that they are required to assure materials compatibility within the context of their use.

(d) ASTM test methods are applied as required.

(e) MIL Handbook No. 5, 17, 23.

Material selection lists are developed based on experience and known material compatibility with specific environments. There are also fracture control and material control plans. Each element contractor has developed its own metals/nonmetals/processed which have been reviewed by and approved by NASA.

The Space Division, Rockwell International Corporation, as the Shuttle system contractor, has developed a materials' tracking and control system called "MATCO." While they do not control the use of materials on the Shuttle elements, they do bring material usage which they feel falls outside the set requirements to the attention of the NASA/JSC project office for further action. In addition, materials-conscious personnel participate in the Panel and working group activities as well as in the reviews conducted on Shuttle elements and subsystems. The Panel will continue to review this question of decision making on materials' acceptance during future reviews at various contractor and NASA sites.

The "MATCO" system noted above contains pertinent data on both metals and non-metals, generates material selection lists, contains usage data on --- what materials are used, where used, quantity, results of usage evaluation, deviation status where there is a deviation from accepted use, and finally the system generates output reports to permit certification of the acceptability for a given configuration usage.

The "MATCO" system on the Orbiter has been implemented since the first drawing release. Associate contractors for other elements of the Shuttle program are currently encoding the data and it is expected that element contractor data outputs may start about January 1976. Payload coverage is under discussion at this time.

4.8 Failure Mode and Effects Analysis (FMEA)

Elements of the Shuttle system and the interfaces beteen elements are subjected to detailed FMEA's. In addition to the FMEA documents there are Critical Items Lists (CIL's), Hazards Lists, Shuttle Hazard Analyses forms (SHA's), and Safety Analysis Reports (SAR's). Taken together they provide a systematic means of assuring nothing, in so far as possible, "falls into the crack." They provide for early identification and resolution of potential problem areas, support design reviews, provide management visibility, and establishes a documented baseline to facilitate hazard/risk/safety problem resolution. In addition this work provides a basis for establishing mandatory test and inspection points under the Quality Control Program and provides valuable input for the maintainability program for Shuttle.

The priority or level of criticality number system is in use, as it has been in prior manned programs. The listing is provided for information:

Criticality Category	Definition (Potential Effect)
1	Loss of life or vehicle, including loss or injury to the public.
2	Loss of mission, including post-launch abort and launch delay sufficient to cause mission scrub.
3	All others (structural or TPS type elements are not classified in any of these above categories if they meet the margin of safety requirements).
3_I	Criticality 3 items which meet one or more of the following categories: (a) Redundant elements are not capable of checkout during normal turnaround. (b) Loss of a redundant element is not readily detectable in flight. (c) All redundant elements can be lost by a single credible event or cause.

5.0 TEST PROGRAMS

5.1 Verification Plans

A Shuttle Master Verification Plan (JSC 07700-10-MVP-01 Rev. A) establishes the requirements and plans to certify the Shuttle system ready for operational use. Since much of the program's confidence will be based on test requirements and results, the Panel has reviewed the evolution of the ground and flight test program including the impact on crew safety of changes in requirements.

5.2 Ground Tests

In most of the preceding sections of this report there have been discussions of test programs as they applied to the specific development of subsystem components, such as the tiles for the Orbiter Thermal Protection Subsystem. The ground tests discussed here are those termed "major ground tests." Such tests involve a combination of system elements and complex facilities. The major ground test programs are outlined in Figure 55.

The ground vibration test program verifies load, vibration, flutter, and flight control system analysis. Vibration testing is performed on a one-quarter scale Shuttle model and on the liquid oxygen tank portion of the External Tank. The first Orbiter will also be subjected to a horizontal vibration test at the Palmdale Assembly Facility as a part of the vehicle checkout. The major full scale

Space Shuttle vertical vibration tests are planned to be carried out at the Marshall Space Flight Center to study the vibration modes of the total assembled Space Shuttle vehicle. Recent changes in the ground vibration test (GVT or MGVT) include:

(a) Deletion of component ground vibration tests on the Orbiter wing, Orbiter vertical fin, and other components.

(b) Delay of the quarter-scale model testing for six-months.

(c) Compression of the mated vertical ground vibration tests to a six months time period.

The vibro-acoustic test program verifies the predictions about the dynamic response of the structure and internally mounted equipment to engine noise and vibration, aerodynamic buffeting and aerodynamic noise. Wind tunnel tests of models have been used to determine the aerodynamic noise pressure levels. Scale model tests of the total Shuttle stack are being used to predict the launch environment and its impact. Full scale tests of a major segment of the Orbiter are to be conducted in the vibro-acoustic test facility at JSC. Recent changes in this test program include the deletion of the forward fuselage vibro-acoustic test.

The Main Propulsion System test program uses the three main engines mounted on a simulated aft section of the Orbiter, together with the External Tank, and includes all necessary plumbing and controls. POGO suppression hardware will be supplied for installation as the tests progress to substantiate the technique used to suppress the longitudinal vibrations peculiar to POGO. These propulsion tests will also provide additional vibration and acoustics information. Recent test program changes include the deletion of the vertical firing attitude, deletion of flight disconnects from the "T-0 Umbilical" and an increase in firings from 14 to 15.

The Orbiter avionics components and their related software and hardware interfaces will be tested at the Rockwell International Space Division's Avionics Development Laboratory. The Avionics Development Laboratory is an engineering tool with emphasis on development support, subsystem evaluation and initial hardware integration. Test results are aimed at:

(a) Demonstrating line replaceable unit functions for all those pieces of hardware that fit that category.

(b) Developing the single-string data processing system functions.

(c) Avionics compatibility with automatic ground checkout equipment.

(d) Progressive testing and combining of subsystems until they simulate a flight control system with computer inputs and control actuator outputs.

