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Space Shuttle Program

FINAL SUBMITTAL

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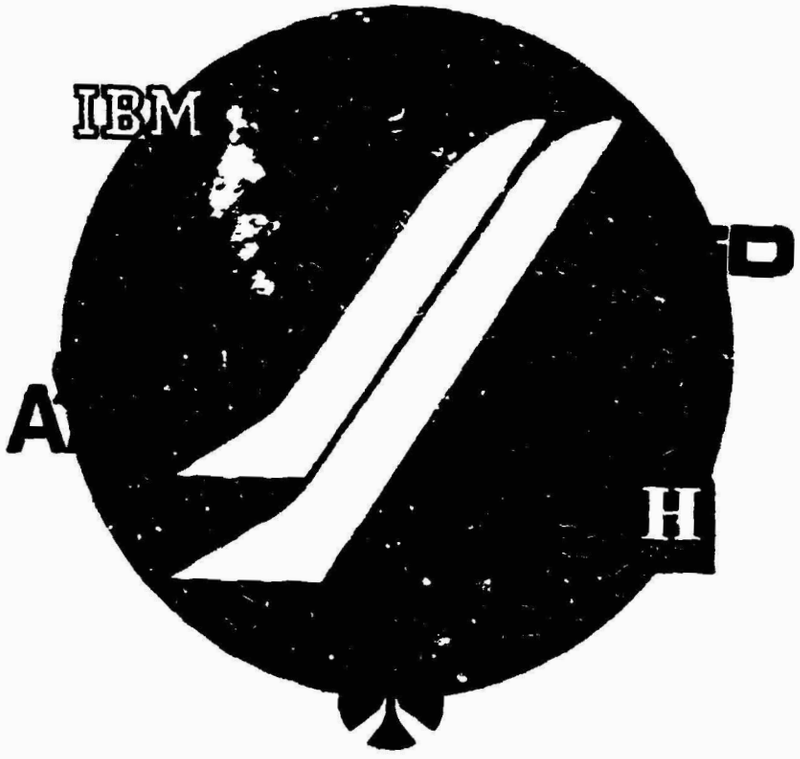

Phase B Final Report
Expendable Second Stage
Reusable Space Shuttle Booster
Volume IX. Preliminary System Specification

Contract NAS9-10960, Exhibit B
DRL MSFC-DRL-221, DRL Line Item 6
DRD MA-078-U2
SD 71-140-9
25 June 1971

Space Division • North American Rockwell 12214 Lakewood Boulevard, Downey, California 90241

SD 71-140-9
(MSC-03321)

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PHASE B FINAL REPORT
EXPENDABLE SECOND STAGE
REUSABLE SPACE SHUTTLE BOOSTER

Volume IX
Preliminary System Specification
Specification No. SS613M0002

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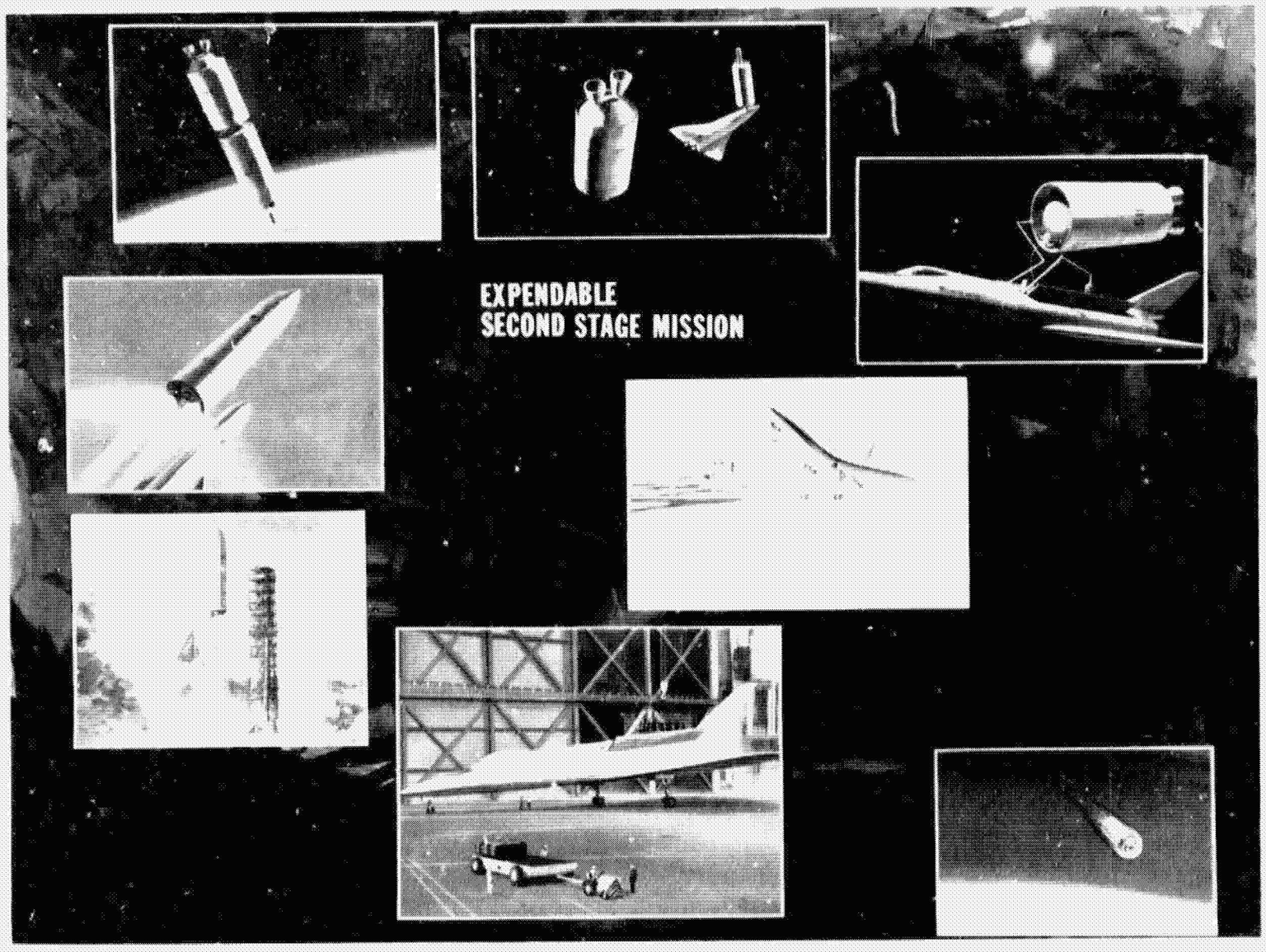
Approved by

B. Hello
Vice President and General Manager
Space Shuttle Program

Space Division • North American Rockwell 12214 LAKEWOOD BOULEVARD • DOWNEY, CALIFORNIA 90241


EXPENDABLE
SECOND STAGE MISSION

FOREWORD

The Space Shuttle Phase B studies are directed toward the definition of an economical space transportation system. In addition to the missions which can be satisfied with the shuttle payload capability, the National Aeronautics and Space Administration has missions planned that require space vehicles to place payloads in excess of 100,000 pounds in earth orbit. To satisfy this requirement, a cost-effective multimission space shuttle system with large lift capability is needed. Such a system would utilize a reusable shuttle booster and an expendable second stage. The expendable second stage would be complementary to the space shuttle system and impose minimum impact on the reusable booster.

To assist the expendable second stage concept, a two-phase study was authorized by NASA. Phase A efforts, which ended in December 1970, concentrated on performance, configuration, and basic aerodynamic considerations. Basic trade studies were carried out on a relatively large number of configurations. At the conclusion of Phase A, the contractor proposed a single configuration. Phase B commenced on February 1, 1971 (per Technical Directive Number 503) based on the recommended system. Whereas a large number of payload configurations were considered in the initial phase, Phase B was begun with specific emphasis placed on three representative payload configurations. The entire Phase B activity has been directed toward handling the three representative payload configurations in the most acceptable manner. Results of this activity are reported in this 12-volume Phase B final report.

Volume I	Executive Summary	SD 71-140-1
Volume II	Technical Summary	SD 71-140-2
Volume III	Wind Tunnel Test Data	SD 71-140-3
Volume IV	Detail Mass Properties Data	SD 71-140-4
Volume V	Operations and Resources	SD 71-140-5
Volume VI	Interface Control Drawings	SD 71-140-6
Volume VII	Preliminary Design Drawings	SD 71-140-7
Volume VIII	Preliminary CEI Specification - Part 1	SD 71-140-8
Volume IX	Preliminary System Specification	SD 71-140-9
Volume X	Technology Requirements	SD 71-140-10
Volume XI	Cost and Schedule Estimates	SD 71-140-11
Volume XII	Design Data Book	SD 71-140-12

This document is Volume IX, Preliminary System Specification, of the Phase B final report.

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ILLUSTRATIONS

TABLE

1.0 INTRODUCTION

This specification establishes the requirements for the system performance, design, and development, and the ground and flight operations of the Expendable Second Stage (ESS) on a Reusable Shuttle Booster System. This system shall be capable of placing payloads in excess of 100,000 pounds in earth orbit.

The ESS on a Reusable Shuttle Booster System shall provide a means for achieving a multimission, economical, large-lift capability system which will be suitable for a wide variety of advanced space missions beginning in the last half of 1979.

2.0 APPLICABLE DOCUMENTS

2.1 Government Documents. The following documents of the issue in effect on the date of invitation for bids or request for proposal form a part of this specification to the extent specified herein. In the event of conflict between documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement.*

Specifications

Federal

Military

MIL-E-5272C (1) 20 January 1960	Environmental Testing, Aeronautical and Associated Equipment, General Specification for (AS)
MIL-F-7179D 3 March 1969	Finishes and Coatings, General Specification for Protection of Aerospace Weapons Systems Structures (AS)
MIL-A-8625C (1) 13 March 1969	Anodic Coatings, for Aluminum and Alloys (AS)
MIL-F-8785B 7 August 1969	Flying Qualities of Piloted Airplanes
MIL-A-8806A (1) 12 September 1967	Acoustical Noise Level in Aircraft; General Specification for (ASG)
MIL-T-21200H (1) 28 October 1968	Test Equipment for Use with Electronic and Fire Control Systems, General Specification for
MIL-M-38310A 15 July 1966	Mass Properties Control Requirements for Missiles and Space Vehicles
MIL-M-45202B 3 October 1968	Magnesium Alloy, Anodic Treatment of (AS)

*Note: Circled numbers herein refer to deviations from Government document requirements in the deviation appendix, Section 10.

Standards

Military

MIL-STD-129D Change 12 11 April 1969	Marking for Shipment and Storage
MIL-STD-143B 12 November 1969	Standard and Specifications Order of Precedence for Selection Of
MIL-STD-454B 10 June 1968	Standard General Requirements for Electronic Equipment (AS)
MIL-STD-808 22 December 1960	Finish, Protective, and Codes for Finishing Schemes for Ground and Ground Support Equipment
MIL-STD-810B 15 June 1967	Environmental Test Methods (AS)
MS 33586A 16 December 1958	Metal, Definition of Dissimilar (AS)
MIL-STD-1472 Change 1 9 February 1968	Human Engineering Design Criteria for Military Systems, Equipments, and Facilities
MIL-STD-1247 21 October 1970	Identification of Pipe, Hose, and Tube Lines for Aircraft, Missiles, Space Vehicles, and Associated Support Equipment and Facilities

Other Publications

Military Bulletins

ANA Bulletin 147	Specifications and Standards of Non-Government Organizations. Released for Flight Vehicle Construction

Manuals

AFSCM-80	General Design and Construction Standards

Regulations

National Aeronautics and Space Administration (NASA)

TMX-53872 (1969 Rev.)	Terrestrial Environment (Climatic) Criteria Guidelines for Use in Space Vehicle Development
TMX-53957 (1969 Rev.)	Space Environment Criteria Guidelines for Use in Space Vehicle Development
Exhibit A of SSME Phase B Statement of Work (1 Mar. 1971)	Contract End Item (CEI) Specification, Space Shuttle Main Engine, 550K(SL)
OMSF Safety Program Directive No. 1A December 1969	System Safety Requirements for Manned Space Flight
SP 6004 1 June 1965	Mass Properties Standard
NHB 6000.1 (1A) December 1969	Requirements for Packaging, Handling, and Transportation for Aeronautical and Space Systems Equipment and Associated Components
NHB 5300.4 (1B) April 1969	Quality Program Provisions for Aeronautical and Space Systems Contractors
MSFC-STD-105	Synthetic Rubber, Age Control of
MSC-02666 15 May 1970	Landing Airfields Selection - With Impact Designs and Operations for Shuttle Orbiters

2.2 Non-Government Documents. The following documents of the issue in effect on date of invitation for bids or request for proposal form a part of this specification to the extent specified herein. In the event of conflict between documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement.

Specifications

76Z0500 (plus Addendum A)	Booster Vehicle Prime Item Specification, Space Shuttle System
CP613M0003	ESS Vehicle Prime Item Specification, Space Shuttle System
76Z0501 (plus Addendum A)	Ground Systems Specification

3.0 REQUIREMENTS

3.1 System Definition

3.1.1 General Description. The ESS on a reusable, space shuttle booster is an integrated two-stage system composed of a reusable shuttle booster and a expendable second stage vehicle. The ESS system with supporting services, equipments, and facilities provide the means for lofting large, bulky, and/or very heavy payloads into low earth orbits.

3.1.1.1 System Functional Areas. The system functional areas and their major elements specified below form the total ESS System.

3.1.1.1.1 ESS System Vehicle Functional Area. The ESS system vehicle functional areas shall consist of the following major elements.

(a) Booster vehicle (see Paragraph 3.7.1.1).

(b) Expendable second stage vehicle (see Paragraph 3.7.1.2).

3.1.1.1.2 Launch Operations and Services Complex (LO&SC) Functional Area. The launch operations and services complex functional area shall consist of the following major elements:

(a) Storage areas and GSE (see Paragraph 3.7.2.1)

(b) Launch pad facility and GSE (see Paragraph 3.7.2.2)

(c) Recovery facility and GSE (see Paragraph 3.7.2.3)

(d) Maintenance and refurbishment (M&R) facility and GSE (see Paragraph 3.7.2.4)

(e) Mission planning and simulation (MP&S) facility and training equipment (see Paragraph 3.7.2.5)

3.1.1.1.3 Payload Module Functional Area. The payload module functional area shall consist of the following major elements:

(a) (TBD) (see Paragraph 3.7.3)

3.1.1.2 Initial Operational Capability (IOC) Baseline. The ESS system IOC baseline shall be the second half of 1979.

3.1.2 ESS System Missions. The ESS System shall be capable of performing the design reference mission defined in Paragraph 3.1.2.1. In addition, the system will be capable of performing the missions defined in Paragraph 3.1.2.2.

3.1.2.1 ESS System Design Reference Mission

3.1.2.1.1 Design Reference Mission. The reference mission to be used in designing the expendable second stage on a reusable space shuttle booster is a logistic supply of maximum payloads into the design reference orbit.

3.1.2.1.2 Design Reference Mission Profile. The design reference mission profile shall be as illustrated in Figure 3-1.

3.1.2.1.3 Design Reference Orbit. The reference orbit to be used in designing an expendable second stage on a space shuttle booster shall be a 270-nautical mile-circular orbit, with a 55-degree inclination. For purposes of performance calculation, the vehicle shall be considered to be launched from a latitude of 28.5 degrees north.

3.1.2.1.4 Mission Duration. Maximum time from ground launch through deorbit burn shall be 24 hours.

3.1.2.2 ESS System Mission Characteristics. The ESS system shall be designed to perform the missions of the three specified payloads summarized in Table 3-1.

3.1.3 System Level Functional Diagrams. The system-level functional diagrams, specified below, shall be used for identifying all system functions. The system-level functional diagrams establish the general relationship of functional areas and the major elements within the system.

3.1.3.1 Top Level Functional Flow Block Diagram (FFBD). The top level FFBD shown in Figure 3-2 portrays the ESS system operations at the system level. The top level FFBD shall be used for developing lower levels of functional flow diagrams and the subsequent definition of system and subsystems design requirements, and mission timelines, and for establishing the need for air vehicle equipment (AVE), ground support equipment (GSE), operating personnel, and training programs for the development of an operational ESS System. The subparagraphs below specify the activity and event

