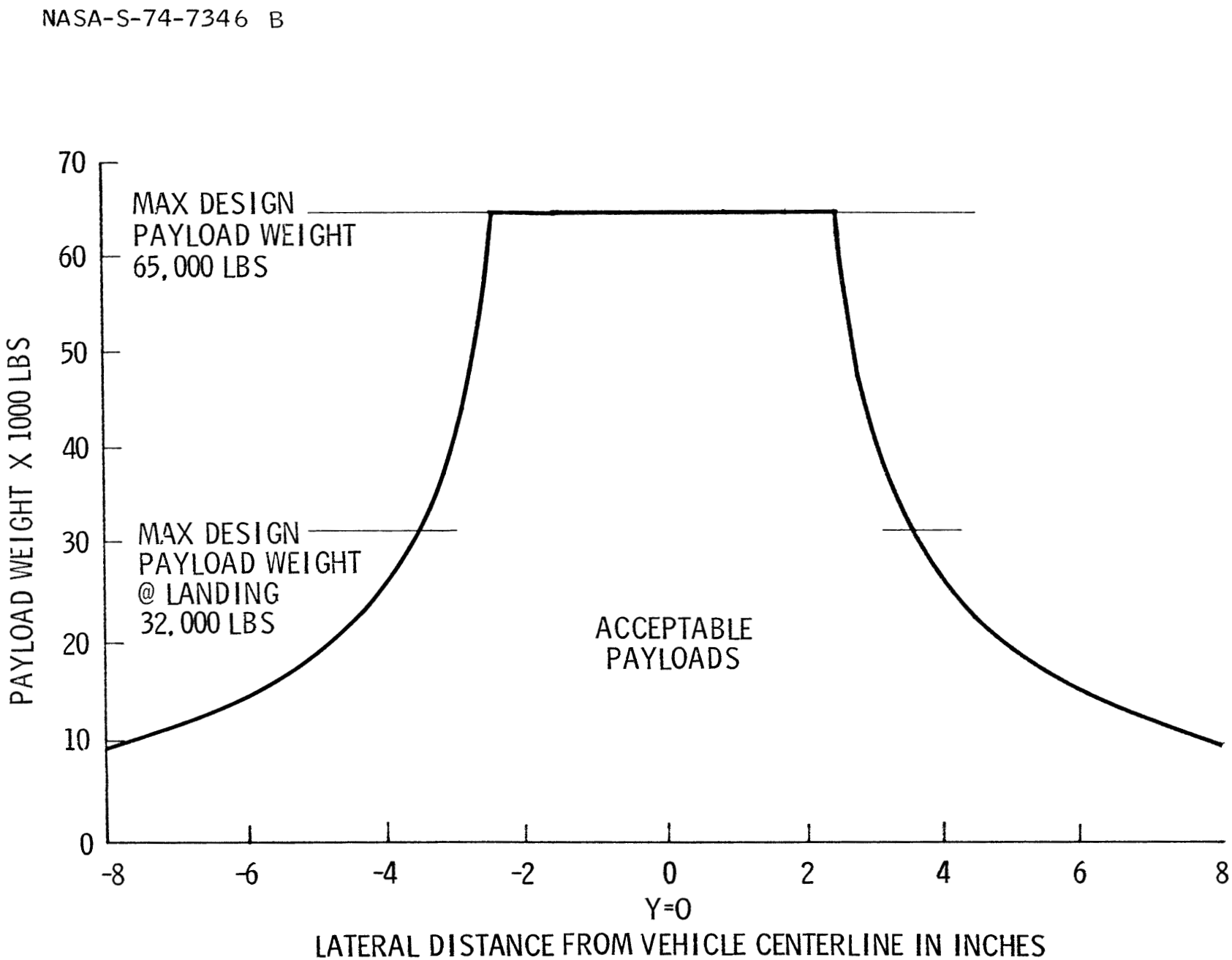


FIGURE 3.3.1.2.1.2.2b

PAYLOAD CG LIMITS, (ALONG Z-AXIS)

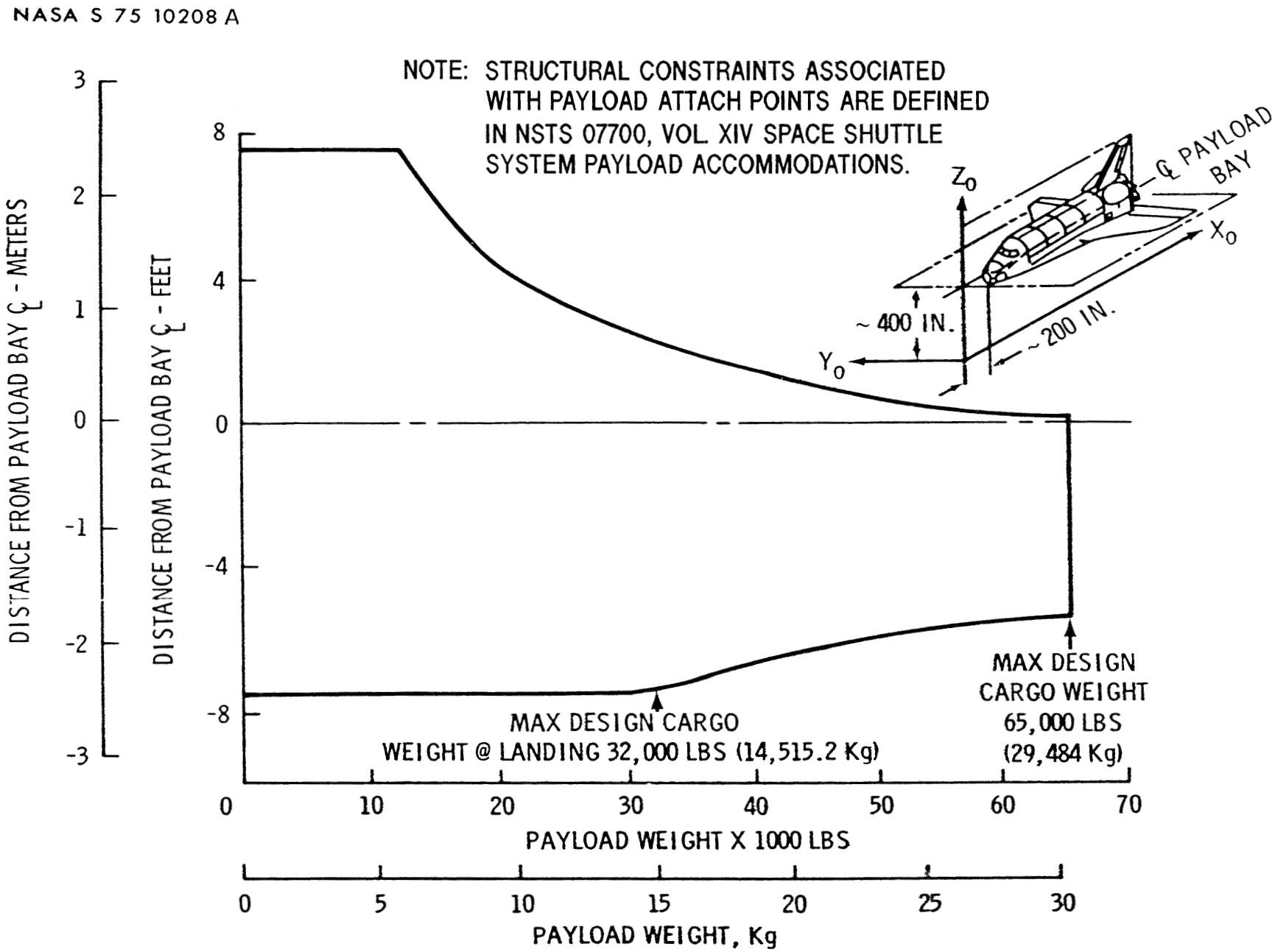


FIGURE 3.3.1.2.1.5.1

ORBITER CG LIMITS AT ET SEPARATION FOR NO-FAIL, AOA/ATO ASCENT

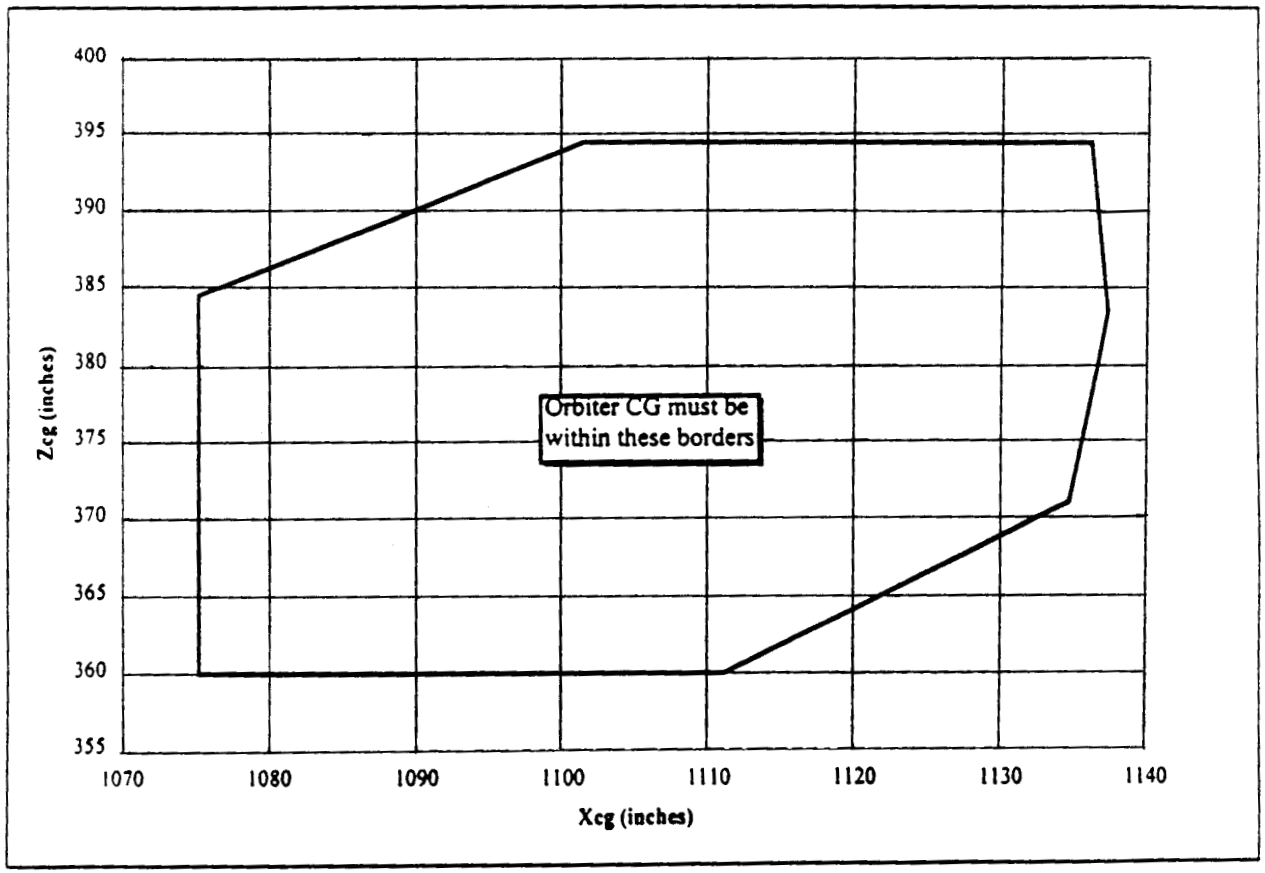


FIGURE 3.3.1.2.3.3.3

ALLOWABLE CONTROL SURFACE DEFLECTIONS DURING HIGH ENTRY HEATING REGIME FOR MACH NO. $\geq$13 (SHADED REGIONS ONLY)

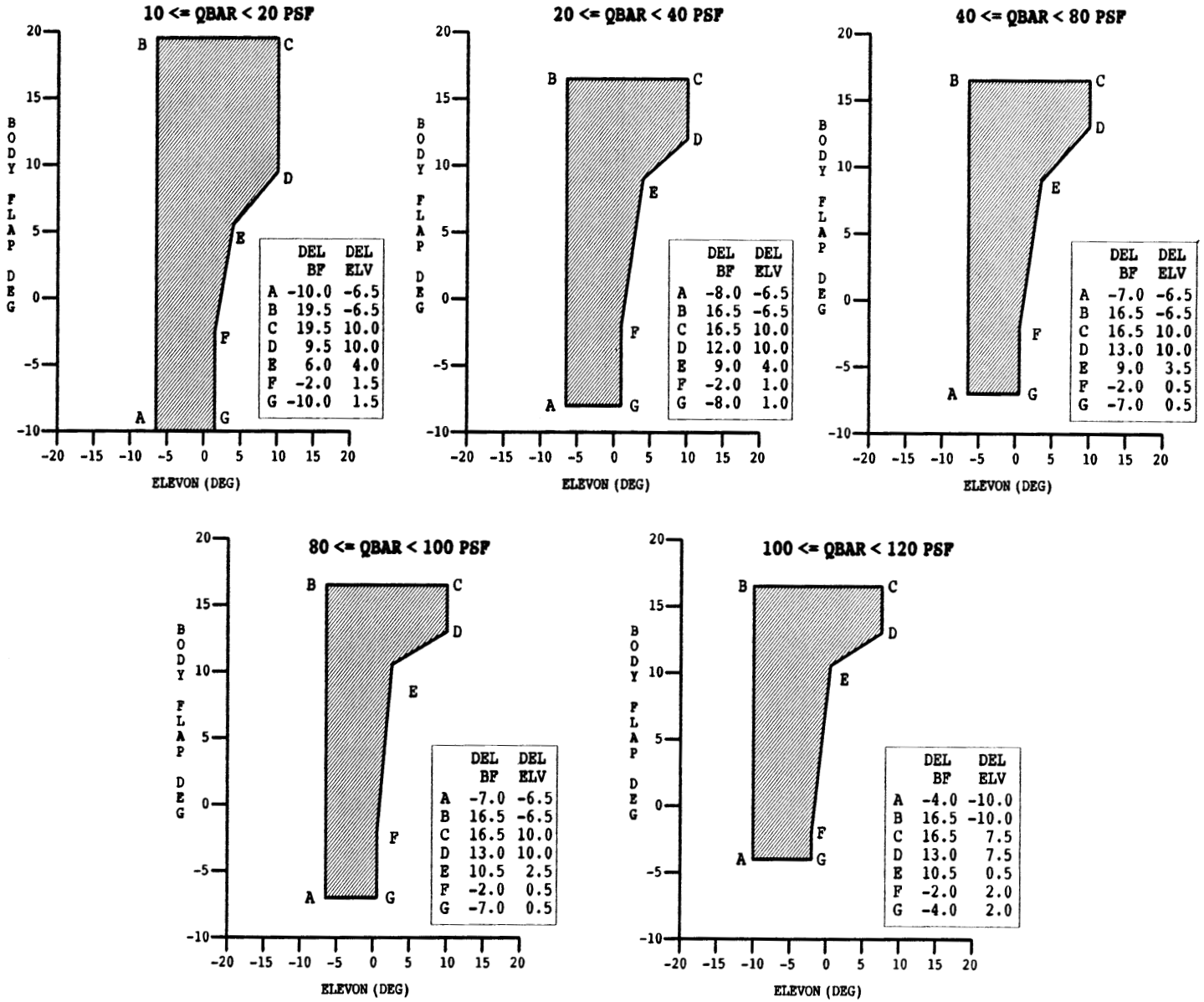
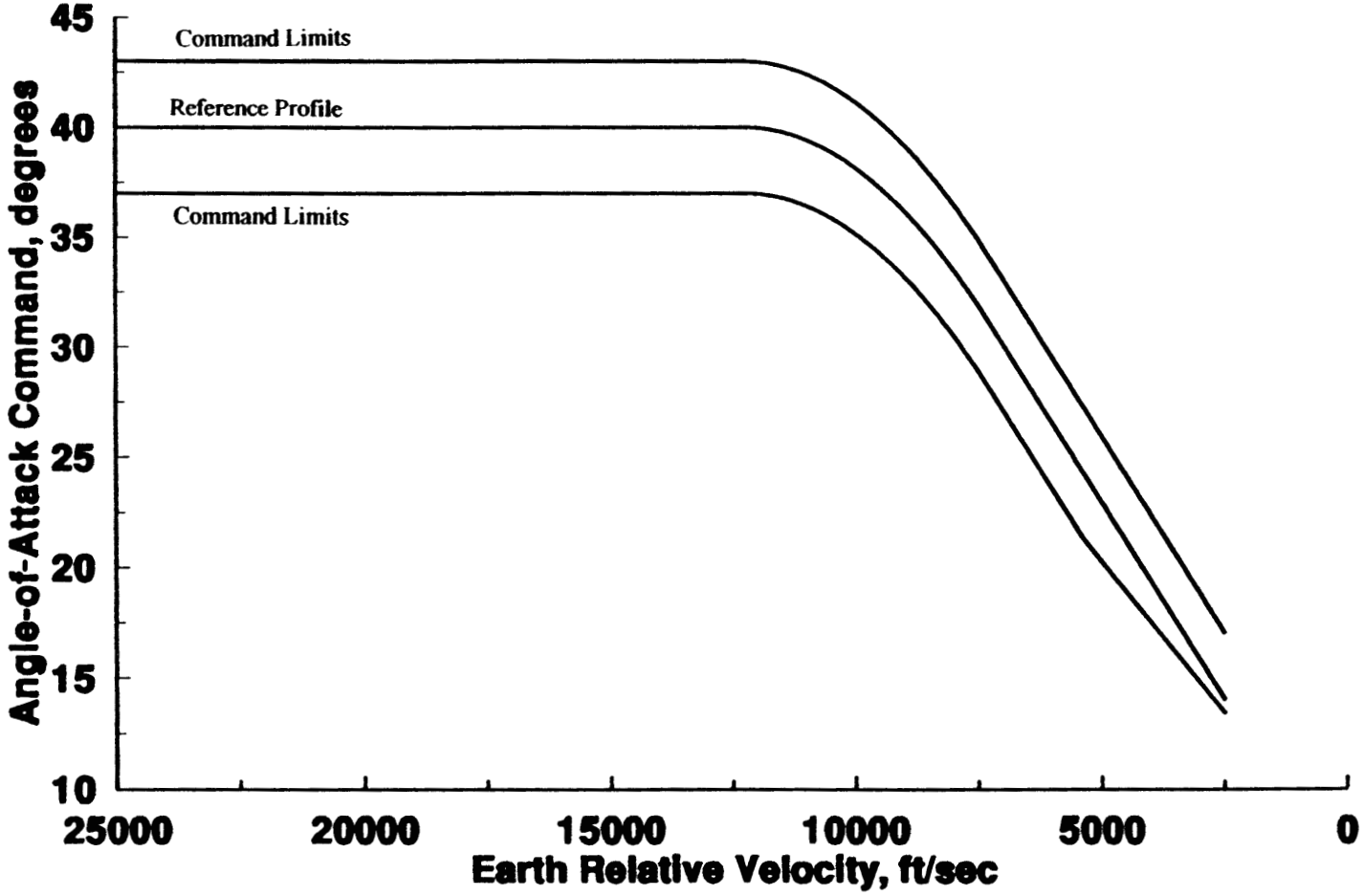


FIGURE 3.3.1.2.3.3.4

ORBITER AOA COMMAND REFERENCE PROFILE AND LIMITS



3.3.2 SRB Characteristics

3.3.2.1 SRB Performance Characteristics

3.3.2.1.1 SRB Ascent

The SRBs, when operating in a normal mode in parallel with the Orbiter Vehicle MEs, shall provide impulse and TVC to thrust the flight vehicle from lift-off to SRB staging.

3.3.2.1.2 SRB Performance Requirements

The following parameters shall define the performance of the SRB over the PMBT range from 40°F to 90°F unless otherwise noted. For the purpose of systems analysis and generation of design/certification environments, a PMBT range from 50°F to 82°F shall be used.

a. Thrust Profile - The thrust profile requirements are defined at a PMBT of 60°F. The vacuum thrust and impulse requirements for SRMs utilizing the nozzle extension defined in Paragraph 3.1.3.1.2.3.4 are provided in Figure 3.1.3.1.2.3.4 and Table 3.1.3.1.2.3.4. The nominal vacuum thrust time curves for all other SRMs shall fall within the limits illustrated in Figure 3.3.2.1.2b. These limits are tabulated in Table 3.3.2.1.2b. The RSRM nominal vacuum impulse shall meet the requirements in Figure 3.3.2.1.2b. The RSRM desired nominal thrust time curve is tabulated in Table 3.3.2.1.2b. The 3-sigma tolerances are used for systems design analysis and are shown in Table 3.3.2.1.2d.

b. RSRM Ignition Interval - The RSRM ignition interval shall be between 202 and 262 ms after ignition command to the NSIs in the safe and arm device up to a point at which the headend chamber pressure has built up to 563.5 psia. A 40 ms time delay for environmental/aging effects allows the late ignition time interval to increase to 302 milliseconds.

c. RSRM Pressure/Thrust Buildup Rate - The maximum rate of headend chamber pressure buildup during the ignition transient shall be between 65.7 psi/10 MS and 115.9 psi/10 MS. The maximum pressure rise rate values of 70.9 psi/10 MS and 115.9 psi/10 MS equate to thrust rise rates of 154,000 lbs/10 MS and 350,000 lbs/10 MS.

d. Shuttle Systems Dynamics Analysis - The RSRM ignition transient forcing function model is defined in NSTS 08209, Volume I. The RSRM design features and processes which affect the ignition transient model shall be controlled and require PRCB approval prior to any change.

e. Dynamic Thrust Vector Alignment Accuracy - The dynamic thrust vector during motor firing (without side load) when the slew rate is zero, shall not exceed the limits shown in Figure 3.3.2.1.2c and stated below:

Misalignment of the dynamic thrust vector with respect to the nozzle centerline shall not deviate more than ± 0.7 degrees for T = 0.5 to T = 10 seconds and ±1.0 degrees for T > 10 seconds.

f. Thrust Differential - The differential thrust between the two SRBs (matched pair of SRMs) on the Shuttle Vehicle shall not exceed the thrust versus time profile defined in the following table and figures. The ignition thrust imbalance requirement accounts for variations in parameters such as ignition interval, pressure/thrust rise rate, pressure-time shape, and avionics time skew between the SRMs on the Shuttle Vehicle Booster (SVB). The individual contributors shall not produce the entire ignition thrust imbalance. The thrust differential requirements of this paragraph shall be for all SRB operation temperatures as defined in Paragraph 3.3.2.1.3. The application of this requirement, for use in flight system design and certification, is defined in the Critical Math Model Database.

Tail-off Thrust Imbalance:	Table 3.3.2.1.2c
Ignition Thrust Imbalance:	Figure 3.3.2.1.2e
Steady State Thrust Imbalance:	Figure 3.3.2.1.2f

Deviation/Waiver 689 is applicable to Paragraph 3.3.2.1.2f.
Refer to Book 4, Active Deviations/Waivers.

g. Thrust Decay Cueing Pressure - The primary cue for initiating the SRB separation sequence is RSRM operating pressure less than or equal to 50 psia in both SRBs.

h. Tail-off Model - The RSRM tail-off thrust differential forcing function model is defined in the Shuttle Performance Assessment Databook, NSTS 08209, Volume I - the RSRM design features and processes which affect the tail-off model shall be controlled and require PRCB approval prior to any change.

3.3.2.1.2.1 RSRM Chamber Pressure Oscillation Limits

RSRM design features and processes which affect RSRM thrust oscillation limits, as defined in the Critical Math Model Database shall be controlled and require PRCB approval prior to any change.

3.3.2.1.3 SRB Temperature Limits

3.3.2.1.3.1 Performance Sizing

The SRB performance requirement shall be based on a PMBT of 60°F.

3.3.2.1.3.2 Design

The RSRM shall be designed for an initial (at ignition) PMBT range of 40°F to 90°F.

3.3.2.1.3.3 (Deleted)

3.3.2.1.4 Center of Gravity (CG)

The SRB CG for redesigned operational vehicle (RSRM), including uncertainty about final predicted value for all weight classes shall be as follows:

Conditions	Longitudinal "X"	Horizontal "Y"	Vertical "Z"
Loaded (Ignition)	1170.0 in ± 7.2	0.0 in ± 1.0	0.0 in ± 1.0
Inert (Separation)	1268.0 in ± 9.0	0.0 in ± 1.0	1.0 in ± 0.5

Reference SRB Coordinate System as shown in TMX-58153, Coordinate Systems for the Space Shuttle Program.

3.3.2.2 SRB Design Characteristics

3.3.2.2.1 External Configuration

The SRB shall conform to the moldline envelope specified in ICD 2-00001.

3.3.2.2.1.1 SRB Reuse

The SRB shall be designed for atmospheric deceleration, parachute deployment, water entry, retrieval, refurbishment, and subsequent reuse in accordance with Paragraph 3.5.3.1.3. The SRB apogee constraints imposed on the nominal ascent trajectory to maintain a high probability of recovery are specified in NSTS 08209, Volume I.

3.3.2.2.1.2 SRB Weight

The SRB design control weights are provided in Paragraph 3.1.3.1.2.3. The nominal, mission specific SRB inert weight is defined in NSTS 09095.

3.3.2.2.1.3 RSRM Propellant Weight

The nominal RSRM weights for usable and residual propellants are specified in NSTS 09095.

3.3.2.2.1.4 Thrust Vector Control (TVC)

The SRB TVC subsystem in conjunction with the RSRM shall be capable of providing pitch, roll, and yaw vehicle movements and shall meet the requirements specified in ICD 2-14001, and the following requirements:

a. Gimbal Axis Orientation - The SRB actuators shall extend and retract in the rock and tilt planes respectively, which are 45° from the pitch and yaw planes.

b. Gimbal Angle - The SRB TVC subsystem shall have a gimbal angle capability of 5° in both the actuator extend and retract directions. The Flight Control System software shall limit the gimbal angle to 2° or less in both directions for all times less than SRB ignition command plus 2.5 seconds. For all times greater than SRB ignition command plus 2.5 seconds, the FCS shall limit the gimbal angle to 4.5° in both directions.

The nozzle null offset angle (the nozzle angle with actuators at null) induced by nozzle axial movement (as a function of RSRM chamber pressure) shall not exceed +0.96° (in the double extend direction) at 0 psi nozzle stagnation pressure, ±0.3° at 615 psi nozzle stagnation pressure, and -.50° (in the double retract direction) at 915 psi nozzle stagnation pressure.

c. Deflection Duty Cycle - The SRB shall be capable of sustaining, without risk to safety-of-flight, a total duty cycle of 266.0°-seconds required for thrust vector control during first stage flight. Deflection duty cycle is defined to be the integral of the absolute value of the total gimbal deflection over time. In addition, the SRB shall be capable of sustaining any one of the maximum deflection duty cycles defined in Table 3.3.2.2.1.4 for the regions of flight specified.

d. Gimbal Rate - The gimbal rate capability specified herein is applicable for the following flight conditions:

Mission Time	Nozzle Angle (Degrees)
Hydraulic System Power Up to 2.5 seconds	(Less than or Equal to) 2.0
2.5 seconds to 8 seconds	(Less than or Equal to) 3.5
8 seconds to 20 seconds	(Less than or Equal to) 4.0
20 seconds to End of Burn	(Less than or Equal to) 4.5

The TVC subsystem shall have a gimbal rate capability as specified in ICD-2-14001. For SRB nozzle gimbal angles greater than the indicated flight conditions, the rate capability shall be 80% of the specified value. The Orbiter FCS will not recognize or be functionally modified for one hydraulic power source failed. The FCS rate limit is not changed with SRB burn time.

e. Angular Acceleration - Net angular acceleration capability of the SRB TVC shall be as specified in ICD-2-14001.

f. Phase Lag - The maximum permissible phase lag between a sinusoidal input command (Orbiter ATVCs driver currents) of 0.2° half amplitude and the sinusoidal nozzle position response shall be 25° at 1.0 hertz and 80° at 3.0 hertz.

g. Step Response - Step response of the SRB TVC shall be as specified in ICD-2-14001.

h. Command Channel Bypass - Each of the four command channels shall be capable of being hydraulically disabled/bypass or enabled/reset by externally generated signals. Actuator response with one or two channels disabled shall be in accordance with ICD 2-14001.

i. Fault Detection - The TVC actuators shall provide interfacing instrumentation compatible with the Fault Detection Isolation and Recovery (FDIR) electronics. The FDIR requirements are specified in ICD 2-14001.

3.3.2.2.1.5 (Deleted)

3.3.2.2.2 SRB Ignition System

The SRB ignition system shall have the capability to be remotely safed or armed from the Launch Control Center.

3.3.2.2.3 SRB Destruct System

The SRBs shall be provided with ground-commanded systems to destruct the SRBs.

3.3.2.2.4 SRB Hydraulic Design

Hydraulic subsystem design and installation shall be in accordance with MIL-H-5440F, amended by NSTS 08318. This specification (MIL-H-5440F, amended) shall take precedence over safety factors stated in Paragraph 3.2.2.1.5.2.

3.3.2.2.5 SRB Radar Beacon Tracking Subsystem (SRBTS)

Each SRB shall provide a C-Band tracking aid compatible with ESMC tracking radars. The transponders shall be uniquely coded for each SRB to ensure radar ground stations can distinguish between the return signals from the two SRBs.

Agreements between ESMC and NASA have baselined that the SRBTS is not required to be functioning at launch commit. Therefore, the SRBTS is assigned a Criticality 3 classification, is not required to provided redundancy, and is exempt from other requirements of this document where flight safety is not compromised.

Use of off-the-shelf hardware qualified for use on other launch vehicles is authorized. Off-the-shelf hardware is exempt from SSP design and construction standards such as parts selections, soldering, printed circuit board techniques, material and process controls and restrictions, and other requirements that cannot be met without hardware redesign.

3.3.2.2.6 (Deleted)

3.3.2.2.7 (Deleted)

3.3.2.3 SRB Interface Characteristics

3.3.2.3.1 SRB/Orbiter Interface

Functional interfaces and performance requirements for control and instrumentation between the SRB and the Orbiter Vehicle are covered in ICD 2-14001.

3.3.2.3.2 SRB/ET Interface

The SRB shall interface with the ET as defined in ICD 2-24001.

3.3.2.3.2.1 SRB/ET Umbilical

An umbilical shall provide a conductive signal path between the SRB and the ET for the following electrical signals:

a. SRB Status Monitor Signals

b. Sequence Commands

3.3.2.3.3 SRB Interface with Shuttle Vehicle Assembly and Checkout Station

The SRB shall interface with the Shuttle Vehicle Assembly and Checkout Station as defined in ICD 2-0A001.

3.3.2.3.4 SRB Interface with SRB Processing and Storage Station

The SRB shall interface with the SRB processing and storage station as defined in ICD 2-4A001, Solid Rocket Booster/Receiving Processing Station Interface Control Document.

3.3.2.3.5 SRB Interface with SRB Retrieval and Disassembly Station

The SRB shall interface with the SRB retrieval and disassembly station as defined in ICD 2-4A002, Solid Rocket Booster/Retrieval Station Interface Control Document.

3.3.2.3.6 SRB Interface with Launch Pad Station

The SRB shall interface with the launch pad station as defined in ICD 2-0A002.

3.3.2.3.7 SRB Interface with SRB/Refurbishment and Subassembly Station

The SRB shall interface with the SRB Refurbishment and Subassembly Station as defined in the ICD 2-4A001.

3.3.2.3.8 SRB to Pad Umbilicals

Two separate umbilicals shall provide the following functions:

a. Purge the aft skirt with heated GN_2.

b. Provide for SRB field joint heater electrical power and control, ground environmental instrumentation and aft skirt strain gauge instrumentation signals paths from prelaunch through lift-off, remain operational during Flight Readiness Firing (FRF) and abort shutdown.

3.3.2.3.9 SRB Interface with LPS Computational System

The SRB shall interface with the LPS computational system as defined in ICD 2-0A003.

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TABLE 3.3.2.1.2b

RSRM NOMINAL THRUST-TIME LIMITS (VACUUM - 60°F) (TP-R074-99)

Time (secs)	Minimum (klb)	Nominal (klb)	Maximum (klb)
1	3048.0	3142.3	3236.6
2	3044.5	3138.6	3232.8
3	3050.7	3145.1	3239.4
4	3068.1	3163.0	3257.9
5	3097.0	3192.8	3288.6
6	3129.5	3226.3	3323.1
7	3149.9	3247.3	3344.7
8	3162.6	3260.4	3358.2
9	3174.8	3273.0	3371.1
10	3184.6	3283.1	3381.6
11	3188.8	3287.5	3386.1
12	3190.4	3289.1	3387.7
13	3192.9	3291.7	3390.4
14	3196.6	3295.4	3394.3
15	3200.6	3299.5	3398.5
16	3205.3	3304.4	3403.6
17	3211.2	3310.5	3409.8
18	3217.2	3316.7	3416.2
19	3221.6	3321.2	3420.9
20	3224.5	3324.3	3424.0
21	3226.5	3326.3	3426.1
22	3212.9	3312.2	3411.6
23	3161.1	3258.8	3356.6
24	3102.2	3198.2	3294.1
25	3049.7	3144.0	3238.3
26	3003.5	3096.4	3189.3
27	2962.1	3053.7	3145.3
28	2923.9	3014.3	3104.7
29	2887.9	2977.2	3066.5
30	2853.4	2941.7	3029.9
31	2820.1	2907.3	2994.5
32	2787.6	2873.8	2960.0
33	2755.9	2841.2	2926.4
34	2725.0	2809.3	2893.6
35	2694.8	2778.2	2861.5
36	2665.3	2747.8	2830.2
37	2636.4	2718.0	2799.5
38	2608.0	2688.7	2769.4
39	2580.0	2659.8	2739.6
40	2552.4	2631.3	2710.2
41	2525.8	2603.9	2682.0
42	2501.2	2578.6	2655.9
43	2479.1	2555.8	2632.4
44	2459.0	2535.1	2611.2
45	2440.5	2516.0	2591.5
46	2423.2	2498.2	2573.1
47	2404.4	2478.8	2553.1

TABLE 3.3.2.1.2b

RSRM NOMINAL THRUST-TIME LIMITS (VACUUM - 60°F) (TR-R074-99) - Continued

Time Seconds	Minimum (klb)	Nominal (klb)	Maximum (klb)
48	2377.6	2451.1	2524.6
49	2345.3	2417.8	2490.4
50	2319.1	2390.9	2462.6
51	2304.2	2375.5	2446.8
52	2295.5	2366.4	2437.4
53	2294.7	2365.6	2436.6
54	2302.3	2373.5	2444.7
55	2314.2	2385.8	2457.4
56	2327.2	2399.2	2471.2
57	2340.0	2412.4	2484.8
58	2352.5	2425.3	2498.0
59	2364.6	2437.8	2510.9
60	2376.3	2449.8	2523.3
61	2387.5	2461.4	2535.2
62	2398.2	2472.4	2546.5
63	2408.5	2482.9	2557.4
64	2418.5	2493.3	2568.1
65	2428.6	2503.7	2578.9
66	2439.0	2514.5	2589.9
67	2449.6	2525.3	2601.1
68	2459.8	2535.9	2612.0
69	2470.4	2546.8	2623.2
70	2479.2	2555.9	2632.6
71	2485.8	2562.6	2639.5
72	2491.3	2568.4	2645.4
73	2496.2	2573.4	2650.6
74	2500.2	2577.5	2654.9
75	2503.2	2580.6	2658.0
76	2505.2	2582.7	2660.2
77	2505.9	2583.4	2660.9
78	2503.7	2581.1	2658.6
79	2493.1	2570.2	2647.3
80	2466.2	2542.4	2618.7
81	2438.0	2513.4	2588.8
82	2416.9	2491.7	2566.4
83	2392.5	2466.5	2540.5
84	2361.0	2434.0	2507.0
85	2330.9	2403.0	2475.1
86	2305.2	2376.5	2447.8
87	2273.1	2343.4	2413.7
88	2231.1	2300.1	2369.1
89	2188.0	2255.7	2323.4
90	2156.5	2223.2	2289.8
91	2140.4	2206.6	2272.8
92	2130.7	2196.6	2262.5
93	2116.0	2181.4	2246.8

TABLE 3.3.2.1.2b

RSRM NOMINAL THRUST-TIME LIMITS (VACUUM - 60°F) (TP-R074-99) - Concluded

Time Seconds	Minimum (klb)	Nominal (klb)	Maximum (klb)
94	2094.6	2159.4	2224.2
95	2067.9	2131.9	2195.8
96	2036.7	2099.7	2162.7
97	2007.2	2069.2	2131.3
98	1981.9	2043.2	2104.5
99	1959.1	2019.7	2080.3
100	1937.1	1997.0	2056.9
101	1911.5	1970.6	2029.7
102	1879.6	1937.7	1995.8
103	1843.4	1900.4	1957.4
104	1806.3	1862.1	1918.0
105	1768.9	1823.7	1878.4
106	1730.8	1784.4	1837.9
107	1649.6	1750.0	1802.5
108	1546.9	1730.5	1782.4
109	1395.3	1715.1	1766.6
110	1167.4	1673.9	1756.4
111	927.2	1586.1	1734.2
112	756.4	1460.3	1719.7
113	630.6	1266.4	1689.3
114	517.2	1019.9	1617.2
115	417.3	823.3	1508.0
116	323.1	688.5	1347.0
117	232.4	573.7	1120.6
118	165.1	469.3	901.6
119	117.8	377.1	747.1
120	83.3	285.0	629.5
121	58.6	204.5	522.4
122	40.5	147.2	427.4
123	28.3	105.9	338.9
124	15.1	75.5	251.0
125	9.6	53.6	181.6
126	0.0	37.1	132.2
127	0.0	25.8	95.8
128	0.0	14.2	68.8

TABLE 3.3.2.1.2b.1 (DELETED)

TABLE 3.3.2.1.2c

RSRM TAIL-OFF THRUST DIFFERENTIAL

Percent Differential Tail-off Time*	Maximum Vacuum Thrust Differential During Tail-off, lbf**
0	225,050
5	265,550
10	354,925
15	465,750
20	530,950
25	520,825
30	520,150
35	476,625
40	423,450
45	362,700
50	333,850
55	297,900
60	277,450
65	260,200
70	234,175
75	217,950
80	193,450
85	161,000
90	133,450
95	117,750
100	96,975

* Differential tail-off time is defined as the time interval beginning at the first web time and ending at the last SRM action time.