The Shuttle Avionics Integration Laboratory (SAIL) established at JSC will conduct avionics systems integrated testing in support of the Approach and Landing Tests (ALT), Vertical Flight Tests (VFT), and operational mission phases. Integrated testing includes both open-loop and closed-loop testing. Open-loop testing will integrate and verify the avionics system compatibility and redundancy management techniques; closed-loop testing will integrate the avionics hardware and software systems and verify that they are capable of performing each flight phase of the mission. Thus the SAIL is a central facility where the avionics and related hardware (or simulations of the hardware), on-board ground support software, flight software, flight procedures, and associated GSE will be fully integrated and verification tested. Figure 56 shows the Shuttle avionics systems which are to be tested on SAIL.

Another facility supporting the avionics test program is the Software Development Laboratory (SDL). The purpose of this facility is to accomplish flight software development and flight software independent verification.

Static structural tests are planned for major structures on all Shuttle elements. A full-sized Orbiter airframe structural test article (STA) will be tested at Palmdale to determine if it can withstand the design limit and ultimate loads. In addition, it will be subjected to fatigue loeading up to 400 cycles to assure structural integrity. An Orbiter crew module test article, which is the pressurized crew compartment segment of the Orbiter, will be tested in a manner similar to the static test article mentioned above.

The External Tank structural program includes a structural test article consisting of flight-type liquid oxygen and liquid hydrogen tanks and intertank. Tests will be conducted to verify structural integrity at limit and ultimate loads and to determine the liquid oxygen tank model characteristics necessary to determining the all-up Shuttle vehicle structural characteristics.

Solid Rocket Booster and Solid Rocket Motor structural tests will be conducted, as will hot firings to verify their structural integrity, support development of the rocket motor case and verify ballistic performance.

Recent test program changes have deferred the crew module structural test, deferred the airframe structural test, eliminated one intertank structural test article from the External Tank program, deferred the Solid Rocket Booster structural test and deleted the booster first development firing.

The Orbiter thermal vacuum test programs on the forward fuselage, aft fuselage, and OMS/RCS pod have been deleted. The impact of deleting the major ground thermal vacuum test has been subject to study by both JCS and Rockwell International over the past few months. The following results stem from these studies but must be considered in light of additional more detailed work now in progress:

(a) There is an obvious requirement for flight test data.

(b) There will be no off-limit or off-nominal testing to any degree.

(c) There will be no physical pre-flight data on temperature effect of subsystem operation on the integrated vehicle.

(d) There will be some restructuring of the certification/validation program to include additional component and subsystem testing.

(e) Requirements for additional development flight and operational flight instrumentation requirements will have to be determined.

(f) Mission planning will have to pay more attention, in the early flights, to beta angle variations, time required for temperature stabilization.

(g) Conservative attitude constraints will be necessary on the early orbital flights.

Test article fidelity has always been a problem in extrapolating model tests and full size ground tests up to the actual flight hardware and how it operates in its real environment. The ability to extrapolate from ground test activities to flight operations depends upon the degree to which the test articles resemble the flight articles. A Flight Readiness Firing test (FRF) will functionally verify the integrated shuttle system vehicle, launch complex and operating procedures and thus demonstrate the maturity and readiness of the shuttle system for first manned vertical flight.

The Solid Rocket Booster/External Tank separation system test and the Orbiter/External Tank Separation tests are two major tests deferred to flight test program. The verification logic is shown in figure 57. The panel has made a point of repeatedly asking if data were being lost from ground tests that would be useful to our basis of confidence in crew safety during early flights.

The answers given were: "No tests are being conducted during the Approach and Landing Test and Orbital Flight Test programs which affect crew safety that have no counterpart in the ground test program. . . . All elements and maneuvers of the flight test program have counterparts in either ground tests, simulations, or analysis."

5.3 Flight Test Program

The flight test program has two major subdivisions: The Approach and Landing Test Program (ALT) and the Orbital Flight Tests (OFT). These flight tests complement the ground test program described previously and the ALT is planned to commence in mid-1977 using the Boeing 747 carrier aircraft, and the OFT is planned to commence in mid-1979.

5.3.1 Approach and Landing Test Program (ALT)

The Orbiter vehicle 101 (the first off the line) is the primary vehicle planned for the ALT and is configured to include the equipment necessary to evaluate vehicle approach, landing and deceleration requirements dictated by the terminal phase of the operational mission. The design of Orbiter 101 is such that minimum modifications are required to convert it to the operational configuration.

The ALT program is designed to progress from test conditions that provide the greatest margins of safety to test conditions duplicating those expected on the first Orbital Flight Test landing. The ALT program is comprised of two flight test phases:

Phase 1 - Inert Orbiter/747 mated tests to verify satisfactory airworthiness of mated vehicles for supporting orbiter free flight tests.

Phase 2 - Manned Orbiter captive flights to develop Orbiter release profile and Orbiter free flight and landing data.

During ALT the Orbiter is flown without any propulsive power. With the current capabilities of the Orbiter/747 combination, the maximum attainable altitude appears to be somewhat less than 28,000 feet, and with the loss in altitude which is said to occur during the release period the Orbiter would appear to be in free-flight starting at about 20,000 to 24,000 feet. These tests are to be conducted in the area surrounding the Flight Research Center, Edwards, California.

The status of the two phase ALT test plan is:

PHASE 1 -

(a) The extent of the initial Taxi tests of the mated Orbiter/747 at Palmdale has not been fully defined as yet.

(b) The planning for ALT is being done by FRC, Rockwell and Boeing. They will define the requirements under the review of the Orbiter Project Office at JSC. These requirements will appear in the Approach and Landing Test Requirements Document. The actual flight tests needed to meet these requirements will then be developed by the same team.

They will appear in the ALT Mission Objectives Document.

(c) The actual test program will be constructed in a manner that will permit the achievement of objectives to get to the manned Orbiter release point with a minimum number of flights and flight hours.

(d) The ALT manager is from JSC and the assistant manager is from the FRC. The tests are conducted for the ALT manager by the FRC flight test team and during these operations the FRC flight test control room will be utilized to control the flights.