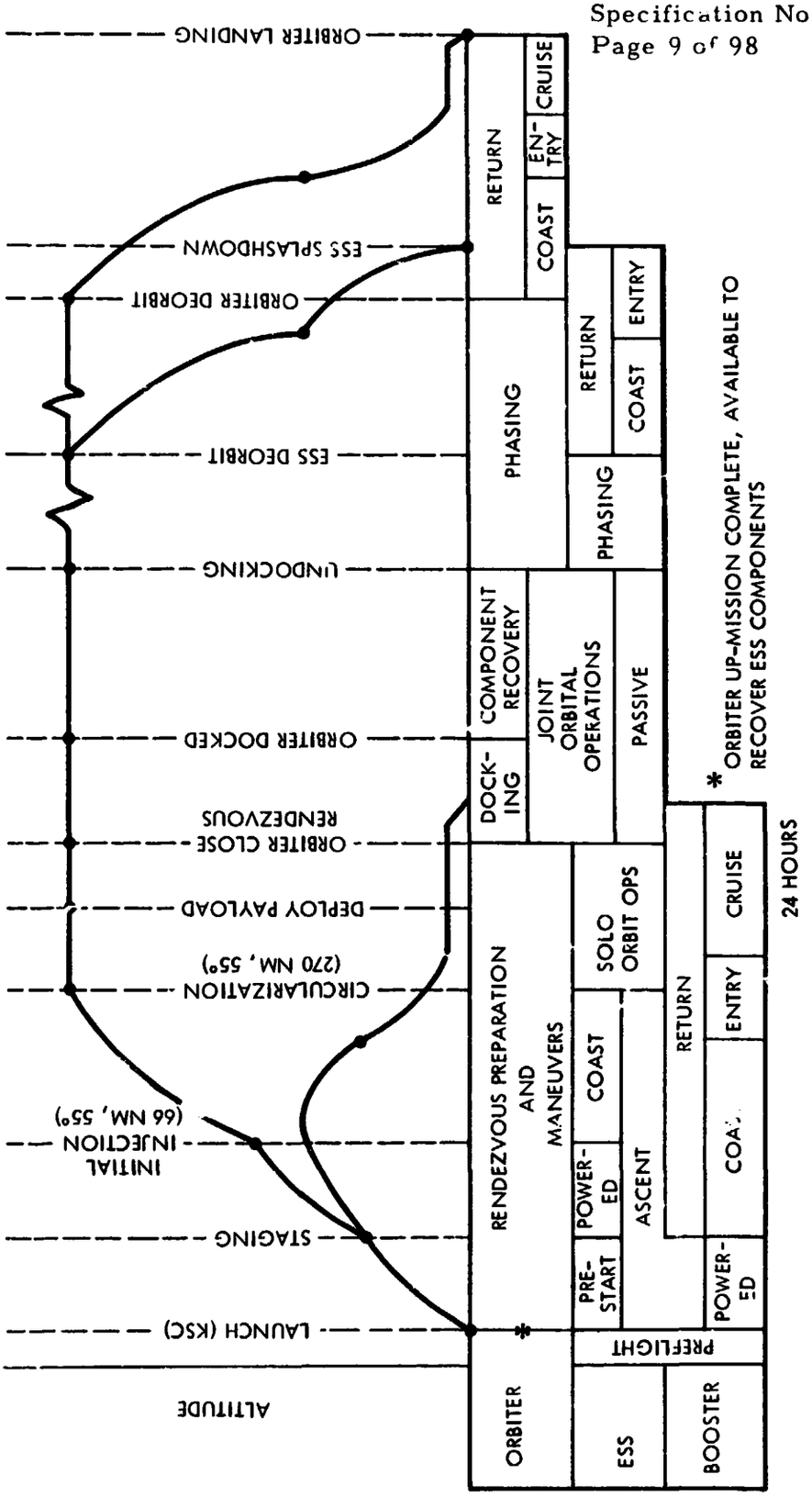

Figure 3-1. Design Reference Mission Profile

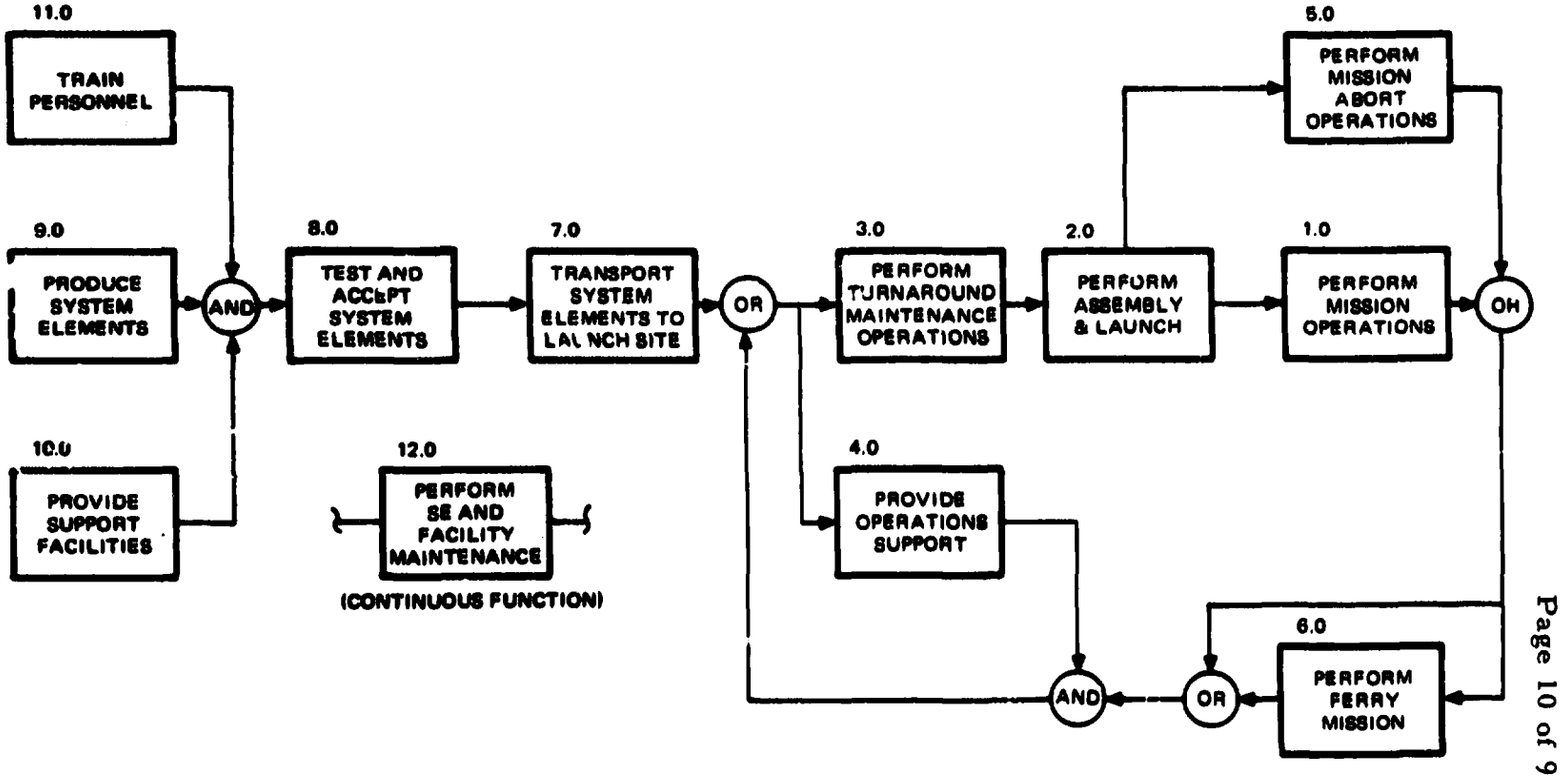

Figure 3-2. Top Level Functional Flow Diagram

Table 3-1. Mission Characteristics

	Space Station Payload	Nuclear Stage Payload	Space Tug Payload
Altitude (nm) (circular)	270	260	100
Inclination (deg)	55	31.5	28.5
Payload (lb)	176,960	83,000	107,180
Length/diameter (in.)	1335/406	2034/396	785/180

coverage of FFBD Items 1.0 through 5.0 of Figure 3-2. This top-level functional flow diagram is taken directly from the space shuttle, because the ESS System must be compatible and complimentary, and differs only in the lower level functions.

3.1.3.1.1 Perform Assembly and Launch (2.0). Shall include mission planning and launch support, payload integration vehicle mating, erection, transport, propellant loading, final servicing, checkout, launch countdown, ignition, and release.

3.1.3.1.2 Perform Mission Operations (1.0). Shall cover all activities from ESS vehicle liftoff through boost, staging, orbit, and deorbit.

3.1.3.1.3 Perform Maintenance (3.0). Shall begin with transport to the maintenance and repair facility, inspection, preflight data processing. maintenance, checkout, and storage (as required), and shall end with delivery to the vehicle assembly/launch area.

3.1.3.1.4 Provide Operations Support (4.0). Shall include the pre-mission, mission, and post-mission operations management functions. Contents of mission operations support shall include, but not be limited to:

(a) Mission planning

(b) Mission profiles

(c) Communication and air traffic control

3.1.3.1.5 Perform Mission Abort Operations (5.0). Shall include all ESS and booster abort possibilities starting with pad abort and progressing through launch, staging, on-orbit for the ESS, and entry, cruise and landing for the booster.

3.1.3.2 Top Level Schematic Block Diagram (SBD). The top level schematic block diagram (SBD) shown in Figure 3-3 specifies the functional areas described under Paragraph 3.1.1.1. The top level SBD identifies interfaces between functional areas.

3.1.4 System Level Layout Drawings

(TBD)

3.1.5 Interface Definition. The functional, physical, procedural, and environmental interface requirements between this system and other systems (e.g., large payloads, and flight operations and services) and between functional areas (e.g., ESS vehicle, launch operations and services, and payload module) within the ESS System are specified in Paragraph 3.7. The following list shall comprise the major elements of the system interface control documents which shall define all functional, physical, procedural, and environmental interfaces between major elements of the system.

(1) ICD No. S 080-1001 — Booster and ESS (see Paragraph 3.7.1.1.3.1)

(2) ICD No. (TBD) — Booster and Storage Area (see Paragraph 3.7.1.1.3.2)

(3) ICD No. SR 2.4.4-11190 — Booster and Launch Pad (see Paragraph 3.7.1.1.3.2)

(4) ICD No. SR 2.4.4-11191 — Booster and Recovery Facility (see Paragraph 3.7.1.1.3.2)

(5) ICD No. SR 2.4.4-11189 — Booster and M&R Facility (see Paragraph 3.7.1.1.3.2)

(6) ICD No. (TBD) — Booster and MP&S Facility (see Paragraph 3.7.1.1.3.2)

(7) ICD No. SR 2.4.4-11192 — Booster and Control Center (see Paragraph 3.7.1.1.3.3)

(8) ICD No. SR 2.4.4-11192 — Booster and Track, and Communications Net (see Paragraph 3.7.1.1.3.3)

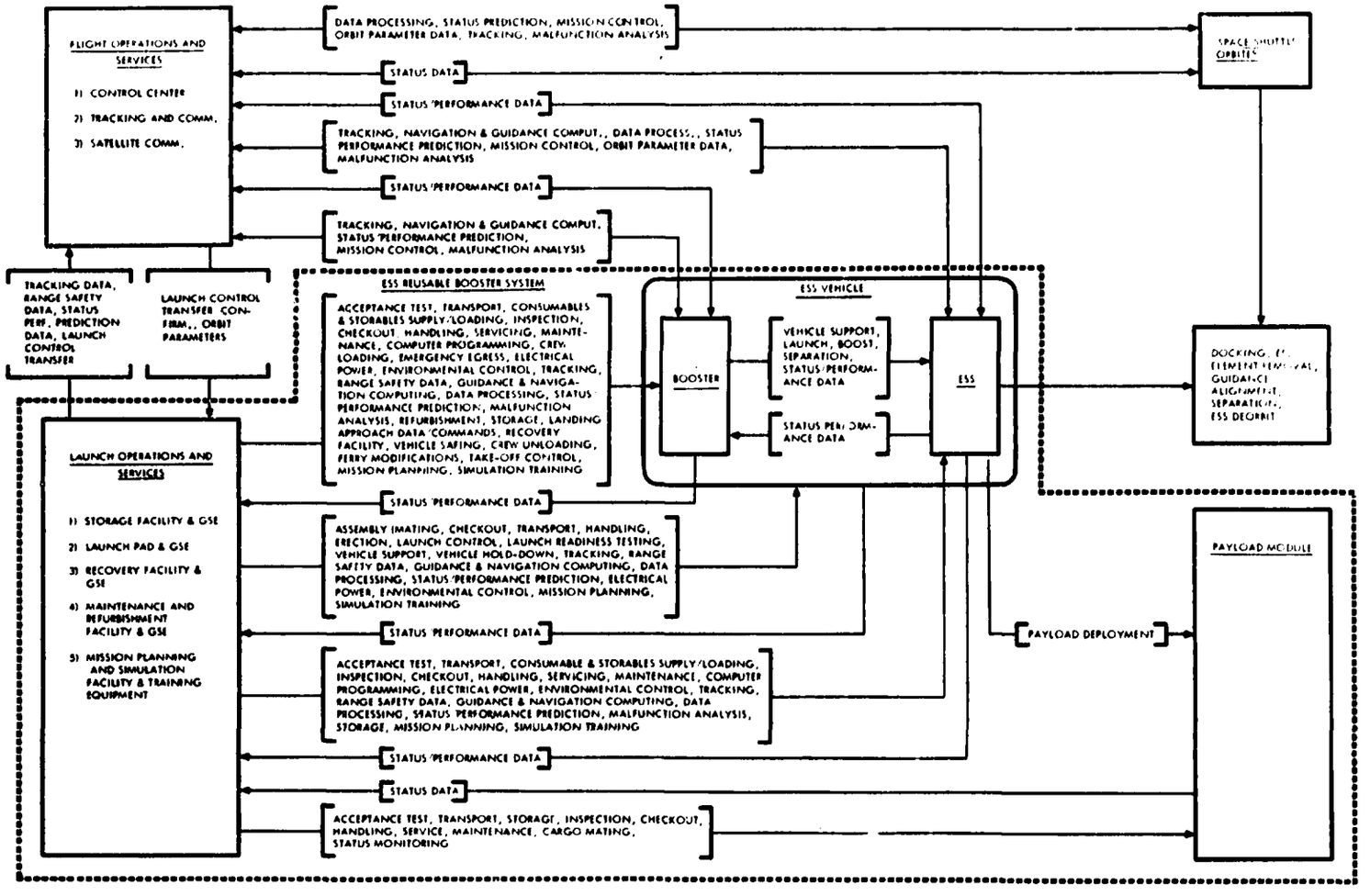

Figure 3-3. Top-Level Schematic Block Diagram - ESS/Reusable Booster System

(9) ICD No. S 080-1002 ESS and Space Shuttle Engine (see Paragraph 3.1.6)

(10) ICD No. S 080-1003 ESS and Launch Pad (see Paragraph 3.7.1.2.3.2.2)

(11) ICD No. S 080-1003 ESS and M&R Facility (see Paragraph 3.7.1.2.3.2.3)

(12) ICD No. (TBD) ESS and Control Center (see Paragraph 3.7.1.2.3.3.1)

(13) ICD No. (TBD) ESS and Track, and Communications Net (see Paragraph 3.7.1.2.3.3.2)

(14) ICD No. (TBD) ESS and Satellite Communications Net (see Paragraph 3.7.1.2.3.3.3)

(15) ICD No. S 080-1004 ESS and Payload (see Paragraph 3.7.1.2.3.4)

(16) ICD No. (TBD) Storage Area and Payload (see Paragraph 3.7.2.1.10.3)

(17) ICD No. (TBD) Storage Area and Control Center (see Paragraph 3.7.2.1.10.4)

(18) ICD No. (TBD) Launch Pad and Control Center (see Paragraph 3.7.2.2.16.3)

(19) ICD No. (TBD) Launch Pad and Track, and Communications Net (see Paragraph 3.7.2.2.16.4)

(20) ICD No. (TBD) Launch Pad and Satellite Communications Net (see Paragraph 3.7.2.2.16.5)

(21) ICD No. S 080-1005 Space Shuttle Orbiter and ESS (see Paragraph 3.1.7.4.1)

(22) ICD No. SR 2.4.4-11187 Space Shuttle Orbiter and Payload (see Paragraph 3.1.7.4.1)

(23) ICD No. (TBD) M&R Facility and Control Center (see Paragraph 3.7.2.4.5.16.3)

(24) ICD No. (TBD) MP&S Facility and Control Center (see Paragraph 3.7.2.5.5.16.3)

3.1.6 Government Furnished Property List. The equipment specified in the following list shall be supplied by the Government for installation and/or integration into or with the major elements of the space shuttle system.

Item No.	Nomenclature	Specification and/or Part No.
1	Main engine, 550,000 (SL) pound thrust	ICD No. 13M15000B
2	(TBD)	
3	(TBD)	
4	(TBD)	
5	(TBD)	
6	(TBD)	

3.1.7 Operational Concept

3.1.7.1 Launch Site

3.1.7.1.1 Launch Site Facilities. The following facilities shall be provided at the launch site or in the same general location:

(a) Launch pad

(b) Recovery facility

(c) M&R facility

(d) Storage area

(e) MP&S facility

3.1.7.1.2 Prime Launch Site. The ESS system shall be capable of being launched from a launch site located at KSC.

3.1.7.1.3 Alternate Launch Sites. The ESS system shall be capable of being launched from the following alternate launch sites:

(TBD)

3.1.7.2 Launch. The ESS design shall be based on the following launch concepts:

(a) An on-time, all-azimuth launch capability shall be provided.

(b) Checkout is performed on board the ESS by executive control from the ground, with status display in the booster and on the ground.

(c) Use of specialized facilities (e.g., clean room, altitude chamber, etc.) are not required.

3.1.7.3 Launch Reaction Time - Design Reference Mission. The ESS design shall be based on the following concepts for the launch reaction time for the design reference mission.

(a) The ESS shall be capable of launch from a launch status (see Section 6.0) within four hours.

(b) The ESS shall be capable of launch within (TBD) hours following a postponed launch.

3.1.7.4 Recovery

3.1.7.4.1 Component Recovery. Selected high value reusable ESS components shall be capable of on-space recovery via the orbiter, utilizing the manipulator mechanisms.

3.1.7.4.2 Docking. The ESS shall have provisions for docking of the space shuttle orbiter for component recovery.

3.1.7.4.3 Safing. On-board provisions shall be made to place the ESS vehicle in a safe condition following main engine cutoff.

3.1.7.5 Maintenance and Refurbishment Facility. The maintenance and refurbishment facility shall provide a complete capability for scheduled and unscheduled maintenance of the ESS elements. The facility shall be defined for Type (TBD) traffic models.

3.1.7.6 Storage Area. The storage area shall provide the capability for storing mission-ready vehicles and equipment. The area shall be defined for Type (TBD) traffic models.

3.1.7.7 Mission Planning and Simulation Facility. The MP&S facility shall provide the capability for creating mission software for ESS vehicle use and personnel training for all mission ground and flight phases (same as Space Shuttle 3.1.7.8).

3.2 Characteristics

3.2.1 Performance. The following performance requirements are arranged in conformance with the functional flow diagram shown in Figure 2.

3.2.1.1 Assembly and Launch. The ESS system shall be capable of achieving the launch rates specified in Paragraph 3.7.2 for the Type (TBD) traffic models with a turnaround time not to exceed two calendar weeks per booster vehicle.

3.2.1.1.1 Vehicle Preparation. Booster and ESS mating and payload handling facilities and GSE shall be provided to support the requirements of Paragraph 3.2.1.1. Vehicle design shall be based on the booster and ESS plus payload being mated prior to transportation to the launch pad.

3.2.1.1.2 Payload Loading. Payload handling accommodations shall be provided to permit handling procedures consistent with the turnaround time specified in Paragraph 3.2.1.1.

3.2.1.1.3 Service Storables. Vehicle servicing of non-hazardous storables shall be performed prior to moving to the launch pad.

3.2.1.1.4 Transport to Launch Facility. The mated booster/ESS/payload shall be capable of being transported to the launch facility by means of the LUT and crawler. Roadways from the mating area to the launch pad shall be capable of supporting the combined weight of the mated unfueled vehicles including any payload which may be mated onto the ESS.

3.2.1.1.5 ESS Vehicle Erection. The M&R facility shall be capable of erecting and mating the booster, ESS, and payload. Provisions shall be made during vehicle transport and at the launch facility to restrain the vehicles under environmental conditions defined in TMX 53872, as modified by the requirements of this specification.

3.2.1.1.6 Pad Preparations

3.2.1.1.6.1 Personnel Ingress/Egress and Interface Connection Access. The shuttle system shall provide the following ingress/egress capability:

(a) The launch facility shall provide emergency egress capability for all pad personnel as defined in Paragraph 3.7.2.2.9.

(b) The booster and launch facility shall provide for rapid and safe ingress and egress of flight personnel and support personnel when the ESS and booster vehicles are in the vertical position.

(c) The launch facility shall provide access routes to all pad/vehicle interface connections.

3.2.1.1.6.2 Communication Links. Communication links shall be provided between the control center and ground crews during pad preparations.

3.2.1.1.6.3 Launch Readiness Checks. Launch readiness checks shall be performed on-board the ESS by executive control from the ground and with status display on the ground and in the booster prior to placing the ESS vehicle into standby status.

3.2.1.1.6.4 Weather Sensitivity. The vehicles shall be insensitive to weather conditions during pad preparations and standby periods.

3.2.1.1.7 Launch Operations

3.2.1.1.7.1 Launch Time. The ESS system vehicles shall be capable of launch as specified in Paragraph 3.1.7.3.

3.2.1.1.7.2 Propellant Loading Sensitivity. Systems sensitivity to propellant loading shall be minimized.

3.2.1.1.7.3 Flight Personnel. Flight personnel loading shall be performed subsequent to propellant loading and prior to performing final checkout and countdown.