** Maximum thrust imbalance impulse during the differential tail-off period must be ≤ 4,000,000 lbf/sec.

This differential is based upon Shuttle flight-derived data, enveloping 3-sigma flight-derived thrust differential, 3-sigma web time dispersions, and 3-sigma shape dispersions.

TABLE 3.3.2.1.2d

SRB ±3-SIGMA TOLERANCE REQUIREMENTS

Parameter	SRB Pair Population	Maximum Differential Between Paired SRBs
Web Time	± 4.9*	2.0
Action Time	-	3.0
Web Time Average Vac Thrust	± 5.2* (5.3)	-
Vac Delivered Specific Impulse	± 0.5	1.0
Propellant Weight	± 0.21	-
SRB Inert Weight Prelaunch	± 0.85	-

* Does not include uncertainty in temperature prediction.

( ) Total SRB Population Percent

TABLE 3.3.2.2.1.4

SRB GIMBAL DEFLECTION DUTY CYCLE

	Duty Cycle, Deg - Sec				
Region	Roll Man 0 - 30 Sec	High Qbar 30 - 70 Sec	Post High q 70 - 110 Sec	SRB Tail-off 110 Sec-Sep	1st Stage 0 - Sep
Total Duty Cycle	52	130	97	55	266

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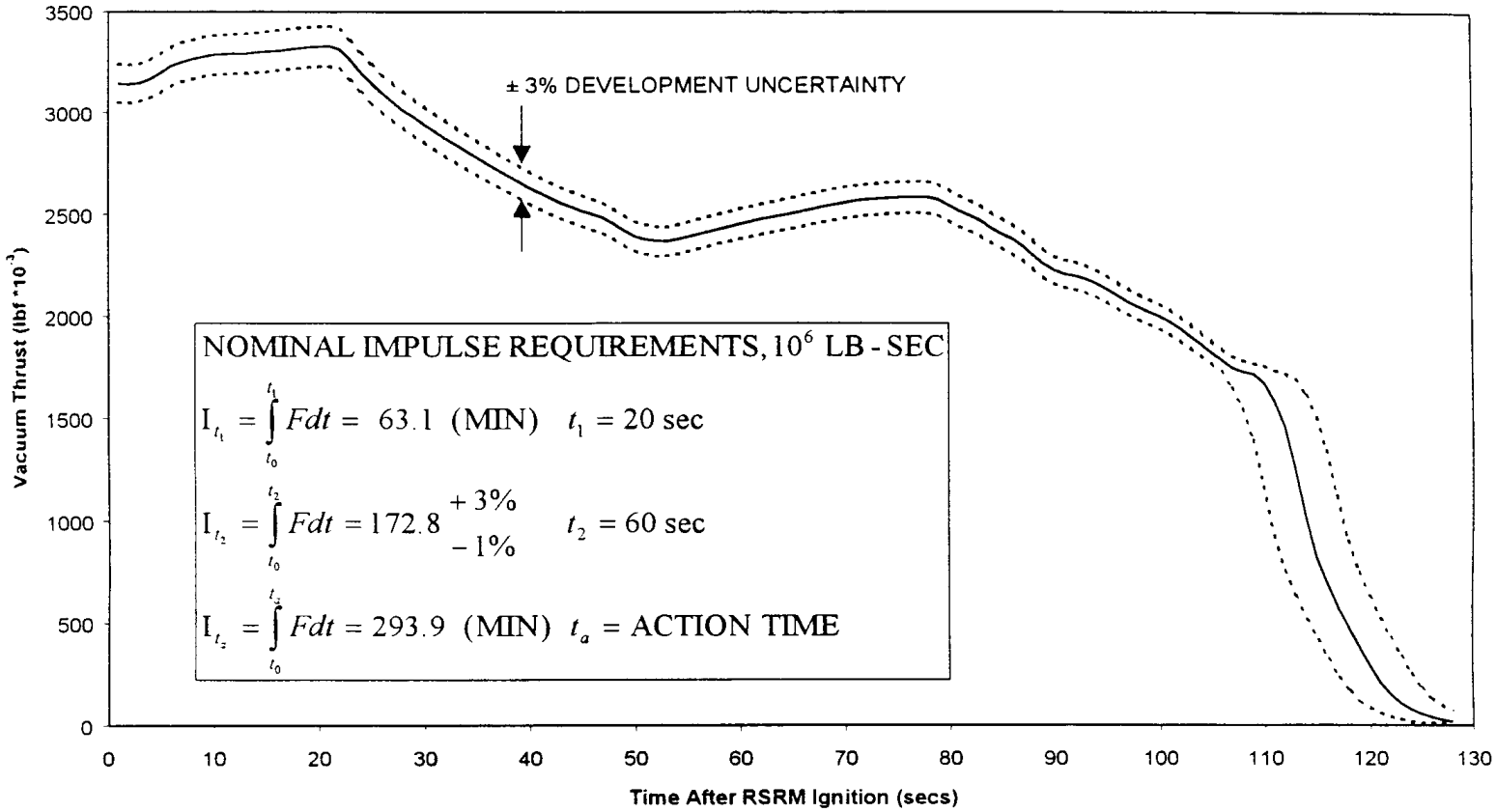
FIGURE 3.3.2.1.2b

RSRM NOMINAL PERFORMANCE REQUIREMENTS (VACUUM, 60°F PMBT)



NOTE: THE NOMINAL THRUST-TIME CURVE OF THE QUALIFIED RSRM MUST FALL WITHIN THE PREDICTABILITY ENVELOPE AND IS FURTHER CONSTRAINED BY THE TOTAL IMPULSE REQUIREMENT

FIGURE 3.3.2.1.2b.1 (DELETED)

FIGURE 3.3.2.1.2c

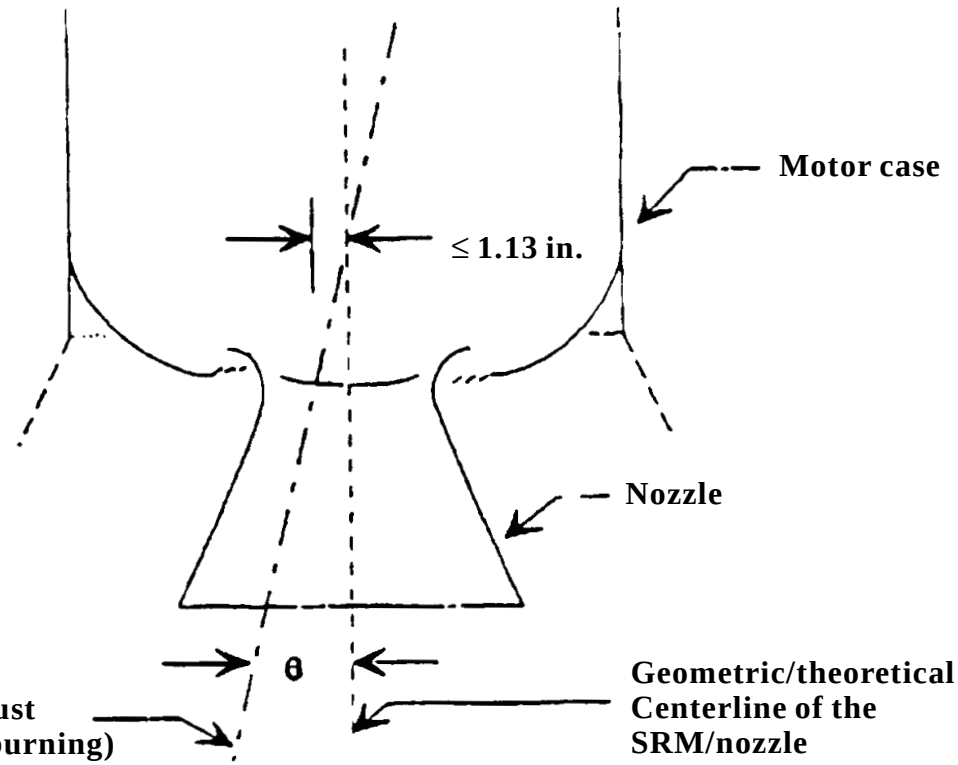
SRB SYSTEM THRUST VECTOR ALIGNMENT

The line of action shall be ≤ 1.13 inches of the nozzle, SRM centerline

The line of action of the thrust vector, during web burning, shall be within the following θ (half angle) to a line coincident with or parallel to the SRM/nozzle centerline

θ = 0.7 deg for T = 0.5 to T = 10.0 sec.

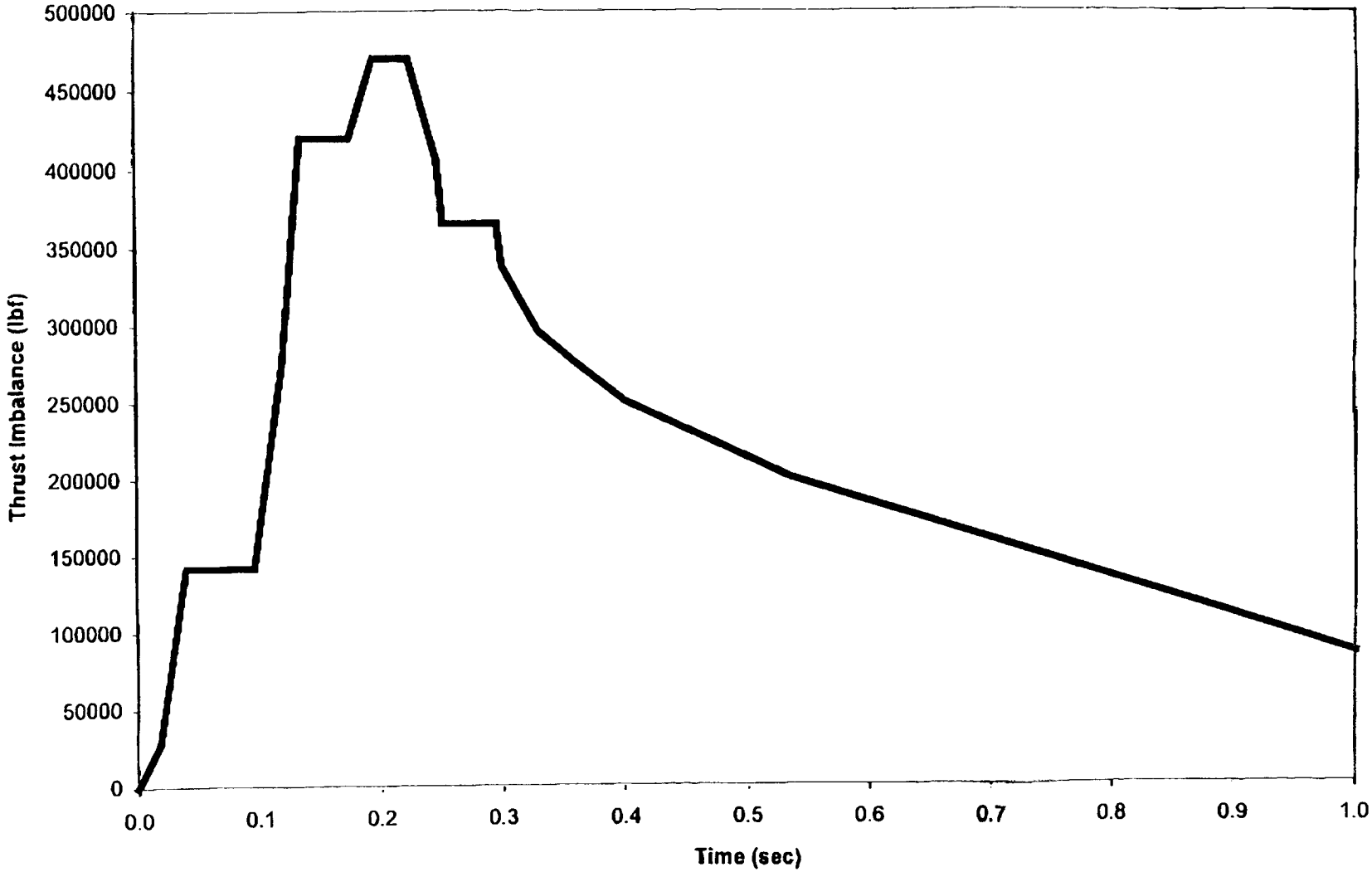
θ = 1.0 deg for T > 10.0 sec.



Dynamic Thrust Vector Requirement is applicable at any nozzle position when the slew rate is zero and at any pressure

FIGURE 3.3.2.1.2e

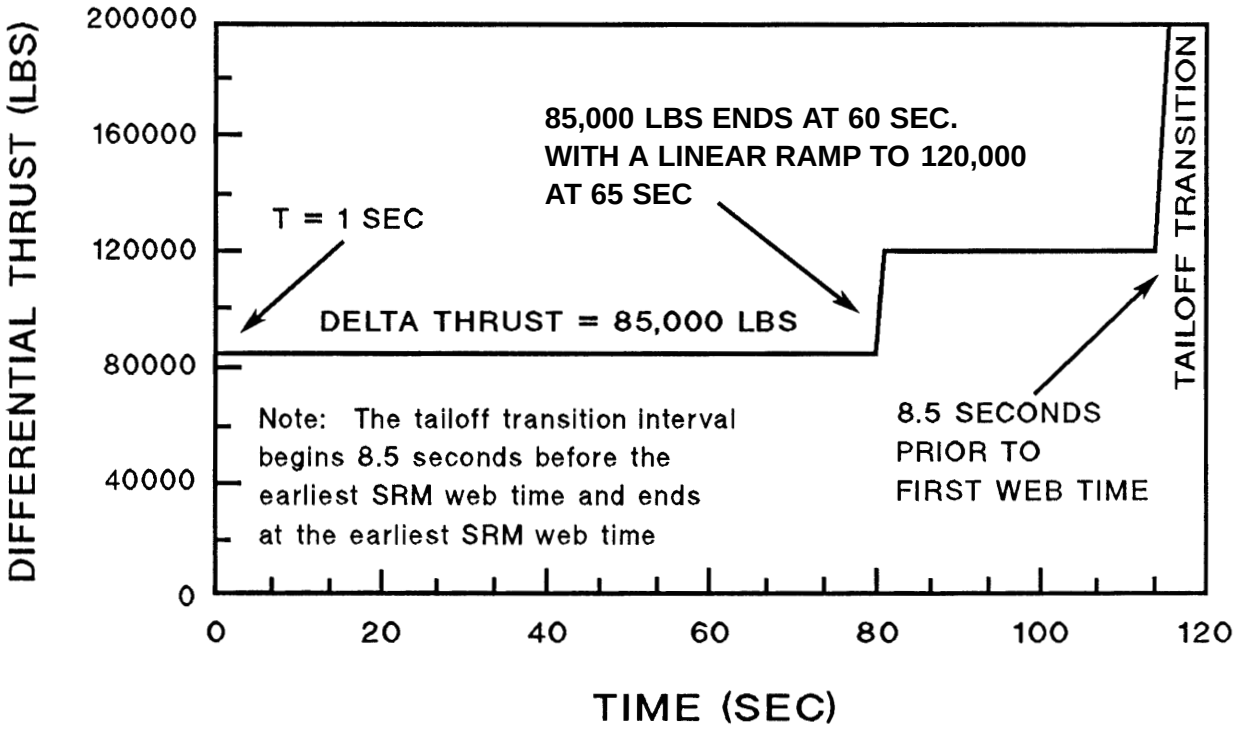
IGNITION THRUST IMBALANCE



NOTE: IMBALANCE INCLUDES EFFECT OF 3 SIGMA AVIONICS TIME SKEW, IGNITION INTERVAL RANGE IS 202 TO 203 MS.

FIGURE 3.3.2.1.2f

STEADY STATE THRUST IMBALANCE



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3.3.3 ET Characteristics

3.3.3.1 ET Performance Characteristics

3.3.3.1.1 External Tank Mass Data

3.3.3.1.1.1 ET Size

The ET shall conform with the moldline envelope specified in ICD 2-00001, and be sized to accommodate the main stage propellant loading specified in NSTS 08209, Volume I.

3.3.3.1.1.2 ET Weight

The ET and MPS propellant design control weights are defined in Paragraph 3.1.3.1.2.2 (Design Control Parameter - reference Paragraph 6.1.37). The nominal, mission specific ET inert weights and usable propellants and gaseous residuals are defined in NSTS 09095. The nominal weights for usable propellants and gaseous residuals in the ET and associated lines are defined in NSTS 08209, Volume I, Table 4.1.1.

3.3.3.1.1.3 Center of Gravity (CG)

The lightweight ET (6,000 pounds weight reduction) CG shall be as specified below:

Condition	Longitudinal (X_{ET})	Lateral (Y_{ET})	Vertical (Z_{ET})
Inert	1347.0 in $\pm$10.5	2.5 in $\pm$5.25	425.5 in $\pm$5.25

The super lightweight ET (7,500 pounds weight reduction from LWT) shall be as specified below:

Condition	Longitudinal (X_{ET})	Lateral (Y_{ET})	Vertical (Z_{ET})
Inert	1352.0 in $\pm$10.5	3.0 in $\pm$5.25	429.40 $\pm$5.25

3.3.3.1.1.4 ET Ullage Volume

The ET ullage volume shall be a minimum of 1.56% of the LO_2 tank usable volume and 1.53% of the LH_2 tank usable volume at engine start command.

3.3.3.2 ET Design Characteristics

3.3.3.2.1 Structural Stability

The ET Structure shall not require pressurization for stability or GSE support for the attached Orbiter during ground handling, transportation, or while on the launch pad in either a fueled or unfueled condition with the exception of the propellant tanks, which may be designed to require pressure stabilization during fill and drain operations, or during high wind operations defined in NSTS 07700, Volume X - Book 2, Appendix 10.10, Paragraph 3.1.2, but shall not require pressure stabilization during replenish operations.

3.3.3.2.1.1 (Deleted)

3.3.3.2.1.2 ET Ullage Pressure

Ullage pressure management is required by the ET during propellant fill and drain operations for structural stability and for enhancements of the ET TPS. The specific ullage pressure requirements for the LO_2 and LH_2 tanks are defined in ICD-2-0A002.

3.3.3.2.2 Preparation and Servicing

The ET preparation and servicing, excluding final servicing, shall be completed prior to standby status (reference Paragraph 6.1.1).

3.3.3.2.3 Propellant Management Instrumentation

Measurements shall be provided to accommodate propellant loading, mainstage tank pressurization, and LH_2 depletion, to satisfy the requirements of Paragraphs 3.2.1.2.8, 3.2.2.1.13 and ET pressurant flow requirements.

3.3.3.2.3.1 Propellant Loading

The vehicle shall provide level indications for propellant loading visibility of the LH_2 and LO_2 tanks.

3.3.3.2.3.2 LH_2 Propellant Depletion Sensors

The LH_2 tank shall provide propellant depletion signals to the Orbiter for Orbiter SSME cutoff.

3.3.3.2.3.3 Ullage Pressure

The ET shall provide signals of LO_2 and LH_2 ullage pressure to the Orbiter. The ET shall provide two low range (0-5 psig) LO_2 ullage pressure measurements which utilize ground power and ground readout for the LPS.

3.3.3.2.4 Propellant Slosh Damping

The ET shall provide slosh damping in the LO_2 and LH_2 tanks. The mission conditions to be considered in establishing propellant loading are nominal conditions for the design reference missions specified in Paragraph 3.2.1.1.3. The LO_2 slosh damping ratio for the lightweight ET with three or four slosh baffles, and the SLWT ET with three slosh baffles in the LO_2 tank shall be greater than or equal to the minimum requirements specified in Table 3.3.3.2.4.1.

The LH_2 slosh damping ratio for the LWT and SLWT ET shall be greater than or equal to the minimum damping requirement specified in Tables 3.3.3.2.4.2 and 3.3.3.2.4.3, respectively.

Figure 3.3.3.2.4.1 defines the minimum LO_2 slosh damping required for the LWT or SLWT tanks. Figure 3.3.3.2.4.2 defines the separate minimum LH_2 slosh damping requirements for the LWT and SLWT tanks.

3.3.3.2.5 Handling

The ET with thermal protection system installed shall be capable of being hoisted, erected, transported, handled, etc., without requiring ET insulation inspection or special verification subsequent to completion of the handling activity.

3.3.3.2.6 Thermal Protection

The ET shall incorporate thermal protection, as required, to satisfy all functional and performance requirements within the design environments specified in Paragraph 3.2.2.1.17 and minimize the formation of ice as specified in NSTS 16007.

3.3.3.2.7 (Deleted)

3.3.3.2.8 ET/Orbiter Safe Separation Distance and ET Rupture Altitude

For mission phase specified in subparagraphs, the ET shall be designed to ensure the ET debris does not impact the Orbiter and that ET environments and disposal requirements of Paragraph 3.2.1.1.17 are satisfied.

3.3.3.2.8.1 For RTLS

The ET shall not rupture above 50,000-foot altitude.

3.3.3.2.8.2 For TAL

The ET shall not rupture until a debris hit probability of ≤2x10-4 is attained with full RCS jet authority or <1x10-3 is attained for either of the following:

a. BFS engaged

b. Primary Avionics Software System (PASS) operating with any single avionics or jet failure that results in a loss of down firing jet authority

The hit probability is a function of the rupture time of the ET and the relative distance between the ET and the Orbiter at rupture. That hit probability can be minimized by a range of MECO conditions. Therefore, because the system could not be certified worst-on-worst, the certification examined the range of conditions and found the worst ET time line and the worst Orbiter separation distance trajectories enveloped all other conditions.

The hit probabilities above levy the following requirement against the ET for rupture time:

a. For the LWT condition that minimizes the ET rupture time, the LWT shall not rupture prior to 175 seconds after ET separation. For the LWT condition that minimizes the relative distance between the ET and the Orbiter at rupture, the LWT shall not rupture prior to 190 seconds after ET separation.

b. For the SLWT condition that minimizes the ET rupture time, the SLWT shall not rupture prior to 177 seconds after ET separation. For the SLWT condition that minimizes the relative distance between the ET and the Orbiter at rupture, the SLWT shall not rupture prior to 191 seconds after ET separation.

3.3.3.2.8.3 For Normal and AOA Missions with Orbital Insertion Altitudes <140 nm (through ET-90)

The ET shall not rupture above 294,000-foot altitude.

3.3.3.2.8.4 For Normal and AOA Missions with Orbital Insertion Altitudes >140 nm (through ET-90)

The ET shall not rupture above 286,000-foot altitude. This requirement is based on flight-derived data base and analysis of ET thermal indicator model in conjunction with the entry reference trajectories.

3.3.3.2.8.5 For Normal and AOA/ATO Missions (ET-91 and Subsequent ETs)

The ET shall not rupture above 249,000-foot altitude based on the undispersed ascent heating environments and nominal SLWT entry heating reference trajectories specified

in NSTS 07700, Volume X - Book 2, Appendix 10.11, Table 10.11.1. The nominal rupture altitude requirement combined with the 3-sigma flight-derived rupture altitude spread (actual vs. predicted) ensures the ET will not rupture above 283,000-foot altitude during flight.

3.3.3.2.9 (Deleted)

3.3.3.3 ET Interface Characteristics

3.3.3.3.1 ET Interface with Orbiter

See Paragraph 3.3.1.3.1 for interface requirements.

3.3.3.3.2 ET Interface with SRB

See Paragraph 3.3.2.3.2 for interface requirements.

3.3.3.3.3 ET Interface with Shuttle Vehicle Assembly and Checkout Station

The ET shall interface with the Shuttle Vehicle Assembly and Checkout Station as defined in ICD 2-0A001.

3.3.3.3.4 ET Interface with ET Processing and Storage Station

The ET shall interface with the ET Processing and Storage Station as defined in ICD 2-2A001, External Tank/Receiving, Storage and Checkout Station Interface Control Document.

3.3.3.3.5 ET Interface with Launch Pad Station

The ET shall interface with the Launch Pad Station as defined in ICD 2-0A002.

3.3.3.3.6 ET Interface with LPS Computational System

The ET shall interface with the LPS computational system as defined in ICD 2-0A003.

TABLE 3.3.3.2.4.1

MINIMUM LO_2 DAMPING REQUIREMENT

Tank Height (in)	Volume X Min LOX Damping (%)
0.0	1.00
227.0	1.00
227.0	0.50
300.0	0.50
300.0	0.20
387.12	0.20
389.00	0.17
425.00	0.16
450.00	0.15
479.10	0.15
488.00	0.16
500.00	0.18
511.25	0.20
650.00	0.20

TABLE 3.3.3.2.4.2

MINIMUM LWT LH_2 DAMPING REQUIREMENT

Tank Height (in)	Volume X Min LWT LH_2 Damping (%)
0.0	0.80
57.00	0.80
105.00	0.80
106.00	4.10
149.00	1.12
151.00	6.22
251.00	0.49
253.00	0.71
269.00	0.46
270.00	2.49
322.00	0.63
324.00	0.85
340.00	0.55
342.00	2.57
422.00	0.33
430.00	0.54
499.00	0.09
515.00	0.52
587.00	0.07
589.00	0.44
637.00	0.15
710.00	0.03
760.00	0.04
761.00	0.41
833.00	0.06
835.00	0.42
912.00	0.04
914.00	0.11
930.00	0.20
1038.00	0.02
1040.00	1.40
1050.00	1.21
1052.00	2.89
1096.00	0.01
1158.00	0.01

TABLE 3.3.3.2.4.3

MINIMUM SLWT LH_2 DAMPING REQUIREMENT

Tank Height (in)	Volume X Min SLWT LH_2 Damping (%)
0.0	0.80
57.00	0.80
104.00	0.80
106.00	3.97
149.00	1.15
152.00	6.16
269.00	0.47
270.00	2.53
340.00	0.52
342.00	2.57
400.00	0.67
513.00	0.21
515.00	0.56
587.00	0.23
589.00	0.58
636.00	0.28
701.00	0.20
756.00	0.20
761.00	0.57
833.00	0.22
835.00	0.58
904.00	0.20
930.00	0.36
989.00	0.20
1030.00	0.17
1039.00	0.65
1040.00	1.48
1050.00	1.21
1052.00	2.89
1096.00	0.01
1158.00	0.01

FIGURE 3.3.3.2.4

MINIMUM SLOSH DAMPING REQUIREMENTS FOR LWT TANK

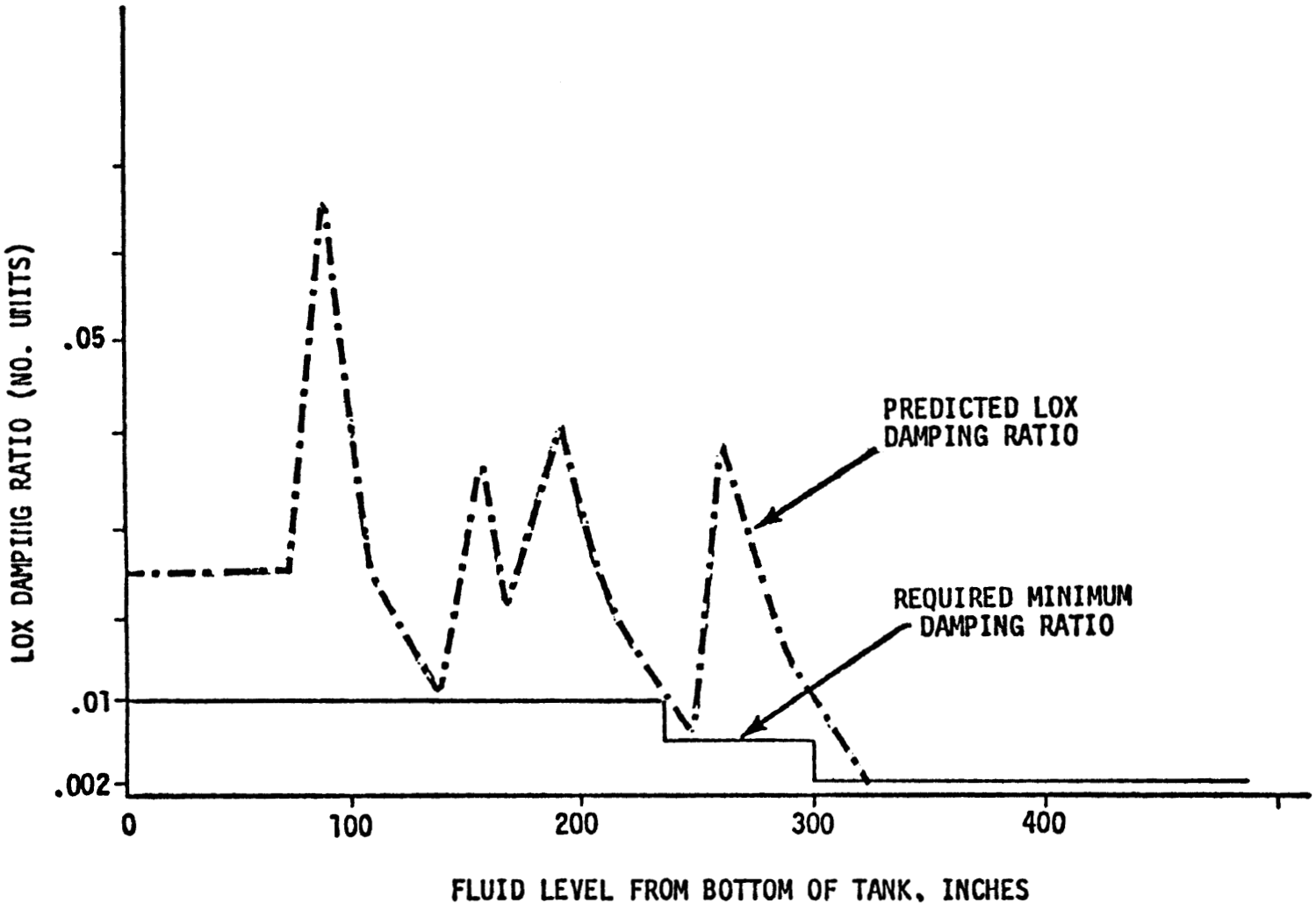


FIGURE 3.3.3.2.4.1

MINIMUM LO_2 SLOSH DAMPING REQUIREMENTS FOR LWT AND SLWT TANKS

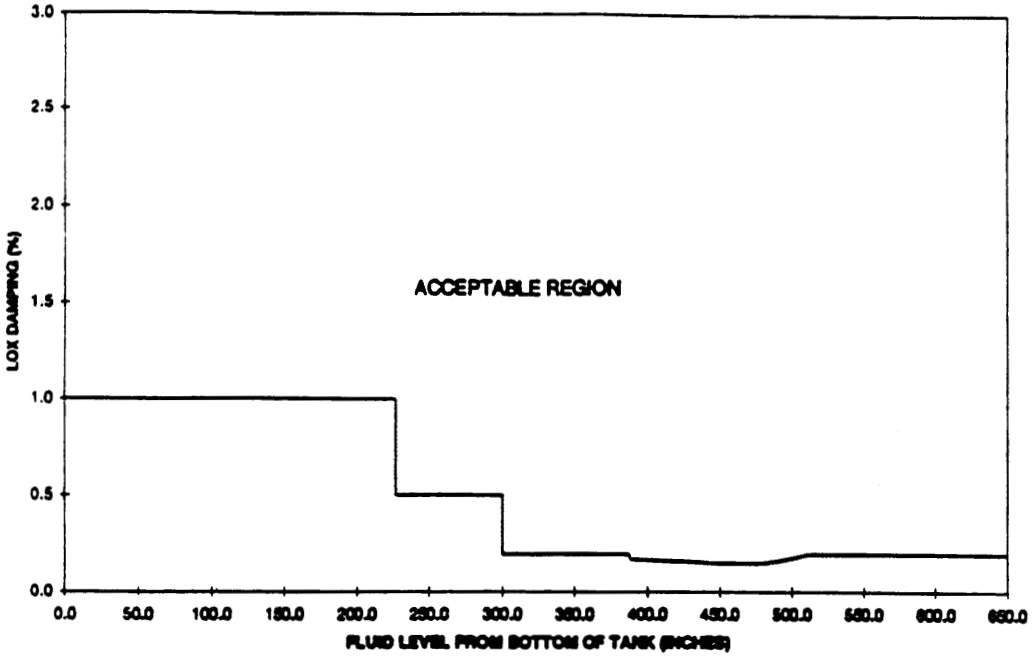
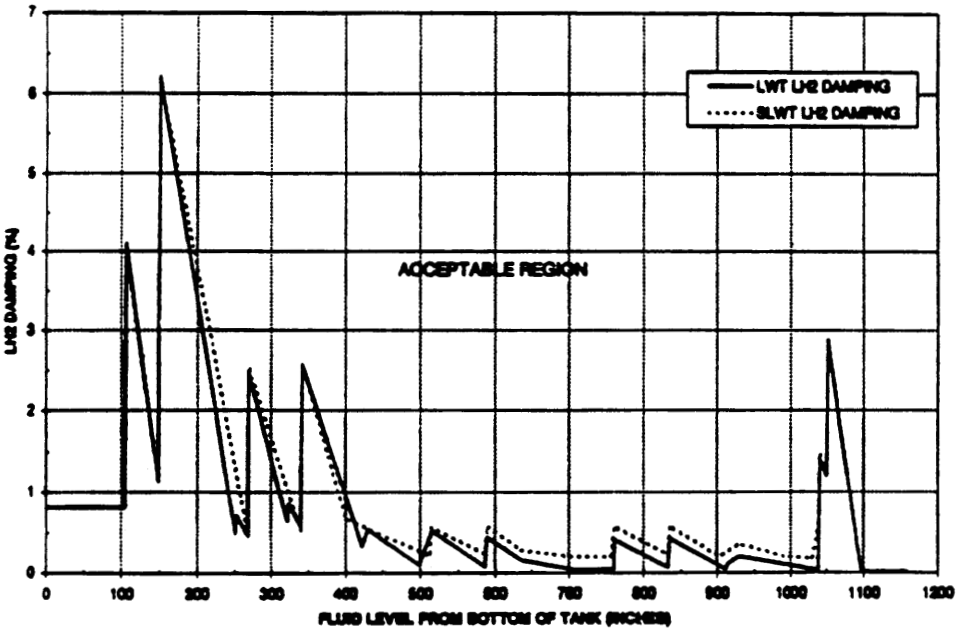


FIGURE 3.3.3.2.4.2

MINIMUM LH_2 SLOSH DAMPING REQUIREMENTS FOR LWT AND SLWT TANKS



3.3.4 Main Engine Characteristics

The SSME shall meet the requirements specified below and in ICD 13M15000.