(e) The 747 test instrumentation system is designed and installed by the same team. It will be compatible with the FRC test control and data reduction facilities. Data reduction and analysis by FRC is conducted with JSC support and the same tapes and other data are forwarded to JSC for their independent analysis.

(f) It is expected that during this phase of the program that Ferry configuration flight tests will be conducted in parallel on a non-interference basis.

PHASE 2 -

(a) Phase 2 begins at the completion of the inert Orbiter/747 testing. The current baseline consists of eleven Orbiter free flights, starting with pilot-controlled landing series (5 flights); autoland landing demonstration (3 flights); and finishing with weight/c.g. envelope investigations (3 flights). These free-flights are being structured to allow early termination of the program or to skip individual flights if testing shows the data are not required. During the initial portion of this phase, the manned Orbiter captive flights are held to a minimum necessary to develop the release (techniques).

(b) The flight test team is to be headed by a JSC test conductor and comprised principally of JSC and Rockwell flight control personnel. The control of the flights will be from the JSC control room with a test liaison group stationed at FRC. It is expected that FRC will supply experienced aerodynamic flight controllers to the JSC control center.

(c) The planning, including requirements and flight test details, are established and developed by the NASA/Rockwell team under the auspices of the Orbiter Project Office at JSC. The free-flight test program is developed specifically by the Flight Operation Division of JSC and becomes a part of the ALT Mission Objectives Document.

The baseline flight test program as provided to the Panel at the time of its review and inspection visits shows 14 carrier/orbiter inert flights; 5 carrier/orbiter active flights to refine separation techniques and to do integrated systems testing, and 11 orbiter free-flights. Table XIII is a further explanation of the Orbiter Free Flight Program at this time.

Given its special interest in the complex avionics system used on the Orbiter the Panel asked a number of questions regarding flight control avionics support of the ALT program. The many ground tests conducted prior to flight will give a basis for confidence in the avionics subsystems used on the ALT program. In addition, the orbiter will contain an "all-up" fail operational/fail safe flight control avionics subsystem with a dedicated backup flight control subsystem and a backup air data nose boom system. At the same time the ground support group will have the support of Shuttle Avionics Integrated Laboratory, Software Development Laboratory, and the Avionics Development Laboratory available.

5.3.2 Shuttle Training Aircraft

The Shuttle Training Aircraft is a Grumman Gulfstream II turbojet aircraft modified to provide an inflight simulation of Orbiter performance and flying characteristics in the Terminal Area Energy Operations. The purpose of this training program using the modified Gulfstream II is for pilot training and the development and verification of procedures. The simulation system consists of a specially constructed and programmed simulation computer and necessary inertial sensor systems. The displays, controls, radio, navigation systems are essentially Orbiter Hardware. The simulation capability is as follows:

(a) Altitude - 43,000 feet to simulated touchdown

(b) Airspeed maximum of 350 knots or Mach number of 0.8

(c) Payload of 5600 pounds

(d) Orbiter modes simulation for automatic landing systems/control stick steering and backup systems

(e) Turbulence and wind conditions expected to apply to Orbiter operations

5.3.3 Orbital Flight Tests

The culmination of the flight test program occurs with the manned Orbital flight, a program currently encompassing a sequence of six manned flights. The first orbital flight is designed to be short and benign to demonstrate basic flight worthiness. A decision was reached by senior NASA management to proceed with the design and development of the manned first flight only after prolonged and detailed study of the manned versus unmanned options. A review of the decision will be conducted eighteen months prior to the first orbital flight. A summary of the manned vs. unmanned study provided to the Panel is given below:

(a) Recovery of the Orbiter on every flight is required for orderly continuation of the flight test program.

(b) Flight experience shows many cases where the presence of crew saved the mission from failure.

(c) The crew role in the shuttle is identical to that in aircraft and spacecraft test operations; however, crew capability in some areas of the shuttle design concerns is very limited.

(d) Manned landings can be made at alternate sites in the event of dispersed entry conditions or automatic system failure. Capability of crew to deal with contingencies provides greater safety for the population in the landing area.

(e) The ground test program has been constructed to give confidence that design concerns have been acceptably minimized prior to the first orbital flight, manned or unmanned.

(f) Tailoring of the first vertical flights to improve safety margins will be accomplished as practical for either manned or unmanned flight tests.

(g) Abort and ejection capabilities are consistent with aerospace testing precedents, that is they cover many but probably not all foreseeable failure possibilities.

(h) Commitment to unmanned flight implies a successful Approach and Landing Test Autoland program as a prerequisite.

(i) Unmanned capability requirement can be reinstated later if unforeseen circumstances demand.

The early development Orbital flights will be launched from the KSC site and will land at Edwards Air Force Base. These flights are to be under the control of the JSC Mission Control Center once lift off is achieved. Depending upon the progress achieved in the early flights, there is a good chance that the fifth or sixth flight will both launch and land at the KSC site.

The contingency planning and design for abort conditions during the flight test program will continue to be of great interest to the Panel. This is true for both the Orbital and ALT programs. The Panel, for instance, is interested in plans to assure that requirements of abort operations and system capabilities are compatible.

6.0 SYSTEMS INTEGRATION

6.1 General Objectives

The management of the integration effort has been covered in earlier sections of this report. This section is meant to identify the technical challenges of integrating the elements at this point in the Panel's review.

An example of the many technical areas that must be managed to assure that the Shuttle elements work together are:

Flight Performance
Load and Structural Dynamics
Flight Control
Integrated Avionics
Integrated Propulsion/Fluids
Mechanical Systems
Ground Operations
Major Integrated Ground Tests
Computer Systems and Software
Systems Engineering
Safety, Reliability and Quality Assurance
Payload Accommodations

The Main Propulsion System is used here to illustrate the complexity of the relationships between components found in various elements which form single end-to-end integrated systems. Other areas to be examined by the Panel include electrical system and avionics system.

6.2 Systems Integration Challenges

Some of the challenges the program must resolve on the Space Shuttle System are:

Flight Performance Margins
Induced Loads
Ice/Frost Shedding
SRB/ET/Orbiter Separation
POGO Suppression
Forebody drag

Many of these challenges have been discussed in the section of the report on the various program elements.