3.2.1.1.7.4 Flight Personnel Safety. The launch facility shall provide ingress and egress and emergency escape capability for all flight personnel as defined in Paragraph 3.7.2.2.9.

3.2.1.2 Mission Operation

3.2.1.2.1 ESS System Vehicle Characteristics

3.2.1.2.1.1 Payload Delivery. The ESS system shall be capable of delivering the payload size and weight specified in Paragraph 3.2.2.3.

3.2.1.2.1.2 ESS System Vehicle Configuration. The airborne ESS system shall consist of a booster and ESS vehicle. The booster and ESS vehicles shall have the following characteristics:

(a) The booster shall be fully reusable (space shuttle booster).

(b) The booster stage and ESS stage shall be sequentially ignited.

(c) The ESS system shall be capable of integrated vehicle vertical launch and booster vehicle horizontal landing.

3.2.1.2.1.3 Booster Takeoff and Landing. (See Space Shuttle, Paragraph 3.2.1.2.1.3.)

3.2.1.2.1.4 Booster Capability. From a vertical launch, the booster shall be capable of boosting the ESS vehicle to the altitude and velocity specified in Paragraph 3.7.1.1.1.1 and subsequently returning to accomplish a horizontal landing near the launch site.

3.2.1.2.2 Booster Vehicle Flight Crew. (See Space Shuttle, Paragraph 3.2.1.2.2.)

3.2.1.2.3 Booster. The booster vehicle shall provide a shirtsleeve environment for flight personnel. (Same as Space Shuttle, Paragraph 3.2.1.2.3.)

3.2.1.2.4 ESS and Booster Guidance and Navigation. The ESS vehicle on-board guidance and navigation system shall be capable of performing a non-rendezvous orbital mission. The booster vehicle on-board guidance and navigation system shall be capable of performing ascent and return to a preselected landing site.

3.2.1.2.5 Flight Control

3.2.1.2.5.1 ESS Vehicle Rotational and Translational Control. The ESS vehicle shall be provided with the capability for three-axis rotational and one-axis translational control.

3.2.1.2.5.2 Booster Rotational Control. The booster vehicle shall be provided with the capability for three-axis rotational control.

3.2.1.2.5.3 Booster and ESS Flight Control Automatic Hold Capability. The booster and ESS vehicles flight control system shall be provided with an automatic attitude hold capability for all mission phases and shall be provided with automatic control for booster landing.

3.2.1.2.6 On-Board Checkout. The ESS system shall be provided with a on-board checkout capability.

3.2.1.2.7 Telecommunications. Voice and data communications shall be provided from the booster vehicles to the ground stations. The ESS shall be capable of communicating either direct or via satellite to the MSFN. Continuous ESS and booster communications and tracking shall not be required.

3.2.1.2.8 Useful Life. The ESS vehicles shall be capable of performing a single mission with normal maintenance and shall have a minimum (TBD) year shelf life.

3.2.1.3 Maintenance and Refurbishment. The ESS system shall provide the capability of accomplishing maintenance and refurbishment (M&R) at maintenance level I (see Paragraph 3.5.1.1) on either the ESS or booster vehicle in two calendar weeks or less. M&R, as it applies to the ESS, is receiving inspection, maintenance, storage, installation, and checkout.

3.2.1.3.1 Booster Safing. (Same as Space Shuttle Paragraph 3.2.1.3.1.)

3.2.1.3.2 Off-Loading

3.2.1.3.2.1 Equipment. Equipment shall be provided at the safing area to off-load booster flight personnel and orbiter-recovered ESS hardware components.

3.2.1.3.2.2 Booster Flight Personnel, and Data. (Same as Space Shuttle Paragraph 3.2.1.3.2.2.)

3.2.1.3.2.3 Post-Flight Inspections. All off-loading shall be accomplished prior to performing post-flight inspections. (Same as Space Shuttle Paragraph 3.2.1.3.2.4.)

3.2.1.3.3 Data. Ground data processing equipment shall be provided to process data immediately after landing. Data analysis shall be formatted to allow for identification and initiation of M&R actions. (Same as Space Shuttle Paragraph 3.2.1.3.3.)

3.2.1.3.4 Repair. An M&R area with appropriate access equipment shall be provided to perform inspection, and scheduled and unscheduled M&R actions. (Same as Space Shuttle Paragraph 3.2.1.3.4.)

3.2.1.3.5 Booster and ESS System Vehicles and Subsystem Checkout. The booster and ESS shall be capable of performing system and subsystem checkout, following M&R actions, by utilizing the vehicle's on-board checkout capabilities.

3.2.1.3.6 ESS and Booster Storage and Preparation. Area for storing and preparing ESS and booster vehicles for mission use shall be provided.

3.2.1.4 Booster and ESS Transport or Ferry

3.2.1.4.1 Booster Vehicle Ferry. The booster vehicle shall be capable of ferry flight. Vehicle ferry capability shall be available. (Same as Space Shuttle Paragraph 3.2.1.4.1.)

(a) Following factory acceptance

(b) Landing from an orbital mission

(c) From a previous ferry flight

3.2.1.4.2 Preflight Operations. The following capabilities shall be provided to support ferry flight operations. (Same as Space Shuttle Paragraph 3.2.1.4.2.)

3.2.1.4.3 Ferry Preflight Operations - Post-Orbit. The following capabilities shall be provided for preflight operations following a boost flight by the booster vehicle (these capabilities are in addition to those of Paragraph 3.2.1.4.2). (Same as Space Shuttle Paragraph 3.2.1.4.3.)

3.2.1.4.4 Takeoff and Landing. Booster vehicle only. (Same as Space Shuttle Paragraph 3.2.1.4.4.)

3.2.1.4.5 Cruise and Approach. Booster vehicle only. (Same as Space Shuttle Paragraph 3.2.1.4.5.)

3.2.1.4.6 ESS Transport. The ESS vehicle shall be capable of being transported from the factory acceptance area to the launch facility within a suitable ESS transfer vehicle.

3.2.1.4.6.1 Transport Support Equipment. Support equipment to support transportation of ESS shall be provided. Existing S-II transportation equipment shall be used whenever practicable.

3.2.1.4.6.2 Towing. The ESS vehicle and transporter shall be capable of being towed by commercial and/or military vehicles if the transporter is not self-propelled or has an emergency breakdown.

3.2.1.4.6.3 System Checkout. An on-board checkout capability shall be provided in the ESS to detect and isolate malfunctions and to verify proper system operation as a post-transportation and preflight activity.

3.2.1.4.6.4 Safing. The ESS on-board system shall provide a safing of the vehicle for all transportation modes.

3.2.1.5 Mission Abort. The ESS system shall provide for safe mission termination in the event major malfunctions occur during prelaunch preparations and subsequent to liftoff. Malfunction criteria shall be in accordance with Paragraph 3.2.3.2(C)2.

3.2.1.5.1 Personnel Emergency Egress. The system shall provide for booster flight personnel emergency egress. (Same as Space Shuttle Paragraph 3.2.1.5.1.)

3.2.1.5.2 Launch Abort. During launch, an abort capability including booster and ESS separation and continued booster flight to safe landing, and ESS flight to a safe area shall be provided.

3.2.1.5.3 Landing Go-Around. The booster vehicle shall be capable of performing one go-around at landing sites. (Same as Space Shuttle Paragraph 3.2.1.5.4.)

3.2.1.5.4 Booster Single Engine Out. The ESS system shall be capable of mission continuation of the ESS in event of a single main engine out on the booster after launch.

3.2.2 Physical Characteristics. The following physical characteristics are identified to assure physical compatibility between major ESS system elements:

3.2.2.1 Engines. The main engines for the ESS and booster shall be bell-type engines. The main engines shall comply with the space shuttle main engine specification referenced in Paragraph 2.1.

3.2.2.1.1 Air Breathing Engine Fuel. Air breathing engines in the booster shall be designed to use ASTM-Jet A as an engine fuel. (Same as Space Shuttle Paragraph 3.2.2.2.)

3.2.2.2 Gross Weight. The ESS system liftoff weight shall not exceed (TBD) pounds.

3.2.2.3 Payload Weight. The ESS element shall be capable of operating with payloads of (TBD) pounds and less, to the design reference missions.

3.2.2.3.1 Vehicle Design Payload Capability. ESS vehicles shall be designed to a payload capability of (TBD) pounds in excess of the payload weight of Paragraph 3.2.2.3, for missions launched in an easterly direction and limited to a 100 nautical-mile orbit.

3.2.2.3.2 Payload Size. The ESS element shall be capable of operating with payloads having a diameter of less than 34 feet and a length of less than 170 feet.

3.2.2.4 Payload Handling. Provisions shall be made for carrying and separating the ESS/payload combinations from the booster.

3.2.2.4.1 Payload Deployment Mechanism. The ESS element shall provide a mechanism to separate the payload from the ESS.

3.2.2.5 Propulsion System Safe Shutdown. The ESS/booster propulsion systems shall be capable of safe shutdown at any time.

3.2.2.6 Battery Preconditioning. Batteries in the ESS system for use in emergency situations shall not require preconditioning prior to accepting loads.

3.2.2.7 Propellant Depletion. The booster shall be capable of depleting propellants prior to landing. (Same as Space Shuttle Paragraph 3.2.2.9.)

3.2.3 Reliability

3.2.3.1 Failure Mode and Effects Analysis. (TBD)

3.2.3.2 Redundancy. The following characteristics shall be used as guidelines for all ESS design:

(a) Where redundancy is needed, full mission capability shall be developed, avoiding minimum requirement, minimum performance, back-up system concepts.

(b) System redundancy techniques shall be selected and implemented so that switching of system functions between redundant elements or paths in the event of a failure in an active functional path does not create a transient condition causing unacceptable system/vehicle performance.

(c) 1. The mated vehicle system shall remain operational following any single failure in a non-electronic system or any one failure in electronic systems. The vehicle system is in operational condition if remaining mission* objectives can be accomplished without compromise.

2. Structural components such as rocket engine thrust chambers, vehicle structures, tanks, and fluid lines, are not considered to be active elements and need not meet Item 1 above but shall have safety factors as specified below:

(a) (TBD)

3.2.4 Maintainability. ESS vehicle design shall incorporate maintainability features that will permit accomplishment of all necessary maintenance and repair with a minimum expenditure of maintenance resources, particularly with respect to manpower and elapsed time. Special consideration shall be given to provision of maintainability characteristics that will minimize turn-around time.

*Refer to design reference mission.

3.2.4.1 Maintainability Design Requirements. Maintainability design requirements shall be specified in terms of elapsed maintenance time, manhours, numbers of personnel, or other such measures of maintainability, either individually or in combination. Specification of maintainability design design requirements is intended to ensure "designed-in" maintainability characteristics needed to:

(a) Achieve short turn-around time for the booster and space recoverable hardware components through ease of refurbishment and repair action.

(b) Facilitate accomplishment of unscheduled maintenance under all expected operational and environmental conditions.

With respect to unscheduled maintenance, special emphasis shall be placed upon equipment accessibility, use of the on-board checkout system for fault isolation and post-repair verification, and correction of malfunctions by replacement of the LRU containing the fault. No in-flight maintenance is contemplated, and no scheduled maintenance will be performed at the launch pad.

3.2.4.2 Mean-Time-To-Repair (MTTR). The ESS vehicles will have a MTTR of less than (TBD) days.

3.2.5 Availability. "This section is not applicable to this specification."

3.2.6 System Effectiveness Models. (TBD)

3.2.7 Environmental Conditions

3.2.7.1 Natural Environments. The ESS system shall be designed in accordance with the natural environment criteria specified in NASA TMX-53957 and TMX-53872, and as modified by the requirements of this specification.

3.2.7.2 Induced Environment. The ESS vehicle elements shall be designed in accordance with the induced environmental criteria specified in (TBD) with the exception (if any) noted in the following subparagraphs. The GSE shall be designed in accordance with the induced environmental criteria specified in (TBD), with the exception (if any) noted in the following subparagraphs.

3.2.7.2.1 Acceleration Load Factor. The normal mission resultant load factor on the flight crew for booster flights shall not exceed four g's in any direction. (Same as Space Shuttle Paragraph 3.2.7.2.1.)

3.2.7.2.2 Acoustics, Vibration, and Shock

3.2.7.2.2.1 Acoustics. During ascent, reentry, landing, and ferry flights, the noise levels in the booster crew compartments shall not exceed those in specification MIL-A-8806.

3.2.7.2.2.2 Vibration. (TBD)

3.2.7.2.2.3 Shock. (TBD)

3.2.8 Transportability. (TBD)

3.3 Design and Construction

3.3.1 Materials, Parts, and Processes. All materials, parts, and processes selected for use in design and construction of the ESS system shall be compatible with the performance and environmental criteria for the end item as specified in the CEI specifications. Materials, parts, and processes used on off-the-shelf hardware or hardware previously developed on other Government contracts shall be acceptable provided the hardware is verified to be compatible with the performance and environmental criteria as specified in this specification.

3.3.1.1 General Design and Construction Standards. Unless otherwise specified herein or in the detail equipment specifications, the requirement of AFSCM 80-series publications listed in Paragraph 2.1, shall be incorporated as an integral part of the requirements of this specification by reference.

3.3.1.2 Selection of Specifications and Standards. Specifications and standards for necessary commodities and services shall be selected in accordance with MIL-STD-143 except as otherwise specified herein. The DOD Index of (TBD), shall be the source of issues in effect from which selections are to be made.

3.3.1.2.1 Selection of Qualified, Standard, and Commercial Parts. Parts selection for use on the ESS shall be made from controlled parts with demonstrated adequacy for the intended application and environments. Qualified parts (see Paragraph 6.0) and preferred standard parts (see

Paragraph 6.0) lists may be used as sources of selection. If commercial grade parts (see Paragraph 6.0) are used, prior notification shall be given to the procuring agency.

3.3.1.3 Materials and Parts. Standard, proven, and economical parts such as airframe hardware and mechanical, electrical, hydraulic, and pneumatic components, shall be specified to the maximum extent consistent with reliability, maintainability, and performance requirements thus implementing (TBD). Materials shall be chosen on the basis of suitability for intended use and the availability in this country during national emergency. Noncritical materials shall be used wherever practical under the constraints otherwise specified. Raw materials in mill product form shall be specified in terms of military specifications or approved industry association specifications such as the Aeronautical Material Specification (AMS) whenever possible. When the above specifications are not applicable, the contractor shall establish specifications for the materials and for the properties of the materials and the parts.

3.3.1.4 Standard, Commercial, and Qualified Parts. The selection of parts shall be made in accordance with the requirements of the government design specification applicable to that equipment. Parts which are in current production and available, as indicated by being on qualified parts lists, shall be used to the maximum extent possible. Those parts which are to be obtained from only certain of the many suppliers listed on the QPL shall be considered nonstandard (selected) parts. When no general specifications exist, the selection procedure for parts shall follow the order of precedence established in MIL-STD-143. Unless otherwise specified, air vehicle commercial parts covered by ANA Bulletin 147 shall be considered as being within Group I standards as defined by MIL-STD-143.

3.3.1.5 Moisture and Fungus Resistance. System equipment shall be designed so that the materials comprising its makeup are basically not nutrients for fungus. Fungus nutrient materials may be used in permanently hermetically sealed assemblies and other accepted and qualified uses such as paper capacitors and treated transformers. Other necessary fungus nutrient material applications will require treatment by a method which will render the resulting exposed surface fungus resistant. Moisture resistance is considered the property of not degrading in the presence of moisture or absorbing and holding moisture. The criteria for and determination of fungus and moisture resistance shall be in accordance with MIL-E-5272 and MIL-STD-810, as appropriate. Fungus inert materials are listed in MIL-STD-454, Requirement 4.

3.3.1.6 Corrosion of Metal Parts. The protective finishes and finish schemes of all ground equipment shall comply with the requirements of MIL-STD-808. Airborne equipment finishes and coatings shall comply with the requirements of MIL-F-7179, Type II protection classification, and the following additional requirements:

(a) The organic finishes or finish systems used shall provide the necessary corrosion resistance for the metal being protected and for all materials used in areas subjected to severe corrosive environments.

(b) The use of dissimilar metals (as defined in MS 33586) in direct contact is prohibited. When dissimilar metals are required to be joined, their faying surfaces shall be adequately insulated, preferably by (TBD) sealant or an approved sealing compound, to assure protection from electrolytic corrosion. Additional organic finishing or barrier tapes may be used, subject to requirements and restrictions of MIL-F-7179.

(c) The chemical finishes used shall provide adequate corrosion resistance; however, those parts or surfaces of parts located in corrosion susceptible areas or which form exterior surfaces of the system shall require chemical finishing to provide maximum corrosion resistance. All parts made of 2000 and 7000 series non-clad strength aluminum alloys susceptible to extreme abrasive environments shall be sulfuric acid anodized in accordance with MIL-A-8625 within the limitations of Paragraph 3.3 therein. These same non-clad aluminum alloy parts which are determined to be fatigue critical shall be shot peened, as required, and the anodic coating applied to a controlled thickness to assure no loss in fatigue strength. In the event that the size or geometry of the part prohibits the use of an anodic coating, other suitable corrosion protection methods (e.g., painting) shall be utilized.

(d) Magnesium alloys shall be given a pretreatment conforming to MIL-M-45202. In addition to the required finish, the interior of magnesium alloy parts shall receive two coats of exterior paint.

(e) All low-alloy, high-strength steel parts (over 220 kpsi) located in corrosive environments shall require suitable anodic protection either by vacuum deposition or by an approved process, non-embrittling to high-strength steels. In the event that anodic protection is not possible, other suitable corrosion protection methods (e.g., painting) shall be utilized.

(f) Cadmium metal parts and cadmium coated parts are specifically prohibited from use.

(g) All permanently installed fasteners (non-removable) penetrating exterior surfaces shall be wet installed with the appropriate primer in the wet condition or an approved sealing compound. Quick-release fasteners and removable fasteners in similar locations shall be so designed or installed to provide a seal to prevent moisture or fluids from entering.

(h) All exterior joints and seams, including those in attachment wells, control surface wells, and structures under fairings shall be fay surface sealed with (TBD) sealant or an approved sealing compound. Removable panels and access doors in exterior locations shall also be sealed, either by mechanical seals or by separable fay surface sealing.

(i) The exterior mold lines of the ESS vehicle shall be aerodynamically smooth. Sharp edges of all parts installed on the exterior shall be broken.

3.3.1.7 Contamination Control. Cleanliness of the assembled spacecraft shall be to the requirements of (TBD). Fluid cleanliness shall be in accordance with (TBD).

3.3.1.8 Storage. The ESS system hardware shall be designed for a storage life of (TBD) years in the environment defined in (TBD) except that in those cases where age-sensitive materials cannot be avoided, replacement of such materials shall be permitted on a schedule basis during the storage period.