3.3.4.1 Main Engine Performance Characteristics

3.3.4.1.1 (Deleted)

3.3.4.1.2 Engine Requirement Operating Conditions

The engine operating requirement conditions for thrust, specific impulse, and mixture ratio are given in Table 3.3.4.1.2.

Deviation/Waiver 540 is applicable to Paragraph 3.3.4.1.2.
Refer to Book 4, Active Deviations/Waivers.

3.3.4.1.3 Main Engine Assessment Operating Conditions

The engine operating conditions for assessment values of thrust, specific impulse, and mixture ratio, where the hardware has been identified, are given in NSTS 08209, Volume I. The SSME flight engine power level shall be limited to 104% Rated Power Level (RPL) for nominal ascent and intact aborts for all SSME configurations other than the Block II SSME. The Block II SSME may be operated at 106% RPL for nominal ascent and intact aborts. The SSME Full Power Level (FPL) of 109% shall be allowed for contingency aborts.

3.3.4.1.4 Off Nominal Performance Data

Off nominal SSME performance data for assessment of flight-derived data will be included in NSTS 08934, Space Shuttle Operational Data Book, Volume III, Shuttle Systems Analysis Data for application to realtime in-flight failure detection and ascent performance analysis. These assessment data will include changes in thrust, mixture ratio, and specific impulse. The data will be of sufficient accuracy to permit use by the Abort Region Determinator (ARD) for abort decisions to ensure flight safety.

3.3.4.2 Main Engine Design Characteristics

3.3.4.2.1 Main Engine Weights

The main engine design control weights are defined in Paragraph 3.1.3.1.2.4 (Design Control Parameter - reference Paragraph 6.1.37). The nominal, mission-specific main propulsion engine weight is specified in NSTS 09095.

3.3.4.2.2 Main Engine Hydraulic Design

Hydraulic subsystem design and installation shall be in accordance with MIL-H-5440F, amended by NSTS 08318. This specification (MIL-H-5440F, amended) shall take precedence over safety factors stated in Paragraph 3.2.2.1.5.2.

3.3.4.2.3 Main Engine Flight Acceleration Safety Cutoff System

The SSME shall provide a capability to monitor high pressure turbopump vibration and initiate a safe engine shutdown in the event safety critical vibration conditions are encountered. The system design shall be fail-safe (precludes inadvertent shutdown with single-failure) when operated in an active shutdown mode. The system will be operated in the data record mode only.

3.3.4.2.4 Main Engine Thermal Design Environments

The main engine nozzle shall satisfy all functional and performance requirements within the thermal design environments specified in Paragraph 3.2.2.1.17, Design Environments. The nozzle entry heating design environment shall be based on a normal ETR mission, with the Orbiter elevon and body flap limits specified in Paragraph 3.3.1.2.3.3.3, and with the Orbiter reference AOA profile as specified in Paragraph 3.3.1.2.3.3.4.

3.3.4.3 Main Engine Interface Characteristics

3.3.4.3.1 Main Engine Interface with Orbiter

See Paragraph 3.3.1.3.4 for interface requirements.

TABLE 3.3.4.1.2

MAIN ENGINE OPERATING CONDITIONS (VACUUM) (2)

Nominal Power Level (NPL) (1)	
Percent RPL	104
Thrust, lbf	488,800
Specific Impulse, (lbs/sec)/lb_m	≥450.4
Mixture Ratio	6.0
Nozzle Exit Area, in^2	6391.3
RPL (1)	
Percent RPL	100
Thrust, lbf	470,000
Specific Impulse, (lbs/sec)/lb_m	≥450.2
Mixture Ratio	6.0
Nozzle Exit Area, in^2	6391.1
Minimum Power Level (MPL)	
Percent RPL	65
Thrust, lbf	305,500
Specific Impulse, (lbs/sec)/lb_m	≥448.6
Mixture Ratio	6.0
Nozzle Exit Area, in^2	6389.1

NOTES:

(1) The engine will be capable of being operated at sea level conditions without the use of altitude test facilities or restrainer arms at RPL and above.

(2) All values referenced to the nominal pressurant tapoffs. Mixture ratio is based on engine inlet flows. All values referenced to the propellant inlet condition ranges specified in Figure 4.2.1-1 of ICD 13M15000. Power level is variable in 1% increments (4,700 pounds) of RPL for the power level range of MPL to FPL by electrical signal. For operational missions, the SSME mixture ratio shall be as specified in the Trajectory Design Data Package. The mixture ratio tolerance is specified in ICD 13M15000. The engine operating conditions for assessment values of the thrust, specific impulse, and mixture ratio, where the hardware has been identified, are given in NSTS 08209, Volume I. The SSME flight engine power level shall be limited to 104% RPL for nominal ascent and intact aborts for all SSME configurations other than the Block II SSME. The Block II SSME may be operated at 106% RPL for nominal ascent and intact aborts. The SSME FPL of 109% RPL shall be allowed for contingency aborts. Nozzle exit area is used for scaling thrust from pressure at sea level to vacuum.

Deviation/Waiver 540 is applicable to Table 3.3.4.1.2.
Refer to Book 4, Active Deviations/Waivers.

3.3.5 Shuttle Carrier Aircraft

3.3.5.1

A SCA and a backup SCA shall be provided. The SCAs shall be capable of transporting any Space Shuttle Orbiter from an end-of-mission or abort landing site to the SLF at KSC.

3.3.5.1.1

Each SCA shall be capable of ferrying an Orbiter weighing up to 240,000 pounds, with a CG as defined in Figure 3.2.1.6.2. This weight includes the ferry kit items.

3.3.5.1.1.1

Each SCA shall be capable of transporting an Orbiter configured for ferry flight, ferry kit items (maximum of 240,000 pounds), from any CONUS landing site to the SLF at KSC. The SSP approved CONUS sites are stated in NSTS 07700, Volume X - Book 3, Appendix 10.17, to this document.

3.3.5.1.1.2

Each SCA shall be capable of transporting an Orbiter configured for ferry flight, including the ferry kit items (maximum of 220,000 pounds), from any TAL site to the SLF at KSC. The SSP approved TAL sites are as stated in NSTS 07700, Volume X - Book 3, Appendix 10.17, to this document.

3.3.5.1.1.3 Reference Ferry Mission

The reference mission consists of three ground-air-ground cycles and 6.5 hours of flight time. The Orbiter, in ferry configuration, will weigh up to 220,000 pounds on 90% of the ferry missions and between 220,000 and 240,000 pounds on 10% of the ferry missions.

NOTE: The reference ferry mission does not change the ferry hardware ground-air-ground cycles for hardware certification.

3.3.5.1.2 (Deleted)

3.3.5.2

Each SCA shall be capable of providing up to 200 amps of 28 VDC electrical power to the Orbiter during the ferry mission for the purpose of operating certain Orbiter electrical equipment (e.g., heaters, pumps, fans).

3.3.5.2.1 (Deleted)

3.3.5.2.1.1 (Deleted)

3.3.5.3

The SCA/Orbiter interface requirements are specified in Paragraph 3.3.1.3.5 of this document.

3.3.5.3.1 (Deleted)

3.3.5.3.2 (Deleted)

3.3.6 Mission Equipment Kit Characteristics

3.3.6.1 Mission Equipment Kit Performance Characteristics

A mission kit is flight hardware that either extends the capability of the SSV or provides an interface to the cargo. Performance characteristics of individual mission equipment kits will depend on the kit's function and will be defined by the procuring element project office to the supplying contractor and shall be incorporated in the CEI specifications.

3.3.6.2 Mission Equipment Kit Design Criteria

All mission equipment kits shall be designed to conform to the following general design criteria:

a. Installation/removal, reconfiguration or maintenance time required for turn-around between missions shall be minimized.

b. The capability for installation/removal, reconfiguration or maintenance in both the horizontal (preparation facility) or vertical (launch pad) shall be considered.

c. The parts list breakdown (details, subassembly or assembly) shall be structured to consider usage of all or portions of the mission kits to provide multiple mission options and to allow the option to fly unneeded portions of the kits as "scar" weight.

d. Kit designs which lend themselves to partial usage shall contain the loose hardware (caps, plugs, covers, etc.) for achieving the partial flight configuration.

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3.4 GROUND OPERATIONS COMPLEX PERFORMANCE AND DESIGN CHARACTERISTICS

3.4.1 Primary and First Alternate Landing Sites

These sites, KSC and EAFB, are classified as the preferred EOM and AOA sites. The launch site shall be the RTLS. These sites are identified in NSTS 17462, Flight Requirements Document.

3.4.1.1 Support Requirements

Capabilities shall be provided for:

a. Support of Orbiter Vehicle operations starting at post blackout through approach and landing rollout.

b. Orbiter Vehicle and conventional aircraft flight crew and ground crew egress and ingress. Additionally, at DFRC, the ground system shall provide the Orbiter crew the capability of a quick access/immediate transport vehicle. The vehicle shall provide interim medical support during crew transport to the medical facility. (This requirement is baselined for STS-43. If possible, use on STS-40 is highly desirable.)

c. Orbiter Vehicle post-landing operations including installation of SSME covers and OMS/RCS thruster covers and Orbiter Vehicle ground power, cooling, purge and PRSD venting.

d. Towing of the Orbiter clear of the runway.

e. Communications between the Orbiter and a ground control/operations center and ground crews.

f. Conventional aircraft, landing and T-O.

g. Servicing and T-O/landing operations for the Orbiter and carrier aircraft.

h. Emergency operations associated with other than normal landing and post-landing operations of the Orbiter and conventional aircraft.

i. Visual observation of the landing site for coordinating rescue and safety personnel in support of the Orbiter and conventional aircraft.

j. Removal of a disabled Orbiter from the runway.

k. Support payload safing and/or removal.

l. Orbiter mate and demate with the carrier aircraft.

3.4.1.2 Design Characteristics

3.4.1.2.1 Runway Size

The runway dimensions are defined in NSTS 07700, Volume X - Book 3, Appendix 10.17, to this specification.

3.4.1.2.2 Landing Runway Loads

For purposes of runway design, the following criteria shall be used:

Design Landing Weights	
Nominal Operations	230,000 pounds
Abort Operations	256,000 pounds
Design Wheel Load - Static	70,000 pounds
Tire Pressure	310-320 psi
Main Gear Loads	90% gross vehicle weight
Main Gear Spacing	23 feet center-to-center
Main Gear Tire Spacing	36 inch center-to-center
Orbiter Runway Operations	600 landings

3.4.1.2.3 Runway Surface

As a design goal the runway surface shall minimize tire wear during dry crosswind landing conditions.

3.4.1.2.4 Towway

A towway, capable of accommodating the Orbiter, shall be provided between the landing area and the Orbiter deservicing area.

3.4.1.2.5 Landing Aids

The following landing aids shall be provided:

a. Microwave Scanning Beam Landing System (MSBLS)

b. Tactical Air Navigation (TACAN)

c. Flood lights to illuminate touchdown and landing rollout

d. Approach lighting to provide final approach guidance

e. An Aim Point Identification Light System (APILS) at the intercept of the extended runway centerline and the high wind outer glide slope or an appropriate visual aim point

f. Two sets of Precision Approach Path Indicator (PAPI) lights at the nominal and high wind outer glide slope intercept points

g. Ball/Bar inner glide slope lights at the intersection of the touchdown zone and 1 1/2 degree glide slope

h. Provision to vary the intensity level for applicable lighting aids to accommodate day, dawn/dusk, and night operations

The location of the above aids are identified in NSTS 07700, Volume X - Book 3, Appendix 10.17, to this specification.

3.4.1.2.6 TACAN and MSBLS Flight Checks

A TACAN and MSBLS commissioning flight inspection shall be performed after initial installation.

3.4.1.2.7 Survey Requirements

Site coordinate and datum information shall be provided in NSTS 07700, Volume X - Book 3, Appendix 10.17, to this specification.

3.4.1.2.8 Orbiter/Ground Communication

An S-Band and an Ultrahigh Frequency (UHF) voice communications system shall be provided to handle operational communications between the ground and the Orbiter through landing, rollout and post-landing power up.

3.4.1.2.9 (Deleted)

3.4.1.2.10 (Deleted)

3.4.1.2.11 (Deleted

3.4.1.2.12 (Deleted)

3.4.1.2.13 (Deleted)

3.4.1.2.14 (Deleted)

3.4.1.3 Interface Characteristics

The primary and secondary landing site shall interface with the Orbiter as defined in ICD 2-1A001 and ICD 2-1D003.

3.4.1.4 Landing and Post-Landing TV

TV coverage requirements are specified in NSTS 08240, Television Plan.

3.4.1.5 Medical Requirements

Capabilities shall be as defined in JSC 13956, Medical Operations Requirements Document, current revision.

3.4.1.6 Meteorological Measurement Requirements

Capabilities and personnel shall be provided for:

a. Surface observations of ceiling, visibility, atmospheric pressure, temperature, dew point, wind direction and speed, and precipitation

b. Measurement of wind vs altitude profiles and transmission of data

c. Digital satellite coverage and radar coverage

d. A ground weather observer with voice communications to JSC/Spaceflight Meteorological Group (SMG)

e. An airborne weather observer available to report any marginal visibility conditions to the flight director

f. Capability for determining the threat of lightning

3.4.2 Second Alternate Landing Site (Backup Weather Alternate)

This site, White Sands Space Harbor, is identified as an EOM and an AOA site in NSTS 17462.

NOTE: This is the only identified AOA site for high inclination launches.

3.4.2.1 Support Requirements

The following capabilities shall be provided:

a. Within five hours of notification

   1. Support of Orbiter Vehicle operations starting at post blackout through approach and landing rollout

   2. Communications between the Orbiter and a ground control/operations center

3. Visual observation of the landing site for coordinating rescue and safety personnel in support of the Orbiter

4. Emergency operations associated with other than normal landing and post-landing operations of the Orbiter and conventional aircraft

5. Towing of the Orbiter clear of the runway

6. Orbiter Vehicle and conventional aircraft flight crew and ground crew egress and ingress

7. Installation of SSME covers and OMS/RCS thruster covers

8. Removal of a disabled Orbiter from the runway

b. Within two weeks of notification

1. All capabilities defined in Paragraph a above

2. Orbiter Vehicle post-landing operations

3. Support payload safing and/or removal

4. Orbiter Vehicle ground power, cooling, purge and PRSD venting

5. Servicing and T-O/landing operations for the Orbiter and carrier aircraft

3.4.2.1.1 (Deleted)

3.4.2.1.2 (Deleted)

3.4.2.1.2.1 (Deleted)

3.4.2.1.2.2 (Deleted)

3.4.2.1.2.3 (Deleted)

3.4.2.1.2.4 (Deleted)

3.4.2.1.2.5 (Deleted)

3.4.2.1.2.6 (Deleted)

3.4.2.1.2.7 (Deleted)

3.4.2.1.2.8 (Deleted)

3.4.2.1.2.9 (Deleted)

3.4.2.1.2.10 (Deleted)

3.4.2.1.2.11 (Deleted)

3.4.2.1.3 (Deleted)

3.4.2.2 Design Characteristics

3.4.2.2.1 Runway Site

The runway dimensions are defined in NSTS 07700, Volume X - Book 3, Appendix 10.17, to this specification.

3.4.2.2.2 Landing Runway Loads

For the purpose of runway design, the following criteria shall be used:

Design Landing Weights	
Nominal Operations	230,000 pounds
Abort Operations	256,000 pounds
Design Wheel Load - Static	70,000 pounds
Tire Pressure	310-320 psi
Main Gear Loads	90% gross vehicle weight
Main Gear Spacing	23 feet center-to-center
Main Gear Tire Spacing	36 inch center-to-center
Orbiter Runway Operations	600 landings

3.4.2.2.3 Runway Surface

As a design goal the runway surface shall minimize tire wear during dry crosswind landing conditions.

3.4.2.2.4 Towway

A towway, capable of accommodating the Orbiter, shall be provided between the landing area and the Orbiter deservicing area.

3.4.2.2.5 Landing Aids

The following landing aids shall be provided:

a. Microwave Scanning Beam Landing System (MSBLS)

b. Tactical Air Navigation (TACAN)

c. Flood lights to illuminate touchdown and landing rollout

d. Approach lighting to provide final approach guidance

e. An APILS at the intercept of the extended runway centerline and the high wind outer glide slope or an appropriate visual aim point

f. Two sets of PAPI lights at the nominal and high wind outer glide slope intercept points

g. Ball/Bar inner glide slope lights at the intersection of the touchdown zone and 1 1/2 degree slide slope

h. Provision to vary the intensity level for applicable lighting aids to accommodate day, dawn/dusk, and night operations

The location of the above aids are identified in NSTS 07700, Volume X - Book 3, Appendix 10.17, to this specification.

3.4.2.2.6 TACAN and MSBLS Flight Checks

A TACAN and MSBLS commissioning flight inspection shall be performed after initial installation.

3.4.2.2.7 Survey Requirements

Site coordinate and datum information shall be provided in NSTS 07700, Volume X - Book 3, Appendix 10.17, to this specification.

3.4.2.2.8 Orbiter/Ground Communication

An S-Band and an UHF voice communications system shall be provided to handle operational communications between the ground and the Orbiter through landing, rollout, and post-landing power up.

3.4.2.2.9 (Deleted)

3.4.2.2.10 (Deleted)

3.4.2.3 Interface Characteristics

The alternate landing site shall interface with the Orbiter as defined in ICD 2-1D003.

3.4.2.3.1 (Deleted)

3.4.2.3.2 (Deleted)

3.4.2.3.3 (Deleted)

3.4.2.3.4 (Deleted)

3.4.2.3.5 (Deleted)

3.4.2.3.6 (Deleted)

3.4.2.3.7 (Deleted)

3.4.2.3.8 (Deleted)

3.4.2.4 Medical Requirements

Capabilities shall be as defined in JSC 13956, current revision.

3.4.2.5 Meteorological Measurement Requirements

Capabilities and personnel shall be provided for:

a. Surface observations of ceiling, visibility, atmospheric pressure, temperature, dew point, wind direction and speed, and precipitation

b. Measurement of wind vs altitude profiles and transmission of data

c. Digital satellite coverage and radar coverage

d. A ground weather observer, in voice communication with the JSC/SMG

e. An airborne weather observer available to report any marginal visibility conditions to the flight director

f. Capability for determining the threat of lightning

3.4.3 TAL, Contingency In-plane Landing and ELSs

3.4.3.1 Transoceanic Landing Sites

3.4.3.1.1 Support Requirements

Capabilities shall be provided for the following:

a. Support of Orbiter Vehicle operations starting at post blackout through approach, landing, recovery and return to launch site

b. Crew egress

c. Communications between Orbiter and ground operations

d. Post-landing towing and securing

e. Emergency operations associated with other than normal landing and post-landing operations of the Orbiter and conventional aircraft

f. Servicing and T-O/landing operations for the Orbiter and carrier aircraft

g. Support payload safing and/or removal

3.4.3.1.2 Design Characteristics

3.4.3.1.2.1 Runway

There shall be no Orbiter Vehicle unique runway design requirements. The runway shall be as defined in NSTS 07700, Volume X - Book 3, Appendix 10.17, to this specification.

3.4.3.1.2.2 Landing Aids

The following visual landing aids shall be provided:

a. Microwave Scanning Beam Landing System (MSBLS)

b. Tactical Air Navigation (TACAN)

c. Flood lights to illuminate touchdown and landing rollout

d. Approach lighting to provide final approach guidance

e. An APILS at the intercept of the extended runway centerline and the high wind outer glide slope or an appropriate visual aim point

f. Two sets of PAPI lights at the nominal and high wind outer glide slope intercept points

g. Ball/Bar inner glide slope lights at the intersection of the touchdown zone and 1-1/2° slope

h. Provision to vary the intensity level for applicable lighting aids to accommodate day, dawn/dusk, and night operations

The location of the above aids are identified in NSTS 07700, Volume X - Book 3, Appendix 10.17, to this specification.

3.4.3.1.2.3 Shuttle Orbiter Arresting System (SOAS)

A SOAS shall be provided when the surface available for Orbiter landing rollout is less than 12,800 feet.

3.4.3.1.2.4 TACAN and MSBLS Flight Checks

A TACAN and MSBLS commissioning flight inspection shall be performed after initial installation.

3.4.3.1.2.5 Survey Requirements

Site coordinate and datum information shall be provided in NSTS 07700, Volume X - Book 3, Appendix 10.17, to this specification.

3.4.3.1.2.6 Orbiter/Ground Communications

A UHF air traffic control voice capability shall be provided for voice communications between the Orbiter, the tower, and the MCC.

3.4.3.1.3 Interface Characteristics

The ground operations at the TAL site shall interface with the Orbiter as defined in ICD 2-1D003.

3.4.3.1.4 Meteorological Measurement Requirements

Capabilities and personnel shall be provided to satisfy the following meteorological measuring requirements:

a. Surface observation of ceiling, visibility, atmospheric pressure, temperature, dew point, wind direction and speed, and precipitation

b. A ground weather observer, in voice communication with the JSC/SMG

c. An airborne weather observer available for reporting any marginal visibility conditions to the flight director

d. Airborne observer aircraft, aircraft equipment, and crew requirements as follows:

Equipment

1. The aircraft and pilot shall be instrument flight rated certified by the governing aviation organization
2. The field of view shall be sufficient to allow the flight crew representative to see and evaluate local weather phenomena, as well as PAPIs, ball/bar, aim points, etc. This shall require a cockpit seat
3. A communication link that shall allow the flight crew representative aboard the aircraft to communicate directly with the CAPCOM position at the JSC MCC. This communication shall be compatible with the existing "QUINDAR" keying system for A/G communications
4. TACAN and VHF Omnidirectional Radio Range/Distance Measuring Equipment (DME)
5. All safety equipment standard in a commercial for-hire aircraft
6. A multi-engine aircraft, if much of the flight profile is over water beyond gliding distance of a single engine aircraft

Aircraft performance

1. A sufficient rate of climb to reach 10,000 feet above Mean Sea Level (MSL) in no more that 10 minutes
2. A sustained level flight capability of at least 200 knots indicated airspeed at 10,000 feet above MSL

e. Measurement of wind vs altitude profiles and transmission of data to JSC Meteorological Interactive Data Displays System

f. Digital satellite coverage and radar coverage

3.4.3.1.5 Medical Requirements

Capabilities shall be as defined in JSC 13956, current revision.

3.4.3.2 Augmented Emergency Landing Site (AELS)

3.4.3.2.1 Support Requirements

The AELS shall provide for:

a. Crew and passenger survival

b. An Orbiter approved tow bar to allow clearing of the runway by airfield personnel if essential to airfield flight operations

3.4.3.2.2 Design Characteristics

3.4.3.2.2.1 Runway

There shall be no Orbiter unique runway design requirements. The runway shall be as defined in NSTS 07700, Volume X - Book 3, Appendix 10.17, to this specification.

3.4.3.2.2.2 Landing Aids

Several landing aids are desired to improve the probability of a successful Orbiter landing. NASA will provide and maintain configuration management of the Shuttle unique systems. It is expected that the majority of the equipment will be operated by qualified DOD personnel as an additional duty on a best effort basis.

a. Microwave Scanning Beam Landing System (MSBLS)

b. Tactical Air Navigation (TACAN)

c. Flood lights to illuminate touchdown and rollout

d. APILS at the intercept point of the extended runway centerline and the high wind outer glide slope or appropriate visual aim point

e. One set of the PAPI lights at the high wind outer glide slope intercept point if practical

f. Ball/Bar inner glide slope lights at the intersection of the touchdown zone and 1-1/2° slopes

g. Provision to vary the intensity level for applicable lighting aids to accommodate day, dawn/dusk, and night operations

The locations of the above aids are as defined in NSTS 07700, Volume X - Book 3, Appendix 10.17, to this specification.

3.4.3.2.2.3 Shuttle Orbiter Arresting System (SOAS)

A SOAS shall be provided when the surface available for Orbiter landing rollout is less than 12,800 feet. This system will be in place during potential landing opportunities if practical or be in a position to be deployed by existing personnel if time allows (2-hour maximum).

3.4.3.2.2.4 TACAN and MSBLS Flight Checks

A TACAN and MSBLS commissioning flight inspection shall be performed after initial installation.

3.4.3.2.2.5 Survey Requirements

Site coordination and datum information shall be provided in NSTS 07700, Volume X - Book 3, Appendix 10.17, to this specification.

3.4.3.2.2.6 Orbiter/Ground Communications

A UHF air traffic control voice capability shall be provided for voice communications between the Orbiter and the control tower.

3.4.3.2.3 Interface Characteristics

The AELSs shall interface with the Orbiter as defined in ICD 2-1D003.

3.4.3.2.4 (Deleted)

3.4.3.2.5 (Deleted)

3.4.3.3 Emergency Landing Sites (ELS)

3.4.3.3.1 Support Requirements

The ELSs shall be acceptable premission selected sites providing for crew and passenger survival with no Orbiter Vehicle unique support.

3.4.3.3.2 Design Characteristics

3.4.3.3.2.1 Runway

There shall be no Orbiter Vehicle unique runway design requirements. The runway shall be as defined in NSTS 07700, Volume X - Book 3, Appendix 10.17, to this specification.

3.4.3.3.2.2 Landing Aids

A TACAN shall be provided at all locations except Kinshasa, Zaire, and Dakar, Senegal. DME only shall be provided at Kinshasa, Zaire, and Dakar, Senegal.

3.4.3.3.3 Interface Characteristics

The ground operations at the ELSs shall interface with the Orbiter as defined in ICD 2-1D003.

3.4.4 Orbiter Processing Facility (OPF)

3.4.4.1 Performance Characteristics

A capability shall be provided to perform the following functions:

a. Orbiter and payload safing and deservicing

b. Hypergolics pod removal and installation

c. Payload/mission kit removal and installation and interface verification

d. Orbiter maintenance including TPS refurbishment

e. SSME on Orbiter maintenance and engine changeout

f. Validation of Orbiter and payload communications interfaces with the support network including an RF interface (such as Ku-Band, S-Band) with the network TDRS test station - Merritt Island Launch Area (MILA).

g. Verify Orbiter systems for flight

h. Installation/removal of ferry kit

i. Personnel ingress/egress into or from Orbiter

j. Payload T-0 Services

3.4.4.2 Design Characteristics

3.4.4.2.1 Control/Monitor Equipment

Ground support control and monitor equipment provided by the LPS shall interface with onboard serial digital control and data management subsystem and supporting GSE. This equipment may be controlled from the LCC.

3.4.4.2.2 Environment Protection

The OPF shall be of hangar type construction and shall provide only basic protection from the elements. Special provisions for environmental protection for payload removal and installation shall be defined in Paragraph 3.6.12.2 and shall provide class 100,000 conditioned air to the crew compartment. The air in this facility shall be High Efficiency Particle Air (HEPA) filtered.

3.4.4.2.3 OPF Fire Protection Water

There shall be a water spray system in the OPF to provide fire protection.

3.4.4.3 Interface Characteristics

The OPF shall interface with the Orbiter as defined in ICD 2-1A002.

3.4.5 Shuttle Vehicle Assembly and Checkout Station

3.4.5.1 Performance Characteristics

Two Shuttle Vehicle assembly and checkout stations shall be provided in the VAB to perform the following functions:

a. Stacking and alignment of SRB on MLP

b. Erection and mating of ET to SRB

c. Erection and mating of Orbiter to ET

d. Element integration and interface checkout

e. Checkout of Space Shuttle Flight Vehicle

f. Installation of pyrotechnics

g. Provide lightning protection system in accordance with NSTS 07636, Lightning Protection, Test and Analysis Requirements.

3.4.5.2 Design Characteristics

3.4.5.2.1 Control/Monitor Equipment

Ground support control and monitor equipment provided by the LPS shall interface with onboard serial digital control and data management subsystems and supporting GSE. This equipment may be controlled from the LCC.

3.4.5.2.2 Access Platforms

The station shall be provided with platforms in support of SRB, ET, and Orbiter Vehicle handling, mating, servicing, and checkout. All platforms, including carry-on platforms, that will interface directly with a SSV element shall be designed to provide a minimum clearance between the platform and the SSV element as defined in ICD 2-0A001.

3.4.5.2.3 Roadway

A roadway capable of supporting crawler/transporter with the MLP and total assembled Shuttle Vehicle shall be provided between the Shuttle Vehicle assembly and checkout station and the launch pad station.

3.4.5.2.4 Interface Characteristics

The Shuttle Vehicle Assembly and Checkout Station shall interface with the Shuttle Vehicle as defined in ICD 2-0A001.

3.4.5.2.5 VAB Fire Protection Water

There shall be a water spray system in the Shuttle Vehicle Assembly and checkout station to provide fire protection.

3.4.6 Launch Pad Station

3.4.6.1 Performance Characteristics

Two launch pads and mobile launch platforms shall be provided to perform the following functions:

a. Support the fully assembled flight vehicle in the vertical attitude for transportation from the vehicle assembly station to the launch station.

b. Prelaunch checkout.

c. Vehicle servicing and deservicing.

d. Countdown.

e. Personnel ingress and egress.

f. Payload servicing/installation and payload removal/deservicing.

g. Prelaunch escape for crew, passenger, and ground crew from flight vehicle interface to a safe area as specified in Paragraph 3.2.1.2.12, Emergency Egress.

h. (Deleted).

i. Validation of Orbiter and Payload communications interfaces with the support network including an RF interface (such as S-Band) with the network TDRS test station - MILA. Use of the Orbiter Ku-Band at the pad is not allowed.

j. SSME removal and installation.

k. Contingency access to the Orbiter, ET and SRB TPS and the Orbiter/ET attach fittings and umbilical connectors will be provided for post-FRF inspection and repair.

l. Orbiter weather protection.

3.4.6.2 Design Characteristics

3.4.6.2.1 Control/Monitor Equipment

Ground support control and monitor equipment provided by the LPS shall interface with onboard serial digital control and data management subsystem and supporting GSE. This equipment shall be controlled from the LCC and shall also interface with the onboard RF system.

3.4.6.2.2 Holddown

A holddown capability shall be provided to hold the flight vehicle on the mobile launch platform during SSME thrust buildup to maximum thrust level. The holddown subsystems shall withstand the effects of ground winds, vehicle dynamics, SSME thrust vector alignment, SSME thrust vector excursions, and shall require minimum refurbishment after exposure to the vehicle lift-off environment.

3.4.6.2.3 Service Tower

The service tower shall be provided with:

a. Elevators.

b. Crew Access and Emergency Egress. The crew cabin access arm shall track the vehicle/crew hatch for wind conditions up to 44 knots with the wind conditions monitored and the system controlled by applicable OMRSD requirements.

c. Vehicle reactant storage.

d. (Deleted).

e. Lightning protection in accordance with NSTS 07636.

f. Umbilical support for ET GH_2 venting.

g. Umbilical Support for the ET GO_2 Venting. The ET GO_2 vent shall track the vehicle for wind conditions up to 42 knots with the wind conditions monitored and the system controlled by the applicable OMRSD requirements.

3.4.6.2.4 Power Sources

The launch pad facility shall be provided with an emergency safing power source in addition to the primary and secondary power source.

3.4.6.2.5 Gas Supply

A gas storage area and associated lines shall be provided at the launch station to provide gases for the Shuttle Vehicle.

3.4.6.2.6 Propellant/Reactant Loading

Cryogenic propellant/reactant loading capability of the Shuttle ground system shall be as follows:

a. Simultaneous or sequential LO_2 and LH_2 main propellant loading or drain.

b. Concurrent and sequential flight vehicle main propulsion and payload propellant loading.

c. Emergency drain capability shall not be precluded through the normal fill and drain system.

d. Main propellant fast fill loading shall not require onboard personnel support, shall occur prior to crew and passenger ingress, and shall be completed within approximately 114 minutes.

e. Reactant loading and closeout shall be completed prior to “standby” (see Paragraphs 3.2.1.2.2 and 6.1.1) and shall not require onboard personnel support.

3.4.6.2.7 Storable Propellant Loading

Storable propellant (hypergolic) servicing, including emergency drain capability shall be provided.

3.4.6.2.8 Venting

Venting capability and disposal of hazardous vapors shall be provided to satisfy all Shuttle Vehicle and payload requirements.

3.4.6.2.9 (Deleted)

3.4.6.2.10 Acoustic Deflection/Suppression

Plume deflection and water injection shall be provided to minimize the acoustic environment on the Shuttle Vehicle, payloads, and ground facilities. Plume heating and water injection shall not impact the TPS design requirement and there shall be no direct water impingement on the SSME nozzles. No water shall be deposited on the SSME main combustion chamber internal surface above the plane of the nozzle throat.

3.4.6.2.11 SSME Removal and Installation

The launch pad facility shall provide the capability to remove and install the SSMEs.

3.4.6.2.12 Payload Contamination Control

Purging and atmospheric control of the payload bay, independent of the Orbiter Vehicle internal structure, shall be provided by GSE with the payload bay doors opened or closed.

3.4.6.2.13 (Deleted)

3.4.6.2.14 Payload Changeout Room (PCR)

The PCR shall have provisions to support vehicle and payload activities.

3.4.6.2.14.1 Vehicle Support Provisions

a. Vehicle reactant loading system and associated access

b. Vehicle storable propellant distribution system and associated access

c. Provide for access to the Orbiter preflight umbilical and the mid-body access door from the PCR when mated to the Orbiter

3.4.6.2.14.2 Payload Support

Provisions shall be made to accommodate payload upper stage mating, interface verification, servicing, systems checkout, installation and/or removal and associated access as follows:

a. Changeout - The Payload Ground Handling Mechanism (PGHM) shall provide capability for the following:

   1. Installation/removal of identical payloads

   2. Contingency changeout of Line Replaceable Unit (LRU) hardware

b. Payload PCR Occupancy - PCR design and operations shall not preclude payload occupancy of the PCR for PCR reconfiguration, checkout, and servicing operations immediately after pad safing operations following launch. Payload checkout will be completed prior to the arrival of the Shuttle at the pad.

   Facility services shall be provided (e.g., power, contamination control, etc.) from payload installation into the PCR until payload installation in the Orbiter and payload bay doors are closed, or payload removal from the PCR.

   Alternate or redundant services shall be provided to assure a return to a safe configuration and to maintain environmental control.

c. Environmental and Contamination Control - Contamination control for the PCR shall be defined in Paragraph 3.6.12.2.4. Environmental control for the PCR shall be maintained at 70 ± 5°F and 30-50% Relative Humidity (RH). The PCR shall not preclude the installation of a payload supplied local enclosure. The enclosure shall be purged with the localized air conditioning as defined in subparagraph below.

Provide a localized air conditioning system at the 20 and 40-foot work platform levels on the east (outboard) side of the PCR. Flexible ducting between the outlets and the payload will be provided by the user. Requirements are:

1. Temperature - Adjustable between 52° to 75°F min/max range including ± 3°F at a given setting.

2. Humidity - Within 30-50% RH

3. Total Flow - Adjustable between 0 - 250 lb/min max

4. Contamination Control - Same as PCR air (reference Paragraph 3.6.12.2).

d. Access - With the payload installed in PCR and with the payload handling mechanism in the retracted position, the PCR shall:

1. Provide five fixed platforms in addition to the base floor for payload support operations. Each platform shall provide space of approximately 600 square feet which shall be allocated for payload-related equipment use. This area shall be designed for 100 lbs/ft^2. Platform surfaces and joints shall be designed to minimize the fall-through of contamination, debris, and small hardware items.