6.3 Operations

The Orbiter is designed to carry a crew of up to seven including crew and scientific personnel. On a standard mission, the Orbiter can remain in orbit for seven days. While it is planned that an Orbiter would be readied for another flight in fourteen calendar days, the Shuttle can be readied for a rescue mission launch from a standby status within twenty-four hours after notification. For emergency rescue, the cabin can accommodate as many as ten persons so that all the occupants of a disabled Orbiter could be rescued.

Space Shuttle operations consist of four basic phases:

(a) Lift-off to orbit insertion
(b) On-orbit operations

(c) De-orbit to landing

(d) Ground turnaround to prepare for the next flight

Operational constraints have been discussed in previous portions of this report under each of the elements of the Shuttle system as well as in the reliability, quality and safety sections. The Panel's interest continues to focus upon the ability of the nominally designed hardware to meet the contingency situations which can occur during flight test and operational phases of the program. We will monitor the evolution of the launch rules and the mission rules governing both test and operational flights. We will also monitor such safety challenges as (a) intact abort capability, (b) contingency abort capability, (c) payload accommodations, (d) day and night operations, (e) mission control center requirements, (f) post landing thermal conditioning, and (g) EVA operations.

6.4 Main Propulsion System

The Main Propulsion System integrates the Space Shuttle Main Engine (SSME), External Tank (ET), and the interconnecting plumbing and controls within the body of the Orbiter. The subsystems that make up the main propulsion system are:

(a) Propellant feed

(b) Propellant fill and drain

(c) Engine prestart propellant conditioning

(d) ET pressurization and prepressurization

(e) Helium storage and distribution

(f) Propellant management

(g) SSME GN_2 purge using ground supply

(h) POGO suppression

(i) Electrical instrumentation, controls, and displays

A schematic of this system is shown in Figure 58. The selected POGO suppressor system is shown in Figure 59 and the workings of the POGO Integration Panel are shown in Figure 60.

The Main Propulsion System has been designed to meet the fail-safe criteria. Thus, for example, loss of one main engine during ascent would still permit the crew to abort a Mission 3A as follows:

0-250 seconds .... suborbital powered return to launch site

250-330 seconds .... abort once around

330 - main engine cutoff ... mission completion

Shutdown of two of the main engines will result in loss of the Orbiter for a majority of mission phases during the ascent.

Prevalves, fill valves, and disconnect valves are all designed to remain in the last actuated position, in the event of loss of pneumatic pressure to the valve actuator, or loss of electrical power to the controlling solenoid valves. Pneumatic pressure is continuously applied to these valves during their critical function period, to further assure their remaining in the desired position.

6.5 Summary

The Panel has examined a portion of the efforts conducted in integrating the total Shuttle system during the past reporting period. With the completion of the Preliminary Design Reviews for each of the elements and the Space Shuttle System, the Panel can better undertake a review of the integrated systems which cross over element interfaces such as the electrical system, and the mentioned Main Propulsion System.

7.0 APPENDIX

7.1 PANEL AUTHORITY

The Aerospace Safety Advisory Panel was established under Section 6 of the National Aeronautics and Space Administration Authorization Act, 1968 (PL 90-67, 90th Congress, 81 Stat. 168, 170). In addition, the Panel has been rechartered pursuant to Section 14 (b) of the Federal Advisory Committee Act, (PL 92-463, October 6, 1972). The duties of the Panel are set forth in both the 1968 Act and in NASA Management Instruction 1156.14A dated January 18, 1973: "The Panel shall review safety studies and operations plans referred to it and shall make reports thereon, shall advise the Administrator with respect to the hazards of proposed or existing facilities and proposed operations and with respect to the adequacy of proposed or existing safety standards, and shall perform such other duties as the Administrator may request."

Over the years the Panel has evolved its role to include not only safety per se, but has included mission success as a consideration that it should be concerned with, as well as crew or public safety. We feel that this broader consideration of the programs and their management gives us more confidence in the more limited area of safety alone.

7.2 PANEL ACTIVITIES

January 15, 1974	MDAC-East Role in Shuttle Program Organization Orbital Maneuvering System Baseline, Schedule, Status Integration of Pod into Orbiter Reaction Control System Requirements	MDAC, St. Louis, Missouri
February 26, 1974	Program Manager's Top View TPS Development Status Systems Integration Management Man-in-The-Loop Ferry Mode Preliminary Design Review Results	JSC-Houston
May 13-14, 1974	The External Tank Program, Overall View ET Baseline Design Program Interfaces Major issues and their proposed resolution. Lightning Protection Design Transportation Structural Test Program Reliability, Quality Assurance and Safety Subcontractor program MSFC Management of the External Tank Program	Michoud Assembly Plant, LA
June 5-6, 1974	SSME Quarterly Review SSME Controller discussions	MSFC, Huntsville
July 16-17, 1974	Space Shuttle Main Engine Controller Program Overview Responsibilities, Role, Organization Controller Technical Description Computer Program Overview Plated Wire Memory Theory Memory structure build-up Technical Review---in depth Design Control and Configuration Management Production and Procurement R & QA Summary Status MSFC Management of SSME Controller Program	Honeywell, Aero-Space Div., FLA
August 22-23, 1974	The TPS Program Overview and JSC Mgt. Ames' Shuttle related programs Ames' Management Approach and iMplementation	AMES, CA Lockheed, CA

Panel Activities continued:

	TPS materials and tile configuration program Current and Projected facilities and their application to the TPS TPS aero-noise effects program Definition of TPS aero-heating environment and other environmental effects. Rockwell Subcontract to Lockheed and how it is managed Tile Program, Lockheed Organization, personnel, responsibilities Tile materials and processes Tile Production Tile testing Tile R and QA Current Status Current significant problems and their resolutions.	
September 16-17, 1974	RI System Integration Contractor Role Commonality System Safety System Integration Challenges Tour of Facilities and Mockups Orbiter Thermal Protection System SSME Program update ISTB Program Status Combustion devices status Turbomachinery Devices statsus Engine systems and controls status Controller status	RI/Downey, CA
October 15, 1974	Orbiter Approach and Landing Test Program Ferry Operations Manned vs. Unmanned External Tank disposal after flight Space Shuttle Flight Test Program Abort/Contingency Operations and their impact	JSC/Houston
January 6, 1975	Space Shuttle Update and Status Report Approach and Landing Test, PDR results Avionics and their management Management and Direction of Systems Integration MSFC Space Shuttle Survey and Major Management and Technical Challenges Main Engine, External Tank, SRB, Orbiter Program Revisions under active consideration Current status	JSC/Houston

March 3, 1975	KSC Space Shuttle Planning	KSC, Florida
	KSC Roles and Responsibilities	
	- Operations, Maintenance, Sustaining Engineering	
	KSC Organizational Relationships	
	- Overall Organization	
	- Intercenter Relationships	
	- Participation in Panels, Working Groups, Task Teams	
	- Contracting Philosophy	
	- Manpower planning Experience levels, skill retention, skill mix.	
	Overview of Ground Operational Tasks	
	- Shuttle	
	- Payloads (offline)	
	Documentation and Control	
	Facility and GSE Overview	
	- Types and KSC effort/Responsiblity	
	- KSC facility baseline/current status/ problems	
	- Test Facilities/Plans/Schedules	
	- Launch Preparation System System Operation Software Validation/Test/Use of SAIL	
	KSC Operational Flow	
	- Ground turnaround Allocation vs. Assessment STAG/Control	
	- Payloads, online	
	Summary of KSC Shuttle operations	
April 7-8, 1975	Space Shuttle Systems (MSFC Elements)	MSFC, Alabama
	- POGO Prevention Planning and implementation	
	- MSFC Integration Activities	
	- MSFC Change Processing	
	- MSFC Systems Tests	
	- Single Failure Point Designs	
	Solid Rocket Booster Project	
	- Description and Status	
	- Integration	
	- Recovery/Retrieval	
	- SRM	
	External Tank Project	
	Description/schedules/cost highlights	
	Top Problems/Sepcial Topics	
	Procurement and Manufacturing status and problems	

SSME Project
- Overview
- Integrated System Test Bed (ISTB) Plan/Status
- Controller status
- Hydraulic Fluid Status
= Fabrication Learning
- Heat Exchanger
- Ground Operations Planning

MSFC Summary

May 5-6, 1975 Shuttle Assessment of Technical and Management challenges RI/CA
Thermal Protection System Review
Hazard Analysis and Risk Assessment
Mechanical Hinges, Gear Boxes, and Doors
System Hazards associated with asymmetrical thrust of SRB's
Procedures/Ground Rules to Alleviate System Failures
Hazradous Gas Detection System
Level II Interfaces
Material Usage and Control
Range Safety
Ground and Flight Test Programs
POGO Prevention
Lightning Design and Protection
SAIL

7.3 RESPONSE TO PANEL'S 1974 ANNUAL REPORT

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

MAY 23 1974

REPLY TO
ATTN OF: MQ

MEMORANDUM

TO: AA/Associate Administrator

FROM: M/Associate Administrator for Manned Space Flight

SUBJECT: Annual Report of the Aerospace Safety Advisory Panel (ASAP)

The Annual Report of the Aerospace Safety Advisory Panel has been distributed to each of the MSF Centers and Program Directors for their careful review. The Program Directors have each coordinated responses to their pertinent items in the report and these detailed responses are attached.

Significant responses from the ASTP office relate to Volume II of the report, pages 8-9, items 1 through 11. They describe a continuing strong program management concept with emphasis on enhancement of personnel motivation and training. The Panel's concern over the need for formal reviews is being met by monthly joint reviews and bi-weekly telecons between the U.S. and Soviet Technical Directors and their staffs. Qualification test data reviews are being continuously held to assure a ready-to-go status. Language training is progressing well on both sides and a recent crew training exercise in Houston accomplished a complete transfer in both English and Russian. FMEA's have been completed for all systems of the CSM and DM/docking system. The Mission Control Center Interaction Plan is in excellent shape and both countries plan a team of experts in each other's control room to assist each Flight Director. Mission simulations are continuing with both U.S. and Soviet crews participating in each other's facilities. Effort is continuing on tracking failures or inadvertent operations which could affect the other crew or spacecraft. It is planned to improve communications by using ATS-F but no contingency action is planned if it is not available. Stadan provides the primary communications coverage and exceeds the minimum requirements for ASTP.

Finally, in response to the Panel's question on sneak circuit and fault current analyses, these are being accomplished on both the CSM and DM/docking system.

The Panel expressed a strong recommendation that the Skylab experience be utilized to the maximum degree possible on current programs. Skylab has almost completed the publication of a series of "Lessons Learned" documents. My office, on March 12, 1974, levied an action item on each Program Office to review these documents and report back to me on implementation of these "lessons learned." I will make these responses available to the Panel upon their receipt.