3.3.1.9 Interchangeability and Replaceability. Airborne equipment, components, and parts shall be interchangeable and replaceable to the extent required by MIL-I-8500. Support equipment shall be interchangeable in accordance with the requirements of MIL-S-8512. Electronic test equipment shall be interchangeable to the extent specified in MIL-T-21200. For those items required to be interchangeable by MIL-I-8500, the interchangeable items of equipment shall be identified for the model designated for the first article configuration inspection.

3.3.1.10 Workmanship. All air vehicle equipment workmanship shall be in accordance with high-grade aircraft practices and of quality to assure safety, proper operation, high reliability, and service life requirements. All facilities and aerospace ground and training equipment workmanship shall be the highest quality commensurate with the use of the item.

3.3.1.11 Electromagnetic Interference. The system shall be designed to the compatibility requirements of (TBD).

3.3.1.11.1 Electromagnetic Radiation. Each major element shall be electromagnetically compatible with other elements in the system. Any one element shall not be a source of interference that could adversely affect the operation of other elements or compromise its own operational capabilities.

3.3.1.12 Identification and Marking. The identification and marking of airborne equipment shall be in accordance with (TBD). The designation of the vehicle shall conform to the requirements of (TBD), and the designation of electronic equipment shall conform to the requirements of (TBD). Serialization markings of new equipment shall conform to the requirements of (TBD). Markings associated with synthetic rubber goods shall conform to the requirements of MSFC-STD-105. Packaging marking requirements shall conform to the requirements of MIL-STD-129. Pipe, hose, and tube lines shall be marked in accordance with MIL-STD-1247.

3.3.1.13 Weight and C.G. Control. Booster or ESS weight and c.g. control characteristics shall be in accordance with requirements of SP6004 and MIL-M-38310.

3.3.2 (Reserved for Future Use)

3.3.3 (Reserved for Future Use)

3.3.4 Safety

3.3.4.1 Range Requirements. The ESS system shall meet the safety requirements established by the Air Force Eastern Test Range (TBD).

3.3.4.2 Safety Requirements. The system safety program for the ESS shall be compatible with the requirements of the OMSF safety program.

3.3.4.3 Safe Mission Termination. The ESS system shall provide for safe mission termination in the event major malfunctions occur during prelaunch preparations and subsequent liftoff. The desired safe mission termination capabilities shall allow for safe booster flight personnel egress prior to liftoff and for separation of the ESS from the booster following liftoff.

3.3.4.4 Emergency Landing. The booster vehicle element shall be provided life support, survival, and rescue equipment for emergency water and land landings. (Same as Space Shuttle Paragraph 3.3.4.4.)

3.3.4.5 Radiation-Hazards. (TBD)

3.3.4.6 Non-Hazardous Material Selection. Materials used shall be selected with characteristics that do not present potential hazards either to personnel or equipment due to intended use or intended use environment. Material characteristics of particular concern are: ignition, flammability, toxicity, smokability, expansion, contraction, shock sensitivity, oxidization sensitivity, sublimability, reversion, decomposition, etc.

3.3.4.7 GSE Safety Requirements. GSE pressure systems shall be designed for a minimum safety factor of four (burst pressure to maximum operating pressure).

3.3.4.8 Personnel Noise Protection. Ground personnel shall not be exposed to noise levels in excess of 90 decibels in any octave band without appropriate protection. (Same as Space Shuttle Paragraph 3.3.4.8.)

3.3.4.9 Electrical Discharge. The ESS system design shall incorporate a means of discharging electrical potential differences between air vehicles without vehicles damage or degradation.

3.3.5 Human Performance/Human Engineering

3.3.5.1 Booster, Man-Machine Interface Commonality. The booster vehicle shall provide, where practical, for consistent man-machine interfaces. (Same as Space Shuttle Paragraph 3.3.5.1.)

3.3.5.2 Personnel Skill Requirements. The ESS system shall not require personnel skills more demanding that those required for operational high-performance land-based aircraft systems.

3.3.5.3 Visibility. Visibility from the booster cockpits during landing shall be comparable to high-performance aircraft standards. (Same as Space Shuttle Paragraph 3.3.5.3.)

3.3.5.4 Booster Vehicle Displays and Controls. (Same as Space Shuttle Paragraph 3.3.5.4.)

3.3.5.5 Habitability. Booster flight personnel compartment volumes, environments, furnishings, and other accommodations shall be comparable, in life support, health, rest, diversion, and convenience levels, to military air transports.

3.3.5.6 Ingress and Egress Provisions. The flight personnel compartment of the booster shall provide outward opening doors or hatches to permit rapid egress. Prelaunch support equipment shall provide for rapid ingress and egress of flight personnel and ground crews. (Same as Space Shuttle Paragraph 3.3.5.6.)

3.3.5.7 Sizing for Personnel. The space shuttle booster shall provide furnishings, equipment, workspaces, and accessways sized for personnel within the 5th and 95th percentile dimensional range of U. S. Air Force population, March 1972. (Same as Space Shuttle Paragraph 3.3.5.7.)

3.3.5.8 Vertical and Horizontal Operations. The ESS system shall provide for maintenance of the booster and ESS vehicles when in the vertical (prelaunch), and horizontal (prelaunch, and, for booster only, the post-flight) attitudes.

3.4 Documentation. The documentation data for the ESS system shall consist of specifications, drawings, and interface control documentation as shown in Figure 3-4.

3.5 Logistics

3.5.1 Maintenance. Three levels of maintenance shall be provided for the ESS system elements and support equipment.

3.5.1.1 Maintenance Level I. Maintenance Level I shall consist of all maintenance activities accomplished directly on system-installed hardware. Maintenance Level I shall include fault isolation; removal and replacement of components, LRU's, or subsystems; servicing, replenishing, inspection, and repair in place.

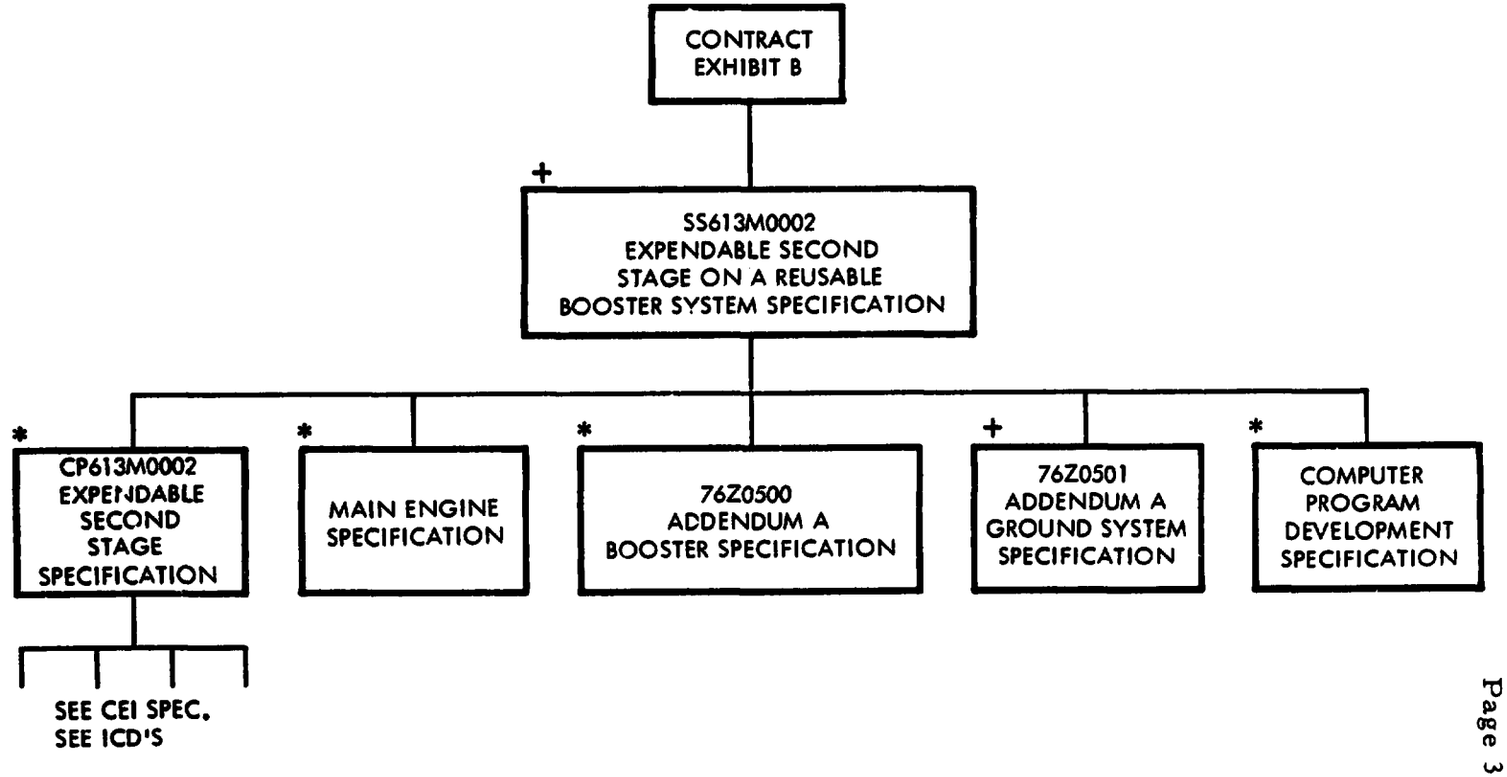

Figure 3-4. Control Document Tree

3.5.1.2 Maintenance Level II. Maintenance Level II shall consist of those maintenance activities performed in direct support of first-level maintenance and involves disposition or repair of hardware removed during first-level maintenance activities. Maintenance Level II shall normally be performed at maintenance shops equipped with special test and checkout equipment and in close proximity to line operations. Level II maintenance shall provide for the removal, replacement, repair, calibration, adjustment, checkout, test, and inspection to the lowest replaceable part. Equipment modifications may be accomplished, when justified, by equipment availability and certification capability.

3.5.1.3 Maintenance Level III. Maintenance Level III shall consist of those maintenance activities performed in direct support of first and second-level maintenance. Maintenance Level III may also involve disposition or repair of hardware removed during first, second and third-level maintenance activities. Maintenance Level III shall normally be performed at more remote locations, such as contractor and vendor factories or government repair and overhaul facilities. Maintenance Level III shall involve major repair or overhaul which is beyond the capabilities of the second-level maintenance facilities.

3.5.2 Supply Support. The ESS system shall be designed and constructed to be compatible with the supply support system policy, location, and distribution and management system specified below.

3.5.2.1 Sparing Policy. The ESS program policy for supporting system operations with spare hardware shall be:

(a) Electrical and electronic spares shall be maintained to the black box level.

(b) Mechanical, structural, TPS, and propulsion spares shall be maintained at the lowest replaceable serialized unit level (LRU).

(c) GSE shall be maintained to the lowest replaceable unit level.

3.5.2.2 Supply Support Locations. Logistics support centers (LSC) shall be established at the prime contractor's, associate contractor's, and selected major subcontractors' facilities, and at the launch operational site. The LSC configuration and support policy shall be consistent with the level of supply support required for equipment, and vehicle hardware, material support.

3.5.2.3 Supply Support Inventory Distribution and Management System. Distribution and control of the ESS program support hardware and materials shall be maintained by an inventory management system. Normal and expedited supply and resupply of support materials and equipment shall be statused at each LSC to support program contract end items consistent with support requirements.

3.5.3 Facilities and Facility Equipments. ESS and space shuttle system facilities and equipment shall be provided to support launch site and alternate recovery site operations. Existing facilities and equipment shall be utilized, wherever possible. New procurement or modifications shall be held to a minimum.

3.5.3.1 Launch Site Facilities and Equipment. Characteristics of the launch site facilities and GSE shall be as specified in Paragraph 3.7.2 and its subparagraphs.

3.5.3.2 Alternate Recovery Site Facilities and Equipment for Booster Only. The booster vehicle shall be capable of utilizing alternate recovery facilities and equipment. Alternate recovery facilities and equipment shall be used to support booster ferry flight operations. Characteristics of alternate recovery site facilities and GSE shall be as specified in 3.7.2.3. (Same as Space Shuttle Paragraph 3.5.3.2.)

3.6 Personnel and Training

3.6.1 Personnel. Manning support of the ESS system and its equipment through all system life cycle phases shall include operational personnel, maintenance crew, and systems control personnel. This manning level shall be defined for a Type (TBD) traffic model and be complementary to the basic space shuttle program.

3.6.1.1 Operational Personnel. The ESS operational personnel shall consist of flight personnel and launch and booster recovery ground crew personnel.

3.6.1.1.1 Flight Personnel. Flight personnel shall consist of booster flight crews. (Same as Space Shuttle Paragraph 3.6.1.1.1.)

	Launch Rate/Year		Ferry Flights/Year	
	(1)		(1)	
Booster Commanders	(TBD)	(TBD)	(TBD)	(TBD)
Booster Pilots	(TBD)	(TBD)	(TBD)	(TBD)
(1) Type (TBD) Traffic Model				

3.6.1.1.2 Launch and Recovery Ground Crews. Ground crews shall be provided to support the following ESS-booster activities at operational and alternate launch sites, and during ferry flight operations.

3.6.1.1.2.1 Operational Launch Site. Ground crews shall be provided to perform operational services during the following activities to support each operational launch site.

(a) Prelaunch
(b) Launch standby
(c) Post launch

3.6.1.1.2.2 Landings. Recovery ground crews will be provided, at primary sites and transported to alternate landing sites, to perform booster post landing operations. (Same as Space Shuttle Paragraph 3.6.1.1.2.2.)

3.6.1.1.2.3 Ferry Flights. Ground crews shall be provided to perform preflight servicing and post-flight operations for booster ferry flights. (Same as Space Shuttle Paragraph 3.6.1.1.2.3.)

3.6.1.1.2.4 Ground Crew Requirements. Ground crew personnel to support a Type (TBD) traffic model shall be as shown in Figure 3-5.

3.6.1.2 Maintenance Crews. Maintenance crews shall be provided at each operational site to perform the following:

(a) Preflight and post-flight inspections
(b) Scheduled and unscheduled maintenance operations
(c) Modifications and changes
(d) Major periodic inspections

	Pre-Launch	Launch Standby	Post Launch	Post Landing	Booster Pre-ferry
Launch Rate/Yr	(1)	(1)	(1)	(1)	(1)
Launch Site Ground Crew	(TBD)	(TBD)	(TBD)		
Pre-launch System C/O Personnel	(TBD)				
Prime Site Recovery Ground Crew				(TBD)	(TBD)
Alt Site Recovery Ground Crew				(TBD)	(TBD)

(1) Type (TBD) Traffic Model

Figure 3-5. Launch and Recovery Personnel

3.6.1.2.1 Maintenance Crew Requirements. Maintenance crews to support a Type (TBD) traffic model shall be as shown here:

	Launch Rate/Year
	(1)
M&R Crew	(TBD)
System Control Personnel	(TBD)

(1) Type (TBD) traffic model

Maintenance and Refurbishment and Systems Control Personnel

3.6.1.3 Systems Control Personnel. Systems control personnel shall be provided to support each operational site to:

(a) Operate simulation equipment.

(b) Assist in flight control of the vehicle.

(c) Operate the mission control center.

(d) Prepare flight plans and profiles.

(e) Assess the perfcrmance of the subsystems from preflight and post-flight data.

3.6.1.3.1 Systems Control Personnel Requirements. Systems control personnel to support a Type (TBD) traffic model shall be as shown in Figure 7.

3.6.2 Training

3.6.2.1 Contractor and Government Training. Training services shall be provided to support the operational use of the ESS system.

3.6.2.1.1 Place of Training. Training shall be provided at:

(a) The contractor's facility

(b) Operational sites

(c) Mission control centers

3.6.2.1.2 Type of Training. The following types of training shall be provided:

(a) Classroom presentations

(b) Shop demonstrations

(c) On-the-job training

(d) Practical-application on trainers and simulators

3.6.2.1.3 Training Program. The training program shall:

(a) Provide for training through the (TBD) level.

(b) Include training on all contractor-furnished equipment.

(c) Include training on Government-furnished equipment, if the Government does not possess in-house capability.

(d) Include interfaces between all Government-furnished subsystems.

3.6.2.1.4 Training. Training of ESS support personnel shall be provided consistent with the Type (TBD) traffic model.

3.6.2.2 Training Equipment. Equipment shall be provided for training purposes as specified in Paragraph 3.7.2.5.5. Training equipment shall include:

(a) Vehicle interface simulators

(b) Vehicle systems simulation trainers

3.6.2.2.1 Training Equipment Maintenance. Training equipment utilized at contractor's facilities shall be updated and refurbished to support the operational training facilities.

3.6.2.3 Training Devices. Training devices shall be provided and shall include:

(a) Models

(b) Dioramas

(c) Operational parts and assemblies

3.6.2.3.1 Use of Training Devices. Training devices shall be employed to develop skills for individuals, groups, and teams in operations familiarization in:

(a) Systems

(b) Subsystems

(c) Components

3.6.2.3.2 Skill Development. Skills shall be developed to perform the following tasks:

(a) Operational sequences

(b) Systems and subsystem operation

(c) Fault detection and isolation

(d) Normal and emergency procedures

(e) Servicing

(f) Inspection

(g) Maintenance

(h) Overhaul procedures

3.6.2.4 Course Materials and Training Aids. Training material shall include:

(a) Handbooks

(b) Workbooks

(c) System and subsystem study guides

(d) Training handouts

(e) Operational and maintenance documentation

(f) Informal documents such as course outlines and lesson plans

(g) Wall charts

(h) Transparency slides

(i) Schematics

(j) Systems configurations

3.7 Functional Area Characteristics

3.7.1 ESS System. The ESS system vehicles shall consist of a payload element, a booster element and an ESS element. The ESS System vehicles elements shall interface with other functional areas as shown in Figure 3-3.

3.7.1.1 Booster. The booster shall be a manned vehicle configured for vertical launch when mated to the ESS plus payload (Reference Paragraph 3.7.1.2). (Same as Space Shuttle Paragraph 3.7.11.)

3.7.1.1.1 Booster Performance Characteristics

3.7.1.1.1.1 Booster Vehicle Boost Capability. The booster vehicle, with the ESS vehicle attached, shall be capable of lifting off the pad and accelerating to a velocity of (TBD) feet per second at an altitude of (TBD) feet.

3.7.1.1.1.1.1 Thrust Vectoring. The booster vehicle shall provide the capability of controlling the thrust vector to satisfy trajectory requirements.

3.7.1.1.1.2 Booster Reentry Capability. The booster vehicle, after booster engine cutoff (BECO) and separation from the ESS, shall be capable of reentering the atmosphere and decelerating to an atmospheric cruise altitude.

3.7.1.1.1.3 Booster Aerodynamic Cruise. The booster vehicle, after booster-ESS separation, shall be capable of cruising to the launch site under its own power. (Same as Space Shuttle Paragraph 3.7.1.1.1.3.)

3.7.1.1.1.4 Booster Landing Capability. Paragraph 3.2.1.2.1.3 and its subparagraphs are incorporated herein by reference. (Same as Space Shuttle Paragraph 3.7.1.1.1.4.)

3.7.1.1.1.5 Booster Ferry Capability. Paragraph 3.2.1.4 and its subparagraphs are incorporated herein by reference. (Same as Space Shuttle 3.7.1.1.1.5.)