2. Utilizing the platforms specified in d.1 above, (except for small areas blanked by payload attachment fittings) provide a capability for 360° access around the longitudinal axis of a 60-foot cylindrical payload 5 to 15 feet in diameter using extensible or insert platforms designed for 50 lbs/ft^2. A two-foot platform width in the horizontal plane shall be a design goal for a 15-foot diameter payload. Insert platforms shall minimize fall-through of contamination, debris, and small hardware items. With the payload installed in the Orbiter payload bay, the PCR shall provide:

   (a) Personnel and equipment access platforms to all Orbiter/payload accommodation interfaces with payload installed in the payload bay, with live load capability of 50 lbs/ft^2.

   (b) Personnel and equipment access to exposed surface of payload installed in the payload bay throughout entire payload bay length when bay doors are open and PGHM extended mold line for unique servicing and adjustments of payload elements. These access provisions shall include five fixed PGHM platforms with attachable inserts, and a live load capability of 100 lbs/ft^2 for fixed and 50 lbs/ft^2 for attached insert platforms.

Access of two feet below payload and six feet above a 60-foot long payload shall not be precluded by structural dimensions of the PCR payload area.

Provisions for access to installation/removal of mid-fuselage Orbiter LRUs, payload liner, keel fittings, bridge fittings, and mission kits, when the PCR is mated to the Orbiter and the payload bay doors are open and payload not in Orbiter or PCR.

Provisions for access to the Orbiter payload bay doors, interior (radiators) when payload bay doors are open, and exterior when payload bay doors are closed.

e. Handling

1. Provisions for handling individual payloads and multiple payloads (up to five) weighing up to 65,000 pounds total for installation or removal of integrated payload(s) to or from the Orbiter payload bay shall be provided.

2. Payload Component Handling Equipment Hoist System - A hoist system shall be provided for lifting payload components and handling equipment off payload segments installed on the PGHM and translation to the fixed work platforms. The maximum single item weight is 1,000 pounds.

3. Devices shall be provided for lifting GSE and payload elements up to 8,000 pounds. to and from various platform levels within the PCR, without retraction of the PCR.

f. Ingress/Egress

1. Provide a personnel airlock with air shower for ingress and egress. Also provide an airlock for payload ground support equipment and payload flight elements. The airlock shall be sized to accommodate equipment up to a maximum envelope of 6' W x 8' H and weight not to exceed 8,000 pounds and live loads of 100 lbs/ft^2. A clothing change room with clothing storage lockers and shoe cleaning equipment shall be provided adjacent to both air locks. An access control station will be located outside the entrance to the change room.

2. The capability for emergency egress shall be provided on each side of each primary work level, and shall include internal passageways, exit doors, and stairways that are external to the PCR enclosure.

3. An equipment storage room shall be located adjacent to the anteroom to store, in a clean environment, the tools and equipment used in the payload changeout room. Provisions shall be made for GSE carts used in vehicle processing.

g. Communications/Data - Provide communications from the PCR to the appropriate ground station (voice, landline, coax, direct RF) as follows:

1. Landlines

   (a) Voice Communication - Payload voice communication capability will be provided by the NASA Operational Intercom System (OIS) within KSC and to specific locations within Cape Canaveral Air Force Station (CCAFS). A secure voice communication capability will be provided by the NASA OIS within KSC and to specific locations within CCAFS for DOD payload processing.

   (b) Data Lines - Payload data lines shall be provided from the launch complex to specific locations within KSC and to the CCAFS interface.

   (c) S-Band Pick-Up Antenna - Provide S-Band pick-up antenna to be used during pad RF open-loop Payload Interrogator (PI)/S-Band interface test; cabling to connect antenna to facility PI interface at the PCR. The pick-up antenna shall be capable of supporting various S-Band antenna locations for different payloads.

2. RF Communications - Provide an open-loop RF communication capability for the payload(s) to communicate within line-of-sight from the PCR to the payload facilities.

   (a) The RF links to be provided are:

   <u>Emergency Band</u>

   S-Band (SGLS)

   X-Band

   K-Band

   C-Band

   (b) Data Relay Antenna - A reradiating antenna system for the above frequency bands shall be provided on the exterior of the PCR. The user interfaces are in the PCR at the 207-foot level.

3. Telephone - Telephone shall be provided at all internal PCR levels and at specified critical locations to provide the capability for “on” and “off” site communications. Each telephone handset shall have a press-to-talk capability.

4. Timing - IRIG B timing signals shall be provided at all interior PCR platform levels and at the pad surface park site for trailerized AGE vans.

h. <u>Electrical Power</u>

1. Provide electrical power complying to MIL-STD-1542, Electromagnetic Compatibility (EMC) and Grounding Requirements for Space System

Facility, for the following services at both sides of all interior PCR platform levels. Connected GSE heat load will not exceed 100,000 BTU/hr into the PCR.

(a) 120/208 VAC, 3 phase, 60 Hz at, 36 kVa each

(b) 120 VAC, single phase, 60 Hz at, 4.8 kVa each

A single-point emergency manual cutoff shall be provided at each major work level for the electrical power supplied at the level.

2. The following electrical power outlets per KSC-STD-E-0011, Electrical Power Receptacle and Plugs, shall be provided on the pad surface in the area of the PCR:

(a) 480 VAC, 3 phase, 60 Hz at, 104 kVa

(b) (Deleted)

(c) 208 VAC, single phase, 60 Hz at 12.5 kVa

(d) 120 VAC, single phase, 60 Hz at 21 kVa

(e) 120/208 VAC, three phase, 60 Hz at 36 kVa each

i. Consumable Servicing

1. Provide the capability for supporting non-hazardous payload consumable loading/unloading, pressurization venting and draining. Payload consumable handling will be accomplished by payload GSE.

2. Provide the capability for supporting payload consumable loading/unloading, pressurization venting, and draining. Payload consumable handling will be accomplished by payload GSE.

j. Security

1. Personnel Access - Personnel access capability into and out of the PCR shall be provided at an airlock for normal operations (excludes emergency egress). Access provisions shall allow up to 15 support personnel to enter/leave the room within a 15-minute period.

2. Visual and Aural Access - For DOD payloads neither the payloads nor the payload GSE shall be visible from outside the PCR enclosure after installation in the PCR. The DOD will provide the controls and/or equipment required to prevent visibility by unauthorized personnel when such personnel are required to be inside the PCR enclosure. Aural communications

generated inside the secure PCR area shall be attenuated such that communication security of mission data shall not be compromised.

k. Payload Cleaning - A built-in vacuum system for cleaning payload elements and support equipment shall be provided with inlets in the airlock, anteroom, and both sides of each interior PCR work platform level.

l. RF Shielding

1. External Radiations - The PCR, with PCR doors closed, shall provide attenuation of the local external (to the PCR) RF environment such that the extraneous RF environment in the vicinity of the DOD payload does not exceed one volt/meter over the frequency range from 15 kHz up to 30 GHz.

2. Communication Security - The PCR, with the PCR doors closed, shall provide attenuation of payload-generated emissions such that communication security of mission data will not be compromised.

m. Pneumatics

1. Work Platform Pneumatic Supply - A GN_2 and He manifold shall be provided to all work platform levels on the west (pivot point) side of the PCR. Outlets shall be capable of providing 3,000 + 100 (psig) per SE-S-0073, Specification, Fluid Procurement and Use Control.

2. Special Purity GN_2 Supply Line - A stainless steel line capable of 4 ft^3/hr at 30 psig shall be provided from the launch pad to an outlet between the 30 and 50-foot work platform levels on the west side (pivot point) of the PCR. The user will provide controls at the outlet to regulate the supply. A special purity GN_2 supply trailer will be provided by the DOD at the pad surface.

n. Utility Air

1. A compressed air source within the PCR (up to 120 psig) shall be provided with outlets appropriately positioned on the major work platform levels.

2. A compressed air source (up to 120 psig) shall be provided at the pad surface for use under the canister installed on the retracted PCR, and the adjacent area where payloads will be off-loaded from transporters.

o. Support Trailers

1. An area on the launch pad adjacent to the PCR hinge column shall be provided for parking up to three 10’ x 50’ trailers containing payload checkout equipment.

2. An area adjacent to the ground inlet of the special purity GN_2 supply line shall be provided for parking an approximately 8’ x 40’ DOD GN_2 trailer.

p. Payload Canister Hoist and Support - An area shall be provided on each launch pad to accommodate and hoist the payload canister during the transportation and installation of payload(s) into the PGHM/PCR.

3.4.6.2.15 Orbiter/SSME Fire Protection

A water spray system shall be provided to protect all surfaces of the Orbiter aft fuselage from a SSME post-shutdown potential hydrogen fire. The water spray system provides water spray coverage of the Orbiter/ET 17-inch disconnects also.

3.4.6.2.15.1 Orbiter/SSME Fire Detection

A fire detection system shall be provided to detect the presence of unexpected uncontrolled fires at various locations where MPS LH_2 system leakage is most likely to occur. Sensor outputs shall be monitored by the LPS.

3.4.6.2.16 Disposition of Unburned Hydrogen in SSME Exhaust

The facility shall provide a hydrogen burn-off system to minimize the accumulation of unburned hydrogen in the vicinity of the flight vehicle for the following situations:

a. On-pad SSME Start Sequence

b. Nominal On-pad SSME Firing

c. FRF Shutdown

d. On-pad Abort Shutdown

3.4.6.2.17 Launch Pad Fire Water Protection

There shall be a water spray system to provide fire protection for the Fire Suppression System (FSS), Reactants Supply System (RSS), LH_2 storage area, GH2 storage area, the LOX storage area, the hyperoxidizer storage area, and the hyperfuel storage area.

3.4.6.2.17.1 Pad Water System Freeze Protection

The launch pad water system shall remain operational during environmental conditions specified in NSTS 07700, Volume X - Book 2, Appendix 10.10.

3.4.6.2.18 Hydraulic Servicing

Shuttle ground hydraulic systems shall be designed in accordance with SW-E-0002, and be capable of providing the hydraulic servicing for Orbiter aerosurface control, SSMEs, and SRB nozzle actuation during prelaunch checkout.

3.4.6.2.19

The station shall be provided with platforms in support of the SSS for vehicle servicing and checkout. All platforms, including carry-on platforms, that will interface directly with an SSV element shall be designed to provide a minimum clearance between the platform and the element as defined in ICD 2-0A002.

3.4.6.2.20 Prelaunch Emergency Egress of Personnel

The launch pad shall provide for emergency egress of flight and ground crew personnel from the flight vehicle to a safe area on the ground. The emergency egress path across the OAA shall provide protection against an environment of up to 450°F for five minutes during a launch pad fire. The crews shall not be exposed to touch temperatures with direct contact surfaces greater than 120°F along the OAA escape path (reference Paragraphs 3.2.1.2.12 and 3.3.1.2.6.1).

3.4.6.2.21 Orbiter Weather Protection

While the rotating service structure is in place around the SSV, it shall provide protection for the Orbiter TPS from the effects of hail and wind-driven rain.

3.4.6.3 Interface Characteristics

The Launch Pad Station shall interface with the Shuttle Vehicle as defined in ICD 2-0A002.

3.4.7 ET Processing and Storage Station

3.4.7.1 Performance Characteristics

An area shall be provided in the VAB for receipt, checkout, processing, and servicing and/or storage for four external tanks, their components, and ground support equipment.

3.4.7.2 Design Characteristics

3.4.7.2.1 Lifting and Handling

Provisions shall be made for moving and handling of the tank within the storage areas and for movement of the tank to the vehicle assembly area.

3.4.7.2.2 Environmental Protection

The processing and storage station shall provide only basic protection from the elements with no temperature or humidity control.

3.4.7.2.3 Access

The station shall have vertical access provisions for the ET, both external and internal.

3.4.7.2.4 Ground System

A grounding system shall be provided within the processing and storage area to prevent static charge buildup on the ET.

3.4.7.3 Interface Characteristics

The ET Processing and Storage Station shall interface with the ET as defined in ICD 2-2A001.

3.4.8 SRB Rotation, Processing and Surge Facility (RPSF)

3.4.8.1 Performance Characteristics

An area shall be provided for the receipt, inspection, handling, rotations processing and/or surge for two (2) flight sets of RSRM segments and for assembly of the Aft booster assembly prior to transporting to the VAB for final SRB assembly and checkout.

3.4.8.2 Design Characteristics

3.4.8.2.1 Lifting, Handling and Transporting

Provisions shall be made for lifting, handling and transporting of RSRM segments and SRB assemblies within the RPSF and transporting to the VAB.

3.4.8.2.2 Hazardous Operations

The facility shall be located such that hazardous operations will not impact other unrelated site activities.

3.4.8.2.3 Environmental Protection

The rotation, processing, and surge facility shall provide only basic protection from the elements with no temperature or humidity control.

3.4.8.2.4 Ground System

A grounding system shall be provided within the facility to prevent static charge buildup.

3.4.8.2.5 RPSF Fire Water Protection

There shall be a water spray system in the RPSF to provide fire protection.

3.4.8.3 Interface Characteristics

The RPSF shall interface with the RSRM segments and SRB assemblies as defined in ICD 2-4A001.

3.4.9 SRB Retrieval and Disassembly Station

3.4.9.1 Performance Characteristics

Capabilities shall be provided for the retrieval, return, disassembly, cleaning, preservation, and shipment of the expended SRBs.

3.4.9.2 Design Characteristics

Provisions shall be made for retrieval of the SRBs at splashdown and handling of the expended SRBs from retrieval through the station to shipment.

3.4.9.3 Interface Characteristics

The SRB Retrieval and Disassembly Station shall interface with the SRBs as defined in ICD 2-4A002.

3.4.10 Parachute Refurbishment Station

3.4.10.1 Performance Characteristics

An area and support equipment shall be provided for the cleaning, drying, inspection, repair, repacking, and storage of the SRB recovery system and Orbiter drag parachutes.

3.4.10.2 Design Characteristics

The station shall be environmentally controlled.

3.4.10.3 Interface Characteristics

Interface provision shall be compatible with the requirements of Paragraph 3.4.10.1.

3.4.11 Hypergolic Maintenance and Checkout Station

3.4.11.1 Performance Characteristics

A facility shall be provided to perform the following functions off-line for the vehicle systems designated below:

3.4.11.1.1

Orbiter Forward Reaction Control System, Orbiter APS.

a. Drain, flush, purge and decontaminate

b. Leak and functional test

c. Refurbishment and maintenance

d. Storage and handling

3.4.11.1.2 Orbiter APU

a. Flush and purge

b. Handling and preparation for shipment

3.4.11.1.3 SRB Hydraulic Power Unit (HPU)

a. Service, drain and purge

b. Handling and hot fire

3.4.11.2 Design Characteristics

The facility shall be located such that hazardous operations will not impact other unrelated site activities and be designed so that operations and maintenance can be performed simultaneously on different modules with no operational impact.

3.4.11.2.1 Facility Location and Layout

The facility shall be located such that hazardous operations will not impact other unrelated site activities and be designed so that operations and maintenance can be performed simultaneously on different modules with no operational impact.

3.4.11.2.2 Hypergol Maintenance Facility (HMF) Fire Water Protection

There shall be a water spray system to provide fire protection in the hypergolic maintenance and checkout station.

3.4.11.3 Interface Characteristics

The HMF shall be compatible with the Orbiter module interfaces as defined in ICD 2-1A003.

3.4.12 SSME Maintenance Station

3.4.12.1 Performance Characteristics

A capability shall be provided to perform the following functions for SSMEs:

a. Inspection

b. Repair

c. Checkout

d. Storage

3.4.12.2 Design Characteristics

The station shall be located within an environmentally controlled enclosure.

3.4.12.3 Interface Characteristics

Interface provisions shall be compatible with the requirements of Paragraph 3.4.12.1.

3.4.13 (Deleted)

3.4.13.1 (Deleted)

3.4.13.2 (Deleted

3.4.13.3 (Deleted)

3.4.14 Flight Crew System Station

3.4.14.1 Performance Characteristics

A capability shall be provided for the storage, repair, maintenance, and servicing of flight crew system equipment. This station will also be utilized by flight crews for purposes of bench reviews/familiarization of flight crew system equipment.

3.4.14.2 Design Characteristics

The station shall be located within an environmentally controlled enclosure.

3.4.14.3 Interface Characteristics

Interface provisions shall be compatible with the requirements of Paragraph 3.4.14.1.

3.4.15 LRU Maintenance Station

3.4.15.1 Performance Characteristics

Shop and laboratory capability shall be provided for the maintenance, repair, test, analysis, acceptance, and packaging of designated Shuttle system LRUs.

3.4.15.2 Design Characteristics

The station shall be located within an environmentally controlled enclosure.

3.4.15.3 Interface Characteristics

Interface provisions shall be compatible with requirements of Paragraph 3.4.15.1.

3.4.16 LPS Station

3.4.16.1 Performance Characteristics

A LPS shall be provided to perform monitor, control, data processing and display in support of maintenance, test, checkout, launch control, and operational management of Shuttle Vehicle, payloads, and ground systems involved in launch site ground turnaround operations. The LPS shall have the capability to exchange information with other data systems. The LPS shall make use of the onboard capability for checkout of flight systems and shall augment this capability to the extent required to meet OMRSD requirements and accomplish adequate checkout.

3.4.16.2 Design Characteristics

3.4.16.2.1 General

The LPS shall consist of an integrated network of computers, data links, displays, controls, hardware interface devices, and computer software designed to control and monitor flight systems, payloads, and those GSE and facilities utilized for direct support of vehicle activities.

3.4.16.2.2 Automated or Manual Capability

The LPS shall provide for automatic and manual sequencing and control with operator override capability.

3.4.16.2.3 Exception and Continuous Monitoring

Exception and continuous monitoring capability is required. A capability shall exist to select the specific measurements to be monitored and to revise the limits associated with exception monitoring.

3.4.16.2.4 (Deleted)

3.4.16.2.5 Fault Isolation

The capability to perform fault isolation to an LRU or group of LRUs within the flight or ground systems shall be provided by the combined onboard and ground system (Reference NSTS 07700-10-MVP-01, Shuttle Master Verification Plan, Volume I, General Approach and Guidelines, Paragraph 3.6.2). The LPS shall augment the onboard fault isolation programs to provide fault isolation for flight vehicle systems (reference Paragraph 3.3.1.2.3.8).

3.4.16.2.6 Uplink Capability

Capability shall be provided to initiate uplink commands in a format compatible with the Shuttle data processing and/or uplink command system as defined by ICD-2-0A003. (Both hardwire and RF capability shall exist.)

3.4.16.2.7 Realtime Data Display

The operator engineer shall be provided the capability to access Shuttle, payloads, and ground systems test data in realtime for display as required to support ground turnaround operation.

3.4.16.2.8 Test Data Recording

A capability shall be provided to record all raw test data (downlink) prior to any preprocessing and all commands transmitted (uplink).

3.4.16.2.9 Historical Test Data Retrieval and Display

A capability shall be provided to retrieve and display historical test data.

3.4.16.2.10 Interactive Data Analysis

Provision shall be made to access recorded ground turnaround operations data via remote terminals.

3.4.16.2.11 (Deleted)

3.4.16.2.12 (Deleted)

3.4.16.2.13 LPS Software System

The LPS software system shall provide a medium by which the test engineer can effectively and efficiently communicate with the test article through the LPS computer system. Automated checkout programs shall be operable in the operator intervention mode as well as automatic mode. The software system must be capable of supporting the functions allocated to the LPS by NSTS 07700, Volume XVIII - Book 1, Computer Systems and Software Requirements, Allocation of Computational Functions and NSTS 07700, Volume XVIII - Book 2, Computer Systems and Software Requirements, Allocation of Simulation Functions.

3.4.16.2.14 Post Test/Launch/Mission Data Reduction and Evaluation

The LPS shall have a capability to provide assessment of system anomalies encountered during ground turnaround operations or launch. In addition, the capability for assessment of selected flight data is required to support Shuttle maintenance requirements.

3.4.16.3 Interface Characteristics

The LPS shall interface with other Shuttle elements and data systems as defined in NSTS 07700, Volume V, Information Management Requirements, and NSTS 07700, Volume XVIII, ICD 2-0A003 and SS-P-0002-150, Computer Program Development Specification.

3.4.17 SRB Refurbishment and Subassembly Station

3.4.17.1 Performance Characteristics

An area shall be provided for the receipt and storage of SRB subassemblies, excluding the RSRM segments, from the vendor or from the SRB retrieval and disassembly station, and for their handling, refurbishment, assembly, and verification for flight prior to their movement to the SRB processing and storage station at KSC, for mating with the RSRM forward and aft assemblies.

3.4.17.2 Design Characteristics

3.4.17.2.1 Lifting, Handling and Transporting

Provisions shall be made for movement of the SRB subassemblies from the storage area, to the refurbishment, assembly, and verification areas, lifting and handling within these areas, and movement to the SRB processing and storage station at KSC.

3.4.17.2.2 Hazardous Operations

The facility shall be located such that hazardous operations will not impact other unrelated site activities.

3.4.17.2.3 Environmental Protection

The storage, refurbishment, assembly, and verification areas shall be environmentally controlled.

3.4.17.2.4 Ground System

A grounding system shall be provided within the facility to prevent static charge build up.

3.4.17.3 Interface Characteristics

The SRB and subassemblies shall interface with the SRB refurbishment and subassembly area as defined in ICD 2-4A001.

3.4.18 Orbiter and Carrier Aircraft Mate/Demate Station

3.4.18.1 Performance Characteristics

The capability shall be provided to mate and demate the Space Shuttle Orbiter and the SCA, to support the ferry mission.

3.4.18.2 Design Characteristics

3.4.18.2.1 Mate/Demate Device

The mate/demate device, shall provide the capability to perform the physical mating. The demate operation shall be essentially the same, except done in reverse sequence.

3.4.18.3 Interface Characteristics

The Orbiter and carrier aircraft mate/demate station shall interface with the Orbiter and carrier aircraft as defined in ICD 2-1D004.

3.4.19 Cargo Interface Verification Equipment

The purpose of this equipment is to provide maximum assurance of Orbiter/cargo compatibility prior to installation of the cargo into the Orbiter payload bay.

3.4.19.1 Performance Characteristics

Equipment shall be provided to simulate the physical and electrical functional interfaces between the Orbiter and cargo. The equipment shall provide capability to perform the following functions:

a. Aid the verification of cargo location and electrical interface functions within the Orbiter cargo bay.

b. Support up to five cargo elements with a maximum weight of 65,000 pounds in either the horizontal or vertical mode.

c. The structural, mechanical, and electrical systems shall be designed for use as individual pieces of equipment to support testing and for combined use integration test requirements.

3.4.19.2 Design Characteristics

3.4.19.2.1

The major structural elements are:

a. Mid-body structural interface shall simulate a 15 feet wide by 60 feet long Orbiter bay. Provision shall be made for installing cargo attach fittings, or equivalent j-hooks in the vertical facility, in the sill longeron area to accommodate the Orbiter 3.933-inch vernier concept. Dimensional tolerances for the cargo/Orbiter interface locations shall be in accordance with those specified in NSTS 07700, Volume XIV, Attachment 1 (ICD 2-19001).

b. Aft crew station support structure and the MS/FS/OOS consoles

c. Xo 576 bulkhead connector panels

d. Xo 1307 bulkhead connector panels

e. Payload bay wire tray function

f. Standard interface panel connectors, including connector type and clocking, and standard mixed cargo harnesses

g. Primary longeron fitting, or equivalent j-hook in the Vertical Processing Facility (VPF)

h. Stabilizing longeron fitting, or equivalent j-hook in the VPF

i. Xo 645 power interface panel

3.4.19.2.1.1 Cleanliness

The equipment shall be designed to be compatible with and facilitate the maintenance of a class 100,000 environment as specified in Federal Standard 209B, Clean Room and Work Station Requirements, Controlled Environment.

3.4.19.2.2 Interface Verification

The interface verification equipment shall demonstrate Orbiter to cargo/electrical interface compatibility by simulating the Orbiter interface within specification tolerances as stated in NSTS 07700, Volume XIV, Attachment 1 (ICD 2-19001) and the exceptions identified in Appendix V (Ground Operations). The electrical system shall perform the following functions:

a. Thruput digital command/data, discretes and analog signals from the cargo to the cargo support GSE (“bent pipe”)

b. Provide encoded digital commands and discrete signals as required to the cargo subsystems

c. Perform quantitative data processing of selected analog, discrete and digital data. This includes:

    1. Simulating the cargo related data handling capabilities of the Orbiter Communications and Data Handling System

    2. Performing functional testing of the cargo as required to verify Orbiter interfaces

    3. Simulating the Flight Computer Operating System (FCOS) response to payload data, (timing, etc.)

    4. Simulating all cargo related Orbiter data outputs from the FCOS and interleaving of Orbiter and payload data

d. Provide a test measurement system for monitoring payload interface signal characteristics

e. Provide a simulation of Orbiter bus power for cargo subsystems

f. Provide a source of AC and DC to payload D&C equipment in the payload station

g. Provide a closed loop simulation of the Orbiter/cargo RF link

3.4.19.2.2.1 Electromagnetic Compatibility

The design objective shall be to minimize the generation of and susceptibility to electromagnetic interference.

3.4.19.2.3 Interface Verification Equipment Design Requirements

It shall be a design goal that the electrical interface verification equipment can be disassembled, transported to a new site, reassembled, and verified for operations.

3.4.19.2.4 Electrical System

It shall be a design goal that the electrical system be capable of stand-alone operation, provide flexibility in performance and operation over the Orbiter to cargo interface specification ranges, and provide for growth of additional requirements.

3.4.20 RSRM Storage Stations at Vendor Facilities

3.4.20.1 Performance Characteristics

An RSRM segment storage capability shall be incrementally developed to support the required flight rate as specified in NSTS 07700, Volume III. Minimum capability shall include the ability to support an unplanned program stand-down of up to six months at any time in the program.

3.4.20.2 Design Characteristics

3.4.20.2.1 Lifting, Handling and Transporting

Provisions shall be made for the access and egress of transportation vehicles and for the loading and unloading of the segments.

3.4.20.2.2 Hazardous Operations

The facility(s) shall be located so that hazardous operations will not impact the safety of other unrelated site activities.

3.4.20.2.3 Environmental Protection

The storage area shall protect the RSRM segments from the elements as follows: RSRM segments shall not be allowed to be exposed to rain, snow, temperatures lower than 40°F, or humidity conditions which could result in condensation on hardware. The capability shall be provided to monitor the temperature and humidity of the storage area.

3.4.20.2.4 Ground System

A grounding system shall be provided within the facility to prevent static charge buildup on the segments.

3.4.20.3 (Deleted)

3.4.21 ET Storage Station at Vendor Facilities

3.4.21.1 Performance Characteristics

An ET storage capability shall be incrementally developed to support the program mission model. Minimum capability shall be six ETs at the ET project contractor's facility.

3.4.21.2 Design Characteristics

3.4.21.2.1 Lifting and Handling

Provisions shall be made for the moving and handling of the ETs within the storage station.

3.4.21.2.2 Environmental Protection

The storage area shall protect the ETs from the elements as follows: no rain or snow; temperature, no lower than 11°F; and humidity - no condensation on the hardware.

3.4.21.2.3 Ground System

A grounding system shall be provided within the storage area to prevent static charge buildup on the ET.

3.4.21.2.4 (Deleted)

3.4.22 Payload Canister

3.4.22.1 Performance Characteristics

Payload canisters shall be provided to transport and install payloads horizontally and vertically.

3.4.22.2 Design Characteristics

3.4.22.2.1 Design Characteristics for Standard Canister

The standard canister shall be designed to accommodate payloads up to 65,000 pounds, 15 feet maximum diameter, and 60 feet maximum length.

3.4.22.2.1.1 Environmental Control

Payload environmental requirements include the following:

a. Temperature - 71° +/- 6°F

b. Humidity - 50% relative humidity max

c. Cleanliness - The payload canister shall provide internal surface cleanliness levels established by SN-C-0005, Contamination Control Requirements, Table II. The payload canister interior shall be continuously supplied with Class 100, guaranteed Class 5000 (Hepafiltered) conditioned air, containing <15ppm hydrocarbons.

d. Shock Vibration - The sum of static and dynamic loadings sustained by the payload during handling and transportation shall be controlled to be below the design flight loads of the payloads.

3.4.22.2.1.2 Gas Service

Payloads requiring special instrument purges of payload elements should note the following. A mount for K-bottle and provisions for a bulkhead fitting are provided on the canister. Bottle regulator and flexible lines will be provided by the user.

3.4.22.2.1.3 Electrical Power

Payload electrical power capability during transportation is 115/120 vac, 1 Phase, 60 Hz at 1.8 kVa.

3.4.22.2.1.4 RF Attenuation

The canister provides 15 dB RF attenuation capability over the frequency range from 10 MHz to 18 GHz.

3.4.22.2.2 (Deleted)

3.4.22.2.2.1 (Deleted)

3.4.22.2.2.2 (Deleted)

3.4.22.2.2.3 (Deleted)

3.4.22.3 (Deleted

3.4.22.4 (Deleted)

3.4.23 Orbiter Modification and Refurbishment Facility

3.4.23.1 Performance Characteristics

An Orbiter modification and repair capability shall be developed to support the program mission model. The facility shall provide the capability to perform the following:

a. Protect an Orbiter from the natural elements.

b. Service the thermal protection system, including tile inspection, refurbishment and replacement.

c. Deservicing and safing hypergolics, ammonia and PRSD systems.

d. Modification, repair, and/or replacement of selected line replacement units and systems.

e. Provide a towway between this facility and the OPFs and VAB.

f. Provide Orbiter environmental control.

g. Provide support systems including one 30-ton bridge crane, HAVA with hypergol vent capability, compressed air, fire protection, floor trenches, and floor jacks.

h. Provide support services for operating personnel including offices, security, parking, paging, and warning.

3.4.23.2 Design Characteristics

3.4.23.2.1 Control/Monitor Equipment

Provide limited control and monitor equipment to verify that modification and refurbishment of Orbiter hardware/systems are in accordance with maintenance and replacement requirements.

3.4.23.2.2 Environment Protection

The facility shall be of hanger type construction and shall provide basic protection from the elements. GSE shall provide Class 100,000 conditioned air to the crew compartment and payload bay.

3.4.23.3 Interface Characteristics

The facility shall interface with the Orbiter as defined in ICD-2-1A002.

3.4.23.4 Towway

A towway capable of accommodating the Orbiter with payload shall be provided between the facility and the VAB and OPF.

3.4.24 EDO Pallet Station

3.4.24.1 Performance Requirements

A capability shall be provided to perform the following functions for the EDO pallet:

a. Inspection

b. Checkout

c. Storage

d. Repair

3.4.24.2 Design Characteristics

3.4.24.2.1

Lifting and handling provisions shall be made for the moving and handling of the EDO pallet.

3.4.24.2.2 Environmental Protection

The storage area shall provide only basic protection from the elements. Filtered air (HEPA) to be provided for inspection, checkout and repair activities.

3.4.24.2.3 Ground System

A grounding system shall be provided within the facility to prevent static buildup on the pallet.

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3.5 OPERABILITY

3.5.1 Reliability

Shuttle System reliability shall be in accordance with NSTS 5300.4(1D-2), Safety, Reliability, Maintainability and Quality Provision for the Space Shuttle Program. Any deviation/waiver of reliability requirements shall be in accordance with NSTS 22206, Requirements for Preparation and Approval of Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL).

3.5.1.1 Flight System Reliability

3.5.1.1.1 Flight Vehicle Subsystem Reliability

The redundancy requirements for all flight vehicle subsystems (except primary structure, thermal protection systems, and pressure vessels) shall be established on an individual subsystem basis, but shall not be less than fail safe during all mission phases including intact aborts with the exception of the subsystem causing the abort. Redesigns or new designs approved after February 1, 1992 shall not reduce the system redundancy for intact abort operations to be less than that provided prior to the redesign (fail safe minimum). New system designs approved after February 1, 1992 shall have the same redundancy requirements for intact aborts as for nominal mission operations.

Items not meeting the above requirements shall be identified in the individual element CIL.

This fail safe requirement does not apply to the premature firing failure mode of pyrotechnic devices and functional systems, except associated avionics and circuitry, or to the aero-surface actuators, SSME actuators, or SRB TVC actuators when subjected to gross contamination of their hydraulic supply.

The SSME shall be relieved of the fail safe operational requirements when a shutdown is prevented by vehicle applied shutdown inhibit command.

NOTE: Waivers of the Reliability and Redundancy requirements Paragraphs 3.3.1.2.3.1.2, 3.5.1.1.1, 3.5.1.1.2 and 3.5.1.1.3 are documented in NSTS 08399, SSP CIL located in WebPCASS and are no longer documented in NSTS 07700, Volume X, as authorized by Space Shuttle PRCBD S004600G, dated 6/23/93.

3.5.1.1.1.1 Primary Structure, Thermal Protection, Pressure Vessels

The primary structure, TPS, and pressure vessels subsystems shall be designed to preclude failure by use of adequate design safety factors, relief provisions, fracture control, or safe life and/or fail safe characteristics.

3.5.1.1.1.2 (Deleted)

3.5.1.1.2 Redundancy Verification

Redundant functional paths (see Paragraph 6.1.16) or subsystems shall be designed so that their operational status (see Paragraph 6.1.15) can be verified during ground turn-around without removal of LRUs. In addition, these redundant functional paths of subsystems shall be designed so that their operational status can be verified in-flight to the maximum extent possible, but as a minimum shall provide capability for redundancy management in the event of a malfunction of a functional path and shall provide information to the crew regarding redundancy status of the affected system sufficient to determine if a failure occurred and if an abort decision is required. Exceptions to the in-flight verification requirement of redundant functional paths include:

a. Standby redundancy (redundant paths where only one path is operational at any given time)

b. All functional paths of any subsystem which is inoperative (during such inoperative periods)

c. Pyrotechnic devices

d. Mechanical linkage

e. Critical items of redundant functional paths which meet one of the following criteria:

    1. Functional Criticality 1R items which are two-fault tolerant or greater and of which at least two remaining paths are readily detectable during flight

    2. Functional Criticality 2R items which are single-fault tolerant or greater and of which at least one remaining path is readily detectable during flight

Critical redundant items whose failure cannot be detected during normal ground turn-around operations or during flight shall be identified in the individual element CIL. Redundancies within a functional path shall be so designed that their operational status can be verified prior to each installation into the vehicle.

NOTE: Waivers of the Reliability and Redundancy requirements Paragraphs 3.3.1.2.3.1.2, 3.5.1.1.1, 3.5.1.1.2 and 3.5.1.1.3 are documented in NSTS 08399, SSP CIL located in WebPCASS and are no longer documented in NSTS 07700, Volume X, as authorized by Space Shuttle PRCBD S004600G, dated 6/23/93.

3.5.1.1.3 Separation of Critical Functions

Alternate or redundant means of performing a critical function (see Paragraph 6.1.4) shall be physically separated or protected at least to the extent of separating the first means from the second means, such that an event which causes the loss of one means of performing the function will not result in the loss of alternate or redundant means. Any deviation/waiver to requirements for physical separation of critical functions shall be in accordance with NSTS 22206. These requirements do not apply to the following items:

a. Safing and arming device used on the RSRM ignition system

NOTE: Waivers of the Reliability and Redundancy requirements Paragraphs 3.3.1.2.3.1.2, 3.5.1.1.1, 3.5.1.1.2 and 3.5.1.1.3 are documented in NSTS 08399, SSP CIL located in WebPCASS and are no longer documented in NSTS 07700, Volume X, as authorized by Space Shuttle PRCBD S004600G, dated 6/23/93.

Deviation/Waiver 640 is applicable to Paragraph 3.5.1.1.3.
Refer to the Deviations/Waivers Section in front of the document.

3.5.1.1.4 Protection of Redundant Components

Redundant components susceptible to similar contamination or environmental failure causes such as shock, vibration, acceleration, or heat loads shall be physically oriented or separated to reduce the chance of multiple failure from the same cause(s).

3.5.1.1.5 Isolation of Subsystem Anomalies

Isolation of anomalies of critical functions (see Paragraph 6.1.4) shall be provided such that a faulty subsystem element can be deactivated either automatically or manually without disrupting or interrupting alternate or redundant functional paths or other subsystems which could cause a Criticality 1 or 2 condition. During ground operations, capability to fault - isolate to the line replaceable unit or group of units without disconnections or use of carry-on equipment, shall be provided. This requirement shall apply to the ET and the SRB only when they are in the VAB or on the pad, and to the SSME only when installed in the Orbiter.