Significant responses from the Space Shuttle Office relate to Volume I, pages 12 through 16, and Volume II, pages 19, 35, 43 and 45 through 47. In the area of the Panel's concern about integration activities of Rockwell, JSC has given a task to the contractor to look at separating their integration function from the Orbiter task (due May 31). In the area of subcontractor/vendor control, Rockwell is rewriting their Procurement Management Plan with a new emphasis on commonality management (expected by June 1974). In response to the concern with weight control, a combination effort of strict weight control measures, a specific Orbiter weight reduction activity, and a series of overall weight and performance trade-offs are being pursued. In the area of abort requirements, continuing attention is being paid to determine abort capabilities for the various mission phases for the design which is evolving from the driving requirements of operational uses. The Panel expressed concern in the Avionics area because they felt that the systems were on the leading edge of the state-of-the-art. The response indicates that the program has a handle on the design solutions. Specifically, experience on both hardware and software for a Performance Monitoring System has been gained at the Mission Control Center. Good judgements based on these experiences will be exercised to keep requirements manageable. Similarly, the Autoland System is being very carefully designed using the 16 unpowered automatic approaches and landings with the CV 990 as an experience base. Also being used is Sperry-Rand with their CV 990 test program experience. With regards to the man-in-the-loop versus automated systems, an approach of using automatic functions for expensive and sophisticated systems where split-second decisions are required is being followed. This is borne out by 747 aircraft use of Autoland for consistent low "g" landings in all weather. Turnaround time is of great concern and is receiving full attention of a panel working with latest design, logistic and maintainability information as it becomes available. The concern about all-weather capability is being worked both with regards to effects on the TPS and on Avionics. It may be necessary, however, to sacrifice some all-weather characteristics for thermal characteristics on the TPS. Operational alternates are available since chances of bad weather at both prime and contingency landing sites is very low. In addition, automatic landing and overrun equipment is being installed to better handle all weather problems. On the SSME Controller, the Panel had questioned the reasons for not considering a magnetic core memory. The response lists a series of reasons for not using the core approach but also indicates that an MSFC committee is reviewing the whole controller development problem with a report to JSC due on May 22, 1974. The Panel felt that test organizations at Rockwell were not yet firmly established. This area has since been significantly improved and staffed, including government roles and responsibilities for most of the test sites. On the TPS the Panel correctly pointed out that major design issues include strain, isolation, adhesives, joints, TPS/fuel compatibility, dynamic seals and development of a 100-mission life coating. In response, an up-to-date status of development testing on each of these design issues is provided in the attached detailed answers. On the SSME, the change to Mil-H-83282 hydraulic fluid caused some questions on possible further evaluation required. In response, materials in contact with the fluid are being identified and materials compatibility is being reviewed (including DOD testing and service experience). In addition, an acceptance and design verification program is being initiated to test SSME components and systems with Mil-H-83282 fluid. The Panel also questioned whether the SSME flex line material was compatible with oxygen and not subject to hydrogen embrittlement. This is a well-recognized problem and the materials have been selected accordingly. The Panel pointed out the different requirements for the SSME combustion chamber as compared to the J-2 engine. The response indicates that the Narloy material was selected to best meet the unique requirements of high thermal conductivity, high strength and ductility, high metalurgical stability and life characteristics. Although the Panel next pointed out that the optimum technique for reentry has not been defined, the response indicates that much wind tunnel data, flight simulations, aerothermal dynamics work, etc. which is in progress may cause many changes and the technique may well have to be developed from operational phase experience. The Panel also questioned adequacy of controls for qualification of "off-the-shelf" hardware. A special Level II Directive was deemed necessary to insure adequate controls and it is in the final review/approval cycle. Finally, the Panel's concern for effective measures to prevent stress corrosion was recognized early by the Shuttle Program and is controlled by a NASA materials and process specification, including a contractor materials control and verification plan, which incorporates material sign-off of drawings and records of all deviations with rationale for each.

In conclusion, I would like to thank the Panel for its thorough and excellent report and assure them that their thoughtful questions are continuing to provide an excellent checklist for our program management function.

John F. Yardley

John F. Yardley

Attachments
as stated

KMI 1058.7/SP

October 10, 1973
Effective Date

JOHN F. KENNEDY SPACE CENTER, NASA
MANAGEMENT INSTRUCTION

SUBJECT KSC/MSFC MEMORANDUM OF UNDERSTANDING FOR SHUTTLE EXTERNAL TANK (ET) AND SOLID ROCKET BOOSTER (SRB) SUPPORT EQUIPMENT

1. PURPOSE

This Instruction incorporates into the KSC Issuance System a Memorandum of Understanding between the John F. Kennedy Space Center, NASA (KSC) and the George C. Marshall Space Flight Center (MSFC) for Shuttle External Tank (ET) and Solid Rocket Booster (SRB) support equipment. This Memorandum establishes those items of support equipment for the Shuttle External Tank and Solid Rocket Booster which will be the responsibility of KSC and those items which will be the responsibility of MSFC.

RC Hock
R. C. Hock
Acting Director of Executive Staff

Attachment:
A. Memorandum of Understanding

Distribution:
STDL-P

ATTACHMENT A to
KMI 1058.7/SP

ET and SRB SUPPORT EQUIPMENT

MEMO OF UNDERSTANDING

7/16/73

1. Support equipment has been defined in three categories:

Ground Support Equipment (GSE):

GSE consists of that equipment and associated software which is required to check out, service, handle, provide access to, maintain and safe the External Tank, and Solid Rocket Booster, their subassemblies or other system elements at the launch and landing sites only. Includes such items as:

- o Fixed facility access stands, horizontal and vertical
- o Facility support and storage stands
- o Purge and pressurant gas supplies and consoles
- o Ground ECS
- o Launch processing system and associated software
- o Launch site electrical and mechanical BME
- o Standard test equipment
- o Standard power supplies and battery GSE
- o Ground transportation prime mover
- o Facility leak detectors

Special Test Equipment (STE):

STE consists of that equipment and associated software which is required to support checkout, development, and qualification testing of the External Tank, and Solid Rocket Booster, their subassemblies or other elements during manufacturing buildup and development.

Includes such items as:

- Internal access platforms
- Special test cable kits and boxes
- Other equipment with an intimate design interface with the flight hardware

Transportation and Support Equipment (TSE):

TSE consists of that hardware which is required to transport, handle, and maintain the External Tank and Solid Rocket Booster, their system elements to and from the contractor's facilities, other government facilities, and to and from the launch site and landing sites(s) exclusive of tooling used within the factory and commercial conveyance equipment. Includes such items as:

- Transporter
- LRU handling slings and dollies

2. The selected contractor will furnish all materials and services to design develop, test, qualify, manufacture, assemble, check out, and maintain the STE and TSE. Checkout and maintenance at the launch site is excluded.