3.7.1.1.1.6 Booster Control

3.7.1.1.1.6.1 Booster Nonatmospheric Controls. The booster shall be provided with rotational control around all three axes to control roll during boost, and stabilize attitude during the pre-entry phase. (Same as Space Shuttle Paragraph 3.7.1.1.1.6.1.)

3.7.1.1.1.6.2 Booster Aerodynamic Controls. The booster shall be provided with aerodynamic controls to control the booster during reentry, transition, cruise, and landing. The booster aerodynamic controls shall be adequate for horizontal takeoff. Booster elevons shall be capable of assisting in roll control during the ascent phase of the mated system.

3.7.1.1.1.7 Booster Guidance and Navigation. (Same as Space Shuttle Paragraph 3.7.1.1.1.7.)

3.7.1.1.1.8 Booster Flight Controls. The booster shall be provided with manual and automatic flight controls. (Same as Space Shuttle Paragraph 3.7.1.1.1.8.)

3.7.1.1.1.9 Booster Personnel and Life Support. (Same as Space Shuttle Paragraph 3.7.1.1.1.9.)

3.7.1.1.1.10 Booster Telecommunications. (Same as Space Shuttle Paragraph 3.7.1.1.1.10.)

3.7.1.1.1.11 Booster Display and Controls. Paragraph 3.3.5.4 and its subparagraphs are incorporated herein by reference. (Same as Space Shuttle Paragraph 3.7.1.1.1.11.)

3.7.1.1.2 Physical Characteristics

3.7.1.1.2.1 Booster Liftoff Weight. The liftoff weight of the booster vehicle shall not exceed (TBD) pounds.

3.7.1.1.3 Booster Interfaces

3.7.1.1.3.1 ESS Vehicle Interface. A mechanical interface shall be provided to secure the booster and ESS during the boost phase. At staging, the interface shall allow for decoupling of the booster and ESS. Control, communications, and system status data interface with ESS shall be through a hardwire link prior to staging.

3.7.1.1.3.2 Launch Operations and Services Interface. (Same as Space Shuttle Paragraph 3.7.1.1.3.2.)

3.7.1.1.3.3 Flight Operations and Services Interface. (Same as Space Shuttle Paragraph 3.7.1.1.3.3.)

3.7.1.1.4 Contract End Item (CEI). The booster vehicle shall be in accordance with CEI No. 76Z0500, plus Addendum A.

3.7.1.2 ESS Vehicle. The ESS shall be an unmanned vehicle with provisions for placing large payloads into earth orbit and will have the following characteristics:

(a) The ESS configuration shall be a modified S-II vehicle capable of providing on-orbit positioning of large payloads.

(b) ESS engines - The ESS shall employ the following engine type:

(1) LO_2/LH_2 fueled thrusters and rocket engines shall be utilized to inject the ESS into orbit and for orbital maneuvers.

(2) The main propulsive engines shall conform to engine specification (TBD).

(c) Thermal protection system - A thermal protection system shall be provided. The types shall be designated Block I and Block II.

(1) Block I - The Block I thermal protection system shall consist of bolt-on type external erosion barrier panels over spray foam insulation.

(2) Block II - The Block II thermal protection system shall consist of bonded ablative panels.

(d) Avionics system - An integrated avionics system shall provide for:

(1) Data and control management

(2) Guidance, navigation, and flight control

(3) Power, distribution, and control

(4) Checkout and fault isolation functions

(5) Communications

(e) Auxiliary power - Batteries shall provide ESS electrical power.

(f) Environmental control - Environmental control shall be provided for equipment and thermal control.

3.7.1.2.1 Performance

3.7.1.2.1.1 ESS Boost Capability

3.7.1.2.1.1.1 Ascent to Orbit. Following staging, the ESS vehicle shall have attained a velocity of (TBD) feet per second and an altitude of (TBD) feet. The ESS vehicle shall be capable of ascending, with a maximum payload, to a design reference injection orbit of 66 by 100 nautical miles, and retain sufficient propellant to provide a (TBD) fps ΔV, on-orbit capability in excess of the injection orbit.

3.7.1.2.1.1.2 Orbital Maneuvering System (OMS) Tank Size. The ESS OMS tanks shall be sized for (TBD) fps ΔV.

3.7.1.2.1.1.3 Thrust Vectoring. The ESS shall have the capability of vectoring the thrust to meet trajectory requirements.

3.7.1.2.1.2 Deorbit Capability. The ESS vehicle shall be capable of deorbiting to a preselected area of (TBD) dimensions.

3.7.1.2.1.2.1 ESS Deorbit Methods. The ESS shall be capable of deorbiting by two independent methods. This may be accomplished by redundancy within a single system.

3.7.1.2.1.3 ESS Control

3.7.1.2.1.3.1 ESS Nonatmospheric Controls. The ESS shall be provided with rotational control around all three axes, and translational control on one axis. The controls shall control and stabilize attitude to fulfill mission requirements.

3.7.1.2.1.4 ESS Guidance and Navigation

3.7.1.2.1.4.1 Orbital Phase. The on-board guidance system of the ESS shall guide the vehicle in establishing orbits. With the addition of optional equipment, the on-board guidance system shall provide the capability of rendezvousing with passive targets assisted by vectoring signals from Government-operated support functions.

3.7.1.2.1.4.2 Return Phase. The on-board deorbit sequencer system of the ESS shall guide the ESS vehicle during deorbit.

3.7.1.2.1.4.3 Guidance and Navigation Attitude Constraints. The ESS guidance and navigation system performance shall operate satisfactorily in any vehicle attitude.

3.7.1.2.1.5 ESS Flight Controls. The ESS shall be provided with automatic flight controls.

3.7.1.2.1.5.1 Automatic Flight Controls. The ESS automatic flight control system shall be capable of accepting inputs from the guidance and navigation system (Paragraph 3.7.1.2.1.4). The automatic flight control system shall be capable of commanding the thrust vector (Paragraph 3.7.1.2.1.1.3) and the non-aerodynamic vehicle controls (Paragraph 3.7.1.2.1.3.1).

3.7.1.2.1.5.1.1 Thrust Vectoring and Attitude Control - Thrust Phase. The ESS flight control system shall employ completely automatic thrust vectoring and attitude control, utilizing Guidance and Navigation inputs.

3.7.1.2.1.5.1.2 Thrust Vectoring and Attitude Control - Drifting Phase. The ESS flight control system shall employ completely automatic thrust vectoring and attitude control, utilizing Guidance and Navigation inputs.

3.7.1.2.1.5.1.3 Attitude Control and Maneuvering Deorbit Phase. The ESS flight control system shall employ completely automatic attitude control and maneuvering control, utilizing guidance and navigation inputs.

3.7.1.2.1.6 ESS Payload Delivery. The ESS shall deliver its payload to a predetermined orbit.

3.7.1.2.1.7 ESS Telecommunications

3.7.1.2.1.7.1 ESS to Booster Vehicle. The ESS shall provide for two-way real-time data.

3.7.1.2.1.7.2 ESS to MSFN. The ESS shall provide up and down data and transponding to support tracking capability when the ESS is within line-of-sight of a ground station.

3.7.1.2.1.7.3 ESS to Relay Satellite. The ESS shall provide data via relay satellite when the ESS is within line-of-sight of a satellite.

3.7.1.2.2 ESS Physical Characteristics

3.7.1.2.2.1 ESS Liftoff Weight. The liftoff weight of the ESS shall not exceed (TBD) pounds.

3.7.1.2.2.2 ESS Payload Provision. The ESS shall provide accommodation for a payload as specified in Paragraph 3.2.2.3.

3.7.1.2.3 ESS Interfaces

3.7.1.2.3.1 Booster Vehicle Interface. Paragraph 3.7.1.1.3.1 and its subparagraphs are incorporated herein by reference.

3.7.1.2.3.2 Launch Operations and Services Interface

3.7.1.2.3.2.1 Storage Area and CSE Interface. The ESS vehicle shall have mechanical and electrical interface features compatible with:

(a) Transport equipment attach fittings

(b) Handling equipment attach fittings

(c) Tank pressurization line fittings

(d) Grounding cable attach fittings

(e) (TBD)

3.7.1.2.3.2.2 Launch Pad Facility and GSE Interface. The ESS shall have mechanical and electrical interface features compatible with:

(a) Tank pressurization line fittings

(b) Ground heat exchange line fittings

(c) Ground power umbilical connector fittings

(d) Communications umbilical connector fittings

(e) Propellant loading line fittings

(f) Venting line fittings

(g) Grounding cable attach fittings

(h) (TBD)

3.7.1.2.3.2.3 Maintenance and Refurbishment Facility and GSE Interface. The ESS vehicle shall have mechanical and electrical interface features compatible with:

(a) Transport equipment attach fittings

(b) Handling equipment attach fittings

(c) Work stands and platforms

(d) Nondestructive testing (NDT) equipment

(e) Tank pressurization line fittings

(f) Ground power umbilical connector fittings

(g) Air conditioning and ventilation line fittings

(h) Ground heat exchanger line fittings

(i) Subsystems servicing equipment line fittings

(j) Communications umbilical connector fittings

(k) Grounding cable attach fittings

(l) Hydraulic line fittings

(m) Pneumatic line fittings

(n) (TBD)

3.7.1.2.3.2.4 MP&S Facility and Equipment Interface. The ESS vehicle shall have mechanical and electrical interface features compatible with:

(a) Mission software cassets

(b) (TBD)

3.7.1.2.3.3 Flight Operations and Services Interface

3.7.1.2.3.3.1 Control Center Interface. Communications systems characteristics of the ESS vehicle shall be compatible with control center operations at KSC and MSC.

3.7.1.2.3.3.2 Tracking and Communications Network. The ESS vehicle long-range tracking and communications subsystems shall be compatible with characteristics of the existing MSFN.

3.7.1.2.3.3.3 Satellite Communications Network. The ESS vehicle long-range data communications subsystem shall be capable of operating with the MK-1 tracking and data relay satellite system.

3.7.1.2.3.4 Payload Interface. The ESS vehicle shall contain the necessary mechanisms to install, hold down, and separate from the payload.

3.7.1.2.4 Contract End Item (CEI). The ESS vehicle shall be in accordance with CEI No. CP613M0003.

3.7.2 Launch Operations and Services Complex. The launch operations and services complex shall consist of the following:

(a) A storage area and GSE (see Paragraph 3.7.2.1)

(b) A Launch Pad Facility and GSE (see Paragraph 3.7.2.2)

(c) A Booster Recovery Facility and GSE (see Paragraph 3.7.2.3)

(d) A Maintenance and Refurbishment Facility and GSE (see Paragraph 3.7.2.4)

(e) A Mission Planning and Simulation Facility and equipment (see Paragraph 3.7.2.5

The facilities (a) through (e) interface with other system elements as shown in Figure 3-3. Launch operations and services complex shall be sized and equipped for two ESS vehicle flights per year.

3.7.2.1 Storage Area and GSE Performance and Physical Characteristics. The storage area and appropriate GSE shall be provided to store the ESS and Booster vehicles, and the payloads. The storage area shall provide protection for ESS, boosters, and payloads from the weather environments encountered at the primary launch site. The storage area GSE shall be capable of providing the support necessary to maintain operational integrity of the stored vehicles and payloads during storage period.

3.7.2.1.1 Environmental Control During Storage. A temperature range of (TBD)°F to (TBD)°F and relative of (TBD) percent to (TBD) percent shall be maintained during storage modes.

3.7.2.1.2 Storage Area Power

3.7.2.1.2.1 Primary Power Source. A primary power source shall be provided to operate GSE elements specified in Paragraph 3.7.2.1.4 and other storage area functions (e.g., lighting, environmental control, etc.) which are required to maintain ESS, booster, and payload integrity during storage.

3.7.2.1.2.2 Secondary Power Source. A secondary source of power shall be provided that is independent of commercial or other base power.

3.7.2.1.3 Gas Storage Supply and Lines. A gas storage supply and associated lines shall be provided to maintain ESS and booster propellant tank pressurization and inerting during storage.

3.7.2.1.4 Storage Area Ground Support Equipment

3.7.2.1.4.1 Transport Equipment. Equipment shall be provided to transport the ESS, booster, and payload to and from the storage area.

3.7.2.1.4.2 Pressurization Equipment. Gas pressurant distribution, and control and monitoring equipment shall be provided to maintain pressurization of the vehicle tankage.

3.7.2.1.4.3 Handling Equipment. Storage area handling equipment shall be provided to move the vehicles and payloads within the area.

3.7.2.1.4.4 Subsystem Monitoring

3.7.2.1.4.4.1 ESS and Booster Subsystem Monitoring. Status monitoring of the ESS and booster subsystems shall be accomplished with vehicle on-board checkout subsystems.

3.7.2.1.5 Storage Area

3.7.2.1.5.1 Type III Storage Area. The Type III storage area shall be sized and equipped to store (TBD) ESS, (TBD) boosters, and (TBD) payloads and GSE simultaneously.

3.7.2.1.5.2 Type IV Storage Area. The Type IV storage area shall be sized and equipped to store (TBD) ESS, (TBD) boosters, and (TBD) payloads and GSE simultaneously.

3.7.2.1.6 Storage Area Communications. A two-way voice communications link shall be provided in the storage area between the storage area and control center.

3.7.2.1.7 Vehicle and Payload Grounding. A single point ground shall be provided between each vehicle and ground and between each payload and ground during storage periods.

3.7.2.1.8 (Reserved for future use)

3.7.2.1.9 (Reserved for future use)

3.7.2.1.10 Storage Area Interface

3.7.2.1.10.1 Booster Vehicle Interface. Paragraph 3.7.1.2.3.1 and its subparagraphs are incorporated herein by reference.

3.7.2.1.10.2 ESS Vehicle Interface. Paragraph 3.7.1.2.3.2.1 and its subparagraphs are incorporated herein by reference.

3.7.2.1.10.3 Payload Interface. The storage area GSE shall have mechanical and electrical interface features compatible with:

(TBD)

3.7.2.1.10.4 Control Center Interface. The storage area shall have functional interface features compatible with:

(a) Control center communications link

(b) (TBD)

3.7.2.2 Launch Pad Facility and GSE Performance and Physical Characteristics. A launch pad facility and appropriate GSE shall be provided to prepare, maintain, and launch the ESS system vehicles. Launch pad equipment shall:

(a) Retain the vehicle with hold down devices during the launch preparations, launch standby, and launch status modes

(b) Provide for subsystem servicing, propellant loading, booster personnel loading, and personnel emergency egress

(c) Provide GSE to support and maintain operational integrity of the ESS vehicle during launch preparation and launch standby modes.

(d) Support the following classification:

Launch Pad for a LO and SC Facility - One launch pad shall be provided to support the LO and SC operations.

3.7.2.2.1 Hold Down. Hold-down blocks shall be provided for the reusable booster/ESS/payload vehicle with launch pad retention provided for loads up to full thrust.

3.7.2.2.2 Service Tower. The Service Tower shall be provided with:

(a) An elevator

(b) Swing across arms and platforms

(c) Lines and umbilicals

3.7.2.2.2.1 Elevator. The Service Tower elevator shall provide access to critical ESS system areas.

3.7.2.2.2.2 Swing Access Arms and Platforms. Swing access arms and platforms shall be provided at levels corresponding to ESS vehicle system access doors, connections, and interface areas.

3.7.2.2.2.2.1 Access Arm Movement and Stowage. The access arms shall be capable of moving away from ESS vehicle areas to stowed positions within (TBD) seconds.

3.7.2.2.2.3 Lines and Umbilicals. Fueling, pressurant, vent lines, and umbilicals sh be incorporated as part of the service tower structure.

3.7.2.2.3 Power Sources. The Launch Pad Facility and GSE shall be provided with:

(a) A primary power source

(b) A secondary power source

3.7.2.2.3.1 Primary Power Source. A primary power source shall be provided to:

(a) Operate GSE elements

(b) Operate Service Tower functions

3.7.2.2.3.1.1 GSE. The primary power source shall provide power for the GSE elements specified in Paragraph 3.7.2.2.

3.7.2.2.3.1.2 Service Tower Functions. The primary power source shall provide power for the Service Tower functions required to configure the ESS, booster, and payload subsystems during launch preparation and checkout modes and to maintain subsystem integrity during launch standby and launch status modes.

3.7.2.2.3.2 Secondary Power Source. A secondary power source shall be provided that is independent of commercial and other base power.

3.7.2.2.4 Launch Pad Facility Gas Storage. A gas storage supply and associated lines shall be provided at the Launch Pad Facility to maintain ESS, and booster propellant tank pressurization during launch preparation and launch standby modes.

3.7.2.2.5 Launch Pad Facility Propellant Storage. A propellant storage supply and associated lines shall be provided to load ESS and booster propellant tankage.

3.7.2.2.6 Launch Pad Facility Propellant Loading

3.7.2.2.6.1 Propellant Loading Sequence. Propellant loading of the booster and ESS vehicles shall be as follows:

(a) LO_2 and LH_2 flow shall be started sequentially, then tanking can be continued in parallel flow for the booster vehicle.

(b) LO_2 shall be loaded into the ESS vehicle to at least 40-percent tank capacity prior to LH_2 tanking.

(c) Propellants, liquids, and gases other than LO_2 or LH_2 may be loaded simultaneously. Propellants, liquids, and gases other than LC_2 or LH_2 may be loaded with LO_2 or LH_2 if no safety hazard is involved.

3.7.2.2.6.2 Propellant Loading Time. Propellant loading shall occur prior to booster crew boarding and shall be completed within (TBD) minutes.

3.7.2.2.6.3 Inerting Gases. Inerting gases shall be provided to pressurize and purge LO_2 and LH_2 tankage and lines prior to propellant loading.

3.7.2.2.6.3.1 Inerting Procedure. Inerting gases shall be applied until all air has been exhausted and a maximum of (TBD) psia has been attained.

3.7.2.2.6.4 Contamination Level Monitoring. A means shall be provided to monitor and record liquid, gas, and propellant contamination levels during loading operations.

3.7.2.2.7 Launch Pad Facility Venting. Vent lines from booster and ESS tankage shall be provided. The vent lines shall be routed to separate areas (burn ponds). Separation of the vent lines and burn ponds shall preclude contact with other liquids, gases, or propellants.

3.7.2.2.7.1 Burn Ponds. Burn ponds shall be provided to accept and dispose of excess fluids and gases expelled from the booster and ESS.

3.7.2.2.7.1.1 Burn Pond. Burn ponds shall be provided for hydrogen gas.

3.7.2.2.7.1.2 Burn Pond Location. The burn ponds shall be separated from each other and shall be located a safe distance from other facilities and personnel areas.

3.7.2.2.8 Launch Pad Facility Personnel Loading. (Same as Space Shuttle Paragraph 3.7.2.2.8.)

3.7.2.2.9 Launch Pad Facility Prelaunch Abort and Blast Room Provisions. (Same as Space Shuttle Paragraph 3.7.2.2.9.)

3.7.2.2.10 Launch Pad Facility Communications. A hardline communications link between the control center and launch pad (for ground crew, booster vehicle flight crew) shall be provided and be operational until access arm retraction. An RF link communications backup shall be provided. (Same as Space Shuttle Paragraph 3.7.2.2.10.)