Deviation/Waiver 480 is applicable to Paragraph 3.5.1.1.5.
Refer to Book 4, Active Deviations/Waivers.

3.5.1.1.6 Arming/Disarming Explosives

Provisions shall be made for arming explosive devices as near to the time of expected use as is feasible. Provisions shall be made to promptly disarm explosive devices when no longer needed.

3.5.1.2 Ground System Reliability

3.5.1.2.1 (Deleted)

3.5.1.2.1.1 GSE Fail Safe

All GSE (except primary structure and pressure vessels) shall be designed to sustain a failure without causing loss of vehicle systems or loss of personnel capability (fail safe - see Paragraph 6.1.2.2). GSE structure and pressure vessels shall be designed with safety factors as specified in Paragraph 3.2.2.2.2.

NOTE: Waivers of the GSE Fail Safe requirement are documented in NSTS 08399, SSP CIL located in WebPCASS and are no longer documented in NSTS 07700, Volume X, as authorized by Space Shuttle PRCBD S004600G, dated 6/23/93.

3.5.1.2.2 GSE Failure Protection

GSE failures shall not propagate sequentially in associated support equipment or induce a failure in the flight vehicle.

3.5.1.2.3 GSE Input Verification

GSE used for flight vehicle subsystem operation, test, checkout, or maintenance shall provide for routine verification tests before a flight vehicle connection is made to assure that each fluid or electrical/electronic input to the vehicle is compatible with the related vehicle subsystems.

3.5.1.2.4 GSE Automatic Switching

Provision shall be made for automatic switching to a safe mode of operation for GSE failure modes which could result in the loss of a critical function (see Paragraph 6.1.4) and where there is not enough time for manual correction of the condition. Caution and warning shall be provided for these time-critical functions.

3.5.2 Maintainability

3.5.2.1 Shuttle Systems Maintainability

Shuttle systems design and operational maintenance requirements shall be developed with a goal to minimize flight hardware turnaround time intervals from landing to the subsequent launch. When applicable, the design and operations shall employ in-flight checkout to minimize the ground turnaround interval. The Shuttle flight systems and their LRUs shall be designed such that they are accessible for maintenance.

3.5.2.2.1 SRB/ET Buildup, Mating and Service

The SRB and ET shall have their respective LRUs located and access provided such that minimum time to replace or service them is required during the buildup, verification, and assembly of the SRB/ET. The Orbiter and SRB shall be capable of alignment, connection, inspection, and verification of mechanical and electrical interfaces during mating operations.

3.5.2.2.2 Orbiter Mating, Maintenance and Servicing

The Orbiter shall be capable of having planned maintenance performed within the time allocation specified for turnaround. The Orbiter LRUs shall be located and access provided to allow removal and replacement. The Orbiter and ET shall be capable of alignment, connection, inspection, and verification of electrical, fluid, and mechanical interfaces during the mating operations.

3.5.2.2.3 Shuttle Flight Vehicle Checkout

The Orbiter Vehicle, ET, and SRB shall be capable of checkout after ground system connection on the launch pad. Provision shall be made to allow for maintenance of appropriate LRUs in the vertical position.

3.5.2.2.4 Shuttle Flight Vehicle Access

The Orbiter Vehicle, ET, and SRB shall be capable of access to equipment installations, element interfaces, and service umbilicals requiring inspection, servicing, installation, or verification.

3.5.2.2.5 (Deleted)

3.5.2.3 Ground Systems Maintainability

The operational ground system including equipment and facilities, shall provide turnaround support of flight hardware during Shuttle ground operations within the specified turnaround allocation defined in Paragraph 3.5.2.1. The design of the ground support equipment and facilities shall consider fault isolation, ease of replacement of failed components, and operation manpower as part of the design consideration.

3.5.2.3.1 Turnaround Support

The ground system shall be capable of a minimum service life in accordance with Paragraph 3.5.3.1.

3.5.2.3.2 Turnaround Flow

Ground system maintenance, refurbishment, and revalidation of turnaround facilities of in-line refurbishment of turnaround support equipment shall not interfere with flight

vehicle operations. The support equipment hardware shall be packaged for ease of access and replacement of component parts.

3.5.2.3.3 Shuttle Flight Vehicle Access

The mobile launch platform, service tower, VAB, and pad shall be capable of providing access to flight vehicle interfaces, equipment installations, and service umbilicals requiring inspection, servicing, installation, or verification.

3.5.2.3.4 Launch Preparation

The crawler/transporter, mobile launch platform, service tower, and pad shall be capable of supporting flight vehicle launch preparation and launch activities in a time-frame compatible with the traffic model.

3.5.3 Shuttle Flight Vehicle and GFE Life

3.5.3.1 Design-Life

Each Space Shuttle element and GSE shall meet the design-life specified. Additionally, each Space Shuttle element and GSE shall implement a life extension program (reference Paragraph 3.5.3.2 and 6.1.36) to maintain the SSS operational capability at the flight rate specified in NSTS 07700, Volume III. Reusable flight elements shall be certified for all natural and induced flight and ground environments which they experience during their useful-life. This includes recovery, handling, storage, transportation, and flight environments. Refurbishment and/or checkout between missions shall be performed to assure the operational requirements are met for the planned mission.

3.5.3.1.1 Orbiter Vehicle

Each Orbiter Vehicle shall be capable of performing 100 orbital missions, including ground turnaround operations, with scheduled subsystem maintenance and/or refurbishment or replacement, as determined to be most cost effective. Hardware known to have time, age, or cycle limits exceeded before 100 orbital missions shall be identified in NSTS 08171, File II, Volume III and usage tracked by Time/Age/Cycle Control System to permit replacement or refurbishment when appropriate. Time, age, or cycle limits shall be identified for all non-redundant Criticality 1 hardware items/systems which cannot be inspected. Intervals for maintenance, inspection, and/or checkout will be determined and specified in the OMRSD that are appropriate for each subsystem. Hardware items/subsystems for which time, age, or cycle limits have not been identified may continue in use until they fail to meet performance or margin of safety requirements.

3.5.3.1.2 External Tank (ET)

The ET shall be capable of launch within six years of delivery to NASA, with the exception of the nose cone LRU, which shall be capable of launch within eight years of delivery, and the reformulated thermal protection systems which shall be demonstrated to have a useful life in excess of mission requirements on a mission-by-mission basis until a six-year useful life can be demonstrated.

3.5.3.1.3 Solid Rocket Booster (SRB)

Each SRB shall be capable of a minimum of 20 vertical launches with recovery, retrieval and refurbishment after each mission. Extensions of the 20 mission design-life will be assessed on a case-by-case basis with a documented life extension program (reference Paragraph 3.5.3.2) which provides extensions of one reuse each for a maximum of 25 reuses. Maximum shelf-life of a loaded segment is three years. The documented life extension program shall provide extension of RSRM shelf-life to five years maximum justified annually. A vertically assembled SRB will be capable of being left stacked for a maximum of one year, 180 days of which can be in the mated configuration (reference Paragraph 3.2.1.2.11).

3.5.3.1.4 Carrier Aircraft

The carrier aircraft shall have an operating life of 270 ferry missions.

3.5.3.1.5 Main Engine

SSME components, including alternate high pressure turbopumps, shall be capable of a service life, between overhauls, of 30 starts or 15,000 seconds total time at power levels no greater than 104% RPL except for Rocketdyne high pressure pumps and the flexible ducts which shall be capable of a service life, between overhauls, of 20 starts or 10,000 seconds total time at power levels no greater than 104% RPL.

3.5.3.2 Life Extension

Life extension programs shall meet the requirements specified below as a minimum and will include certification to the projected life extension. More comprehensive approaches may be used if deemed appropriate and cost effective. For hardware that is to be extended, the approach for life extension and effectivity shall be documented in the element Master Verification Plan or System Integrity Assurance Program Implementation Plan. Hardware that is to be replaced shall be included in NSTS 08171, File II, Volume III to permit logistics planning.

3.5.3.2.1 Evaluation Requirements

All Shuttle System flight hardware shall be evaluated on the basis of its criticality to ensure that its projected useful-life supports the Shuttle System operational capability

for the duration of the program. The steps defined below shall be taken prior to hardware exceeding its minimum design-life requirements and on a schedule to facilitate resource acquisition in accordance with program logistics requirements.

3.5.3.2.1.1 Criticality 1 Hardware

All Criticality 1 hardware and hardware which becomes Criticality 1 during abort shall have life extended by life extension or replacement. Hardware that is to be replaced shall be included in NSTS 08171, File II, Volume III to permit logistics planning.

3.5.3.2.1.2 Criticality 1R and Criticality 2 Hardware

All Criticality 1R and Criticality 2 hardware shall be analyzed using the design-life sensitivity criteria in Paragraph 3.5.3.2.2 to determine whether the hardware is design-life sensitive. Hardware that is determined to be design-life sensitive shall be (a) extended by life extension, (b) replaced, (c) approved for limited life use only, or (d) have the design-life sensitivity eliminated. Hardware that is to be replaced or that is identified as design-life sensitive by this analysis shall be documented in NSTS 08171, File II, Volume III. Hardware that is determined not to be design-life sensitive but has reached its contract design-life shall have its projected life extended by life extension or as part of the flight readiness process defined in NSTS 08117, Requirements and Procedures for Certification of Flight Readiness (CoFR), and turnaround checkout/verification prior to each flight. The design-life sensitivity criteria shall be used each flight to reaffirm that the hardware is not design-life sensitive.

3.5.3.2.1.3 Criticality 2R and Criticality 3 Hardware

Criticality 2R and Criticality 3 hardware shall be replaced as attrition occurs. Hardware that is to be replaced shall be included in NSTS 08171, File II, Volume III to permit logistics planning.

3.5.3.2.2 Design-life Sensitivity Criteria

Hardware described in Paragraph 3.5.3.2.1.2 shall be considered design-life sensitive if any of the following criteria apply:

a. It contains age sensitive parts or materials.

b. The turnaround maintenance/checkout is not adequate to assure proper functioning and the hardware has reached its minimum design-life.

c. Its failure history indicates potentially age life related failures.

d. Its performance trending indicates degradation that could be age life related.

e. A Government Industry Data Exchange Program alert analysis identifies age sensitive parts used in the item.

f. Inspection/test indicates potential failure related to age life.

3.5.4 Safety

Shuttle System safety shall be in accordance with NSTS 5300.4(1D-2).

3.5.4.1 Flight System Safety

3.5.4.1.1 Safety Design Preferences

The flight vehicle shall, in the following order of preference, be designed to eliminate hazards (see Paragraph 6.1.5) by appropriate design measures; or prevent hazards through use of safety devices or features; or control hazards through use of warning devices, special procedures, and emergency protection subsystems.

3.5.4.1.2 Crew Warning and Emergency Provisions

The flight vehicle shall have capability to provide crew warning of hazardous conditions and provisions for corrective action, emergency crew and passenger egress/escape, abort action, or mission termination.

3.5.4.1.3 (Deleted)

3.5.4.1.4 Materials

Flight vehicle materials shall be selected with characteristics which do not present hazards to personnel or equipment in their intended use or environment.

3.5.4.1.5 Isolation of Hazardous Conditions

Provisions shall be made to physically isolate or separate hazardous, incompatible subsystems, materials, or environments.

3.5.4.1.6 Purging, Venting, Drainage, Detection

3.5.4.1.6.1 Hazardous Gases and Liquids

Provisions shall be made to prevent hazardous accumulations of gases and liquids in the flight vehicle (i.e., toxic, explosive, flammable, or corrosive). Detection of hazardous gases shall be required in critical areas and closed compartments where hazardous

fluids could accumulate during ground operations, even where ground supplied purge is provided to insure no hazardous conditions exist.

EXCEPTION: Except for the LO_2 and LH_2 Orbiter/ET disconnect cavities.

3.5.4.1.6.2 (Deleted)

3.5.4.1.7 Drain, Vent, and Exhaust Port Design

Flight vehicle drains, vents, and exhaust ports shall prevent exhaust fluids, gases, or flames from creating hazards to personnel, vehicle, or equipment.

3.5.4.1.8 Protection of Critical Functions

Flight vehicle subsystems shall be designed to prevent inadvertent or accidental activation or deactivation of safety-critical functions or equipment which would be hazardous to personnel or vehicles during flight and ground operations.

3.5.4.1.9 Battery Protection

Flight vehicle batteries shall be isolated and/or provided with safety venting systems and/or explosion protection.

3.5.4.1.10 Flight Vehicle Separation

Flight vehicle subsystems or equipment which are severed or disconnected during mission events (e.g., staging) shall not degrade mission success or crew safety.

3.5.4.1.11 Pressure Vessel Protection

Pressure vessels shall be protected against overpressurization or underpressurization which could be hazardous to personnel or flight vehicle.

3.5.4.1.12 Range Safety

The Flight Termination System shall comply with the range safety Flight Termination System requirements of AFETRM 127-1, Air Force Eastern Test Range Manual 127-1, Range Safety Manual, or ESMCR 127-1, Eastern Space and Missile Center Regulation 127-1, Range Safety. New designs initiated after June 30, 1993, shall comply with ERR 127-1, Eastern Range Regulation 127-1, Range Safety (if initiated prior to January 1, 1996) or with EWR 127-1, Eastern and Western Range 127-1, Range Safety

Requirements (if initiated after January 1, 1996). For these new designs, specific system/component design requirements will be tailored from the ERR 127-1 or EWR 127-1 requirements through DOD/NASA negotiations. In those instances where adherence is judged to be inappropriate from either an operational or technical standpoint, such instances shall be brought to the attention of the DOD/NASA for resolution. The design, performance, development, acceptance, and qualification test requirements for a Shuttle Range Safety Command Destruct System to be used on the SRB, left and right, of the SSV shall be in accordance with MSFC-SPEC-30A90506C, Shuttle Range Safety Command Destruct System Specification.

Deviation/Waiver 388 is applicable to Paragraph 3.5.4.1.12.
Refer to Book 4, Active Deviations/Waivers.

3.5.4.1.13 Flammable Gas Concentration Limit

The flight vehicle shall be designed to preclude the concentration of flammable gases in critical areas and closed compartments from exceeding the lower flammable limit for the combination of gases that may be present in areas or compartments for prelaunch, flight, and post-landing operations. This excludes expected air intrusion incurred during mission operations. Specific prelaunch redlines shall be established to minimize hazardous concentrations in-flight. The flight vehicle shall provide a sampling system which connects with a ground detection system capable of periodic sampling of the concentrations of hydrogen and oxygen where these fluids could exist.

3.5.4.1.14 Air Liquefaction

Shuttle flight systems shall be designed to prevent air liquefaction external to cryogenic systems or to control problems resulting from air liquefaction which could present a hazard to personnel, hardware, or cause operational anomalies during ground operations.

3.5.4.1.15 In-flight Detection

Provide the capability to have a hazardous gas detection system that is capable of periodic sampling of concentrations of hydrogen and oxygen in the aft compartment during the ascent phase of flight, for post-flight evaluation/maintenance of the vehicle.

3.5.4.2 Ground System Safety

3.5.4.2.1 Facilities and Non-flight Equipment

Facilities and non-flight equipment shall be designed to preclude or counteract failures and hazards that could jeopardize personnel safety, damage, or degrade the vehicle, facilities, and GSE.

Deviation/Waiver 581 is applicable to Paragraph 3.5.4.2.1.
Refer to Book 4, Active Deviations/Waivers.

3.5.4.2.2 Flight Vehicle Safing for Ground Operations

Flight vehicle safing shall be provided by GSE during ground turnaround, maintenance, and refurbishment operations.

3.5.4.2.3 Emergency Egress

The ground system shall facilitate emergency egress of flight crews, passengers, and ground crews to a safe area during all ground operational phases.

3.5.4.2.4 Hazardous Gas Detection and Disposal

The ground system shall provide for safe disposal of hazardous vented or boil-off gases. Detection of hazardous gases shall be required in ground systems' critical areas and closed compartments where such detection is critical to personnel safety or ground operations.

3.5.4.2.4.1 Redundant Hydrogen and Oxygen Detection Capability

The ground system shall provide a redundant/alternate capability to detect hydrogen and oxygen in the flight vehicle from main propulsion system propellant loading to launch to prevent a launch delay or a launch scrub should the primary system be lost.

3.5.4.2.5 Flight Vehicle Handling and Safing

The ground system shall provide protection of personnel and equipment during safing and handling a vehicle following return from a mission.

3.5.4.2.6 Air Liquefaction

Shuttle cryogenic GSE and facility systems shall be designed to preclude or minimize and control air liquefaction to prevent detrimental effects on equipment and personnel.

3.5.4.2.7 Range Safety

The GSE shall comply with the range safety requirements of AFETRM 127-1 or ESMCR 127-1, or for new designs, EWR 127-1, as appropriate. In those instances where adherence is judged to be inappropriate from either an operational or technical standpoint, such instances shall be brought to the attention of the DOD/NASA for resolution.

3.5.4.2.8 Material Handling Equipment and Operating Personnel

Material handling equipment and operating personnel shall be certified in accordance with the requirement of NSTS 08114, Requirements for Periodic Certification of Material Handling Equipment and Operating Personnel.

3.5.4.2.9 Laser Applications

Lasers and/or laser systems shall be properly operated, handled, and maintained such that they do not present a hazard to personnel, including Shuttle crew, support and operations personnel. Human laser exposure safety levels and guidelines are defined in ANSI/Z136.1-1993, American National Standard for Safe Use of Lasers. Additional definition is given in Paragraph 14.0 of NSTS 07700, Volume X - Book 2, Appendix 10.10.

3.5.5 Human Performance

3.5.5.1 (Deleted)

3.5.5.2 Sizing of Personnel

The flight vehicle shall provide furnishings, equipment, work spaces, and access-ways sized for the following design populations:

a. Accommodations used exclusively by the commander and pilot shall be sized for personnel within the 5th to 95th percentile dimensions of the dimensions of the USAF male population as extrapolated to 1980. However, the accommodations shall be readily adaptable to accommodate an individual as small as a 5th percentile female as identified in USAF AMRL-TR-70-5, Anthropometry of AF Women (1968 USAF Women).

b. All other accommodations shall be sized for personnel within the dimensional range of the 5th percentile female (based upon the 1968 USAF women) to the 95th percentile male (based upon the extrapolated 1980 USAF male).

c. The designs of custom tailored equipment, such as flight clothing and EMUs shall be capable of accommodating, on an as-required basis, any individual from a 5th percentile female (based upon the 1968 USAF women) to the 95th percentile male (based upon the extrapolated 1980 USAF male).

3.5.5.3 Human Engineering Criteria

MIL-STD-1472A, Human Engineering Design Criteria for Military Systems, Equipment and Facilities, shall be used as a guide for human engineering design criteria. The touch temperature of crew related flight equipment shall comply with Paragraph 3.3.1.2.4.2, Crew Exposure (maximum temperature).

3.5.6 Transportability

Each Shuttle System element (or element components), when protected in accordance with the requirements of Paragraph 5.0 shall be capable of being handled and transported from its fabrication site to its final operational or launch position without degradation of reliability. The condition of flight elements after transport shall be acceptable, subject to wear from normal use during transport modes.

3.5.6.1 Handling, Packaging and Transportation Compatibility

Shuttle System elements (or element components) shall be compatible with the handling, packaging, and transportation systems to the extent that:

a. The size and weight of the element or element component does not exceed the limitations of feasible handling, packaging, and transportation systems

b. No loads are induced in the element during transportation and handling which will produce stresses, internal loads, or deflections in excess of that for which the element has been designed and certified; and

c. The element is adequately protected against natural environments during transportation and handling

3.5.7 Hazardous Materials and Components

Hazardous materials and components (i.e., fuels, oxidizers, pyrotechnic devices) shall be used, handled, and maintained in a manner that will not constitute a hazard to personnel, vehicle, equipment, payloads, and/or the mission.

3.6 SYSTEM DESIGN AND CONSTRUCTION STANDARDS

3.6.1 Selection of Specifications and Standards

Specifications and standards for use in the design and construction of the SSS shall be selected in accordance with MIL-STD-143B, Standards and Specifications, Order of Precedence for Selection of, with the following exceptions:

EXCEPTIONS:

1. Space Shuttle Main Engine Alternate Turbopump Program shall use MIL-STD-970, Standard and Specifications, Order of Preference for the Selection of, for equipment designed after October 1, 1987.
2. NASA Documents, where specified, shall take precedence.

3.6.1.1 Commonality

The design of the SSS shall provide for maximum efficiency of equipment selection and/or development through multiple applications of common items, reference Paragraph 6.1.21.

3.6.1.1.1 Commonality of Orbiter and SRB TVC Actuators

The procurement specifications of the Orbiter and SRB TVC Actuators (MC621-0015 and 10SPC-0055) shall have identical requirements, which are contained in the following paragraphs (including subparagraphs) of ICD 2-14001: 3.5.1.2.3, Hardstop Response; 3.5.1.2.4b, Secondary Actuator Pressure Gain; 3.5.1.4.1, Servovalve Parameters; 3.5.1.4.2, Secondary Differential Pressure Transducer and 3.5.1.4.3, Servovalve Bypass.

3.6.1.1.2 Commonality of SSP Thermal Protection System Pour Foam

The procurement specification for the pour foam thermal protection system used on the Orbiter to ET umbilical carrier plates and for the ET feedlines at KSC for close-outs and repairs shall be controlled by MSFC-SPEC-2083, Foam, Polyurethane. Application of the pour foam shall be controlled by the applicable installation or refurbishment drawing.

3.6.2 Materials, Parts and Processes

3.6.2.1 Materials and Processes

Materials and processes, except those for new GSE, shall be selected in accordance with SE-R-0006, except (1) MIL-STD-1595, Qualifications of Aircraft, Missile and Aerospace Fusion Welders, may be used in place of MIL-T-5021, Test, Aircraft and Missile

Welding Operators Qualification, for welding operator qualification and (2) NASA-STD-6001, Flammability, Odor, Offgassing, and Compatibility Requirements and Test Procedures for Materials in Environments that Support Combustion, may be used in lieu of NHB 8060.1A and (3) cadmium mecuric oxide batteries may be used for SSME Block II Controller memory backup and (4) SSME fracture-critical hardware shall be verified as required by Paragraph 3.2.2.1.8 and (5) SRB use of 1,1,1-trichloroethane and 1, 1, 2-trichloro-1, 2, 2- trifluoroethane at ambient temperatures as a solvent to be used on the TVC titanium alloy components, except on wetted surfaces of the fuel system. Also, Paragraph 3.1.2.2 of SE-R-0006 is not imposed for the SRB program, based on mandatory inspection provisions to ensure that any drilling or machining of high strength steel does not cause excessive overheating which results in untempered martensite formation. GSE covered by SE-R-0006 shall be limited to only that equipment which enters the vehicle or to equipment where GSE hazardous fluid/gas metals compatibility or induced contaminations can adversely affect flight hardware. The design requirements for new GSE are defined in Paragraph 3.6.16 of this document. The requirement in SE-R-0006 for closeout photographs is not applicable to SSME. Materials and processes may be selected in accordance with MSFC-STD-506, Material and Process Control Standard, in lieu of SE-R-0006 for equipment designed after December 1986.

3.6.3 Parts Selection

Electronic, Electrical, Electromechanical (EEE), mechanical and fluid parts for flight and GSE use shall be selected from the applicable NASA or element projects parts lists, when available, unless specific approval to use nonstandard or otherwise nonconforming parts is obtained from the applicable project manager.

3.6.3.1 Electrical Connector Restriction

Electrical connector configurations as described in MSFC-SPEC-40M38298A, Connector, Electrical, Special, Miniature Circular, Environmental Resistant 200°C, Specification for, used to connect pyrotechnic firing circuits to the NASA standard initiator, type 1 (NSI-1) are restricted to the specific configurations listed below:

a. NBS8GE8-2SE Connector Configuration shall be used to connect ET/SRB strut pyrotechnic firing circuits to the NSI-1.

   NOTE: When using this connector, assure that there is adequate structural clearance.

b. NBS9GE8-2SE, -2SF, and -2SH Connector Configurations shall be used to connect all other pyrotechnic firing circuits to the NSI-1.

EXCEPTIONS: 1. KSC shall use NBS6G connectors for the NSI connections on the SRB holddown posts due to structural clearance restrictions.

2. KSC shall use NBS6GE connectors for the NSI connections on the ET vent arm umbilical, ET T-0 static lanyard, H_2 burn-off ignitors, and TSM release pyrotechnic firing line cables.

3.6.4 Moisture and Fungus Resistance

Materials which are non-nutrient to the fungi defined in MIL-STD-810, Material Standards for Environmental Test Methods, Method 508 should be used in the Orbiter crew compartment and in all flight and ground systems fluid vents, dump systems, and relief systems. When fungus nutrient materials must be used, they should be hermetically sealed or treated to prevent fungus growth for the effective lifetime of the component. Materials not meeting this requirement shall be identified as a limited life component and shall identify any action required such as inspection, maintenance, or replacement periods. Fungus treatment should not adversely affect unit performance or service life. Materials so treated should be protected from moisture or protective agent. Fungus resistant materials are listed in MIL-STD-454, Standard General Requirements for Electronic Equipment, Requirement No. 4.

For flight systems areas other than the Orbiter crew compartment or fluid systems vents, dump systems, and relief systems, the requirements of this paragraph are applicable where fungus growth could result in the loss of function or otherwise induce a failure which would result in the loss of life or vehicle.

Deviation/Waiver 481 is applicable to Paragraph 3.6.4
Refer to Book 4, Active Deviations/Waivers.

3.6.5 Corrosion of Metal Parts

3.6.5.1 Flight System Corrosion

3.6.5.1.1 Stress Corrosion

SE-R-0006 shall be used for design and materials selection for controlling stress corrosion cracking, except MSFC-SPEC-522B, Design Criteria for Controlling Stress Corrosion Cracking, may be used in lieu of MSFC-SPEC-522A, Design Criteria for Controlling Stress Corrosion Cracking. MSFC-STD-3029, Guidelines for the Selection of Metallic Materials for Stress Corrosion Cracking Resistance in Sodium Chloride Environments, may be used in lieu of MSFC-SPEC-522A for new designs effective November 15, 2000. Stress corrosion control on the Orbiter will be per SD72-SH-0172C, RI Material Control Plan, in lieu of MSFC-SPEC-522A.

MSFC-STD-506 may be used for design and materials selection for controlling stress corrosion cracking in lieu of SE-R-0006 for equipment designed after December 1986.

3.6.5.1.2 Corrosion Protection

Corrosion resistant metals shall be used wherever possible. The use of dissimilar metals, finishes, and coatings shall comply with the requirements of MSFC-SPEC-250, Protective Finishes for Space Vehicle Structures and Associated Flight Equipment, General Specification for.

3.6.5.2 Ground System Corrosion

3.6.5.2.1 Corrosion Protection

The use of dissimilar metal, finish, and coatings shall comply with the requirements of MSFC-SPEC-250, except KSC may use KSC-STD-C-0001B, Protective Coating of Carbon Steel, Stainless Steel and Aluminum on Launch Structures and GSE, for protective coatings.

Deviation/Waiver 582 is applicable to Paragraph 3.6.5.2.1.
Refer to Book 4, Active Deviations/Waivers.

3.6.6 Interchangeability and Replaceability

The definitions of item levels, item exchangeability, models and related items, shall be in accordance with MIL-STD-280A, Definition of Item Levels, Item Exchangeability, Models, and Related Terms.

3.6.6.1 Flight Vehicle Interchangeability

The flight vehicle interfaces shall allow interchangeability (see Paragraph 6.1.13) between any production SRB, ET and Orbiter Vehicle, or between any production Orbiter Vehicle or payload module that may be selected to be mated or installed. Interchangeability of selected major subassemblies shall be possible, e.g., OMS, RCS and APU modules; landing gear; and hydraulic actuators.

3.6.6.2 Replaceability of Hardware

The Shuttle Flight Vehicle hardware shall be interchangeable except for those selected items which will be replaceable (reference Paragraph 6.1.14).

3.6.7 Electromagnetic Compatibility

The Shuttle System and elements thereof including payloads, shall be designed and tested in accordance with SL-E-0001, Specification, Electromagnetic Compatibility

b. MIL-STD-462, Electromagnetic Interference Characteristics, Measurement of

c. MIL-STD-463, Definitions and System of Units, Electromagnetic Interference Technology

The subsystem and/or individual equipment requirements are not applicable to ground system procurements unless specifically required by the procuring activity to meet the requirements for electromagnetic interference critical equipment as defined in SL-E-0001.

The requirement for time-domain transient testing as described in SL-E-0002, Paragraph 6.20 does not apply to the Ascent Air Data System.

3.6.8 Identification and Marking

The identification and marking of Shuttle System equipment shall be in accordance with MIL-STD-130D, Identification and Marking of U.S. Military Property, except that the "design activity code", "manufacturer's trademark" and "licensor code identification", need not be combined with the part number when marking parts and assemblies. The identification and marking of GFE furnished by JSC may be in accordance with MIL-STD-130 or MSC-SPEC-M-1A, Identification and Marking. Pipe, hose, and tube lines of flight vehicles only shall be marked in accordance with MIL-STD-1247B, Markings, Functions and Hazard Designations of Hose, Pipe, and Tube Lines for Aircraft, Missiles and Space Systems. The requirement for marking tube lines is not applicable to the helium injection tube, however, the upstream and downstream tube assemblies shall be identified per MIL-STD-1247B. SRB TVC subsystem tubes, lines and hoses shall be identified with metal part tags per MIL-STD-130. GSE fluid lines and compressed gas cylinders shall be marked in accordance with MIL-STD-101B, Color Code for Pipelines and for Compressed Gas Cylinders. Existing GSE/facility piping installed at KSC Launch Complex 39 shall remain as currently identified; this equipment has been identified in accordance with MIL-STD-1247B and shall be treated as a unique case within the SSP. New GSE/facility piping required to interface with existing Launch Complex 39 equipment shall be identified in accordance with KHB 1700.7, Space Transportation System Payload Ground Safety Handbook, and MIL-STD-101B. Direct electro-chemical etched markings may be used when other marking is not feasible. Requirements shall conform to the requirements of MIL-STD-129E, Marking for Shipment and Storage, or FED-STD-123E, Marking for Shipment (Civil Agencies).

3.6.8.1 (Deleted)

3.6.8.2 Interface Identification

All interface fluid, gaseous, mechanical, and electrical connections (element-to-element, element-to-payload, ground-to-flight) will be identified in a manner to provide ease of

viewing, with and without GSE installed, with the flight element in either horizontal or vertical position.

3.6.8.3 Element Cosmetic Coatings

Cosmetic requirements for all Shuttle elements shall be restricted to appropriate markings or decals, as necessary. Priority consideration shall be given to weight and thermal performance.

3.6.9 Storage

The Shuttle System flight hardware shall be designed for a storage life in accordance with the storage requirements defined in the respective element end item specifications, except that in those cases where age-sensitive materials cannot be avoided, replacement of such materials shall be permitted on a scheduled basis during the storage period.

3.6.10 Drawing Standards

Refer to NSTS 07700, Volume IV, Configuration Management Requirements, Appendix E.

3.6.11 Coordinate System Standards

Coordinate system standards for the Shuttle System are defined in TMX-58153.

3.6.12 Contamination Control

3.6.12.1 System Contamination Control

Contamination of the SSS shall be controlled to assure system safety, performance, and reliability. Control shall be implemented by a coordinated program from design concept through procurement, fabrication, assembly, test, storage, delivery, operations, and maintenance of the Shuttle System. This program shall comply with the requirements of SN-C-0005. Selection of system design shall include self-cleaning (filtering) protection compatible with component sensitivity.

Specific cleanliness levels shall be established for material surfaces, fluid systems, functional items, and habitable areas as required for effective control of contamination.

Fluid particulate cleanliness shall be maintained at acceptable levels for fluids used to service flight elements or major test articles by the use of either a qualified interface filter, a qualified final filter, or approved final filter rationale as specified in SE-S-0073.

Final filters, interface filters, and interface filter/disconnect assemblies shall be qualified as specified in SE-S-0073.

Fluids used in acceptance and qualification of components, and subsequently in assembly of or use in higher level assemblies, subsystems, or systems for verification and operation shall meet the purity cleanliness, and analysis requirements of SE-S-0073. Fluids or fluid components certified or acceptance tested to fluid specifications and or processes prior to SE-S-0073, Revision E, are acceptable for use in the Shuttle fluid systems if those fluids and or processes used are verified by the project elements to be compatible with the requirements of SE-S-0073, Revision E. SSME hydraulic actuator servo components that were tested with MIL-H-5606, Hydraulic Fluid, Petroleum Base; Aircraft, Missile and Ordnance, prior to implementation of testing with MIL-H-83282, Hydraulic Fluid Fire Resistant Synthetic Hydrocarbon Base, Aircraft, may be utilized provided the fluid volume is flushed and replaced with MIL-H-83282 prior to installation on Orbiter.

NSTS 08131, Contamination Control Plan, documents the overall program contamination control tasks and responsibilities.

Equipment designed specifically for the Space Shuttle Program shall comply with the specified requirements. Selection of off-the-shelf equipment for application to the SSP shall comply with the intent of these requirements.

Control of materials and equipment usage during the processing of the Orbiter Vehicle shall conform to NSTS 08242, Limitations for Non-flight Materials and Equipment Used in and Around the Space Shuttle Orbiter Vehicles.

3.6.12.1.1 Filters

3.6.12.1.1.1 Performance Requirements

Filters for flight equipment or GSE final or interface filters shall perform their intended requirements of filtering fluids to restrict downstream fluid contamination levels or to serve as debris screens to protect downstream systems from particles which would degrade systems capability.

3.6.12.1.1.1.1 Maximum Particle Size

3.6.12.1.1.1.1.1

Filters shall remove from the fluid all particulates consistent with acceptable operation of the downstream system, or be consistent with the requirements of SE-S-0073, as applicable.

3.6.12.1.1.1.2 Contamination Tolerance

3.6.12.1.1.1.2.1

The contamination tolerance of the filters shall be established by the design activity based on the upstream fluid characteristics, filter characteristics, service life requirements, and the flow rate and delta pressure requirements of the system.

3.6.12.1.1.1.3 Design Pressure Differential

The design pressure differential for fluid filters and debris screens shall be determined based on the flow characteristics, filter application in the system design, maximum flow rate, and maximum contamination level.

3.6.12.1.1.1.4 External Leakage Requirements

External leakage requirements shall be determined based on the specific application consistent with the overall system requirements.

3.6.12.1.1.2 Design Requirements

3.6.12.1.1.2.1 Burst Pressure

3.6.12.1.1.2.1.1 Flight Application

Burst pressure shall be based on the maximum operating pressure and as specified in Paragraph 3.2.2.1.5.

3.6.12.1.1.2.1.2 Ground Application

Burst pressure shall be based on the maximum expected operating pressure and as specified in SW-E-0002.

3.6.12.1.1.2.2 Collapse Pressure

3.6.12.1.1.2.2.1

Filters shall be designed such that they will not fail structurally or otherwise violate the downstream system internal cleanliness level, when contaminated to the maximum extent predicted for the end of their service lives, and operating at the maximum design pressure differential expected for the system.

3.6.12.1.1.2.3 Proof Pressure

3.6.12.1.1.2.3.1 Flight Application

Proof pressure shall be based on the product of the maximum operating pressure and the proof factor as specified in Paragraph 3.2.2.1.5.

3.6.12.1.1.2.3.2 Ground Application

Proof pressure shall be based on the maximum allowable working pressure and as specified in SW-E-0002.

3.6.12.1.1.2.4 Serviceability

The design of reuseable filters for flight and ground application shall allow visual inspection of both body and element without the aid of special inspection devices.

Deviation/Waiver 550 is applicable to Paragraph 3.6.12.1.1.2.4.
Refer to Book 4, Active Deviations/Waivers.

3.6.12.1.1.3 Materials

3.6.12.1.1.3.1 Filter Assemblies and Filter Elements

The materials used in the construction of filter assemblies and elements shall be compatible with the material specifications as described in Paragraph 3.6.2.1 and SE-S-0073.