3. The contractor will identify those items of, and concepts for, ET or SRB support equipment recommended for use at the launch site.

4. The contractor will analyze specified and potential launch site requirements in the design of STE and TSE from a program cost effectiveness viewpoint in order to maximize commonality. This analysis shall show the design/cost savings or impact of commonality.

5. The contractor's incorporation of unique launch site requirements in STE and TSE shall be approved by the NASA Project Office for accomplishment under an existing ET or SRM procurement or shall be accomplished through a supplemental contract arrangement negotiated and managed by the launch site on a case-by-case basis.

6. The selection of common equipment and the identification of launch site requirements will be the responsibility of KSC. The design and development of this common equipment will be controlled by a co-chairmanship of one KSC Support Equipment Manager and one MSFC Manager appointed by the ET or SRB Project Manager. Neither of the co-chairmen would have unilateral authority to proceed with independent development or make changes to this common support equipment; however, generally the MSFC Manager will be the leading element with the KSC Manager concurring in planned direction or changes. Both Managers will have ready access to the contractor for day-to-day technical discussions and problem resolution; however, the MSFC Manager will initiate all formal direction of the contractor. If a disagreement develops between the co-chairmen that could impede the progress of the common equipment development, the matter will be immediately brought to the attention of the appropriate Project or Projects Office Managers at MSFC and KSC.

7. The design and development of STE, TSE, and common support equipment is included in the present ET and SRM procurement; however, the specific units of this equipment that are required for sole use at the launch site will be funded by KSC.

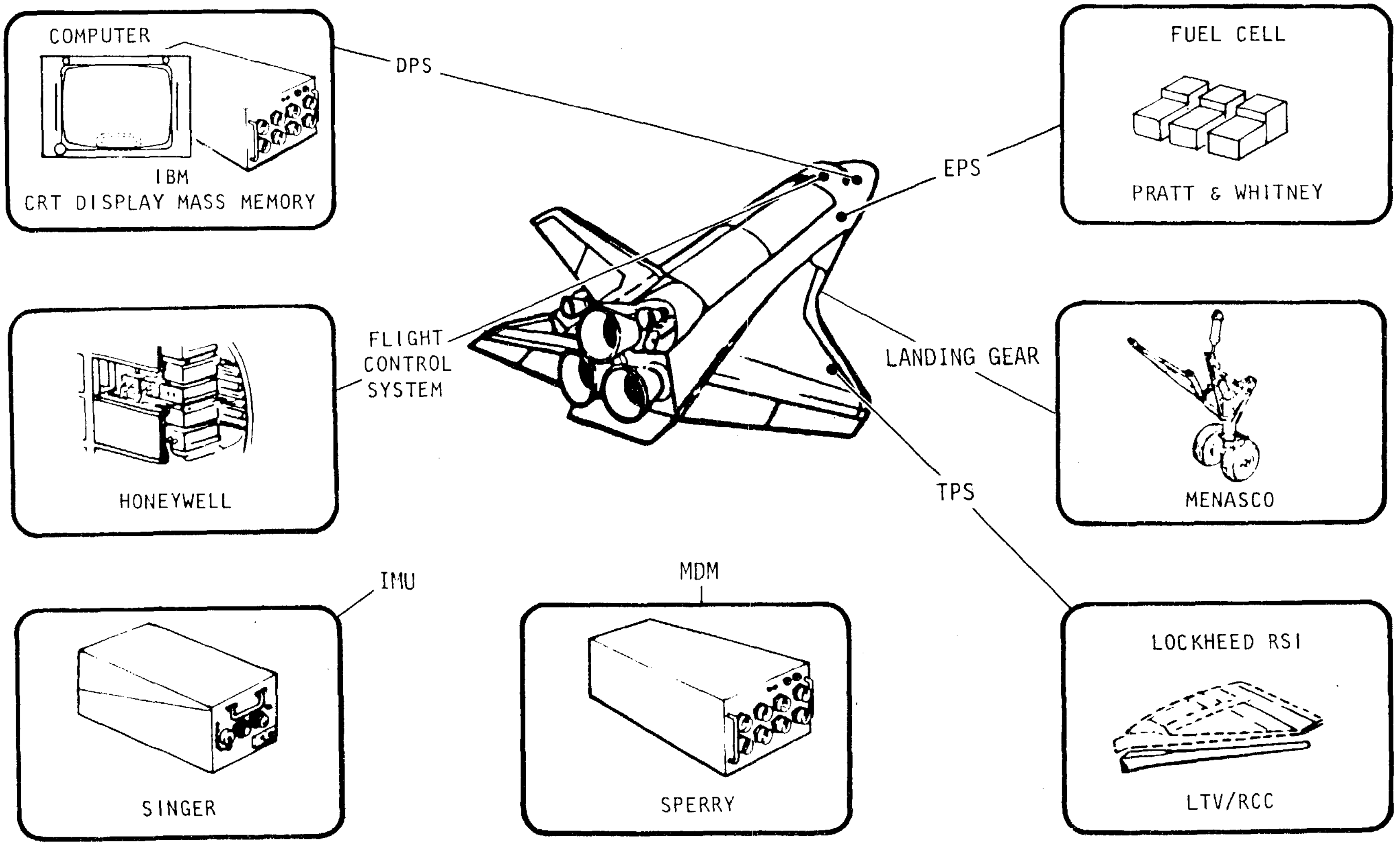
8. The design/procurement/fabrication of GSE is excluded from the present ET and SRM procurements and will be covered under a separate procurement action to be negotiated, managed, and funded by the launch site.

9. If, during the design or development of common usage support equipment, an item evolves to the point that it is no longer cost effective for the program to maintain common usage, then separate design/development actions will be initiated. From this point, the equipment would be classified as STE, thereby placing it under sole MSFC management and budget control; or as GSE, thereby placing it under sole KSC management and budget control.