3.7.2.2.11 Launch Pad Facility Grounding. A single point ground shall be provided between the ESS, booster, Launch Pad Facility, and GSE and ground during pad operations. (Same as Space Shuttle Paragraph 3.7.2.2.11.)

3.7.2.2.12 Launch Pad Facility Ground Support Equipment. The Launch Pad Facility GSE to be provided shall include:

(a) Vehicle transport equipment

(b) Gas pressurant distribution, control, and monitoring equipment

(c) Air conditioning and ventilation equipment

(d) Ground heat exchanger equipment

(e) Ground power unit

(f) Propellant transfer equipment

(g) (TBD)

3.7.2.2.12.1 Vehicle Transport Equipment. Equipment shall be provided to transport the ESS system to the launch pad facility.

3.7.2.2.12.2 Gas Pressurant Distribution, Control, and Monitoring Equipment. Gas pressurant distribution, control, and monitoring equipment shall be provided to maintain pressurization of the ESS and booster during launch preparation and launch standby modes until propellant loading begins.

3.7.2.2.12.3 Air Conditioning and Ventilation Equipment. Air conditioning and ventilation equipment shall be provided to maintain temperature and humidity control for the booster flight crew and critical equipment areas.

3.7.2.2.12.4 Ground Heat Exchanger Equipment. Ground heat exchanger equipment shall be provided to maintain temperature control of critical ESS system vehicles electronics operated during ground checkout modes.

3.7.2.2.12.5 Ground Power Unit. A ground power unit shall be provided to supply power to the ESS system vehicles during launch preparations, launch standby, and launch status modes until power transfer to the ESS system vehicles occurs.

3.7.2.2.12.6 Propellant Transfer Equipment. Propellant transfer equipment shall be provided to load propellants in the ESS, booster and payload tankage.

3.7.2.2.13 On-Board Subsystem Checkout. Status monitoring and checkout of ESS, booster subsystems will be accomplished by on-board checkout subsystems (reference Paragraphs 3.2.1.4.2 and 3.1.7.2).

3.7.2.2.14 (Reserved for future use)

3.7.2.2.15 (Reserved for future use)

3.7.2.2.16 Launch Pad Facility Interfaces

3.7.2.2.16.1 Booster Vehicle Interface. Paragraph 3.7.1.1.3.2.2 and its subparagraphs are incorporated herein by reference. (Same as Space Shuttle 3.7.2.2.16.1.)

3.7.2.2.16.2 ESS Vehicle Interface. Paragraph 3.7.1.2.3.2.2 and its subparagraphs are incorporated herein by reference.

3.7.2.2.16.3 Control Center Interface. The launch pad facility shall have mechanical and electrical interface features compatible with:

(a) Communications umbilical connector fittings

(b) (TBD)

3.7.2.2.16.4 Tracking and Communications Network. The Launch Pad Facility shall have functional interface features compatible with:

(a) Tracking and communications network communications links

(b) (TBD)

3.7.2.2.16.5 Satellite Communications Network. The Launch Pad Facility shall have functional interface features compatible with:

(a) Satellite communications network communications links

(b) (TBD)

3.7.2.3 Recovery and Safing Facility and Support Equipment Performance and Physical Characteristics. (Same as Space Shuttle Paragraph 3.7.2.3.)

3.7.2.4 Maintenance and Refurbishment (M&R) Facility and GSE Performance and Physical Characteristics. The M&R facility and appropriate GSE shall be provided to perform post-recovery and mission preparation operations for the Booster; and mission preparations for the ESS vehicle and the payload.

M&R Bays for a LO and SC Facility - (TBD) M&R bays shall be provided to support LO and SC operations.

3.7.2.4.1 M&R Facility Environmental Protection. The M&R facility shall provide the ESS, booster, payloads and ground crews protection from the weather encountered at the primary launch site.

3.7.2.4.1.1 Environmental Control. A temperature range of (TBD)°F to (TBD)°F and a relative humidity range of (TBD) percent to (TBD) percent shall be maintained in the facility during M&R modes.

3.7.2.4.2 M&R Facility Equipment Requirements. The M&R facility equipment shall be provided to:

(a) Obtain access to the ESS, booster, and payload to allow the performance of inspection and maintenance actions by ground crew personnel.

(b) Pressurize propellant tankage

(c) Provide ground power

(d) Air condition and ventilate critical vehicle areas and booster crew compartments

(e) Cool electronics

(f) Service subsystems

(g) Refurbish the recovered ESS components.

(h) Configure subsystems for performance of checkout after maintenance and mission preparation operations have been performed.

(i) Maintain operational integrity of the vehicles and payload module during M&R modes

(j) Transport the booster to post recovery and mission preparation areas

(k) Erect the booster and install on the LUT

(l) Erect and mate the ESS vehicle to the booster vehicle.

(m) Erect and mate the payload with the ESS vehicle

3.7.2.4.3 Power Sources

3.7.2.4.3.1 Primary Power Source. A primary power source shall be provided to operate the GSE elements specified in Paragraph 3.7.2.4.5 and other M&R facility functions (e.g., lighting, environmental control, traveling crane(s), etc.), required to perform ESS, booster, and payload M&R actions.

3.7.2.4.3.2 Secondary Power Source. A secondary source of power shall be provided. The secondary power source shall be independent of commercial or other base power.

3.7.2.4.4 Gas Storage. A gas storage supply and associated lines shall be provided to maintain ESS and booster propellant tank pressurization and inerting during M&R modes.

3.7.2.4.5 M&R Facility Ground Support Equipment

3.7.2.4.5.1 Transport Equipment. Transport equipment shall be provided to transport the booster to the post recovery and mission preparation areas. (Same as Space Shuttle Paragraph 3.7.2.4.5.1.) Transport equipment shall be provided to transport the ESS and payload in the M&R Facility and in the immediate area.

3.7.2.4.5.2 Handling and Loading Equipment. Handling and loading equipment shall be provided to mate the ESS vehicle to the booster vehicle and to mate the payload with the ESS vehicle.

3.7.2.4.5.3 Work Stands and Platforms. Work stands and platforms shall be provided to allow personnel access to the ESS, booster, and payload areas.

3.7.2.4.5.4 Nondestructive Test Equipment. Nondestructive test equipment shall be provided to perform nondestructive testing (NDT) operations on the vehicle structure to verify integrity.

3.7.2.4.5.5 Gas Pressurant, Distribution, and Control Equipment. Gas pressurant, distribution, and control equipment shall be provided to pressurize and inert tankage during M&R operations.

3.7.2.4.5.6 Ground Power Unit. A ground power unit (electrical/hydraulic/pneumatic) shall be provided to supply power to the ESS, booster, and payload during M&R operations.

3.7.2.4.5.7 Air Conditioning and Ventilating Equipment. Air conditioning and ventilating equipment shall be provided to maintain temperature and humidity control of booster flight personnel and critical equipment areas.

3.7.2.4.5.8 Ground Heat Exchanger Equipment. Ground heat exchanger equipment shall be provided to maintain thermal control of critical electronics operated during checkout modes.

3.7.2.4.5.9 Subsystem Servicing Equipment. Subsystems servicing equipment (hydraulics, pressurants, coolants, etc.) shall be provided to service vehicle and payload subsystems during M&R actions.

3.7.2.4.5.10 Vehicle and Payload Precheckout Equipment. Equipment required to configure the vehicle and payload subsystems for checkout and for maintaining operational integrity during M&R modes shall be provided.

3.7.2.4.5.11 ESS and Booster Subsystems Checkout. ESS and booster subsystems checkout subsequent to M&R actions shall be accomplished with on-board checkout subsystems.

3.7.2.4.5.12 Communications. A two-way voice communications link shall be provided between the M&R facility and control center.

3.7.2.4.5.13 Grounding. A single point ground shall be provided between work stands, ESS, and booster vehicles and ground, between work stands and payload and ground during maintenance modes and between the mated ESS vehicle and ground during mission preparation modes.

3.7.2.4.5.14 Vehicle Erection. Erecting equipment shall be provided, at the M&R facility to rotate the ESS vehicle (dry weight) and the payload from the horizontal to the vertical (erect) position. Erecting time shall not exceed (TBD) minutes starting from vehicle/erecting equipment mating and ending with the vehicle erect.

3.7.2.4.5.15 (Reserved for future use)

3.7.2.4.5.16 M&R Interfaces

3.7.2.4.5.16.1 Booster Vehicle Interface. Paragraph 3.7.1.1.3.2.4 and its subparagraphs are incorporated herein by reference. (Same as Space Shuttle Paragraph 3.7.2.4.5.17.1.)

3.7.2.4.5.16.2 ESS Vehicle Interface. Paragraph 3.7.1.2.3.2.3 and its subparagraphs are incorporated herein by reference.

3.7.2.4.5.16.3 Control Center Interface. The M&R facility and GSE shall have mechanical and electrical features compatible with:

(a) Communications umbilical connector fittings

(b) (TBD)

3.7.2.5 Mission Planning and Simulation (MP&S) Facility and Training Equipment Performance and Physical Characteristics. The MP&S facility and appropriate training equipment shall be provided to perform mission planning and personnel training for the ESS system.

3.7.2.5.1 MP&S Facility Environmental Protection. The MP&S facility shall provide the planning and training equipment and personnel with protection from the weather encountered at the primary launch site.

3.7.2.5.2 Environmental Control. A temperature range of (TBD)°F to (TBD)°F and a relative humidity of (TBD) percent to (TBD) percent shall be maintained in the facility during MP&S operations.

3.7.2.5.3 MP&S Equipment Requirements. The MP&S facility equipment shall be provided to:

(a) Prepare initial mission planning software

(b) Develop operational skills as specified in Paragraph 3.6.2.3.2

3.7.2.5.4 Power Sources

3.7.2.5.4.1 Primary Power Source. A primary power source shall be provided to operate the mission planning and training equipment specified in Paragraph 3.7.2.5.5 and other MP&S facility functions.

3.7.2.5.4.2 Secondary Power Source. A secondary source of power shall be provided. The secondary power source shall be independent of commercial or other base power.

3.7.2.5.5 MP&S Facility Planning and Training Equipment. (TBD)

3.7.2.5.5.1 (Reserved for future use)

through

3.7.2.5.5.15 (Reserved for future use)

3.7.2.5.5.16 MP&S Facility Interfaces

3.7.2.5.5.16.1 Booster Vehicle Interface. Paragraph 3.7.1.1.3.2.5 and its subparagraphs are incorporated herein by reference. (Same as Space Shuttle Paragraph 3.7.2.5.5.16.1.)

3.7.2.5.5.16.2 ESS Vehicle Interface. Paragraph 3.7.1.2.3.2.4 and its subparagraphs are incorporated herein by reference.

3.7.2.5.5.16.3 Control Center Interface. The MP&S facility and planning and training equipment shall have mechanical and electrical features compatible with:

(a) Communications umbilical connector fittings

(b) (TBD)

3.7.2.6 Contract End Item (CEI). The Launch Operations and Services Complex shall be described in:

CEI No. (TBD), Ground System General Specification

3.7.3 Payload. (TBD)

3.7.3.1 Payload Module Performance and Physical Characteristics

3.7.3.1.1 Weight and C.G. Distribution (TBD)

3.7.3.1.2 Environmental Control (TBD)

3.7.3.1.3 Power (TBD)

3.7.3.1.4 Payload Mechanical Characteristics

3.7.3.1.4.1 Payload Attach Points. Attach points shall be provided on the payload to:

(a) Effect payload transit and handling during ground operations phases

(b) Provide for deployment of the payload module during the orbital phases.

3.7.3.1.4.2 Commonality. It will be a design objective to maintain a commonality of transport and handling features of the payload with like features on the ESS and booster.

3.7.3.1.4.3 Docking Features (TBD)

3.7.3.1.4.4 (TBD)

3.7.3.1.4.5 (TBD)

3.7.3.1.4.6 Attenuating Devices (TBD)

3.7.3.1.5 Payload Interfaces

3.7.3.1.5.1 ESS Vehicle Interface. Paragraph 3.7.1.2.3.4 and its subparagraphs are incorporated herein by reference.

3.7.3.1.5.2 Storage Area and GSE Interface. Paragraph 3.7.2.1.10.3 and its subparagraphs are incorporated herein by reference.

3.7.3.1.5.3 Launch Pad Facility and GSE Interface. Paragraph 3.7.2.2.16.3 and its subparagraphs are incorporated herein by reference.

3.7.3.1.5.4 Maintenance and Refurbishment Facility and GSE Interface. Paragraph 3.7.2.4.5.16.3 and its subparagraphs are incorporated herein by reference.

3.7.3.2 Contract End Item (CEI). The payload shall be in accordance with CEI No. (TBD)

3.8 Precedence

3.8.1 Documentation. The precedence of Government documents to the requirements of this specification shall be as stated in Paragraph 2.1.

4.0 QUALITY ASSURANCE PROVISIONS

The following paragraphs establish the requirements for formal tests/verifications of the ESS system functional performance, design characteristics, and operability. Formal verification shall establish acceptance of design and development engineering. Each requirement in Section 3 is associated with one or more subparagraphs of Section 4 which defines the verification method(s) and the test category. A Verification Cross Index provides for accountability of each Section 3 requirement. The Index follows Paragraph 4.2.6.10 and identifies all paragraphs in Section 3. Only those requirements identified as Category A have a verification requirement in the System Specification. Those requirements which can be verified by testing at the Prime Item level or below are allocated to the appropriate Prime Item Specification for definition of the test requirement and are identified as Category B requirements. Section 3 paragraphs which do not identify a design and/or performance requirement that is to be formally verified are coded to a "Not Applicable" verification method.

The operational integrity of the system, the individual elements and their interfaces shall be established by collecting and analyzing the data collected during various types of verification which shall include:

(a) Reliability Testing - Special testing for reliability data shall be by exception only. Confidence will be obtained by acquiring data throughout the development, qualification, ground and flight test, acceptance and operational phases of the program. Test data collection and recording requirements will be reviewed for all system level tests. Test data which will be used as a part of the reliability analysis will be collected and recorded as required for system reliability verification purposes. Testing with the primary objective of obtaining reliability data will not be done unless this data cannot be obtained in the Engineering Tests and Evaluations, the Qualification Tests, the Installation Tests, or Formal Performance Verification Tests and Demonstrations.

(b) Engineering Tests and Evaluations - Verification requirements of this type that are not allocated to the Prime Item Specification are limited to those tests which are required for direct support of the design and development activity but which cannot be accomplished by testing performed at the Prime Item Level. In general, these are tests associated with the ESS and/or booster prelaunch/launch/recovery/maintenance and refurbishment activities conducted at KSC to develop the individual elements into a compatible functioning system.

(c) Qualification Testing. Qualification testing as invoked by this specification is primarily that testing which verifies the overall system level requirements. Qualification testing of prime items and critical components is allocated to the appropriate Prime Item Specification wherever possible. Qualification testing of prime items and/or critical components will be specified at the system test level only when the verification requirements cannot be satisfied at the prime item or critical component level. Qualification tests will be performed with rigor, utilizing production configured test articles to verify the functional performance capability in specified environments, and to show compliance with design and performance specifications including margin.

(d) Installation Tests. Installation tests are primarily associated with the support equipment and facilities equipment as installed at the using site. The installation test requirements will be specified in the appropriate Prime Item Specification wherever possible. Installation tests invoked by this specification will be limited to those verification requirements which can be satisfied only by system level tests.

(e) Formal Performance Verification Tests and Demonstrations. Performance Verification Tests and Demonstrations invoked by this specification are limited to those performance verification requirements which must be performed at the system level and cannot be allocated to the appropriate Prime Item Specification. These verifications shall be performed to demonstrate that the system requirements of Section 3 have been satisfied.

4.1 General. The basic program test philosophy is based on progressive, incremental testing in order to meet the program objectives of low cost, flexibility, reliability, maintainability, and safety. The reusable nature of the booster vehicle, the support equipment and facilities allow this approach to be taken with minimum risk to personnel or equipment. This philosophy is also a very cost effective approach to accomplish the test program basic objective: ". . . achieve adequate confidence at minimum cost." The overall test philosophy includes all test and verification activities from tests for material and component selection through initial manned orbital flight of the Space Shuttle. Redundant testing and the resulting proliferation of test hardware and facilities can only be minimized through a well disciplined test/test requirements integration system. Although this system is a necessary part of the final test program, definition of this system is beyond the scope of this specification. The quality assurance requirements identified in this

specification are limited to those formal tests and/or verifications for which the customer requires formal approved documentation in the form of test requirements, test procedures, test acceptance criteria and test results. This includes the activities associated with the preproduction development, qualification and certification of the operationally configured flight elements, support equipment and facilities.

The flight elements will be tested as individual items, first at Test Facilities and then at the Operational Facility. The severity of the flight environment will be progressively increased until the maximum performance attainable by the prime item is achieved. The final phase of development flight testing will involve mated launches from the operationally configured launch facility to demonstrate the Design Reference Mission capability. The requirements associated with this final mated launch phase are included as a part of this System Specification. All design requirements which can be verified by tests at the prime item or lower level are allocated to the appropriate Prime Item Specification.

4.1.1 Responsibility for Tests

4.1.1.1 System Development Contractor. Unless otherwise specified in the contract, the System Development Contractor is responsible for the performance of all tests responsive to the test requirements specified herein as system level test requirements. The System Development Contractor is also responsible for the integration and approval of all tests responsive to test requirements allocated to and contained in the Prime Item Specifications. Except as otherwise specified, the System Development Contractor may use his own facility, those of his suppliers or subcontractors, those of the prime item contractors, or any commercial laboratory acceptable to the customer. All tests and test facilities in response to test requirements set forth in this specification are subject to customer approval prior to the commencement of any test activities. Where customer approval has been identified as a prerequisite to the commencement of a test activity, the material to be approved shall be submitted to the customer in sufficient time for customer review and approval without jeopardizing schedules. All such tests are subject to witnessing by the customer or his designated representative at the customer's discretion. Maximum use shall be made of existing or Government-owned test facilities, wherever practical.

4.1.1.2 Prime Item Contractor Responsibility. The Prime Item Contractor responsibility will be as defined in the applicable Prime Item Specification. In addition, the Prime Item Contractor, in coordination with the System Development Contractor, shall identify those test requirements

which have a direct influence on the integration of the prime items into a total ESS vehicle. The tests and test schedules associated with these so identified test requirements will be subject to approval by the System Development Contractor prior to commencement of the test.

4.1.1.3 Customer Responsibility. Where customer approval is required for any specified phase of the test activity, this approval (or non-approval) shall be accomplished in a timely manner so as not to impact schedule requirements.

4.2 Quality Conformance Inspections. The following paragraphs cover the test/verification requirements necessary to verify that the requirements of Section 3 have been achieved. The Section 3 requirement paragraph number to which the Section 4 paragraph addresses itself is shown in parentheses following the Section 4 paragraph number. Any given Section 4 paragraph may provide verification requirements for all or part of the referenced Section 3 paragraph. Insofar as is practical, the tests are listed in a logical sequence. Contractor quality assurance criteria shall be in general accordance with NASA Publication NHB 5300.4 (1B).