3.6.12.1.1.4 Certification Requirements

All new and recleaned filters shall be certified to comply with their design and performance requirements in accordance with NSTS 07700-10-MVP-01, without the loss of function or release of particles or contaminants at maximum flow rate and pressure differential as defined for their specific application.

3.6.12.1.1.5 Configuration Control

Configuration control shall be in accordance with NSTS 07700, Volume IV, and shall ensure traceability by part number that installed filters are the same design and construction as the certified units.

3.6.12.1.1.6 Process Requirements

The assembly and cleaning process for new and recleaned filters shall be approved and controlled by the design activity to allow compliance of the certification requirements (Paragraph 3.6.12.1.1.3). All fluid filters and debris screens shall be accompanied by a certification of compliance to cleanliness levels and particle rating in accordance with Table 6.1 of SE-S-0073 and visual inspection.

3.6.12.2 Operational Contamination Control

Contamination Control during the operational phases of the Space Shuttle is necessary to ensure overall satisfactory performance of the system. The gaseous and particulate

environment of the Orbiter/Payload and applicable facilities is a concern during all operational phases. Because of the wide range of payloads, it is the objective of the following approach to provide requirements to satisfy the needs of the large majority of payloads. Payloads that have special requirements not covered herein shall provide the necessary system(s) to satisfy such requirements. Although operational phase of the system will be covered primarily, specific requirements which affect design of the elements of the system are included.

The following requirements will be incorporated in the generation of the contamination control plan required in Paragraph 3.6.12.1.

3.6.12.2.1 Element Cross Contamination

SSS element design and operation shall be such as to minimize cross contamination of the elements to a level compatible with mission objectives. Payload-element contamination and cross-contamination shall be minimized by the use of a GSE debris shield when there is a minimum of 24 inches spacing between payloads and the shield does not impede access to the payload.

3.6.12.2.2 Payload Bay Design

The payload bay shall be designed to minimize contamination of payload and critical payload bay surfaces to a level compatible with mission objectives. Orbiter elements which are not easily cleaned, e.g., internal ribbed structure, OMS kits, door actuators, etc., and elements which are sources of particulate, vapor, volatile condensible material, or other contamination, shall be isolated from the payload and critical payload bay surfaces. All nonmetallic materials exposed to the payload shall be selected for outgassing characteristics as specified in Paragraph 3.6.2.1. The payload bay shall be designed to protect critical payload and payload bay surfaces from contamination by the external environment during any closed payload bay door operational phase of the SSS.

3.6.12.2.3 Payload Design

Critical surfaces such as Orbiter radiators, windows, optics, etc., within the payload bay and part of the Orbiter System must be protected in the same manner as payloads. That is, payloads must ensure that their effluents and operations do not jeopardize the performance of these systems. Payloads shall comply with the requirements of Paragraph 3.6.2.1 and also shall provide cleanable exterior surfaces.

3.6.12.2.4 Operational Capabilities

The SSS shall provide the capability for satisfying the following requirements.

3.6.12.2.4.1 Payload Loading and Checkout

Prior to payload loading, the internal surfaces of the payload bay envelope shall be cleaned to a visibly clean level, as defined in SN-C-0005. This cleaning shall be accomplished within a protective enclosure in order to isolate sources of contamination from critical regions. This enclosure shall be continuously purged with nominally class 100, guaranteed class 5000 (HEPA filtered) air per FED-STD-209B and shall contain less than 15 parts per million hydrocarbons, based on methane equivalent. The air within the enclosure shall be maintained at 71 ± 6°F and 55% or less relative humidity. The payload loading operation shall be accomplished so as to avoid contaminating the payload and payload bay by temperature, humidity, and particulates consistent with requirements specified herein. More stringent particulate and relative humidity requirements may be implemented on particular payloads pending technical justification of the requirement.

3.6.12.2.4.2 Contamination Control Subsequent to Payload Loading

Subsequent to payload loading, accumulation of visible particulate and film contamination on all surfaces within the payload bay shall be minimized by controlled work disciplines and HEPA filtration to input air. Cleanliness inspections and effective cleaning shall be performed as necessary to ensure that the intent of this requirement is met. The air purge, temperature, and humidity requirements of Paragraph 3.4.6.2.14.2c shall be maintained.

3.6.12.2.4.3 Preparation for Closeup of Payload Bay

Prior to final closure of the payload bay in preparation for vehicle mating, inspection, and cleaning, as required, shall be conducted to verify that all accessible surfaces within the payload bay, including external surfaces of payloads, meet the visibly clean level stipulated in the above Paragraph 3.6.12.2.4.1. When payload changeout in the vertical configuration is required, the purge gas class, temperature, and humidity requirements of the above Paragraph 3.6.12.2.4.1 shall apply.

3.6.12.2.4.4 Closed Payload Bay Operations

The Orbiter shall be designed for closed payload bay purging by GSE, subsequent to payload bay closure using conditioned purge gas (air or GN_2) which has been HEPA filtered, class 5000, and contains 15 ppm or less hydrocarbons based on methane equivalent. Continuous purging will be supplied except during switchover between mobile and facility GSE at the OPF, VAB, Pad, and during towing from the OPF until Orbiter mating operations are complete in the VAB.

3.6.12.2.4.5 Launch Through Orbit Insertion

3.6.12.2.4.5.1 Cleanliness Levels

The level of cleanliness maintained at preflight on the payload and payload bay, shall be retained through launch to orbital insertion including lift-off, SRB separation, etc.

3.6.12.2.4.5.2 Purging

Any purging, other than that provided by normal depressurization of the payload bay or payloads during this operational phase, shall be the responsibility of the payloads.

3.6.12.2.4.6 On-orbit

Overboard venting of gases or liquids shall be controlled either in design or operation to avoid contamination of the payloads, payload bay, Orbiter windows, optical surfaces, or Orbiter TPS surfaces to a level compatible with mission objectives. As a design and operational goal, venting of gases and liquids from the Orbiter will be limited for sensitive payloads to control in an instrument field of view particles of five microns in size to one event per orbit, to control induced water vapor column density to 10^{12} molecules/cm^2, or less, to control return flux to 10^{12} molecules/cm^2/sec., to control continuous emissions or scattering to not exceed 20th magnitude/sec^2 in the Ultraviolet (UV) range, and to control to 1% the absorption of UV, visible, and infrared radiation by condensibles on optical surfaces. Materials which can contaminate either the payload, payload bay, or Orbiter windows by outgassing when exposed to the vacuum environment shall be selected for low outgassing characteristics as defined in Paragraph 3.6.2.1.

RCS thruster firing operations shall be planned to avoid contamination particularly when the payload bay doors are open. Thruster exhausts shall be designed and controlled in operation to minimize direct impingement or reflection upon the deployed or released (attached or unattached) payload or open payload bay. RCS engine design and operation shall consider the minimization of contamination. The design of other devices to be operated in flight, such as the mechanical manipulator, shall be such that the generation of contamination is controlled to a level compatible with mission objectives.

3.6.12.2.4.7 Reentry Phase (Deorbit to GSE Attachment)

The payload bay shall be repressurized using filtered atmospheric air (50 microns absolute). No control of humidity or concentrations of other gases will be provided by the Orbiter.

3.6.12.2.4.8 Post-landing

3.6.12.2.4.8.1 Primary Landing Station

The Orbiter design and related GSE shall include the capability for closed payload bay purging subsequent to landing as defined in Paragraphs 3.2.1.1.15 and 3.6.12.2.4.4.

The payloads will be removed in the environment as defined in Paragraph 3.6.12.2.4.1, if required.

3.6.12.2.4.8.2 Secondary Landing Site

No special requirements.

3.6.12.2.4.8.3 TAL and Emergency Landing Site

No special requirements.

3.6.13 Traceability

Traceability shall be provided by assigning a traceability identification to each system element identified in Paragraph 3.1.1.1 and providing a means of correlating each to its historical records, and conversely, the records must be traceable to each system element. Ground operations systems traceability requirements shall be in accordance with SW-E-0002.

Deviations/Waivers 437, 477 and 505 are applicable to Paragraph 3.6.13.
Refer to Book 4, Active Deviations/Waivers.

3.6.13.1 Traceability Classification

Traceability classification is the classification of a raw material, part, assembly, or end item for determining the traceability marking and traceability records required or excluded for the item. Engineering Documentation (e.g., specifications and drawings) shall specify traceability for items in accordance with the following:

a. Serial Traceability (TS) - Hardware assemblies and components down to and including the LRU level, shall be traceable by serial where one or more of the following apply:

    1. The item is contained in the CIL.

    2. The item has a limited useful-life.

    3. The item is to be subjected to acceptance induced environmental test (thermal and/or vibration).

    4. The item requires progressive comparative measurements of performance (i.e., transducer curves).

    5. The item is subject to fracture control.

    6. The item contains traceable subordinate units, assemblies, or parts.

b. Lot Traceability (TL) - This classification requires lot serial numbering on items produced (manufactured, processed, inspected, or tested by the batch, mix, heat, or melt) in given time sequence, without changes in materials (substitutions); changes in tooling or processes (which would affect form, fit or function); or substitution of non-certified personnel for those normally requiring certification; and without change in configuration. The “given time sequence” nominally includes identification of work from the initiation of the production order for specific hardware manufacture, through completion of the last operation on the production order, and therefore includes accumulation of generic data which are related to all items of a particular lot. EEE parts specified in “applicable element project parts list,” require lot traceability as a minimum.

Deviations/Waivers 437, 477 and 505 are applicable to Paragraph 3.6.13.1b.
Refer to Book 4, Active Deviations/Waivers.

c. Member Traceability (TM) - Both serial number and lot number traceability shall be required on items which must be identified in such a manner that they can be handled as members of a lot and also controlled as individual items.

d. Exempt from Traceability (E) - All items not falling into one of the previous classifications shall be classified as exempt.

3.6.13.2 Traceability Identification

Each item identified as traceable (TS, TL, TM) shall have a traceability identifier consisting of the federal supply code for manufacturer’s identification number (H-1 handbook) and a serial, lot, or member number. The serial, lot, or member number shall be assigned by the manufacturer.

3.6.14 Electrical Bonding

Electrical bonding shall be in accordance with NSTS 37330, Bonding, Electrical, and Lightning Specifications, in all areas, except in the area of lightning protection where the requirements of NSTS 07636 shall apply.

NOTE: Exception to the requirement is allowed for the remote manipulator system communication scanner assemblies P/N 51140F2263-1 and P/N 51140E2260-1 to relax the requirement to 25 milliohms maximum impedance from the unit case to the mounting surface.

Deviations/Waivers 378 and 687 are applicable to Paragraph 3.6.14.
Refer to Book 4, Active Deviations/Waivers.

3.6.15 Electrical Installations

3.6.15.1 Electrical Connections

Deviations/Waivers to these requirements, excluding NSTS 5300.4(1D-2), for SRB Criticality 3 hardware (including DFI) whose failure will not:

a. Affect any Criticality 1, 1R function

b. Generate external debris during ascent

c. Cause loss of a booster

Shall be dispositioned by the SRB CCB.

3.6.15.1.1 Soldering

Soldering of electrical connections shall be in accordance with NHB 5300.4(3A), Requirements for Soldered Electrical Connectors, as supplemented by JSC 08800, JSC Supplement to NHB 5300.4(3A) Requirements for Soldered Electrical Connections. Soldering of electrical connections for applications designed after January 1, 1988, shall be in accordance with NHB 5300.4(3A-1), Requirements for Soldered Electrical Connectors. Electrical connections in off-the-shelf procured hardware shall meet requirements in accordance with NSTS 5300.4(1D-2), NASA-STD-8739.3, Soldered Electrical Connections, or NHB 5300.4(3A-1).

Deviations/Waivers 379, 394, 441, 442, 447, 462, 482, 483, 484, 513, 514, 530, 559, 562, 564, 573, 574 and 575 are applicable to Paragraph 3.6.15.1.1.
Refer to Book 4, Active Deviations/Waivers.

3.6.15.1.2 Interconnections

Interconnecting cables, harnesses, and wiring, designed after January 1, 1988, shall be in accordance with NHB 5300.4(3G), Requirements for Interconnecting Cables, Harnesses, and Wiring, except for hardware built with equipment or processes which were in existence prior to that date. Splice repairs subsequent to Government acceptance (DD Form 250, Material Inspection and Receiving Report) of interconnecting cables, harnesses, and wiring shall be in accordance with NSTS 08080-1, Manned Spacecraft Criteria and Standards, Standard 88.

Deviations/Waivers 646 and 684 are applicable to Paragraph 3.6.15.1.2.
Refer to Book 4, Active Deviations/Waivers.

3.6.15.1.3 Crimping and Wire Wrap

Crimping and wire wrap requirements for applications designed after January 1, 1988 shall be in accordance with NHB 5300.4(3H), Requirements for Crimping and Wire

Wrap, except for hardware built with equipment or processes which were in existence prior to that date.

Deviation/Waiver 635 is applicable to Paragraph 3.6.15.1.3.
Refer to Book 4, Active Deviations/Waivers.

3.6.15.2 Circuit Boards

Deviations/Waivers to these requirements for SRB Criticality 3 hardware (including DFI) whose failure will not:

a. Affect any Criticality 1, 1R function

b. Generate external debris during ascent

c. Cause loss of a booster

Shall be dispositioned by the SRB CCB.

3.6.15.2.1 Circuit Boards Designated Prior to January 1, 1988

Single and double-sided printed wiring board assemblies shall be designed, documented, and fabricated in accordance with MSFC-STD-154, Printing Wiring Boards, (Copper Clad) Design, Documentation, and Fabrication of, Standard for. Multilayer printed wiring board assemblies shall be designed and documented in accordance with SN-P-0006, Printed Wiring Boards, Multilayer, Plated Through Hole, Design Specification for. The fabrication of multilayer printed wiring board assemblies for flight hardware only shall be controlled by SN-P-0006. Parts mounting design requirements for all types of printed wiring board assemblies shall be in accordance with MSFC-STD-136, Parts Mounting Design Requirements for Soldered Printed Wiring Board Assemblies. GSE is excluded from this requirement.

Flight hardware procured prior to December 19, 1975, containing multilayer printed wiring board assemblies, is not required to comply with SN-P-0006. Off-the-shelf hardware procured after December 19, 1975, without multilayer board assembly redesign, is not required to comply with SN-P-0006.

Deviations/Waivers 382, 383 and 511 are applicable to Paragraph 3.6.15.2.1.
Refer to Book 4, Active Deviations/Waivers.

3.6.15.2.2 Circuit Boards Designated After January 1, 1988

The requirements of NHB 5300.4(3K), Design Requirements for Rigid Printed Wiring Boards and Assemblies, and NHB 5300.4(3I), Requirements for Printed Wiring Boards,

will be utilized for the control of the design documentation and manufacture of printed wiring boards and board assemblies for new Space Shuttle flight hardware and critical GSE.

These requirements will be utilized for the control of the design, documentation, and manufacture of printed wiring boards and board assemblies for existing Space Shuttle designs when printed wiring board redesign requires complete replacement of all printed wiring boards and board assemblies.

The original LRU design and manufacturing requirements, initially qualified, may be utilized for the control of the design, documentation, and manufacture of printed wiring boards and board assemblies used in existing Space Shuttle designs when redesign requires partial replacement of printed wiring boards and board assemblies.

Printed wiring boards and board assemblies not intended for use in critical GSE or flight hardware are exempt from these requirements; however, it is desirable that all printed wiring boards and board assemblies meet the intent of these requirements. Off-the-shelf hardware requiring the complete redesign of all printed wiring boards must also comply with these requirements.

Deviation/Waiver 647 is applicable to Paragraph 3.6.15.2.2.
Refer to Book 4, Active Deviations/Waivers.

3.6.15.3 Moisture and Fungus Resistant Treatment

Electrical, electronic and communications equipment shall be treated for moisture and fungus in accordance with requirements specified in Paragraph 3.6.4.

3.6.16 Facility/Non-flight Equipment Design

3.6.16.1 Facilities

New facilities to be utilized at KSC shall be designed in accordance with NHB 7320.1. Certification shall be accomplished through the Operational Readiness Inspection.

3.6.16.2 Ground Support Equipment (GSE)

GSE contracted or designed prior to October 1991 shall comply with SW-E-0002 - Book 1, Space Shuttle Ground Support Equipment General Design Requirements, Existing GSE. Modifications to this GSE shall comply with SW-E-0002 - Book 1, or SW-E-0002 - Book 2, New GSE. GSE contracted or designed after October 1991 shall comply with the current revision of SW-E-0002 - Book 2 at the time of design. Modifications to this GSE shall comply with either (1) SW-E-0002 revision in effect when the GSE was originally designed, or (2) the latest applicable SW-E-0002 revision in effect at the time contract direction for modification is received.

GSE utilized from previous programs shall meet the material and process requirements specified in Paragraph 3.6.2.1 of this document.

3.6.16.3 Commercial Equipment

Commercial equipment (i.e., tools, components, etc.) shall be procured in accordance with SW-E-0002 and, when required, calibrated and certified periodically.

3.6.16.4 Element Tools

Element tools, including shop aids, shall be designed and fabricated to good shop practices and periodically inspected and maintained in a safe and reliable condition.

3.6.16.5 Special Test Equipment and Devices (STE/D)

Special test equipment and devices shall be designed, fabricated, and certified in accordance with the requirements of SW-E-0002.

3.6.17 Screw Threads

3.6.17.1 Designs Initiated After January 1, 1993

Screw threads for airborne fluid system fasteners and for threaded fasteners used on Shuttle system hardware for fatigue and strength sensitive applications shall be of the unified thread form UNJ, Class 3 fit, designed and procured in accordance with MIL-S-8879C, Screw Threads, Controlled Radius Root with Increased Minor Diameter, General Specification for. Screw thread application categories utilizing the UNJ screw thread form shall be determined using the Thread Application Category Logic as shown in Table 3.6.17. Fastener system designs that would result in safety critical threads should not be used on Shuttle system hardware. Where this requirement is not attainable, fasteners with safety critical thread applications shall be identified by drawing number to avoid interchangeability problems. Fasteners for safety critical applications must meet all the verification requirements stated in MIL-S-8879C.

The following exceptions to MIL-S-8879C are allowed:

a. Nonsafety critical internal thread forms integral to a manufactured part, e.g., tapped holes in housings, structures, etc., may be inspected by the manufacturer using appropriate inspection system per FED-STD-H28/20A, Screw-Thread Standards for Federal Services Section 20 Inspection Methods for Acceptability of UN, UNR, UNJ, M, and MJ Screw Threads.

b. Specifying thread application category “other” on drawings and procurement documents in the UNJ thread designation is optional. The default set of inspection criteria in MIL-S-8879C may be used when these are determined to be adequate for the intended application.

Screw threads for airborne fluid systems fittings, electrical feed through connectors and threaded fasteners for general nonfatigue applications may be of the unified thread form UN or UNR, designed and procured in accordance with FED-STD-H28/2B, Screw-Thread Standards for Federal Services Section 2 Unified Inch Screw Threads-UN and UNR Thread Forms. Class 3 fit is preferred, however, Class 2 fit is acceptable when approved by the appropriate element project.

3.6.17.2 Designs Initiated Prior to January 1, 1993

Screw threads for airborne fluid system fittings, electrical feed through connectors, and threaded fasteners used on Shuttle system hardware for fatigue and strength sensitive applications shall be of the unified thread form UNJ, Class 3 fit, designed and procured in accordance with MIL-S-8879A, Screw Threads, Controlled Radius Root with Increased Minor Diameter, General Specification for, Amendment 1.

Reprocurement of screw thread products originally designed and procured per MIL-S-8879A, Amendment 1, may be accomplished by utilizing the “default” verification method from MIL-S-8879C. When reordering manufactured parts that contain tapped holes, the manufacturer may use appropriate inspection system per FED-STD-H28/20A.

Screw threads for airborne fluid system fittings, electrical feed through connectors and threaded fasteners for general nonfatigue applications may be of the unified thread form UN or UNR, designed and procured in accordance with MIL-S-7742B, Screw Threads, Standard Optimum Selected Series, General Specification for, Amendment 1. Class 3 fit is preferred, however, Class 2 fit is acceptable when approved by the appropriate element project.

Reprocurement of screw thread products originally designed and procured per MIL-S-7742B, Amendment 1 may be accomplished by utilizing the “default” verification method from MIL-S-7742D, Screw Threads, Standard Optimum Selected Series, General Specification for. When reordering manufactured parts that contain tapped holes, the manufacturer may use appropriate inspection system per FED-STS- H28/20A.

3.6.17.3 Requirements Applicable to All Designs Regardless of Origination Date

Use of the UN, UNR, or UNJ unified thread form for nonfatigue applications is allowed for fastener material strength levels up to but not including 160 KSI.

The UNJ unified thread form shall be used to the maximum extent practical for fastener material strength levels 160 KSI and above. The UNR unified thread form may be used for fastener material strength levels 160 KSI and above but only when specifically approved by the appropriate element project.

External threads that are rolled after heat treat are preferred and shall be used to the maximum extent practical for both the UNR and UNJ unified thread forms.

Fastener systems and speciality items that utilize modified UN, UNR, and UNJ unified thread forms, e.g., proprietary fastening system, structural panel fastener systems, asymmetric threaded fasteners, locking threaded inserts, etc., shall be subject to the requirements as stated in their vendor specifications regarding the modified screw thread form and verification procedures.

For unique reuse applications, refurbishment specifications may be used for screw thread form reverification. These unique reuse applications and the corresponding vendor/refurbishment specifications shall meet all program requirements (e.g., strength, corrosion, fatigue, etc.) and must be approved by the appropriate element project.

Airborne fluid system fittings with Class 2 fit shall use safety lockwire.

3.6.18 CEI Specification Format

The CEI specifications for the Shuttle System elements shall be prepared in accordance with NSTS 07700, Volume IV.

The Shuttle computer systems and software shall be designed to be compatible with the requirements of NSTS 07700, Volume XVIII.

3.6.19 Design Criteria and Standards

3.6.19.1

All program references to the JSCM 08080 shall be replaced on an attrition basis by referencing NSTS 08080-1. NSTS 08080-1 represents the baseline of JSCM 08080, Change 10, dated March 2, 1982, as an SSP controlled document. Shuttle System Flight and Ground Systems shall conform to the individual standards of NSTS 08080-1, identified in Table 2.0. Each element project office will provide a plan describing the method and extent of implementation of each of the standards to the Space Shuttle Program Office for information. NSTS 08080-1 shall be implemented for the Orbiter subsystems, as specified in the SD73-SH-0297, Implementation Report for Manned Spacecraft Criteria. Whenever equivalent standards exist at other NASA centers, the element project office may specify these other standards as an alternative and Table 2.0 will be revised to reflect this substitution. Policy relative to the method and extent of implementation of each of the standards towards GFE used with the Shuttle Systems is provided by JSC Management Directive 8080.2.

NOTES: 1. The above requirement for electrical wire etching prior to potting is not applicable for the RMS SPEE P/N 51140F36-3/-5, S/N 201 and 202 (reference SPAR W0568) for STS-37 and subs.

2. Waivers of conformance to NSTS 08080-1, Design Standard 4B, Separation of Redundant Equipment; Design Standard 20A, Redundant Electrical Circuits; and Design Standard 32, Electrical Connectors - Pin Assignment, are documented in NSTS 08399, SSP CIL located in WebPCASS and are no longer documented in NSTS 07700, Volume X, as authorized by Space Shuttle PRCBD S004600L, dated 5/10/96.

3.6.19.2

New or revised NSTS 08080-1 standards shall apply only to SSP hardware designs initiated subsequent to the standard's date of NSTS 07700 incorporation. Application to existing SSP hardware is optional and left to the discretion of the affected project element manager.

3.6.20 Shuttle System Pyrotechnics

All pyrotechnics and associated electrical circuits and electronics shall conform to NSTS 08060, Space Shuttle System Pyrotechnic Specification. For wiring in the SRB, pyrotechnic cable shall be considered encased in conduit when they are constructed using a stranded shield braid over the conductors, with the braided shield terminated to the connector shell by a 360° connection and encased within a protected jacket over the shield. The use of reclaimed high explosive is prohibited as defined in NSTS 08060, except reclaimed MIL-R-398, Cyclotrimethylenetrinitramine (RDX), may be used in SRB confined detonating fuse manifold lots AAM, AAN and AAP.

3.6.21 Lightning Protection

The lightning protection criteria is a combination of avoidance, via protection or procedures, and the application of good design practices. The Shuttle system and its elements shall be designed in accordance with the requirements of NSTS 07636. Exceptions and rationale for system configurations not meeting NSTS 07636 are contained in that document.

3.6.22 Seismic Protection

All GSE used in close proximity to SSV elements, or GSE that can otherwise cause damage to SSV elements by virtue of their operation, or failure to operate during a seismic event, shall be designed considering the hazards defined in TM-82473, Terrestrial Environment (Climatic) Criteria Guidelines for Use in Aerospace Vehicle Development, 1982 Revision, Section XVI, and in accordance with SW-E-0002.

3.6.23 Seismic Monitoring

During the processing or storage of SSV elements in seismic zones 3 or 4 as depicted in Figure 3.6.23, Seismic Zone Map of the United States, constant monitoring and automatic recording capability shall be provided to record all ground motion resulting from a seismic event. These data shall be collected in a manner consistent with the input parameter requirements of the analytical methods that would be used to recertify an element after exposure to seismic loading. The input parameter requirements shall be used to determine equipment locations and recorder trigger levels. An exception may be made for processing or storage of SSV elements whose design requirements exceed seismic loads and that can be recertified by test or inspection rather than analysis subsequent to experiencing seismic load conditions.

3.6.24 Structural Bonding

All structural and thermal protection system bonds on all elements of the flight vehicles which, on debonding, could damage surrounding components or result in damage to the Orbiter TPS, shall be treated as critical processes requiring NASA element design project control and approval of bonding materials and processes, and any changes thereto. All bonding materials shall be controlled to assure that the chemical composition, processing, and mechanical properties meet the design requirements and are consistent with those used for bond certification. The process specification shall comply with the requirements and quality assurance provision of MSFC-SPEC-445, Requirements for Adhesive Bonding, Process and Inspection, except in that validation of adhesive is required prior to use only when the shelf or storage life in the controlling material specification is exceeded.

The following requirements apply in addition to those of MSFC-SPEC-445:

3.6.24.1 Life Verification

Simulated service tests shall be conducted to demonstrate that the materials and processes selected will provide the desired properties for the entire life of the component.

3.6.24.2 Personnel Certification

Personnel performing bonding and quality control operations shall be trained and certified for the bonding process. All certifications shall include on-the-job training.

3.6.25 Electrostatic Discharge (ESD) Protection

3.6.25.1 Hardware Design Protection, Flight Hardware and Critical GSE Designed After June 1, 1991

Hardware Design Protection, Flight Hardware and Critical GSE Designed After June 1, 1991. Assemblies and equipment shall be designed to provide ESD protection for

Electrostatic Discharge Sensitive (ESDS) parts used in the design. The minimum requirement for assemblies is 1,000 volts, and the minimum requirement for equipment is 2,000 volts.

3.6.25.2 Marking of Hardware, Flight Hardware and Critical GSE Designed After June 1, 1991

Marking of Hardware, Flight Hardware and Critical GSE Designed After June 1, 1991. ESDS parts, assemblies, and equipment shall be identified and marked in accordance with the following requirements. Identification shall be placed so as to warn personnel before any ESD damaging procedure can be performed. Parts, assemblies, or equipment susceptible to damage from ESD voltages of less than 16,000 volts shall be considered ESDS for purposes of these requirements.

a. Equipment containing ESDS items shall be identified internally with either the sensitive electronic device symbol from MIL-STD-129E or the EIA specification RE-471 symbol.

   The following caution statement shall be placed adjacent to the ESDS symbol, if room is available:

CAUTION Contains parts and assemblies susceptible to damage by Electrostatic Discharge (ESD).

b. Equipment having external sensitivity shall have ESDS symbols affixed to their exterior.

c. The ESDS cautionary mark on an assembly shall be visible when the assembly is installed in the next higher assembly. Alternative identification shall be used as approved by the procuring NASA installation when the prescribed marking is not possible.

3.6.25.3 Handling Procedures

ESD protective handling procedures shall be developed, documented, and implemented as determined by the design project. These procedures shall apply to all parts, assemblies, and equipments marked ESD sensitive, and shall preclude ESDS items from being subjected to ESD in excess of their rated sensitivity levels.

3.6.25.3.1 Equipment Level Procedures

For equipment level handling and installation, including electrical interconnection, the following additional procedures shall apply:

a. Personnel shall use a wrist strap for grounding while making electrical connection to equipment.

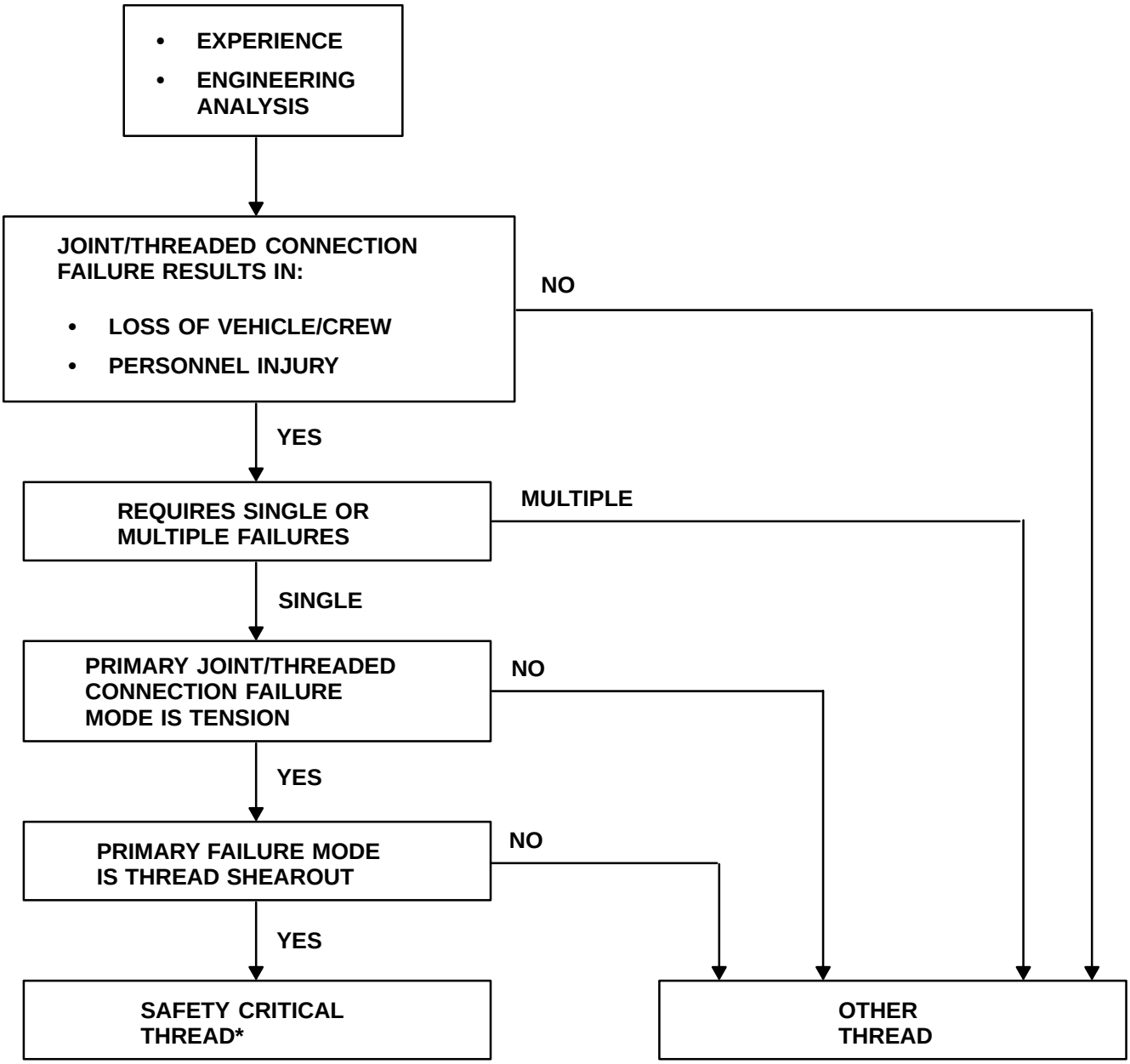
b. ESD-protective covering or protective caps on external terminals, interconnecting cables, and connector assemblies shall not be removed except as directed by approved installation or maintenance procedures.

c. As an ESDS item is installed, contact with electrical connections, including connector pins, shall be avoided except as directed by approved installation or maintenance procedures.

d. Where practical, prior to engaging a de-energized connector and cable with a mating receptacle connected to an ESDS item, the cable connector shield (connector outer shell) shall be grounded to its mating connector shield, to discharge any electrostatic potentials. Interconnecting cables terminated on one end to an ESDS item shall be handled as an ESDS item in accordance with this requirement.

TABLE 3.6.17

THREAD APPLICATION CATEGORY LOGIC FOR UNJ THREAD FORM PER MIL-S-8879C



***Thread application category "Safety Critical" as determined by engineering analysis shall be specified on applicable engineering drawings for designs after January 1, 1993.**

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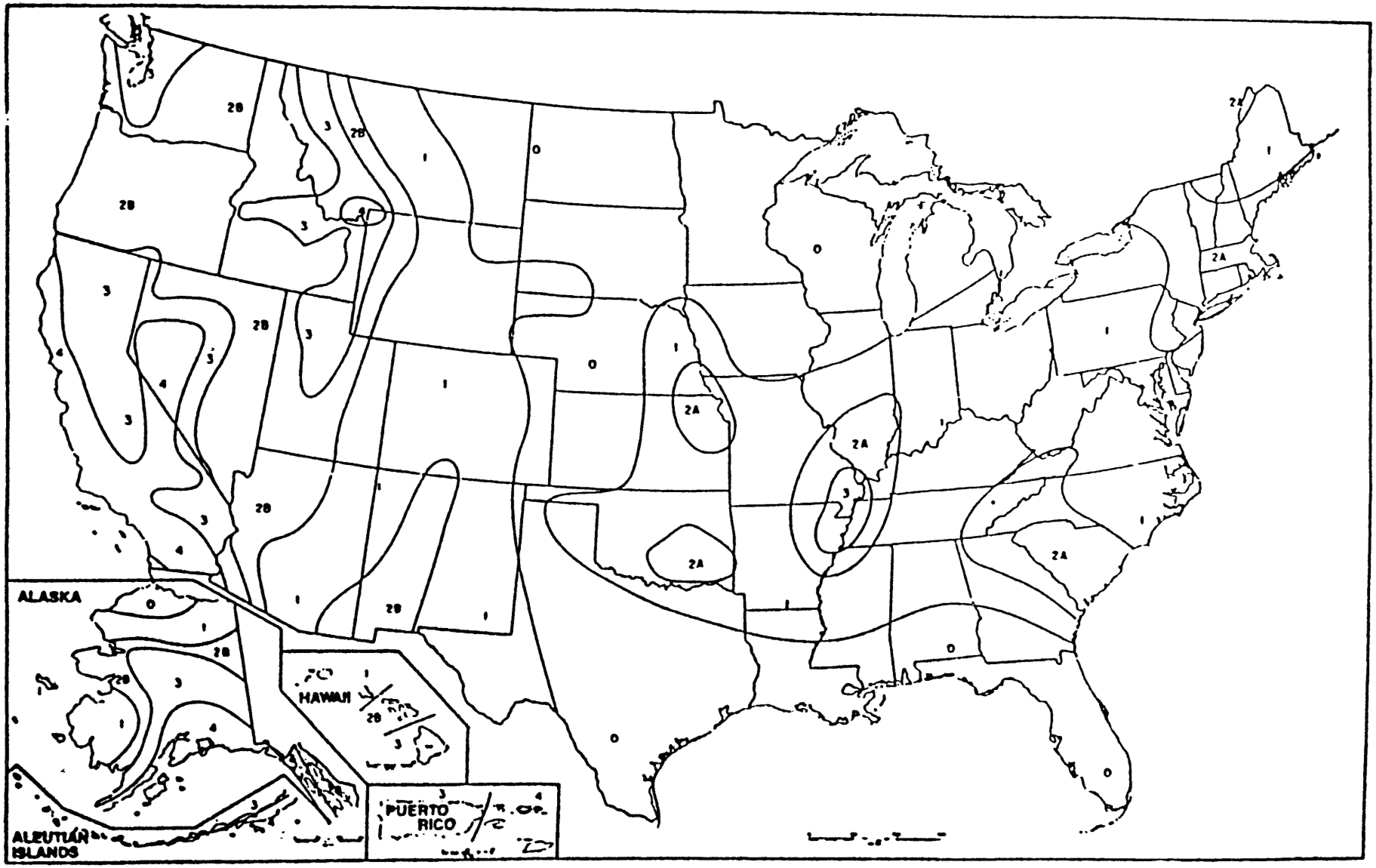
FIGURE 3.6.23

SEISMIC ZONE MAP OF THE UNITED STATES



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3.7 QUALITY ASSURANCE

Shuttle System quality shall be in accordance with NSTS 5300.4(1D-2), except that SSME quality shall be in accordance with NHB 5300.4(1B), Quality Program Provisions for Aeronautical and Space System Contractors, or NSTS 5300.4(1D-2). This exception is also applicable to quality requirements specified in subtier specifications.

Deviations/Waivers 437, 446, 505, 565 and 597 are applicable to Paragraph 3.7. Refer to Book 4, Active Deviations/Waivers.

3.7.1 Inspection Requirements

Nondestructive Inspection (NDI) requirements for materials and parts shall be in accordance with MIL-I-6870B, Inspection Requirements, Nondestructive, for Aircraft Materials and Parts, except that requirements for a NDI plan, materials and parts classification, and NDI technical requirements board need not be applied for SSME materials and parts for which NDI requirements have been issued.

3.7.2 Sampling Requirements

Sampling requirements shall be in accordance with ANSI/ASQCZ1.4-1993, Sampling Procedures and Tables for Inspection by Attributes, and ANSI/ASQCZ1.9-1993, Sampling Procedures and Tables for Inspection by Variables for Percent Nonconforming; or with MIL-STD-105D, Sampling Procedures and Tables for Inspection by Attributes or, MIL-STD-105E, Sampling Procedures and Tables for Inspection by Attributes, and MIL-STD-414, Sampling Procedures and Tables for Inspection by Variables for Percent Defective.

3.7.3 Leakage Measurement

The project elements shall specify leakage measurement requirements. SE-G-0020B, Leakage Measurement of Helium and Nitrogen Test Gases, shall be used as a guide for detailed leakage measurement test procedures when He or N_2 are used as test gases.

3.7.4 Designated Verification

Space Shuttle quality organizations shall develop Designated Verification (DV) programs for the NASA centers and their contractors, that empowers technicians to verify their own work and also witness and verify the work of technicians in training in lieu of independent Quality Assurance (QA) organization inspections. Candidates for DV shall be selected based on experience, proficiency, training and qualification, and they shall be trained in the required QA methods. Where practical, DV may apply to any stable and/or mature process, inspection or test involving functions determined to be Criticality 3. The progress of implementation and the effectiveness of the programs shall be periodically statused to program management.

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4.0 VERIFICATION

4.1 VERIFICATION MATRIX

Responsibility for formal verification of the Shuttle System requirements (Paragraph 3.0) shall be as specified in Table 4.1.

4.2 PAYLOAD AND PAYLOAD CARRIER INTERFACE VERIFICATION REQUIREMENTS

The interface verification requirements for payload equipment mounted or stored in the Orbiter payload bay or the Orbiter crew compartment are defined in NSTS 14046, Payload Interface Verification Requirements.

4.3 VERIFICATION REQUIREMENTS

The guidelines for verification planning and the implementation of verification requirements, are documented in NSTS 07700-10-MVP-01.

4.3.1 System Verification Requirements

Shuttle System verification requirements are documented in NSTS 07700-10-MVP-02, Shuttle Master Verification Plan, Volume II, Combined Element Verification Plan.

4.3.2 Element Verification Requirements

Shuttle element verification requirements are documented in Volumes III through VI and VIII of the Shuttle Master Verification Plan.

Volume III - JSC 07700-10-MVP-03, Orbiter Verification Plan, Volume III (MJ072-0004-3)

Volume IV - JSC 07700-10-MVP-04, Solid Rocket Booster Verification Plan, Volume IV, Booster Assembly (SE-019-019-2H)

Volume V - JSC 07700-10-MVP-05, External Tank Verification Plan, Volume V, Light Weight (MCC-ET-TM01)

Volume VI - JSC 07700-10-MVP-06, Main Engine Verification Plan, Volume VI (RSS-8782)

Volume VIII - JSC 07700-10-MVP-08, KSC, Launch and Landing Site Return to Flight Reverification Plan, Volume VIII (KSC-STSM-09 Volume IV - Suppl.)

4.3.3 Computer Systems Verification

Shuttle computer systems and software verification is documented in NSTS 07700-10-MVP-09, Shuttle Master Verification Plan, Volume IX, Computer Systems and Software Verification Plan, Parts I and II, as follows:

Part I - Guidelines and Standards

Part II - Verification Requirements

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TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX

SECTION 3.0 REQUIREMENT		MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.1											X
3.1.1											X
3.1.1.1											X
3.1.1.2											X
3.1.2											X
3.1.3											X
3.1.3.1											X
3.1.3.1.1											X
3.1.3.1.2											X
3.1.3.1.2.1			X								
3.1.3.1.2.2											X
3.1.3.1.2.2.1						X					
3.1.3.1.2.2.2	(Deleted)										
3.1.3.1.2.2.3										X	
3.1.3.1.2.2.4	(Deleted)										
3.1.3.1.2.3											X
3.1.3.1.2.3.1							X				
3.1.3.1.2.3.2	(Deleted)										
3.1.3.1.2.3.3	(Deleted)										
3.1.3.1.2.3.4	(Deleted)										
3.1.3.1.2.4	(Deleted)										
3.1.3.1.2.4.1					X						
3.1.3.1.2.4.2					X						
3.1.3.1.2.4.3					X						
3.1.3.1.2.5											X
3.1.3.1.2.6											X
3.1.3.1.2.6.1											X
3.1.3.1.2.6.2											X
3.1.3.1.2.7											X
3.1.3.1.2.7.1		X									
3.1.3.1.2.7.2		X									
3.1.4			X			X	X				
3.2											X

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX - Continued

SECTION 3.0 REQUIREMENT		MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.2.1											X
3.2.1.1											X
3.2.1.1.1	(Deleted)										
3.2.1.1.2			X							X	
3.2.1.1.2.1	(Deleted)										
3.2.1.1.2.1.1	(Deleted)										
3.2.1.1.2.1.2	(Deleted)										
3.2.1.1.2.1.3			X	X							
3.2.1.1.2.1.4	(Deleted)										
3.2.1.1.2.1.5	(Deleted)										
3.2.1.1.2.1.6	(Deleted)										
3.2.1.1.2.1.7	(Deleted)										
3.2.1.1.2.1.8	(Deleted)										
3.2.1.1.2.1.9	(Deleted)										
3.2.1.1.2.1.10	(Deleted)										
3.2.1.1.2.1.11	(Deleted)										
3.2.1.1.2.1.12	(Deleted)										
3.2.1.1.2.1.13	(Deleted)										
3.2.1.1.2.1.14	(Deleted)										
3.2.1.1.2.1.15	(Deleted)										
3.2.1.1.2.1.16	(Deleted)										
3.2.1.1.2.1.17	(Deleted)										
3.2.1.1.2.1.18	(Deleted)										
3.2.1.1.3										X	
3.2.1.1.3.1			X							X	
3.2.1.1.3.2	(Deleted)										
3.2.1.1.3.3	(Deleted)										
3.2.1.1.3.3.1			X							X	
3.2.1.1.3.3.2	(Deleted)										
3.2.1.1.3.4			X							X	
3.2.1.1.3.5			X							X	
3.2.1.1.3.6			X							X	
3.2.1.1.3.7			X							X	

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX - Continued

SECTION 3.0 REQUIREMENT		MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.2.1.1.3.8										X	
3.2.1.1.3.8.1	(Deleted)										
3.2.1.1.3.8.2	(Deleted)										
3.2.1.1.3.9	(Deleted)										
3.2.1.1.4										X	
3.2.1.1.4.1										X	
3.2.1.1.5			X		X					X	
3.2.1.1.6			X							X	
3.2.1.1.7			X						X	X	
3.2.1.1.8			X	X						X	
3.2.1.1.9			X			X	X			X	
3.2.1.1.9.1			X							X	
3.2.1.1.9.1.1			X				X			X	
3.2.1.1.9.1.1.1			X				X			X	
3.2.1.1.9.1.1.2							X				
3.2.1.1.9.1.1.3							X			X	
3.2.1.1.9.1.2			X				X			X	
3.2.1.1.9.1.3			X							X	
3.2.1.1.9.2			X			X				X	
3.2.1.1.9.2.1			X			X				X	
3.2.1.1.9.2.1.1			X							X	
3.2.1.1.9.2.2			X			X				X	
3.2.1.1.9.2.3			X							X	
3.2.1.1.10			X			X	X			X	
3.2.1.1.10.1			X							X	
3.2.1.1.10.2			X			X				X	
3.2.1.1.10.2.1			X			X				X	
3.2.1.1.10.2.2			X			X				X	
3.2.1.1.10.2.2.1			X							X	
3.2.1.1.10.2.3			X							X	
3.2.1.1.10.2.4			X							X	
3.2.1.1.10.2.5			X			X				X	
3.2.1.1.11			X							X	
3.2.1.1.12			X							X	

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX - Continued

SECTION 3.0 REQUIREMENT		MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.2.1.1.13			X								
3.2.1.1.14			X							X	
3.2.1.1.15			X								
3.2.1.1.16											X
3.2.1.1.16.1										X	
3.2.1.1.16.2										X	
3.2.1.1.17											X
3.2.1.1.17.1	(Deleted)										
3.2.1.1.17.2										X	
3.2.1.1.18			X	X							
3.2.1.1.19	(Deleted)										
3.2.1.1.19.1	(Deleted)										
3.2.1.1.19.2	(Deleted)										
3.2.1.2											X
3.2.1.2.1	(Deleted)										
3.2.1.2.2			X		X	X	X		X	X	
3.2.1.2.3			X			X			X	X	
3.2.1.2.3.1			X			X			X	X	
3.2.1.2.3.2			X		X	X			X	X	
3.2.1.2.4			X						X		
3.2.1.2.5			X				X		X	X	
3.2.1.2.6									X		
3.2.1.2.7						X			X	X	
3.2.1.2.7.1			X						X		
3.2.1.2.7.2			X						X	X	
3.2.1.2.8			X		X	X	X		X	X	
3.2.1.2.9			X	X	X	X	X		X	X	
3.2.1.2.10	(Deleted)										
3.2.1.2.11			X		X	X	X		X	X	
3.2.1.2.12			X	X					X	X	
3.2.1.2.12.1									X		
3.2.1.2.13			X						X	X	
3.2.1.2.14			X			X	X		X	X	

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX - Continued

SECTION 3.0 REQUIREMENT		MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.2.1.2.14.1						X			X	X	
3.2.1.2.14.2	(Deleted)										
3.2.1.2.14.3							X				
3.2.1.2.14.4						X				X	
3.2.1.2.15	(Deleted)										
3.2.1.2.16	(Deleted)										
3.2.1.2.17											X
3.2.1.2.17.1			X	X						X	
3.2.1.2.17.2			X	X					X	X	
3.2.1.2.18	(Deleted)										
3.2.1.3											X
3.2.1.3.1	(Deleted)										
3.2.1.4											X
3.2.1.4.1											X
3.2.1.4.1.1									X	X	
3.2.1.4.1.1.1	(Deleted)										
3.2.1.4.1.2											X
3.2.1.4.1.2.1										X	
3.2.1.4.2			X	X					X	X	
3.2.1.4.3			X						X	X	
3.2.1.4.3.1									X		
3.2.1.5											X
3.2.1.5.1			X		X	X				X	
3.2.1.5.1.1a			X		X	X				X	
3.2.1.5.1.1b			X		X	X				X	
3.2.1.5.1.1c			X								
3.2.1.5.1.1d			X						X	X	
3.2.1.5.1.1e									X	X	
3.2.1.5.1.1f											X
3.2.1.5.1.1g			X							X	
3.2.1.5.1.1h			X							X	
3.2.1.5.1.1i			X							X	
3.2.1.5.1.1j			X		X	X				X	

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX - Continued

SECTION 3.0 REQUIREMENT		MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.2.1.5.1.1k			X								
3.2.1.5.1.1l			X								
3.2.1.5.1.1m			X							X	
3.2.1.5.1.2a										X	
3.2.1.5.1.2b			X		X	X				X	
3.2.1.5.1.2c			X		X	X				X	
3.2.1.5.1.2d	(Deleted)										X
3.2.1.5.1.3a			X			X				X	
3.2.1.5.1.3b	(Deleted)										
3.2.1.5.2										X	
3.2.1.5.2.1											X
3.2.1.5.2.2											X
3.2.1.5.2.3			X							X	
3.2.1.5.2.4										X	
3.2.1.5.3			X		X	X	X			X	
3.2.1.5.3.1						X					
3.2.1.5.4						X				X	
3.2.1.5.5			X	X							
3.2.1.6											X
3.2.1.6.1			X					X		X	
3.2.1.6.2			X					X	X		
3.2.1.6.3	(Deleted)										
3.2.1.6.3a	(Deleted)										
3.2.1.6.3b	(Deleted)										
3.2.1.6.3c	(Deleted)										
3.2.1.6.3d	(Deleted)										
3.2.1.6.3e	(Deleted)										
3.2.1.6.3f	(Deleted)										
3.2.1.6.3g	(Deleted)										
3.2.1.6.3h	(Deleted)										
3.2.1.6.3i	(Deleted)										
3.2.1.6.3j	(Deleted)										

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX - Continued

SECTION 3.0 REQUIREMENT		MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.2.1.7											X
3.2.1.7.1			X		X	X	X	X			
3.2.1.8											X
3.2.1.8.1									X		
3.2.1.9											X
3.2.1.9.1									X	X	
3.2.1.9.2	(TBD)										X
3.2.1.9.3											X
3.2.1.9.3.1									X		
3.2.1.9.3.2									X		
3.2.1.9.3.3									X		
3.2.2											X
3.2.2.1						X				X	
3.2.2.1.1	(Deleted)										
3.2.2.1.2			X							X	
3.2.2.1.2.1			X							X	
3.2.2.1.2.2			X		X					X	
3.2.2.1.2.3										X	
3.2.2.1.3			X		X	X	X			X	
3.2.2.1.3.1			X								
3.2.2.1.3.2			X			X	X			X	
3.2.2.1.4			X		X					X	
3.2.2.1.4.1			X		X						
3.2.2.1.4.1.1			X		X						
3.2.2.1.4.1.2			X		X						
3.2.2.1.4.1.3			X		X						
3.2.2.1.5			X		X	X	X			X	
3.2.2.1.5.1											X
3.2.2.1.5.2			X		X	X	X				
3.2.2.1.5.3			X		X	X	X				
3.2.2.1.6			X		X	X	X				
3.2.2.1.7			X		X	X	X				
3.2.2.1.8			X		X	X	X				

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX - Continued

SECTION 3.0 REQUIREMENT	MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.2.2.1.9		X		X	X	X				
3.2.2.1.10		X		X		X				
3.2.2.1.11		X			X					
3.2.2.1.12		X			X				X	
3.2.2.1.13		X			X			X	X	
3.2.2.1.14					X				X	
3.2.2.1.15										X
3.2.2.1.15.1					X			X	X	
3.2.2.1.15.2					X			X	X	
3.2.2.1.16		X		X	X			X		
3.2.2.1.17										X
3.2.2.1.17.1		X	X	X	X	X			X	
3.2.2.1.17.1.1		X	X	X	X	X				
3.2.2.1.17.2		X	X	X	X	X	X		X	
3.2.2.1.17.2.1		X		X	X	X			X	
3.2.2.1.17.2.2					X					
3.2.2.1.17.3		X		X	X	X				
3.2.2.1.18		X		X	X	X		X		
3.2.2.1.19		X			X	X			X	
3.2.2.1.20										X
3.2.2.1.20.1					X	X			X	
3.2.2.1.20.2		X			X				X	
3.2.2.1.21		X		X	X	X				
3.2.2.1.22						X				
3.2.2.1.22.1 (Deleted)										
3.2.2.1.22.2		X				X			X	
3.2.2.1.22.3						X				
3.2.2.1.22.4		X				X			X	
3.2.2.1.22.5		X							X	
3.2.2.1.23		X		X		X				
3.2.2.1.24		X		X	X	X				
3.2.2.2								X		
3.2.2.2.1								X		

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX - Continued

SECTION 3.0 REQUIREMENT		MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.2.2.2.2			X		X		X		X		
3.2.2.2.3	(Deleted)										
3.2.2.2.4	(Deleted)										
3.2.2.2.5	(Deleted)										
3.2.2.2.6									X		
3.2.3											X
3.2.4											X
3.2.5											X
3.2.5.1			X	X					X	X	
3.2.5.1.1			X		X		X		X	X	
3.2.6											X
3.2.6.1											X
3.2.6.1.1	(Deleted)										
3.2.6.2	(Deleted)										
3.2.7	(Deleted)										
3.2.7.1	(Deleted)										
3.2.8	(Deleted)										
3.2.8.1	(Deleted)										
3.2.9	(Deleted)										
3.2.9.1	(Deleted)										
3.2.10											X
3.2.10.1											X
3.2.10.2											X
3.2.10.3											X
3.2.10.4											X
3.2.10.5											X
3.2.10.6											X
3.2.10.7											X
3.2.10.8											X
3.2.10.9											X
3.2.10.10											X
3.2.11	(Deleted)										
3.2.11.1	(Deleted)										

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX - Continued

SECTION 3.0 REQUIREMENT		MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.2.12	(Deleted)										
3.2.12.1	(Deleted)										
3.2.13	(Deleted)										
3.2.13.1	(Deleted)										
3.2.14	(Deleted)										
3.2.14.1	(Deleted)										
3.2.15	(Deleted)										
3.2.15.1	(Deleted)										
3.2.16	(Deleted)										
3.2.16.1	(Deleted)										
3.2.17	(Deleted)										
3.2.17.1	(Deleted)										
3.2.18	(Deleted)										
3.2.18.1	(Deleted)										
3.2.19	(Deleted)										
3.2.19.1	(Deleted)										
3.2.20	(Deleted)										
3.2.20.1	(Deleted)										
3.3											X
3.3.1											X
3.3.1.1											X
3.3.1.1.1			X							X	
3.3.1.1.2	(Deleted)										
3.3.1.1.3			X							X	
3.3.1.1.4			X								
3.3.1.1.5			X							X	
3.3.1.1.6			X						X		
3.3.1.1.7			X						X		
3.3.1.1.8			X							X	
3.3.1.1.9			X							X	
3.3.1.1.10			X								
3.3.1.1.11			X							X	
3.3.1.1.12			X								

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX - Continued

SECTION 3.0 REQUIREMENT		MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.3.1.2											X
3.3.1.2.1											X
3.3.1.2.1.1			X								
3.3.1.2.1.2											X
3.3.1.2.1.2.1			X								
3.3.1.2.1.2.1.1			X								
3.3.1.2.1.2.1.2			X								
3.3.1.2.1.2.2			X								
3.3.1.2.1.2.3			X								
3.3.1.2.1.2.4			X							X	
3.3.1.2.1.3			X								
3.3.1.2.1.3.1			X								
3.3.1.2.1.3.1.1	(Deleted)										
3.3.1.2.1.3.1.2	(Deleted)										
3.3.1.2.1.3.2			X								
3.3.1.2.1.3.2.1			X								
3.3.1.2.1.3.2.2	(Deleted)										
3.3.1.2.1.3.2.3	(Deleted)										
3.3.1.2.1.3.2.4	(Deleted)										
3.3.1.2.1.3.3			X								
3.3.1.2.1.3.4	(Deleted)										
3.3.1.2.1.3.5			X								
3.3.1.2.1.3.6			X								
3.3.1.2.1.3.7			X	X							
3.3.1.2.1.3.8			X								
3.3.1.2.1.3.9			X								
3.3.1.2.1.3.9.1			X								
3.3.1.2.1.3.10			X								
3.3.1.2.1.3.10.1			X								
3.3.1.2.1.3.10.2			X								
3.3.1.2.1.3.10.3			X								
3.3.1.2.1.3.10.4	(Deleted)										
3.3.1.2.1.3.11			X								

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX - Continued

SECTION 3.0 REQUIREMENT		MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.3.1.2.1.3.12											X
3.3.1.2.1.3.12.1			X								
3.3.1.2.1.3.12.2			X								
3.3.1.2.1.3.12.3			X								
3.3.1.2.1.3.12.4			X								
3.3.1.2.1.3.12.5			X								
3.3.1.2.1.3.13			X								
3.3.1.2.1.3.14											X
3.3.1.2.1.3.14.1			X								
3.3.1.2.1.3.14.2	(Deleted)										
3.3.1.2.1.3.14.3	(Deleted)										
3.3.1.2.1.3.15	(Deleted)										
3.3.1.2.1.3.15.1	(Deleted)										
3.3.1.2.1.3.15.2	(Deleted)										
3.3.1.2.1.3.16	(Deleted)										
3.3.1.2.1.3.16.1	(Deleted)										
3.3.1.2.1.3.16.2	(Deleted)										
3.3.1.2.1.3.16.3	(Deleted)										
3.3.1.2.1.3.16.4	(Deleted)										
3.3.1.2.1.3.17	(Deleted)										
3.3.1.2.1.4			X								
3.3.1.2.1.4.1			X								
3.3.1.2.1.4.2			X								
3.3.1.2.1.4.3	(Deleted)										
3.3.1.2.1.4.4			X								
3.3.1.2.1.4.5			X								
3.3.1.2.1.5			X							X	
3.3.1.2.1.6			X							X	
3.3.1.2.1.7			X								
3.3.1.2.1.8			X								
3.3.1.2.1.9			X								
3.3.1.2.2											X
3.3.1.2.2.1			X							X	

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX - Continued

SECTION 3.0 REQUIREMENT	MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.3.1.2.2.2		X								
3.3.1.2.2.2.1		X								
3.3.1.2.2.2.2		X								
3.3.1.2.2.2.3		X								
3.3.1.2.2.2.4		X								
3.3.1.2.2.3		X								
3.3.1.2.2.3.1		X								
3.3.1.2.2.3.2		X								
3.3.1.2.2.3.3		X								
3.3.1.2.3										X
3.3.1.2.3.1										X
3.3.1.2.3.1.1		X							X	
3.3.1.2.3.1.2		X							X	
3.3.1.2.3.1.3		X								
3.3.1.2.3.2		X	X						X	
3.3.1.2.3.2.1		X								
3.3.1.2.3.2.2		X								
3.3.1.2.3.3		X							X	
3.3.1.2.3.3.1		X								
3.3.1.2.3.3.2		X							X	
3.3.1.2.3.3.3		X							X	
3.3.1.2.3.3.4		X							X	
3.3.1.2.3.3.5		X								
3.3.1.2.3.4		X							X	
3.3.1.2.3.4.1		X							X	
3.3.1.2.3.5		X							X	
3.3.1.2.3.6		X							X	
3.3.1.2.3.7		X							X	
3.3.1.2.3.8		X							X	
3.3.1.2.3.9		X	X						X	
3.3.1.2.3.10		X	X						X	
3.3.1.2.3.11		X	X						X	
3.3.1.2.3.12		X	X							

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX - Continued

SECTION 3.0 REQUIREMENT	MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.3.1.2.4		X								
3.3.1.2.4.1										X
3.3.1.2.4.1.1		X								
3.3.1.2.4.1.2		X								
3.3.1.2.4.1.3		X								
3.3.1.2.4.1.4		X								
3.3.1.2.4.2		X	X							
3.3.1.2.4.3		X								
3.3.1.2.4.4		X								
3.3.1.2.4.4.1		X								
3.3.1.2.4.4.2		X								
3.3.1.2.4.4.3		X								
3.3.1.2.4.4.4		X	X							
3.3.1.2.4.5		X								
3.3.1.2.4.6		X	X							
3.3.1.2.4.7		X	X							
3.3.1.2.4.8		X								
3.3.1.2.4.9		X	X							
3.3.1.2.5										X
3.3.1.2.5.1		X							X	
3.3.1.2.5.1.1		X								
3.3.1.2.5.2		X								
3.3.1.2.5.2.1		X							X	
3.3.1.2.5.2.2		X							X	
3.3.1.2.5.3		X								
3.3.1.2.5.3.1		X								
3.3.1.2.6										X
3.3.1.2.6.1		X	X							
3.3.1.2.6.2		X								
3.3.1.2.6.3		X								
3.3.1.2.6.4 (Deleted)										
3.3.1.2.6.5		X								
3.3.1.2.7										X
3.3.1.2.7.1		X								
3.3.1.2.7.1.1		X								

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX - Continued

SECTION 3.0 REQUIREMENT		MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.3.1.2.7.2	(Deleted)										
3.3.1.2.7.3			X								
3.3.1.2.7.4			X								
3.3.1.2.7.5			X								
3.3.1.2.7.6			X								
3.3.1.2.7.7			X								
3.3.1.3											X
3.3.1.3.1			X			X					
3.3.1.3.1.1			X			X					
3.3.1.3.1.2											X
3.3.1.3.1.2.1			X			X				X	
3.3.1.3.1.2.2			X			X				X	
3.3.1.3.1.3			X			X					
3.3.1.3.2			X				X				
3.3.1.3.2.1			X				X			X	
3.3.1.3.2.2			X							X	
3.3.1.3.3			X								
3.3.1.3.3.1			X								
3.3.1.3.3.1.1			X								
3.3.1.3.3.2			X								
3.3.1.3.3.3											X
3.3.1.3.3.3.1			X								
3.3.1.3.3.3.1.1			X								
3.3.1.3.3.3.1.2			X								
3.3.1.3.3.3.2			X								
3.3.1.3.3.3.3											X
3.3.1.3.3.3.3.1			X								
3.3.1.3.3.3.3.2			X								
3.3.1.3.3.3.3.3			X								
3.3.1.3.3.3.3.4			X								
3.3.1.3.3.3.3.5			X								
3.3.1.3.3.3.3.6			X								
3.3.1.3.3.3.4			X								

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX - Continued

SECTION 3.0 REQUIREMENT		MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.3.1.3.3.4											X
3.3.1.3.3.4.1			X	X						X	
3.3.1.3.3.4.2			X							X	
3.3.1.3.3.4.3			X							X	
3.3.1.3.3.4.4			X	X						X	
3.3.1.3.3.4.5			X								
3.3.1.3.3.4.6			X							X	
3.3.1.3.3.4.7			X							X	
3.3.1.3.3.5											X
3.3.1.3.3.5.1			X							X	
3.3.1.3.3.5.2			X							X	
3.3.1.3.3.5.3											X
3.3.1.3.3.5.3.1			X								
3.3.1.3.3.5.3.2			X								
3.3.1.3.3.5.3.3			X								
3.3.1.3.3.5.3.4			X								
3.3.1.3.3.5.4			X								
3.3.1.3.3.5.5			X							X	
3.3.1.3.3.5.6			X								
3.3.1.3.3.6											X
3.3.1.3.3.6.1			X								
3.3.1.3.3.6.1.1			X								
3.3.1.3.3.6.1.2			X								
3.3.1.3.3.6.1.3	(Deleted)										
3.3.1.3.3.6.1.4			X								
3.3.1.3.3.6.1.5			X								
3.3.1.3.3.6.1.6			X								
3.3.1.3.3.6.2			X								
3.3.1.3.3.7			X								
3.3.1.3.3.8	(Deleted)										
3.3.1.3.3.9			X							X	
3.3.1.3.3.10			X							X	
3.3.1.3.3.11			X								

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX - Continued

SECTION 3.0 REQUIREMENT		MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.3.1.3.3.12			X								
3.3.1.3.3.13			X								
3.3.1.3.3.14	(Deleted)										
3.3.1.3.3.15	(Deleted)										
3.3.1.3.3.16			X								
3.3.1.3.3.17			X								
3.3.1.3.3.18			X								
3.3.1.3.3.19											X
3.3.1.3.3.19.1			X								
3.3.1.3.3.19.2			X								
3.3.1.3.3.19.3			X							X	
3.3.1.3.4			X							X	
3.3.1.3.5			X					X			
3.3.1.3.6	(Deleted)										
3.3.1.3.7			X								
3.3.1.3.8			X								
3.3.1.3.9			X								
3.3.1.3.10			X								
3.3.1.3.11			X								
3.3.1.3.12			X								
3.3.1.3.13	(Deleted)										
3.3.1.3.14			X								
3.3.1.3.15			X					X			
3.3.1.3.16			X								
3.3.2											X
3.3.2.1											X
3.3.2.1.1							X				
3.3.2.1.2							X			X	
3.3.2.1.2.1							X				
3.3.2.1.3											X
3.3.2.1.3.1							X				
3.3.2.1.3.2							X				

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX - Continued

SECTION 3.0 REQUIREMENT		MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.3.2.1.3.3	(Deleted)										
3.3.2.1.4							X				
3.3.2.2											X
3.3.2.2.1							X				
3.3.2.2.1.1							X				
3.3.2.2.1.2							X				
3.3.2.2.1.3							X				
3.3.2.2.1.4							X			X	
3.3.2.2.1.5	(Deleted)										
3.3.2.2.2							X			X	
3.3.2.2.3							X				
3.3.2.2.4							X				
3.3.2.2.5							X				
3.3.2.2.6	(Deleted)										
3.3.2.2.7	(Deleted)										
3.3.2.3											X
3.3.2.3.1			X				X				
3.3.2.3.2						X	X				
3.3.2.3.2.1						X	X			X	
3.3.2.3.3							X				
3.3.2.3.4							X				
3.3.2.3.5							X				
3.3.2.3.6							X				
3.3.2.3.7							X				
3.3.2.3.8							X			X	
3.3.2.3.9							X				
3.3.3											X
3.3.3.1											X
3.3.3.1.1											X
3.3.3.1.1.1						X					
3.3.3.1.1.2						X					
3.3.3.1.1.3						X					
3.3.3.1.1.4						X				X	

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX - Continued

SECTION 3.0 REQUIREMENT		MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.3.3.2											X
3.3.3.2.1						X				X	
3.3.3.2.1.1	(Deleted)										
3.3.3.2.1.2						X					
3.3.3.2.2						X					
3.3.3.2.3						X					
3.3.3.2.3.1						X					
3.3.3.2.3.2						X					
3.3.3.2.3.3						X					
3.3.3.2.4						X					
3.3.3.2.5						X					
3.3.3.2.6						X					
3.3.3.2.7	(Deleted)										
3.3.3.2.8						X				X	
3.3.3.2.8.1						X				X	
3.3.3.2.8.2						X				X	
3.3.3.2.8.3						X				X	
3.3.3.2.8.4										X	
3.3.3.2.8.5		X				X				X	
3.3.3.2.9	(Deleted)										
3.3.3.3											X
3.3.3.3.1						X					
3.3.3.3.2						X					
3.3.3.3.3						X					
3.3.3.3.4						X					
3.3.3.3.5						X					
3.3.3.3.6						X					
3.3.4					X						
3.3.4.1											X
3.3.4.1.1	(Deleted)										
3.3.4.1.2					X						
3.3.4.1.3					X						
3.3.4.1.4					X						
3.3.4.2											X

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX - Continued

SECTION 3.0 REQUIREMENT		MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.3.4.2.1					X						
3.3.4.2.2					X					X	
3.3.4.2.3					X						
3.3.4.2.4			X		X					X	
3.3.4.3											X
3.3.4.3.1					X						
3.3.5											X
3.3.5.1								X			
3.3.5.1.1			X					X			
3.3.5.1.1.1								X			
3.3.5.1.1.2								X			
3.3.5.1.1.3											X
3.3.5.1.2	(Deleted)										
3.3.5.2								X			
3.3.5.2.1	(Deleted)										
3.3.5.2.1.1	(Deleted)										
3.3.5.3											X
3.3.5.3.1	(Deleted)										
3.3.5.3.2	(Deleted)										
3.3.6											X
3.3.6.1			X								
3.3.6.2			X								
3.4											X
3.4.1											X
3.4.1.1									X	X	
3.4.1.2											X
3.4.1.2.1										X	
3.4.1.2.2									X		
3.4.1.2.3											X
3.4.1.2.4									X		
3.4.1.2.5									X		
3.4.1.2.6									X	X	
3.4.1.2.7											X

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX - Continued

SECTION 3.0 REQUIREMENT		MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.4.1.2.8			X	X							
3.4.1.2.9	(Deleted)										
3.4.1.2.10	(Deleted)										
3.4.1.2.11	(Deleted)										
3.4.1.2.12	(Deleted)										
3.4.1.2.13	(Deleted)										
3.4.1.2.14	(Deleted)										
3.4.1.3									X		
3.4.1.4									X	X	
3.4.1.5										X	
3.4.1.6									X	X	
3.4.2											X
3.4.2.1									X	X	
3.4.2.1.1	(Deleted)										
3.4.2.1.2	(Deleted)										
3.4.2.1.2.1	(Deleted)										
3.4.2.1.2.2	(Deleted)										
3.4.2.1.2.3	(Deleted)										
3.4.2.1.2.4	(Deleted)										
3.4.2.1.2.5	(Deleted)										
3.4.2.1.2.6	(Deleted)										
3.4.2.1.2.7	(Deleted)										
3.4.2.1.2.8	(Deleted)										
3.4.2.1.2.9	(Deleted)										
3.4.2.1.2.10	(Deleted)										
3.4.2.1.2.11	(Deleted)										
3.4.2.1.3	(Deleted)										
3.4.2.2											X
3.4.2.2.1											X
3.4.2.2.2									X		
3.4.2.2.3											X
3.4.2.2.4									X		
3.4.2.2.5									X		

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX - Continued

SECTION 3.0 REQUIREMENT		MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.4.2.2.6									X	X	
3.4.2.2.7											X
3.4.2.2.8			X	X					X	X	
3.4.2.2.9	(Deleted)										
3.4.2.2.10	(Deleted)										
3.4.2.3									X		
3.4.2.3.1	(Deleted)										
3.4.2.3.2	(Deleted)										
3.4.2.3.3	(Deleted)										
3.4.2.3.4	(Deleted)										
3.4.2.3.5	(Deleted)										
3.4.2.3.6	(Deleted)										
3.4.2.3.7	(Deleted)										
3.4.2.3.8	(Deleted)										
3.4.2.4										X	
3.4.2.5									X	X	
3.4.3											X
3.4.3.1											X
3.4.3.1.1									X	X	
3.4.3.1.2											X
3.4.3.1.2.1											X
3.4.3.1.2.2									X		
3.4.3.1.2.3									X		
3.4.3.1.2.4									X	X	
3.4.3.1.2.5											X
3.4.3.1.2.6			X						X	X	
3.4.3.1.3									X		
3.4.3.1.4									X	X	
3.4.3.1.5										X	
3.4.3.2											X
3.4.3.2.1									X		
3.4.3.2.2											X
3.4.3.2.2.1											X

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX - Continued

SECTION 3.0 REQUIREMENT		MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.4.3.2.2.2									X		
3.4.3.2.2.3									X		
3.4.3.2.2.4									X	X	
3.4.3.2.2.5											X
3.4.3.2.2.6			X						X	X	
3.4.3.2.3									X		
3.4.3.2.4	(Deleted)										
3.4.3.2.5	(Deleted)										
3.4.3.3											X
3.4.3.3.1											X
3.4.3.3.2											X
3.4.3.3.2.1											X
3.4.3.3.2.2											X
3.4.3.3.3									X		
3.4.4											X
3.4.4.1									X	X	
3.4.4.2											X
3.4.4.2.1									X	X	
3.4.4.2.2									X		
3.4.4.2.3									X		
3.4.4.3			X						X		
3.4.5											X
3.4.5.1									X		
3.4.5.2											X
3.4.5.2.1									X	X	
3.4.5.2.2									X		
3.4.5.2.3									X		
3.4.5.2.4			X				X		X		
3.4.5.2.5									X		
3.4.6											X
3.4.6.1									X	X	
3.4.6.2											X
3.4.6.2.1									X	X	