Verification requirements that are specified herein are system level only and are identified in the cross reference matrix as Category A. Verification requirements that can be satisfied at the prime item level or lower are allocated to the appropriate Prime Item Specification(s) and are identified in the cross reference matrix as Category B.

Verification requirements classed as Preproduction are those requirements which establish acceptance of the basic design and/or procedure. Requirements classed as Acceptance are those requirements imposed on each delivered article to ensure conformance to the approved design. Verification may be by one or more of several methods including inspection, review of analytical data, demonstration, and test.

4.2.1 Verification of ESS System Characteristics. (See Verification Cross Reference Index, Page 71.)

4.2.1.1 (3.2.1.1) - Assembly and Launch. Verification of achievement of the specified launch rate capability by the ESS system will be accomplished by analysis. The capabilities of the individual system elements demonstrated during the individual system element verifications, and the ESS System capabilities demonstrated during system level operations will be assessed to verify that the launch rates specified in the traffic models can be supported. A repetitive series of launches for the sole purpose of demonstrating a sustained launch rate shall not be done.

4.2.1.2 (3.2.1.1.5) - ESS System Vehicles Erection. Tests will be performed as required to demonstrate the capability of the equipment, procedures, and facilities to erect and mate the ESS vehicle, booster and to restrain the vehicle under all environmental conditions defined in Paragraph 3.2.1.1.5. The capability to demate and lower the ESS and booster to a horizontal condition must also be demonstrated.

4.2.1.3 (3.2.1.1.4) - Transport to Launch Facility. Tests will be performed as required to demonstrate the capability of the equipment, procedures and facilities to transport the mated ESS and booster vehicle from the mating area to the launch pad and return. The ESS vehicle combination empty dry weight will vary with the different unfueled payloads mated onto the ESS.

4.2.1.4 (3.2.1.1.7.1 - 3.2.1.1.7.3 - 3.2.1.2.1.2) - Launch Operations. Tests and operations will be performed as required to demonstrate the capability of the ESS system support equipment, procedures, and facilities in conjunction with the ESS vehicle to accomplish the following activities, not necessarily in the order listed:

(a) Place the ESS vehicle and the launch support equipment and facilities in a launch standby status.

(b) Prepare the ESS vehicle, support equipment and facilities for a launch of the ESS vehicle from standby status as specified in Paragraph 3.2.1.1.7.1. This includes but is not limited to propellant loading of both the ESS and Booster and Booster flight personnel loading, final checkout and countdown.

(c) Perform an integrated ESS system vertical launch.

4.2.1.5 (3.2.1.5) - Mission Abort. No ESS system level tests or demonstrations shall be performed for the sole purpose of verifying the ESS vehicle abort capability. Verification of abort capability shall be accomplished by a combination of ground test and analysis of nominal mission flight test data.

4.2 1.6 (3.2.2.2) - Gross Weight. The ESS vehicle liftoff weight for orbital operational launch shall be verified to be equal to or less than the specified weight in Paragraph 3.2.2.3. Verification shall be by analysis of the weight status of the individual ESS/booster and payload elements.

4.2.2 (3.3) - Verification of ESS System Design and Construction Requirements. The quality assurance provisions to verify compliance with design and construction requirements of Section 3.3 are all allocated to the prime item level.

4.2.3 (3.4) - Verification of ESS System Documentation Requirements. The establishment of a documentation system as defined in Paragraph 3.4 shall be verified by inspection.

4.2.4 Verification of ESS System Logistics Requirements

4.2.4.1 (3.5.1 - 3.5.1.1 - 3.5.1.2 - 3.5.1.3) - Maintenance. The establishment of a Shuttle System maintenance capability at three separate levels, Level I, Level II, and Level III shall be demonstrated. The individual maintenance level capability shall be in accordance with the requirements defined in Paragraphs 3.5.1.1, 3.5.1.2, and 3.5.1.3.

4.2.4.2 (3.5.2 - 3.5.2.1 - 3.5.2.2 - 3.5.2.3) - Supply Support. The establishment of a supply support system for the ESS system shall be demonstrated. The supply support system shall include provisions for sparing, supply support inventory, distribution and management at designated support locations as specified in Paragraphs 3.5.2.1, 3.5.2.2, and 3.5.2.3.

4.2.5 (3.6) - Verification of ESS System Personnel and Training Requirements. Measurement standards to verify adequate manning support for the shuttle program are to be determined.

4.2.6 Verification of ESS System Functional Area Characteristics

4.2.6.1 (3.7.1.1.1) - Booster Vehicle Boost Capability. The capability of the booster vehicle to lift off the launch pad in a vertical launch with an ESS vehicle attached and to accelerate to a velocity and altitude as specified in Paragraph 3.7.1.1.1 shall be demonstrated by an initial operational flight. The trajectory requirements shall be accomplished by controlling the booster thrust vector. The three-axis rotational control's performance capability during nonatmospheric conditions shall be demonstrated. Boost phase guidance shall be by an on-board guidance system.

4.2.6.2 (3.7.1.1.1.2 - 3.7.1.1.1.7.2 - 3.7.1.1.1.8) - Booster Reentry Capability. Following the mated launch to staging altitude/velocity conditions and completion of separation from the ESS, the booster shall demonstrate the capability of reentering the earth's atmosphere and decelerating to an atmospheric cruise altitude. Three axes rotational

control capability during the non-atmospheric condition through the translation to atmospheric conditions shall be demonstrated. The controls shall be actuated by the on-board guidance system.

4.2.6.3 (3.7.1.1.3.1 - 3.7.1.2.3.1) - Booster/ESS Interface Verification. The ESS/booster mechanical interface as described in Paragraph 3.7.1.1.3.1 shall be verified by mating operations on the ground prior to launch, securing of the ESS, to the booster during boost and successful separation at staging. The control, communications, and system status RF interface shall be demonstrated through the same phases.

4.2.6.4 Launch Operations and Services/Booster Interface Verification. (Same as Space Shuttle Paragraph 4.2.5.4.)

4.2.6.5 Flight Operations and Services/Booster Interface Verification. (Same as Space Shuttle Paragraph 4.2.5.5.)

4.2.6.6 (3.2.1.2.5.1 - 3.7.1.2.1.1.1 - 3.7.1.2.1.1.3 - 3.7.1.2.1.6.1-3.7.1.2.1.7.1) - ESS Vehicle Ascent to Orbit Verification. The capability of the ESS to ascend to a design reference orbit as defined in Paragraph 3.7.1.2.1.1.1 with payload and propellant reserve for on-orbit velocity change as defined in Paragraph 3.7.1.2.1.1.1 shall be demonstrated as a part of the integrated mated vehicle initial launch. Thrust vectoring capability to meet trajectory requirements shall be demonstrated. ESS rotational control around all three axes and translation in one axis in response to commands from the on-board guidance system shall be demonstrated.

4.2.6.7 (3.7.1.2.3.2.1 - 3.7.1.2.3.2.2 - 3.7.1.2.3.2.3 - 3.7.1.2.3.2.4 - 3.7.1.2.3.2.5 - 3.7.2.1.10.2 - 3.7.2.2.16.2) - Launch Operations and Services/ESS Interface Verification. The interfaces between the ESS and the Storage Area facility, Launch Pad facility, the Maintenance and Refurbishment facility and the Mission Planning and Simulation facility as described in Paragraphs 3.7.1.2.3.2.1, 3.7.1.2.3.2.2, 3.7.1.2.3.2.3, 3.7.1.2.3.2.4, and 3.7.1.2.3.2.5 shall be verified during normal cycling of the ESS through these facilities during the ESS vehicle development phase. The verification shall include the interface with the appropriate facility oriented GSE as applicable.

4.2.6.8 (3.7.1.2.3.3.1 - 3.7.1.2.3.3.2 - 3.7.1.2.3.3.3) - Flight Operations and Services/Ess Interface Verification. The interfaces between the ESS and the Control Center, the Tracking and Communications Network and the Satellite Communications Network as defined in Paragraphs 3.7.1.2.3.3.1, 3.7.1.2.3.3.2, and 3.7.1.2.3.3.3 shall be verified during

normal cycling of the ESS through the launch and flight operations during the ESS vehicle development phase.

4.2.6.9 (3.7.1.2.3.5.1 - 3.7.1.2.3.5.2) - Payload/ESS Interface Verification. The interface between the ESS and the payload as specified in Paragraphs 3.7.1.2.3.5.1 and 3.7.1.2.3.5.2 shall be verified as part of the prelaunch, launch and orbital flight operations.

4.2.6.10 (3.7.2.2.8.1) - Booster Flight Personnel Loading Time Verification. (Same as Space Shuttle Paragraph 4.2.5.15.)

ESS SYSTEM SPECIFICATION VERIFICATION CROSS REFERENCE INDEX

VERIFICATION CATEGORY LEGEND:

N/A Not Applicable
A System Level Verification
B *Prime Item Level Verification

*NOTE: See referenced Prime Item Specification for verification requirements. Prime Item Specifications are coded in the Section 4 Verification Requirement Column as follows:

① Booster Prime Item Specification No. 76Z0500
② ESS Prime Item Specification No. CP613M0003
③ Ground System General Specification No. 76Z0501
④ Payload Prime Item Specification No. (TBD)
⑤ Orbiter Prime Item Specification No. CP613M0002

SECTION 3 REQUIREMENT REFERENCE	VERIFICATION ALLOCATION					SECTION 4 VERIFICATION REFERENCE
	VERIFICATION CATEGORY			VERIFICATION CLASSIFICATION		
	N/A	A	B	PRE-PRODUCTION	ACCEPTANCE	
3	x					
3.1	x					
3.1.1	x					
3.1.1.1	x					
3.1.1.1.1	x					
3.1.1.1.2	x					
3.1.1.1.3	x					
3.1.1.2	x					

SECTION 3 REQUIREMENT REFERENCE	VERIFICATION ALLOCATION					SECTION 4 VERIFICATION REFERENCE
	VERIFICATION CATEGORY			VERIFICATION CLASSIFICATION		
	N/A	A	B	PRE-PRODUCTION	ACCEPTANCE	
3.1.2	x					
3.1.2.1	x					
3.1.2.1.1	x					
3.1.2.1.2	x					
3.1.2.1.3	x					
3.1.2.1.4	x					
3.1.2.2	x					
3.1.3	x					
3.1.3.1	x					
3.1.3.1.1	x					
3.1.3.1.2	x					
3.1.3.1.3	x					
3.1.3.1.4	x					
3.1.3.1.5	x					
3.1.3.2	x					
3.1.4	x					
3.1.5	x					
3.1.6	x					
3.1.7	x					

SECTION 3 REQUIREMENT REFERENCE	VERIFICATION ALLOCATION					SECTION 4 VERIFICATION REFERENCE
	VERIFICATION CATEGORY			VERIFICATION CLASSIFICATION		
	N/A	A	B	PRE-PRODUCTION	ACCEPTANCE	
3.1.7.1	x					
3.1.7.1.1	x					
3.1.7.1.2	x					
3.1.7.1.3	x					
3.1.7.2	x					
3.1.7.3	x					
3.1.7.4	x					
3.1.7.4.1	x					
3.1.7.4.2	x					
3.1.7.4.3	x					
3.1.7.5	x					
3.1.7.6	x					
3.1.7.7	x					
3.2	x					
3.2.1	x					
3.2.1.1		x		x		4.2.1.1
3.2.1.1.1	x					
3.2.1.1.2			x			③
3.2.1.1.3			x			③

SECTION 3 REQUIREMENT REFERENCE	VERIFICATION ALLOCATION					SECTION 4 VERIFICATION REFERENCE
	VERIFICATION CATEGORY			VERIFICATION CLASSIFICATION		
	N/A	A	B	PRE-PRODUCTION	ACCEPTANCE	
3.2.1.1.4		x		x		4.2.1.3
3.2.1.1.5		x		x		4.2.1.2
3.2.1.1.6	x					
3.2.1.1.6.1			x			③
3.2.1.1.6.2			x			③
3.2.1.1...3			x			① ②
3.2.1.1.6.4			x			① ② (① shuttle)
3.2.1.1.7	x					
3.2.1.1.7.1		x		x		4.2.1.4
3.2.1.1 7.2			x			① ②
3.2.1.1.7.3		x		x		4.2.1.4
3.2.1.1.7.4			x			③ shuttle
3.2.1.2	x					
3.2.1.2.1	x					
3.2.1.2.1.1	x					
3.2.1.2.1.2		x		x		4.2.1 4
3.2.1.2.1.3			x			① shuttle
3.2.1.2.1.4			x	x		①

SECTION 3 REQUIREMENT REFERENCE	VERIFICATION ALLOCATION					SECTION 4 VERIFICATION REFERENCE
	VERIFICATION CATEGORY			VERIFICATION CLASSIFICATION		
	N/A	A	B	PRE-PRODUCTION	ACCEPTANCE	
3.2.1.2.2			x			(1) shuttle
3.2.1.2.3			x			(1) shuttle
3.2.1.2.4		x		x		(1) (2)
3.2.1.2.5	x					
3.2.1.2.5.1		x		x		4.2.6.6
			x			(2)
3.2.1.2.5.2			x			(1) shuttle
3.2.1.2.5.3			x			(1) (2)
3.2.1.2.6			x			(1) (2)
3.2.1.2.7			x			(1) (2) ((1) shuttle)
3.2.1.2.8			x			(2)
3.2.1.3			x			(2)
3.2.1.3.1			x			(1) shuttle
3.2.1.3.2	x					
3.2.1.3.2.1			x			(3) (5) shuttle
3.2.1.3.2.2	x					
3.2.1.3.2.3	x					
3.2.1.3.3			x			(3) shuttle

SECTION 3 REQUIREMENT REFERENCE	VERIFICATION ALLOCATION					SECTION 4 VERIFICATION REFERENCE
	VERIFICATION CATEGORY			VERIFICATION CLASSIFICATION		
	N/A	A	B	PRE-PRODUCTION	ACCEPTANCE	
3.2.1.3.4			x			③ shuttle
3.2.1.3.5			x			① ② (① shuttle)
3.2.1.3.6			x			③
3.2.1.4	x					
3.2.1.4.1			x			① shuttle
3.2.1.4.2			x			③ shuttle
3.2.1.4.3			x			① ③ ⑤ shuttle
3.2.1.4.4			x			① shuttle
3.2.1.4.5			x			① shuttle
3.2.1.4.6	x					
3.2.1.4.6.1			x			②
3.2.1.4.6.2			x			②
3.2.1.4.6.3			x			②
3.2.1.4.6.4			x			②
3.2.1.5		x				4.2.1.5
3.2.1.5.1			x			① ③ shuttle
3.2.1.5.2			x			① ② (① shuttle)

SECTION 3 REQUIREMENT REFERENCE	VERIFICATION ALLOCATION					SECTION 4 VERIFICATION REFERENCE
	VERIFICATION CATEGORY			VERIFICATION CLASSIFICATION		
	N/A	A	B	PRE-PRODUCTION	ACCEPTANCE	
3.2.1.5.3			x			(1) shuttle
3.2.1.5.4			x			(1) shuttle
3.2.2	x					
3.2.2.1			x			(1) (2) ((1) shuttle)
3.2.2.1.1			x			(1) shuttle
3.2.2.2		x				4.2.1.6
3.2.2.3			x	x		(2)
3.2.2.3.1			x	x		(2)
3.2.2.3.2			x	x		(2)
3.2.2.4			x			(2)
3.2.2.4.1			x	x		(2)
3.2.2.5			x			(1) (2) ((1) shuttle)
3.2.2.6			x	x		(2)
3.2.2.7			x			(1) shuttle
3.2.3	x					
3.2.3.1	x					
3.2.3.2	x					
3.2.4	x					

SECTION 3 REQUIREMENT REFERENCE	VERIFICATION ALLOCATION					SECTION 4 VERIFICATION REFERENCE
	VERIFICATION CATEGORY			VERIFICATION CLASSIFICATION		
	N/A	A	B	PRE-PRODUCTION	ACCEPTANCE	
3.2.4.1	x					
3.2.4.2			x			① ② (① shuttle)
3.2.5	x					
3.2.6	x					
3.2.7	x					
3.2.7.1			x			② (① ③ ④ ⑤ shuttle)
3.2.7.2			x			② (① ③ ④ ⑤ shuttle)
3.2.7.2.1			x			① shuttle
3.2.7.2.2	x					
3.2.7.2.2.1			x			① ② (① shuttle)
3.2.7.2.2.2			x			① ② (① shuttle)
3.2.7.2.2.3			x			① ② (① shuttle)
3.2.8	x					
3.3	x					4.2.2
3.3.1			x			② (① ③ ④ ⑤ shuttle sys)

SECTION 3 REQUIREMENT REFERENCE	VERIFICATION ALLOCATION					SECTION 4 VERIFICATION REFERENCE
	VERIFICATION CATEGORY			VERIFICATION CLASSIFICATION		
	N/A	A	B	E-PRODUCTION	ACCEPTANCE	
3.3.1.1			x			(2) ((1) (3) (4) (5) shuttle sys)
3.3.1.2			x			(2) ((1) (3) (4) (5) shuttle sys)
3.3.1.2.1			x			(2) ((1) (3) (4) (5) shuttle sys)
3.3.1.3			x			(2) ((1) (3) (4) (5) shuttle sys)
3.3.1.4			x			(2) ((1) (3) (4) (5) shuttle sys)
3.3.1.5			x			(2) ((1) (3) (4) (5) shuttle sys)
3.3.1.6			x			(3)
3.3.1.7			x			(2) ((1) (4) (5) shuttle sys)
3.3.1.8			x			(2) ((1) (3) (4) (5) shuttle sys)
3.3.1.9			x			(2) ((1) (3) (4) (5) shuttle sys)
3.3.1.10			x			(2) ((1) (4) (5) shuttle sys)
3.3.1.11			x			(2) ((1) (3) (4) (5) shuttle sys)

SECTION 3 REQUIREMENT REFERENCE	VERIFICATION ALLOCATION					SECTION 4 VERIFICATION REFERENCE
	VERIFICATION CATEGORY			VERIFICATION CLASSIFICATION		
	N/A	A	B	PRE-PRODUCTION	ACCEPTANCE	
3.3.1 11.1			x			② (① ③ ④ ⑤ shuttle sys)
3.3.1.12			x			② (① ⑤ shuttle sys)
3.3.1.13			x			② (① ④ ⑤ shuttle sys)
3.3.4	x					
3.3.4.1			x			② (① ③ ④ ⑤ shuttle)
3.3.4.2			x			② (① ③ ④ ⑤ shuttle)
3.3.4.3			x			② (① ③ ⑤ shuttle)
3.3.4.4			x			① shuttle
3.3.4.5	x					
3.3.4.6			x			② (① ③ ④ ⑤ shuttle)
3.3.4.7			x			③ shuttle
3.3.4.8			x			③ shuttle
3.3.4.9			x			② (① ⑤ shuttle)
3.3.5	x					
3.3.5.1	x					

SECTION 3 REQUIREMENT REFERENCE	VERIFICATION ALLOCATION					SECTION 4 VERIFICATION REFERENCE
	VERIFICATION CATEGORY			VERIFICATION CLASSIFICATION		
	N/A	A	B	PRE-PRODUCTION	ACCEPTANCE	
3.3.5.2			x			② (① shuttle)
3.3.5.3			x			① shuttle
3.3.5.4			x			① ⑤ shuttle
3.3.5.5			x			① shuttle
3.3.5.6			x			① ③ ④ ⑤ shuttle
3.3.5.7			x			① ③ ④ ⑤ shuttle
3.3.5.8			x			① ② ③
3.4		x		x		4.2.3
3.5	x					
3.5.1		x		x		4.2.4.1
3.5.1.1		x		x		4.2.4.1
3.5.1.2		x		x		4.2.4.1
3.5.1.3		x		x		4.2.4.1
3.5.2		x		x		4.2.4.2
3.5.2.1		x		x		4.2.4.2
3.5.2.2		x		x		4.2.4.2
3.5.2.3		x		x		4.2.4.2

SECTION 3 REQUIREMENT REFERENCE	VERIFICATION ALLOCATION					SECTION 4 VERIFICATION REFERENCE
	VERIFICATION CATEGORY			VERIFICATION CLASSIFICATION		
	N/A	A	B	PRE-PRODUCTION	ACCEPTANCE	
3.5.3			x			③
3.5.3.1	x					
3.5.3.2	x					
3.6	x					
3.6.1		x				4.2.5
3.6.1.1		x				4.2.5
3.6.1.1.1			x			4.2.5
3.6.1.1.2	x					
3.6.1.1.2.1	x					
3.6.1.1.2.2	x					
3.6.1.1.2.3	x					
3.6.1.1.2.4	x					
3.6.1.2	x					
3.6.1.2.1	x					
3.6.1.3	x					
3.6.1.3.1	x					
3.6.2	x					
3.6.2.1	x					
3.6.2.1.1	x					

SECTION 3 REQUIREMENT REFERENCE	VERIFICATION ALLOCATION					SECTION 4 VERIFICATION REFERENCE
	VERIFICATION CATEGORY			VERIFICATION CLASSIFICATION		
	N/A	A	B	PRE-PRODUCTION	ACCEPTANCE	
3.6.2.1.2	x					
3.6.2.1.3	x					
3.6.2.1.4	x					
3.6.2.2	x					
3.6.2.2.1	x					
3.6.2.3	x					
3.6.2.3.1	x					
3.6.2.3.2	x					
3.6.2.4	x					
3.7	x					
3.7.1	x					
3.7.1.1			x			(1) shuttle
3.7.1.1.1	x					
3.7.1.1.1.1		x		x		4.2.6.1
3.7.1.1.1.1.1		x		x		4.2.6.1
3.7.1.1.1.2		x		x		4.2.6.2
3.7.1.1.1.3			x			(1) shuttle
3.7.1.1.1.4			x			(1) shuttle
3.7.1.1.1.5			x			(1) shuttle

SECTION 3 REQUIREMENT REFERENCE	VERIFICATION ALLOCATION					SECTION 4 VERIFICATION REFERENCE
	VERIFICATION CATEGORY			VERIFICATION CLASSIFICATION		
	N/A	A	B	PRE-PRODUCTION	ACCEPTANCE	
3.7.1.1.1.6	x					
3.7.1.1.1.6.1			x			(1) shuttle
3.7.1.1.1.6.2			x			(1)
3.7.1.1.1.7	x					
3.7.1.1.1.8			x			(1) shuttle
3.7.1.1.1.9			x			(1) shuttle
3.7.1.1.1.10			x			(1) shuttle
3.7.1.1.1.11			x			(1) shuttle
3.7.1.1.2	x					
3.7.1.1.2.1			x			(1)
3.7.1.1.3	x					
3.7.1.1.3.1		x		x		4.2.6.3
3.7.1.1.3.2			x	x		4.2.6.4 shuttle
3.7.1.1.3.3			x	x		4.2.6.5
3.7.1.1.4	x					
3.7.1.2			x			(2)
3.7.1.2.1	x					
3.8.1.2.1.1	x					
3.7.1.2.1.1.1			x	x		4.2.6.6

SECTION 3 REQUIREMENT REFERENCE	VERIFICATION ALLOCATION					SECTION 4 VERIFICATION REFERENCE
	VERIFICATION CATEGORY			VERIFICATION CLASSIFICATION		
	N/A	A	B	PRE-PRODUCTION	ACCEPTANCE	
3.7.1.2.1.1.2			x	x		4.2.6.6
3.7.1.2.1.1.3			x	x		4.2.6.6
3.7.1.2.1.2			x			②
3.7.1.2.1.2.1			x	x		②
3.7.1.2.1.3			x			②
3.7.1.2.1.3.1			x			②
3.7.1.2.1.4	x					②
3.7.1.2.1.4.1			x			②
3.7.1.2.1.4.2			x			②
3.7.1.2.1.4.3			x			②
3.7.1.2.1.5			x			②
3.7.1.2.1.5.1			x			②
3.7.1.2.1.5.1.1			x			②
3.7.1.2.1.5.1.2			x			②
3.7.1.2.1.5.1.3			x			②
3.7.1.2.1.6			x			②
3.7.1.2.1.7	x					
3.7.1.2.1.7.1		x		x		① ②
3.7.1.2.1.7.2			x	x		②

SECTION 3 REQUIREMENT REFERENCE	VERIFICATION ALLOCATION					SECTION 4 VERIFICATION REFERENCE
	VERIFICATION CATEGORY			VERIFICATION CLASSIFICATION		
	N/A	A	B	PRE-PRODUCTION	ACCEPTANCE	
3.7.1.2.1.7.3			x			②
3.7.1.2.2	x					
3.7.1.2.2.1			x			②
3.7.1.2.2.2			x			②
3.7.1.2.3	x					
3.7.1.2.3.1		x		x		4.2.6.3
3.7.1.2.3.2	x					
3.7.1.2.3.2.1		x		x		4.2.6.7
3.7.1.2.3.2.2		x		x		4.2.6.7
3.7.1.2.3.2.3		x		x		4.2.6.7
3.7.1.2.3.2.4		x		x		4.2.6.7
3.7.1.2.3.3	x					
3.7.1.2.3.3.1		x		x		4.2.6.8
3.7.1.2.3.3.2		x		x		4.2.6.8
3.7.1.2.3.3.3		x		x		4.2.6.8
3.7.1.2.3.4		x				4.2.6.9
3.7.1.2.4	x					
3.7.2			x			③
3.7.2.1			x			③

SECTION 3 REQUIREMENT REFERENCE	VERIFICATION ALLOCATION					SECTION 4 VERIFICATION REFERENCE
	VERIFICATION CATEGORY			VERIFICATION CLASSIFICATION		
	N/A	A	B	PRE-PRODUCTION	ACCEPTANCE	
3.7.2.1.1			x			③
3.7.2.1.2	x					
3.7.2.1.2.1			x			③ shuttle
3.7.2.1.2.2			x			③ shuttle
3.7.2.1.3			x			③ shuttle
3.7.2.1.4	x					
3.7.2.1.4.1			x			③
3.7.2.1.4.2			x			③
3.7.2.1.4.3			x			③
3.7.2.1.4.4	x					
3.7.2.1.4.4.1			x			① ② (① shuttle)
3.7.2.1.5	x					
3.7.2.1.5.1			x			③
3.7.2.1.5.2			x			③
3.7.2.1.6			x			③ shuttle
3.7.2.1.7			x			① ② ③ ④
3.7.2.1.10	x					
3.7.2.1.10.1		x		x		4.2.6.4 shuttle

SECTION 3 REQUIREMENT REFERENCE	VERIFICATION ALLOCATION					SECTION 4 VERIFICATION REFERENCE
	VERIFICATION CATEGORY			VERIFICATION CLASSIFICATION		
	N/A	A	B	PRE-PRODUCTION	ACCEPTANCE	
3.7.2.1.10.2		x		x		4.2.6.3
3.7.2.1.10.3		x		x		4.2.6.9
3.7.2.1.10.4			x			③
3.7.2.2			x			③
3.7.2.2.1			x			③
3.7.2.2.2			x			③
3.7.2.2.2.1			x			③
3.7.2.2.2.2			x			③
3.7.2.2.2.2.1			x			③
3.7.2.2.2.3			x			③
3.7.2.2.3			x			③ shuttle
3.7.2.2.3.1			x			③ shuttle
3.7.2.2.3.1.1			x			③ shuttle
3.7.2.2.3.1.2			x			③
3.7.2.2.3.2			x			③ shuttle
3.7.2.2.4			x			③ shuttle
3.7.2.2.5			x			③ shuttle
3.7.2.2.6	x					
3.7.2.2.6.1			x			③

SECTION 3 REQUIREMENT REFERENCE	VERIFICATION ALLOCATION					SECTION 4 VERIFICATION REFERENCE
	VERIFICATION CATEGORY			VERIFICATION CLASSIFICATION		
	N/A	A	B	PRE-PRODUCTION	ACCEPTANCE	
3.7.2.2.6.2			x			③
3.7.2.2.6.3			x			③
3.7.2.2.6.3.1			x			③
3.7.2.2.6.4			x			③
3.7.2.2.7			x			③
3.7.2.2.7.1			x			③ shuttle
3.7.2.2.7.1.1			x			③ shuttle
3.7.2.2.7.1.2			x			③ shuttle
3.7.2.2.8			x			① shuttle
3.7.2.2.9			x			③ shuttle
3.7.2.2.10			x			③ shuttle
3.7.2.2.11			x			③ shuttle
3.7.2.2.12			x			③ shuttle
3.7.2.2.12.1			x			③
3.7.2.2.12.2			x			③ shuttle
3.7.2.2.12.3			x			③ shuttle
3.7.2.2.12.4			x			③ shuttle
3.7.2.2.12.5			x			③ shuttle
3.7.2.2.12.6			x			③

SECTION 3 REQUIREMENT REFERENCE	VERIFICATION ALLOCATION					SECTION 4 VERIFICATION REFERENCE
	VERIFICATION CATEGORY			VERIFICATION CLASSIFICATION		
	N/A	A	B	PRE-PRODUCTION	ACCEPTANCE	
3.7.2.2.13			x			① ②
3.7.2.2.16	x					
3.7.2.2.16.1		x		x		4.2.6.4 shuttle
3.7.2.2.16.2		x		x		4.2.6.3
3.7.2.2.16.3			x			③ shuttle
3.7.2.2.16.4			x			③ shuttle
3.7.2.2.16.5			x			③ shuttle
3.7.2.3			x			③ shuttle
3.7.2.4			x			③
3.7.2.4.1			x			③
3.7.2.4.1.1			x			③
3.7.2.4.2			x			③
3.7.2.4.3	x					
3.7.2.4.3.1			x			③ shuttle
3.7.2.4.3.2			x			③ shuttle
3.7.2.4.4			x			③ shuttle
3.7.2.4.5	x					
3.7.2.4.5.1			x			③
3.7.2.4.5.2			x			③

SECTION 3 REQUIREMENT REFERENCE	VERIFICATION ALLOCATION					SECTION 4 VERIFICATION REFERENCE
	VERIFICATION CATEGORY			VERIFICATION CLASSIFICATION		
	N/A	A	B	PRE-PRODUCTION	ACCEPTANCE	
3.7.2.4.5.3			x			③
3.7.2.4.5.4			x			③
3.7.2.4.5.5			x			③ shuttle
3.7.2.4.5.6			x			③ shuttle
3.7.2.4.5.7			x			③ shuttle
3.7.2.4.5.8			x			③ shuttle
3.7.2.4.5.9			x			③ shuttle
3.7.2.4.5.10			x			③
3.7.2.4.5.11			x			① ②
3.7.2.4.5.12			x			③ shuttle
3.7.2.4.5.13			x			③
3.7.2.4.5.14			x			③
3.7.2.4.5.16	x					
3.7.2.4.5.16.1			x			4.2.6.3, 4.2.6.4
3.7.2.4.5.16.2			x			4.2.6.7
3.7.2.4.5.16.3			x			4.2.6.8
3.7.2.5			x			③
3.7.2.5.1			x			③ shuttle

SECTION 3 REQUIREMENT REFERENCE	VERIFICATION ALLOCATION					SECTION 4 VERIFICATION REFERENCE
	VERIFICATION CATEGORY			VERIFICATION CLASSIFICATION		
	N/A	A	B	PRE-PRODUCTION	ACCEPTANCE	
3.7.2.5.2			x			③ shuttle
3.7.2.5.3			x			③
3.7.2.5.4	x					
3.7.2.5.4.1			x			③ shuttle
3.7.2.5.4.2			x			③ shuttle
3.7.2.5.5	x					
3.7.2.5.5.1	x					
3.7.2.5.5.2	x					
3.7.2.5.5.3	x					
3.7.2.5.5.4	x					
3.7.2.5.5.5	x					
3.7.2.5.5.6	x					
3.7.2.5.5.7	x					
3.7.2.5.5.8	x					
3.7.2.5.5.9	x					
3.7.2.5.5.10	x					
3.7.2.5.5.11	x					
3.7.2.5.5.12	x					
3.7.2.5.5.13	x					

SECTION 3 REQUIREMENT REFERENCE	VERIFICATION ALLOCATION					SECTION 4 VERIFICATION REFERENCE
	VERIFICATION CATEGORY			VERIFICATION CLASSIFICATION		
	N/A	A	B	PRE-PRODUCTION	ACCEPTANCE	
3.7.2.5.5.14	x					
3.7.2.5.5.15	x					
3.7.2.5.5.16	x					
3.7.2.5.5.16.1		x		x		4.2.6.4 shuttle
3.7.2.5.5.16.2		x		x		4.2.6.7
3.7.2.5.5.16.3			x			(3) shuttle
3.7.2.6	x					
3.7.3			x			(4)
3.7.3.1	x					
3.7.3.1.1	x					
3.7.3.1.2	x					
3.7.3.1.3	x					
3.7.3.1.4	x					
3.7.3.1.4.1			x			(4)
3.7.3.1.4.2	x					
3.7.3.1.4.3			x			(4)
3.7.3.1.4.4	x					
3.7.3.1.4.5	x					
3.7.3.1.4.6	x					

SECTION 3 REQUIREMENT REFERENCE	VERIFICATION ALLOCATION					SECTION 4 VERIFICATION REFERENCE
	VERIFICATION CATEGORY			VERIFICATION CLASSIFICATION		
	N/A	A	B	PRE-PRODUCTION	ACCEPTANCE	
3.7.3.1.5	x					
3.7.3.1.5.1		x		x		4.2.6.9
3.7.3.1.5.2		x		x		4.2.6.9
3.7.3.1.5.3		x		x		4.2.6.9
3.7.3.1.5.4		x		x		4.2.6.9
3.7.3.2	x					
3.8	x					
3.8.1	x					

5.0 PREPARATION FOR DELIVERY

5.1 Packaging, Handling, and Transportation

5.1.1 General Requirements. General requirements for packaging, handling, and transportation for the system elements shall be in accordance with the requirements of NASA Publication NHB 6000.1(1A) and the requirements of this specification.

Requirements herein shall define packaging, handling, and transportation methods, equipment, and practices which will prevent hardware damage and assure retention of hardware reliability during delivery and storage.

Requirements for packaging, handling, and transportation shall cover the following system elements:

(a) Flight vehicles, major subsystems, and components

(b) Ground operations equipment

(c) Launch, recovery, and refurbishment site equipment and facilities

(d) Spares

5.1.2 Protective Methods

5.1.2.1 Levels of Protection. Levels of preservation, packaging, and packing, as outlined below, and as further defined in NHB 6000.1(1A), shall be established for each category of hardware.

(a) Preservation and Packaging Level

Level A - Storage for indefinitely long time
Level B - Storage not exceeding one year
Level C - Immediate use by first receiver

(b) Packing Level

Level A - Multiple world-wide (overseas) shipment
Level B - Multiple domestic shipment, covered storage
Level C - Immediate use by first receiver

5.1.2.2 Selection of Levels. Selection of levels shall depend on destination, modes of transport, conditions of environmental control during shipment and storage, duration of storage, and anticipated requirements for transshipment or redistribution.

5.1.2.3 Environmental Analysis. Specific methods of preservation, packaging, packing, and specific transport requirements and methods shall insure protection of the system hardware against the natural and induced environments to which it will be exposed. Analysis and consideration of the hazards associated with these environments shall be performed prior to hardware design and prior to development of protective packaging methods and transport equipment. The hazards analysis shall cover all phases of the hardware production and delivery cycle including in-plant storage and handling; local transportation at point of origin; transportation to destination; and receiving, redistribution, handling, and storage at the destination facility.

5.1.3 Packaging and Transport Data. Necessary packaging and transport design and procedural data shall be prepared in sufficient detail to permit customer review and to fully implement all applicable requirements for items requiring specially designed packaging or transport methods due to special sensitivity to shock, vibration, contamination, corrosion, or temperature, or due to physical characteristics such as size, weight, or configuration.

6.0 NOTES

6.1 Definitions

6.1.1 Launch Standby. A state of readiness from which an ESS vehicle can lift off from a launch pad within a given number of hours. The vehicle configuration is:

(a) Erected in the vertical launch position.

(b) Payload is mated to ESS (non-hazardous cargo loaded).

(c) Vehicle and payload propellant tanks are empty.

(d) Propellant fill and vent lines are connected.

(e) Booster crew is not on board.

6.1.2 Launch Status. A state of readiness from which an ESS vehicle can lift off from a launch pad within a given number of seconds. The vehicle configuration is:

(a) Erected vehicle in the vertical launch position.

(b) Payload is mated to ESS (all cargo loaded).

(c) Vehicle propellant tanks are full.

(d) Propellant lines are disconnected.

(e) Booster crew are on board.

(f) Countdown is in progress or in hold for launch commit.

6.1.3 Preferred Standard Parts. This category consists of those existing established reliability specifications such as the MIL-C-(RFT)-39000 series for resistors, fuses, connectors, transformers, etc. For micro electronics, the integrated circuit configuration as governed by the DOD Specifications MIL-M-38510 shall be used.

6.1.4 Qualified Parts. This category consists of parts and components controlled by military specifications and compatible with the defined ESS usage environments. In all cases, these parts shall undergo 100-percent screening tests prior to their installation in the ESS vehicle.

6.1.5 Commercial Grade Parts. This category consists of non-controlled parts which may be normal inventory of manufacturers or suppliers.

6.1.6 Intact Abort. Intact abort implies the capability of the booster and ESS to separate and continue flight to a safe landing; the ESS to impact in a safe area.

6.1.7 Major Malfunction. (TBD)

6.2 Abbreviations

AVE	Air Vehicle Equipment
BECO	Booster Engine Cutoff
FMEA	Failure Mode and Effect Analysis
GSE	Ground Support Equipment
ICD	Interface Control Document
ILS	Instrument Landing System
KSC	Kennedy Space Center
LO & SC	Launch Operations and Services Complex
LRU	Line Replacement Unit
LSC	Logistics Support Center
MP&S	Mission Planning and Simulation
M&R	Maintenance and Refurbishment
MTTR	Mean Time to Repair
NDT	Nondestructive Testing
TBD	To Be Determined
UCI	Uniform Concrete Index