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX - Continued

SECTION 3.0 REQUIREMENT		MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.4.6.2.2									X	X	
3.4.6.2.3									X		
3.4.6.2.4									X		
3.4.6.2.5									X		
3.4.6.2.6									X		
3.4.6.2.7									X	X	
3.4.6.2.8									X	X	
3.4.6.2.9	(Deleted)										
3.4.6.2.10									X	X	
3.4.6.2.11									X		
3.4.6.2.12			X						X		
3.4.6.2.13	(Deleted)										
3.4.6.2.14											X
3.4.6.2.14.1									X		
3.4.6.2.14.2									X		
3.4.6.2.15			X						X	X	
3.4.6.2.15.1									X		
3.4.6.2.16			X						X	X	
3.4.6.2.17									X		
3.4.6.2.17.1									X		
3.4.6.2.18									X		
3.4.6.2.19									X		
3.4.6.2.20									X		
3.4.6.2.21									X		
3.4.6.3									X		
3.4.7											X
3.4.7.1									X		
3.4.7.2											X
3.4.7.2.1									X		
3.4.7.2.2									X		
3.4.7.2.3									X		
3.4.7.2.4									X		
3.4.7.3									X		

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX - Continued

SECTION 3.0 REQUIREMENT		MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.4.8											X
3.4.8.1									X		
3.4.8.2											X
3.4.8.2.1									X		
3.4.8.2.2									X		
3.4.8.2.3									X		
3.4.8.2.4									X		
3.4.8.2.5									X		
3.4.8.3									X		
3.4.9											X
3.4.9.1									X		
3.4.9.2									X		
3.4.9.3							X		X		
3.4.10											X
3.4.10.1							X				
3.4.10.2							X				
3.4.10.3							X				
3.4.11											X
3.4.11.1											X
3.4.11.1.1									X		
3.4.11.1.2									X		
3.4.11.1.3							X				
3.4.11.2											X
3.4.11.2.1									X		
3.4.11.2.2									X		
3.4.11.3									X		
3.4.12											X
3.4.12.1									X		
3.4.12.2									X		
3.4.12.3									X		
3.4.13	(Deleted)										
3.4.13.1	(Deleted)										
3.4.13.2	(Deleted)										

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX - Continued

SECTION 3.0 REQUIREMENT		MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.4.13.3	(Deleted)										
3.4.14											X
3.4.14.1									X		
3.4.14.2									X		
3.4.14.3									X		
3.4.15											X
3.4.15.1									X		
3.4.15.2									X		
3.4.15.3									X		
3.4.16											X
3.4.16.1									X	X	
3.4.16.2											X
3.4.16.2.1									X		
3.4.16.2.2									X		
3.4.16.2.3									X		
3.4.16.2.4	(Deleted)										
3.4.16.2.5									X	X	
3.4.16.2.6									X		
3.4.16.2.7									X		
3.4.16.2.8									X		
3.4.16.2.9									X		
3.4.16.2.10									X		
3.4.16.2.11	(Deleted)										
3.4.16.2.12	(Deleted)										
3.4.16.2.13									X	X	
3.4.16.2.14									X		
3.4.16.3									X		
3.4.17											X
3.4.17.1							X				
3.4.17.2											X
3.4.17.2.1							X				
3.4.17.2.2							X				
3.4.17.2.3							X				

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX - Continued

SECTION 3.0 REQUIREMENT		MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.4.17.2.4							X				
3.4.17.3							X				
3.4.18											X
3.4.18.1											X
3.4.18.2											X
3.4.18.2.1									X		
3.4.18.3			X					X	X		
3.4.19											X
3.4.19.1									X		
3.4.19.2											X
3.4.19.2.1									X		
3.4.19.2.1.1									X		
3.4.19.2.2									X		
3.4.19.2.2.1									X		
3.4.19.2.3									X		
3.4.19.2.4									X		
3.4.20											X
3.4.20.1							X			X	
3.4.20.2											X
3.4.20.2.1							X				
3.4.20.2.2							X				
3.4.20.2.3							X				
3.4.20.2.4							X				
3.4.20.3	(Deleted)										
3.4.21											X
3.4.21.1						X				X	
3.4.21.2											X
3.4.21.2.1						X					
3.4.21.2.2						X					
3.4.21.2.3						X					
3.4.21.2.4	(Deleted)										
3.4.22											X
3.4.22.1									X		

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX - Continued

SECTION 3.0 REQUIREMENT		MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.4.2.2.2											X
3.4.22.2.1									X		
3.4.22.2.1.1									X		
3.4.22.2.1.2									X		
3.4.22.2.1.3									X		
3.4.22.2.1.4									X		
3.4.22.2.2	(Deleted)										
3.4.22.2.2.1	(Deleted)										
3.4.22.2.2.2	(Deleted)										
3.4.22.2.2.3	(Deleted)										
3.4.22.3	(Deleted)										
3.4.22.4	(Deleted)										
3.4.23											X
3.4.23.1									X		
3.4.23.2											X
3.4.23.2.1									X		
3.4.23.2.2									X		
3.4.23.3									X		
3.4.23.4									X		
3.4.24											X
3.4.24.1									X		
3.4.24.2											X
3.4.24.2.1									X		
3.4.24.2.2									X		
3.4.24.2.3									X		
3.5											X
3.5.1			X		X	X	X		X	X	
3.5.1.1											X
3.5.1.1.1			X	X	X	X	X				
3.5.1.1.1.1			X		X	X	X				
3.5.1.1.1.2	(Deleted)										
3.5.1.1.2			X	X	X	X	X			X	
3.5.1.1.3			X		X	X	X				

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX - Continued

SECTION 3.0 REQUIREMENT		MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.5.1.1.4			X		X	X	X				
3.5.1.1.5			X		X	X	X			X	
3.5.1.1.6			X			X	X			X	
3.5.1.2											X
3.5.1.2.1	(Deleted)										
3.5.1.2.1.1			X		X		X		X		
3.5.1.2.2			X		X		X		X		
3.5.1.2.3			X		X		X		X		
3.5.1.2.4			X		X		X		X		
3.5.2											X
3.5.2.1			X		X	X	X				
3.5.2.2.1						X	X			X	
3.5.2.2.2			X			X				X	
3.5.2.2.3			X		X	X	X			X	
3.5.2.2.4			X		X	X	X				
3.5.2.2.5	(Deleted)										
3.5.2.3									X		
3.5.2.3.1									X		
3.5.2.3.2									X		
3.5.2.3.3									X		
3.5.2.3.4									X		
3.5.3											X
3.5.3.1			X		X		X		X		
3.5.3.1.1			X								
3.5.3.1.2						X					
3.5.3.1.3							X				
3.5.3.1.4								X			
3.5.3.1.5					X						
3.5.3.2			X	X	X	X	X				
3.5.3.2.1			X	X	X	X	X				
3.5.3.2.1.1			X	X	X	X	X				
3.5.3.2.1.2			X	X	X	X	X				
3.5.3.2.1.3			X	X	X	X	X				

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX - Continued

SECTION 3.0 REQUIREMENT		MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.5.3.2.2											X
3.5.4			X	X	X	X	X		X	X	
3.5.4.1											X
3.5.4.1.1			X		X	X	X				
3.5.4.1.2			X		X	X				X	
3.5.4.1.3	(Deleted)										
3.5.4.1.4			X	X	X	X	X				
3.5.4.1.5			X		X	X	X				
3.5.4.1.6											X
3.5.4.1.6.1			X		X	X	X			X	
3.5.4.1.6.2	(Deleted)										
3.5.4.1.7			X		X	X					
3.5.4.1.8			X		X	X	X				
3.5.4.1.9			X		X	X	X				
3.5.4.1.10			X			X	X				
3.5.4.1.11			X		X	X	X				
3.5.4.1.12			X				X				
3.5.4.1.13			X		X	X	X			X	
3.5.4.1.14			X		X	X					
3.5.4.1.15			X								
3.5.4.2											X
3.5.4.2.1					X				X		
3.5.4.2.2			X		X		X		X		
3.5.4.2.3			X						X	X	
3.5.4.2.4									X		
3.5.4.2.4.1									X		
3.5.4.2.5									X		
3.5.4.2.6			X						X		
3.5.4.2.7									X		
3.5.4.2.8					X				X		
3.5.4.2.9											X
3.5.5											X
3.5.5.1	(Deleted)										
3.5.5.2			X	X							

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX – Continued

SECTION 3.0 REQUIREMENT	MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.5.5.3		X	X		X	X		X		
3.5.6		X	X	X	X	X				
3.5.6.1		X	X	X	X	X				
3.5.7		X	X		X	X		X		
3.6										X
3.6.1		X		X	X	X		X		
3.6.1.1		X		X	X	X		X		
3.6.1.1.1		X				X				
3.6.1.1.2		X			X					
3.6.2										X
3.6.2.1		X		X	X	X		X		
3.6.3		X		X	X	X		X		
3.6.3.1		X			X	X		X		
3.6.4		X		X	X	X		X		
3.6.5										X
3.6.5.1										X
3.6.5.1.1		X		X	X	X				
3.6.5.1.2		X		X	X	X				
3.6.5.2										X
3.6.5.2.1						X		X		
3.6.6		X		X	X	X		X		
3.6.6.1		X		X	X	X			X	
3.6.6.2		X		X	X	X				
3.6.7		X		X	X	X		X	X	
3.6.8		X		X	X	X		X		
3.6.8.1 (Deleted)										
3.6.8.2		X		X	X	X		X		
3.6.8.3		X		X	X	X				
3.6.9		X		X	X	X				
3.6.10		X		X	X	X		X		
3.6.11		X			X	X				
3.6.12										X
3.6.12.1		X		X	X	X		X		

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX – Continued

SECTION 3.0 REQUIREMENT	MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.6.12.1.1										X
3.6.12.1.1.1		X		X	X	X		X		
3.6.12.1.1.1.1										X
3.6.12.1.1.1.1.1		X		X	X	X		X		
3.6.12.1.1.1.2										X
3.6.12.1.1.1.2.1		X		X	X	X		X		
3.6.12.1.1.1.3		X		X	X	X		X		
3.6.12.1.1.1.4		X		X	X	X		X		
3.6.12.1.1.2										X
3.6.12.1.1.2.1										X
3.6.12.1.1.2.1.1		X		X	X	X				
3.6.12.1.1.2.1.2		X		X	X	X		X		
3.6.12.1.1.2.2										X
3.6.12.1.1.2.2.1		X		X	X	X		X		
3.6.12.1.1.2.3										X
3.6.12.1.1.2.3.1		X		X	X	X				
3.6.12.1.1.2.3.2		X		X	X	X		X		
3.6.12.1.1.2.4		X		X		X		X		
3.6.12.1.1.3										X
3.6.12.1.1.3.1		X		X	X	X		X		
3.6.12.1.1.4		X		X	X	X		X		
3.6.12.1.1.5		X		X	X	X		X		
3.6.12.1.1.6		X		X	X	X		X		
3.6.12.2		X			X					
3.6.12.2.1		X		X	X	X				
3.6.12.2.2		X								
3.6.12.2.3										X
3.6.12.2.4										X
3.6.12.2.4.1		X						X		
3.6.12.2.4.2		X						X		
3.6.12.2.4.3		X						X		
3.6.12.2.4.4		X						X		
3.6.12.2.4.5										X

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX – Continued

SECTION 3.0 REQUIREMENT	MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.6.12.2.4.5.1		X								
3.6.12.2.4.5.2										X
3.6.12.2.4.6		X								
3.6.12.2.4.7		X								
3.6.12.2.4.8										X
3.6.12.2.4.8.1		X						X		
3.6.12.2.4.8.2										X
3.6.12.2.4.8.3										X
3.6.13		X		X		X		X		
3.6.13.1		X		X		X				
3.6.13.2		X		X		X				
3.6.14		X		X	X	X		X		
3.6.15										X
3.6.15.1										X
3.6.15.1.1		X		X	X	X		X		
3.6.15.1.2		X		X	X	X		X		
3.6.15.1.3		X		X	X	X		X		
3.6.15.2										X
3.6.15.2.1		X		X	X	X				
3.6.15.2.2		X		X	X	X		X		
3.6.15.3		X		X	X	X		X		
3.6.16										X
3.6.16.1								X		
3.6.16.2		X		X		X	X	X		
3.6.16.3								X		
3.6.16.4								X		
3.6.16.5								X		
3.6.17										X
3.6.17.1		X		X	X	X				
3.6.17.2		X		X	X	X				
3.6.17.3		X		X	X	X				
3.6.18		X		X	X	X	X	X		
3.6.19										X

TABLE 4.1

VERIFICATION RESPONSIBILITY MATRIX – Concluded

SECTION 3.0 REQUIREMENT	MOD	ORB	EVA & CREW EQUIP	SSME	ET	SRB	SCA	L&LS	COMBINED ELEMENTS	N/A
3.6.19.1		X	X	X	X	X		X		
3.6.19.2		X	X	X	X	X		X		
3.6.20		X				X		X	X	
3.6.21		X		X	X	X		X	X	
3.6.22								X		
3.6.23		X				X		X	X	
3.6.24		X		X	X	X		X		
3.6.24.1		X		X	X	X				
3.6.24.2		X		X	X	X		X		
3.6.25										X
3.6.25.1		X		X		X	X	X		
3.6.25.2		X		X		X	X	X		
3.6.25.3		X		X		X	X	X		
3.6.25.3.1		X		X		X	X	X		
3.7		X		X		X		X		
3.7.1		X		X		X		X		
3.7.2		X		X		X		X		
3.7.3		X		X		X		X		
3.7.4		X		X	X	X		X		

5.0 PREPARATION FOR DELIVERY

5.1 GENERAL

The requirements specified herein shall govern the preparation for shipment and the transport of Shuttle System elements to all contractor and government facilities or test sites.

5.2 PACKAGING, HANDLING AND TRANSPORT

Packaging, handling and transportation for Shuttle System elements shall be in general accordance with NHB 6000.1(1A), Requirements for Packaging, Handling and Transportation for Aeronautical and Space Systems Equipment and Associated Components, or as amended by the following subparagraphs. Procedures for packaging and packing of parts and equipment shall be in accordance with MIL-STD-794B, Parts and Equipment, Procedure for Packaging and Packing of.

5.2.1 Reusable Containers

Where analysis indicates desirability of using reusable containers, maximum practical utilization shall be made of standard off-the-shelf, low cost metal or plastic containers.

5.2.2 Monitoring Devices

Humidity indicators shall be utilized for all Method II (dessicant) packs. The indicators shall be MS20003 indicator cards except that MIL-I-26860B, Indicator, Humidity, Plug, Color Change, humidity indicators shall be utilized for all gasketed Method II packs. Use of indicator cards procured to MIL-I-8835, Indicator, Humidity, Card, Chemically Impregnated, and designed to specifications other than MS20003 is allowed. Other instrumentation for monitoring or recording intransit environments (e.g., shock, vibration, temperature, etc.) shall be utilized as required by specific element specifications.

5.2.3 Packaging Data

Packaging data shall be provided in accordance with data submittal requirements of the contract.

5.2.4 Packaging of Precision Clean Items

Items cleaned to precision cleanliness levels shall be protected in accordance with SN-C-0005, to assure maintenance of specified cleanliness levels.

5.2.5 Packaging and Shipment of Hazardous Materials

All hazardous material packaging shall comply, as applicable with NHB 6000.1(1A).

5.2.6 Marking for Shipment

Interior and exterior containers shall be marked and labeled in accordance with MIL-STD-129E, or FED-STD-123E, including precautionary markings necessary to ensure safety of personnel and facilities, and to ensure safe handling, transport, and storage. For hazardous materials, markings shall also comply with the requirements of applicable freight tariffs, requirements of the Department of Transportation, Atomic Energy Commission, and Code of Federal Regulations.

5.3 PACKAGING AND SHIPMENT OF PYROTECHNICS

The packaging and shipment of pyrotechnics shall conform to the provisions of NSTS 08060.

6.0 NOTES

6.1 DEFINITIONS

6.1.1 Standby Status

“Standby Status” is defined as ready for launch except main propellant fill, crew ingress and final systems verification. Final systems verification includes SSME Software Checkout.

Reference Paragraph 3.3.3.2.2

6.1.2 Fail Safe

6.1.2.1 Flight Vehicle

Fail safe for the flight vehicle is defined as the ability to sustain a failure and retain the capability to successfully terminate the mission.

Reference Paragraph 3.5.1.1.1

6.1.2.2 Ground Support Equipment

6.1.2.2.1 Loss of Vehicle Systems

Loss of the capability to provide the level of system performance required for normal or emergency operations.

Reference Paragraph 3.5.1.2.1.1

6.1.2.2.2 Loss of Personnel Capability

Loss of personnel function resulting in the inability to perform normal or emergency operations. Also includes loss of capability to prevent injury to the public.

Reference Paragraph 3.5.1.2.1.1

6.1.3 Fail Operational

6.1.3.1 Flight Vehicle

Fail operational for the flight vehicle is defined as the ability to sustain a failure and retain full operational capability for safe mission continuation.

Reference Paragraph 3.5.1.1.1

6.1.4 Critical Function

A critical function is defined as a function which, if lost, would cause loss of personnel or the flight vehicle.

Reference Paragraphs 3.5.1.1.3, 3.5.1.1.5, 3.5.1.2.4

6.1.5 Hazard

A hazard is defined as the presence of a potential risk situation caused by an unsafe act or condition.

Reference Paragraph 3.5.4.1.1

6.1.6 Crossrange

Crossrange is the shortest distance that can be measured from a landing site to the groundtrack produced by an extension of the Shuttle's entry interface orbit.

Reference Paragraphs 3.2.1.1.14, 3.2.2.1, 3.3.1.1.5

6.1.7 Line Replaceable Unit (LRU)

An item whose replacement constitutes the optimum organizational maintenance repair action for a higher indenture item.

Reference Paragraph 3.4.15.1

6.1.8 Reusable Solid Rocket Motor (RSRM)

A segmented motor case with insulation, liner, inhibitor, and propellant; one nozzle assembly complete with flexseal assembly, actuator attach points and jettisonable cone including separation device; ignition system (igniter, initiators, safe and arm device); systems tunnel base and cover attach provisions; aft ET attach ring buildup; RSRM/SRB forward/aft skirt attach provisions; instrumentation and electrical brackets.

6.1.9 Solid Rocket Booster (SRB)

One complete RSRM (see Paragraph 6.1.8) plus structure including forward attach, aft attach ring and struts to SRB-ET interface, recovery, thrust vector control, electrical and instrumentation, and separation subsystems.

6.1.10 Shuttle Vehicle Booster (SVB)

The SVB shall consist of two SRBs (see Paragraph 6.1.9) which are a part of the flight vehicle.

Reference Paragraphs 3.1.1.1, 3.3.1.2.5.1

6.1.11 SRB Recovery

The SRB activity from SRB separation through water impact.

Reference Paragraphs 1.3.1.1, 3.5.3.1.3

6.1.12 SRB Retrieval

The SRB activity from water impact through return to KSC.

Reference Paragraphs 1.3.1.1, 1.3.1.3, 3.3.2.2.1.1, 3.4.9.1, 3.4.9.2, 3.5.3.1.3

6.1.13 Interchangeability

An item which:

a. Possesses such functional and physical characteristics as to be equivalent in performance, reliability, and maintainability to another item of similar or identical purpose

b. Capable of being exchanged for the other item

   1. Without selection for fit or performance

   2. Without alteration of the items themselves or of adjoining items, except for adjustments

Reference Paragraph 3.6.6.1

6.1.14 Replaceability

An item which is interchangeable with another item, but which differs physically from the original item in that the installation of the replacement item requires operations such as drilling, reaming, cutting, filing, shimming, etc., in addition to the normal application and methods of attachment, is defined as being replaceable.

Reference Paragraph 3.6.6.2

6.1.15 Operational Status

The condition of a functional path with regard to its capability to perform its intended function.

Reference Paragraph 3.5.1.1.2

6.1.16 Functional Path

A functional path is a serial set of one or more functional elements (e.g., LRUs) constrained by the following:

a. It is either the only path capable of performing the given function, or it is the smallest set (shortest string) of serial elements for which identical or similar

serial elements can be substituted by automatic or manual control (onboard or via GSE) to perform the same function via a redundant path for fail safe or fail operational capability.

b. The string may contain noncontrollable redundancies within itself to assure a satisfactory mean time between failures for the string (e.g., redundant components within a LRU), but must not contain redundancies needed to provide fail operational or fail safe capabilities.

c. Any point along a path which supports several “downstream” paths must constitute the termination point of the “upstream” functional path and the starting point of “downstream” functional paths.

Reference Paragraph 3.5.1.1.2

6.1.17 Retargeting

Retargeting is the process whereby the computer programs residing in memory of the Orbiter data processing systems are changed and/or the mission dependent software parameters (reference Paragraph 6.1.19, Erasable Load) are updated, verified (reference Paragraph 6.1.20, Verification), loaded into memory, and the load verified.

6.1.18 Dissimilar Mission

A dissimilar mission is a mission different than the one which is currently planned and for which the flight computers have been targeted. The retargeting is for a mission that has been previously planned and for which the computer programs and the mission dependent software parameters have been coded and verified and are available on an appropriate storage medium.

6.1.19 Erasable Load

The mission dependent software parameters are those quantities which form the “erasable” load and which allow the non-programmable portion of the flight program to accommodate a range of similar missions. Updating of the mission dependent software parameters (erasable load) is the process of changing the values of the parameters which specify the particulars of a mission to the non-programmable portion of the computer program.

Reference Paragraph 6.1.17

6.1.20 Verification

Verification of the mission dependent software parameters is the process whereby these software parameters are shown to satisfy the mission objectives compatible with

the mission safety/success requirements. Verification of the flight computer load is the process of confirming that flight programs and/or mission dependent software loaded into the computers are identical with those generated and that they reside in the proper memory locations.

Reference Paragraph 6.1.17

6.1.21 Commonality

Commonality is the shared usage of technical or programmatic items among Shuttle System elements. Element requirements may permit common usage either in identical or similar configurations.

Reference Paragraph 6.1.17

6.1.22 First Stage Flight

The flight phase from lift-off until SRB staging is complete.

6.1.23 Second Stage Flight

The flight phase from completion of SRB staging until ET staging is complete.

6.1.24 Third Stage Flight

The flight phase from completion of ET staging until completion of the OMS insertion burn.

6.1.25 Off-the-shelf Hardware

Off-the-shelf hardware is production or existing design hardware (black box, component) used in or for NASA, military, and/or commercial programs.

Reference Paragraphs 3.3.2.2.5, 3.6.15.1.1

6.1.26 Facilities

Facilities include the land, buildings enclosing usable space, structures having the basic function of a research or operational activity, and other real property improvements as defined in NHB 7320.1.

Reference Paragraphs 3.5.4.2.1, 3.5.1.2

6.1.27 Non-flight Equipment

Non-flight equipment is that equipment used to aid in the processing, maintaining, testing, repairing, etc., of the flight vehicle and all its systems. Non-flight equipment is

comprised of GSE, commercial tools, special test equipment, special test devices, and element tools.

Reference Paragraphs 3.5.4.2.1, 3.6.16.

NOTE: Include reference by new paragraph numbers to the following four paragraphs.

6.1.28 Ground Support Equipment (GSE)

GSE is non-flight equipment with a physical and/or functional interface with the flight hardware that is routinely required for the handling, servicing, inspection, testing, maintenance, alignment, adjustment checkout, repair, and overhaul of flight hardware, and whose design and certification has been in accordance with NSTS 07700, Volume IV.

Reference Paragraphs 3.5.4.2.1, 3.5.1.2

6.1.29 Special Test Equipment/Devices (STE/D)

STE/D are similar to GSE but have not had design and certification reviews in accordance with NSTS 07700, Volume IV.

Reference Paragraphs 3.5.4.2.1, 3.5.1.2, 3.6.23

6.1.30 Commercial Equipment

Commercial equipment (i.e., tools, components, etc.) is commercially available instruments or devices that may or may not interface with flight hardware and are necessary for its normal processing for flight.

Reference Paragraphs 3.5.4.2.1, 3.6.23, 3.5.1.2

6.1.31 Element Tools

Element tools, including shop aids, are uniquely designed devices used to process flight hardware and have no mechanical, electrical, or fluid interaction between the ground equipment and flight systems which could cause risk or damage to the flight hardware or GSE.

Reference Paragraphs 3.5.4.2.1, 3.5.1.2

6.1.32 Demonstrated Safe Life Limit

The maximum operational life of an applicable configuration without failure or the operational life of the lowest failed part.

Reference Paragraph 3.2.2.1.9

6.1.33 Single Flight Reliability

A statistical method utilizing the Weibull function to establish a lower bound on allowable life consistent with a demonstrated reliability statement (e.g., 0.995 reliability/0.90 confidence) for which the last mission is ensured. The mission life shall account for the probability of an abort occurrence.

$$\text{Reliability} = \frac{\exp\left[-\left(\frac{T}{n}\right)^{\beta}\right]}{\exp\left[-\left(\frac{T-T_m}{n}\right)^{\beta}\right]}$$

where: T = life limit
T_m = last mission duration
β = shape parameter at which life limit T is a minimum

and, the estimate of characteristic life,n, is:

$$n = \left[\sum_{i=1}^{n} T_i^{\beta/r}\right]^{\frac{1}{\beta}}$$

where: n = number of suspensions or unfailed units
T_i = operating times
r = $-\ln(\alpha)$
α = 1–confidence level, c

Reference Paragraph 3.2.2.1.9

6.1.34 Design-life

Design-life is a hardware certification requirement established by specification and expressed in terms of a specific number of flights, operating cycles, or period of time (i.e., hours or calendar time). The design-life of a hardware item/system is demonstrated by test and/or analysis, usually prior to its acceptance and delivery.

Reference Paragraph 3.5.3.1, 3.5.3.2.1, 3.5.3.2.2

6.1.35 Useful-life

Useful-life is the inherent operating capability of a given hardware item/system, expressed as a specific number of flights, operational cycles, or period of time (i.e.,

hours or calendar time) during which the hardware item/subsystem can be operated while continuing to meet its prescribed performance and/or margin of safety requirements. The useful-life of a hardware item/system is expected to be equal to or greater than its design-life.

Reference Paragraph 3.5.3.1, 3.5.3.2.1, 3.5.3.2.1.2

6.1.36 Life Extension

Life extension is a planned and approved ongoing process to determine if the projected life of a hardware item/subsystem can be extended for a specific number of flights, operational cycles, or period of time (i.e., hours or calendar time) while assuring that the hardware item/system will continue to meet its prescribed performance and margin of safety requirements. In addition to the certification approaches prescribed in MVP-01, life extension certification may include data from periodic maintenance and checkout, routine and/or special inspection and refurbishment programs, maintenance sampling, fleet leader, failure analysis/trending, etc.

Reference Paragraphs 3.5.3.1, 3.5.3.1.3, 3.5.3.2, 3.5.3.2.1.1, 3.5.3.2.1.2

6.1.37 Design Control Parameter (Weight, Specific Impulse, Thrust, . . .)

A project's Design Control Parameter(s) is (are) established by the Manager, Space Shuttle Program as the maximum or minimum allowable value that project management must design to in order to satisfy program ascent performance requirements. Some examples of design control parameters are maximum design control weight, minimum RSRM propellant, minimum useable MPS LOX and LH_2 quantities, and minimum SSME initial specific impulse and thrust. The maximum design control weight for Orbiter, ET, SRB, RSRM, and SSME is a combination of the nominal design control weight plus manufacturing variations. For RSRM propellant, the control parameter is minimum design control weight (nominal design control weight minus manufacturing variations). Performance reporting will be based on the nominal design control weight for Orbiter, ET, SSME, and SRB elements. The delivered value of the parameter being controlled must be either less than, greater than, or equal to the design control value as appropriate to maximize vehicle ascent performance.

Reference Paragraphs 3.1.3.1.2, 3.1.3.1.2.1, 3.1.3.1.2.2.1, 3.1.3.1.2.2.3, 3.1.3.1.2.3.1, 3.1.3.1.2.3.2, 3.1.3.1.2.3.3, 3.1.3.1.2.4.1, 3.1.3.1.2.4.2, 3.1.3.1.2.4.3, 3.1.3.1.2.5, 3.1.3.1.2.6.1, 3.1.3.1.2.6.2, 3.1.3.1.2.7.1, 3.1.3.1.2.7.2, 3.1.3.1.2.1.5, 3.3.3.1.1.2, 3.3.3.4.2.1.

6.1.38 Critical Initial Flaw Size

The largest flaw that, if present, would grow to failure in four times the number of mission cycles expected in service (see Paragraph 3.2.2.1.9d).

6.2 (DELETED)

6.2.1 (Deleted)

6.2.2 (Deleted)

6.2.3 (Deleted)

6.2.4 (Deleted)

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APPENDIX A

ACRONYMS AND ABBREVIATIONS

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APPENDIX A

ACRONYMS AND ABBREVIATIONS

A/G	Air to Ground
A/A	Air-to-Air
AADS	Ascent Air Data System
AELS	Augmented Emergency Landing Site
AFD	Aft Flight Deck
AFSCF	Air Force Satellite Control Facility
ANSI	American National Standards Institute
AOA	Abort-once-around
	Angle of Attack
APILS	Aim Point Identification Light System
APS	Aft Propulsion System
APU	Auxiliary Power Unit
ARD	Abort Region Determinator
ASI	Aerodynamic Sensitive Item
ATC	Air Traffic Control
ATCS	Active Thermal Control Subsystem
ATO	Abort-to-Orbit
ATP	Authority to Proceed
ATVC	Ascent Thrust Vector Control
BER	Bit Error Rate
BFS	Backup Flight System
BSM	Booster Separation Motor
C&TSS	Communications and Tracking Subsystem
CCAFS	Cape Canaveral Air Force Station
CCTV	Closed Circuit Television
CEI	Configuration End Item
	Contract End Item
CFM	Cubic Feet per Minute
CG	Center of Gravity
COMSEC	Communications Security
CONUS	Continental United States
CR	Change Request
D&C	Display and Controls
dB	Decibel
DFRC	Orbiter Vehicle Interface with Communications and Tracking Functions
DME	Distance Measuring Equipment
DOD	Department of Defense

DPS	Data Processing and Software
DV	Designated Verification
E	Exempt from Traceability
EAFB	Edwards Air Force Base
ECLSS	Environmental Control and Life Support Subsystem
EDM	Electronic Discharge Machine
EDO	Extended Duration Orbiter
EEE	Electronic, Electrical, Electromechanical
EI	Entry Interface
EIRP	Effective Isotropic Radiated Power
ELS	Emergency Landing Site
EMU	Extravehicular Mobility Unit
EOM	End of Mission
EPD&C	Electrical Power Distribution and Control
EPS	Electrical Power Subsystem
ESD	Electrostatic Discharge
ESDS	Electrostatic Discharge Sensitive
ESMC	Eastern Space and Missile Center
ET	External Tank
ETR	Eastern Test Range
EVA	Extravehicular Activity
ft/sec	feet per second
FCOS	Flight Computer Operating System
FCS	Flight Control System
FDIR	Fault Detection Isolation and Recovery
FFD	Functional Flow Diagram
FRD	Flight Requirements Document
FRF	Flight Readiness Firing
FSS	Fire Suppression System
GFE	Government Furnished Equipment
GHz	Gigahertz
GH_2	Gaseous Hydrogen
GMT	Greenwich Mean Time
GN_2	Gaseous Nitrogen
GN&C	Guidance, Navigation and Control
GSE	Ground Support Equipment
Gt	Antenna Gain
H_2	Hydrogen
He	Helium

HEPA	High Efficiency Particle Air
HMF	Hypergol Maintenance Facility
HPFTP/AT	High Pressure Fuel Turbopump/Alternate Turbopump
HPOTP	High-pressure Oxidizer Turbopump
HPU	Hydraulic Power Unit
Hz	Hertz (cycles per second)
ICD	Interface Control Document
IMU	Inertial Measurement Unit
ISS	International Space Station
ISSA	International Space Station Alpha
IVA	Intravehicular Activity
kHz	Kilohertz
kVa	Kilovoltampere
lb	pound
lbf	Pounds Force
LCC	Launch Control Center
LH_2	Liquid Hydrogen
LO_2	Liquid Oxygen
LOX	Liquid Oxygen
LPS	Launch Processing System
LRU	Line Replaceable Unit
LWT	Lightweight Tank
MCC	Mission Control Center
MECO	Main Engine Cutoff
MFVA	
MHz	Megahertz (megacycles per second)
MILA	Merritt Island Launch Area
MLP	Mobile Launch Platform
	Mobile Launcher Platform
MMU	Manned Maneuvering Unit
MOP	Maximum Operating Pressure
MOV	Main Oxidizer Valve
MOVA	
MPL	Minimum Power Level
MPS	Main Propulsion Subsystem
MSBLS	Microwave Scanning Beam Landing System
MSL	Mean Sea Level
N_2	Nitrogen
NDI	Nondestructive Inspection

NPC	Non-propulsive Consumables
NPL	Nominal Power Level
NRZ	Non-return-to Zero
NSI	NASA Standard Initiator
O_2	
OAA	Orbiter Access Arm
ODS	Orbiter Docking System
OIS	Operational Intercom System
OMRS	Operations and Maintenance Requirements and Specification
OMRSD	Operations and Maintenance Requirements and Specification Document
OMS	Orbital Maneuvering Subsystem
OPF	Orbiter Processing Facility
ORB	Orbiter
OSHA	Occupational Safety and Health Administration
PAPI	Precision Approach Path Indicator
PASS	Primary Avionics Software System
PCM	Pulse Code Modulator
PCR	Payload Changeout Room
PDRS	Payload Deployment and Retrieval System
PEG	Powered Explicit Guidance
PEWAT	Pressure at End of Web Action Time
PGHM	Payload Ground Handling Mechanism
PI	Payload Interrogator
PIC	Pyrotechnic Initiator Control
PIP	Payload Integration Plan
PLBD	Payload Bay Door
PM	Phase Modulated
PMBT	Propellant Mean Bulk Temperature
PRM	Performance Reference Mission
PRSD	Power Reactant Supply and Distribution
psf	pounds per square foot
psi	pounds per square inch
PVT	Pressure, Volume, and Temperature
QA	Quality Assurance
RCS	Reaction Control Subsystem
RF	Radio Frequency
RH	Relative Humidity

RMS	Remote Manipulator System
RPL	Rated Power Level
RPSF	Rotation, Processing and Surge Facility
RSRB	Reusable Solid Rocket Booster
RSRM	Redesigned Solid Rocket Motor
	Reusable Solid Rocket Motor
RSS	Reactants Supply System
RTLS	Return to Launch Site
S&A	Safe and Arm
SCA	Shuttle Carrier Aircraft
SEU	Single Event Upset
SLF	Shuttle Landing Facility
SLWT	Super Lightweight Tank
SMG	Spaceflight Meteorological Group
SOAS	Shuttle Orbiter Arresting System
SPEE	Special Purpose End Effector
SRB	Solid Rocket Booster
SRBTS	SRB Radar Beacon Tracking Subsystem
SSME	Space Shuttle Main Engine
SSP	Space Shuttle Program
SSS	Space Shuttle System
SSV	Space Shuttle Vehicle
STDN	Space Tracking and Data Network
STE/D	Special Test Equipment/Device
SVB	Shuttle Vehicle Booster
T-O	Takeoff
TACAN	Tactical Air Navigation
TAL	Transoceanic Abort Landing
TDRS	Tracking Data Relay Satellite
TDRSS	Tracking and Data Relay Satellite System
TELCG	Thermo-Electric Liquid Cooling Garment
TGHR	Time-critical Ground Handling Requirement
TL	Lot Traceability
TM	Member Traceability
TPS	Thermal Protection System
TS	Serial Traceability
TSM	Tail Service Mast
TV	Television
TVC	Thrust Vector Control
UHF	Ultrahigh Frequency
UPR	Unplanned Payload Return
UV	Ultraviolet

VAB	Vehicle Assembly Building
VCU	Video Control Unit
VDC	Volts, Direct Current
VPF	Vertical Processing Facility
wt	weight
WAT	Web Action Time
Xo	