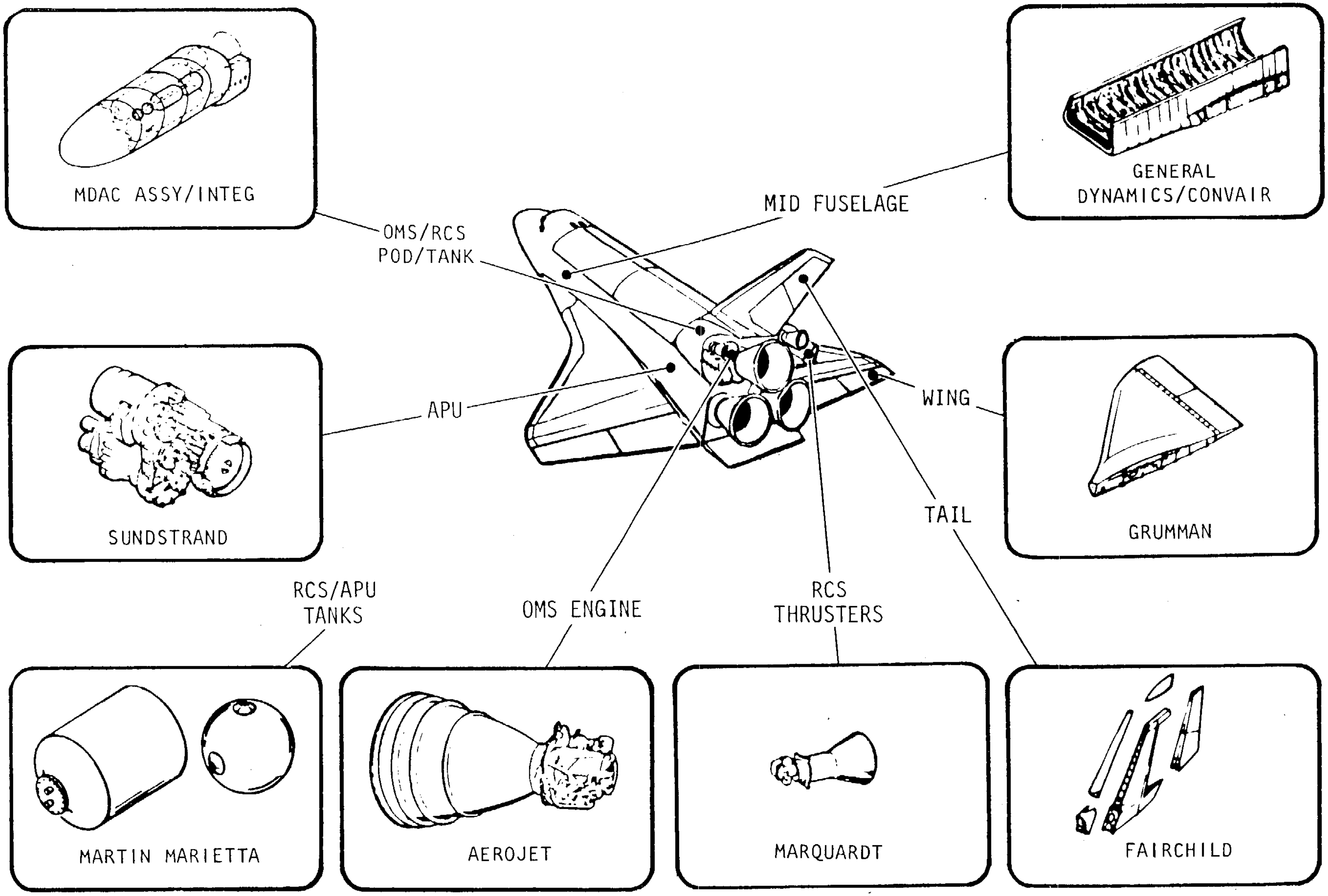
R. H. Gray
R. H. Gray
Manager, Shuttle Projects Office
KSC

Roy E Godfrey
Roy E. Godfrey
Manager, Shuttle Projects Office
MSFC

7.5 MAJOR ORBITER SUBCONTRACTORS



MAJOR ORBITER SUBCONTRACTORS



7.6 SPACE SHUTTLE SYSTEM PRELIMINARY DESIGN REVIEW

Objectives

The purpose of the SSS-PDR is to conduct an end-to-end review to assure that the Space Shuttle System level requirements will be satisfied by current hardware and software design and planning. The system level aspects of the element programs will be examined, including the Orbiter, External Tank, Solid Rocket Booster, Space Shuttle Main Engine, Payload Accommodations and Ground Systems. The objectives to be accomplished during the PDR are to:

(a) Review the total Space Shuttle System design, including as required, individual elements, payload accommodations and the ground systems to assure compliance with Space Shuttle System requirements.

(b) Review current hardware and software design and predicted capability as compared with mission requirements.

(c) Review current designs and plans against quality, reliability, maintainability and safety requirements.

Review Items

At the PDR, the participants will be expected to review various data which describe the system design. These data will include (1) documents (plans), (2) drawings and schematics, (3) manufacturing and test layout and flows, and (4) other back-up data.

Review Operations

Review Teams. The reviews will be accomplished by teams that have the responsibility for reviewing assigned areas. A team captain has been assigned to each of the major technical areas to be reviewed. Each team captain will be responsible to the review chairman for nominating the members of the team necessary to accomplish an adequate review of his assigned area. Each review team should include the NASA technical area manager and support personnel, flight and ground operations personnel, project element representatives as appropriate, and contractor representatives as required.

In accomplishing the review objectives, each team prepares Review Item Dispositions (RID's) to describe significant discrepancies and inconsistencies. Each team captain reviews all RID's generated by his team to eliminate redundancies and duplicate RID's. The team captain submits the team findings and recommended RID dispositions to the review coordinator in the form of a team review packaging consisting of (1) a set of team minutes, and (2) all RID's written by the team. The team captain has the overall responsibility for all activity of his team and assure that all review ground rules and schedules are met. He prepares the appropriate response to each RID and recommends the disposition to be taken.

Review Item Disposition (RID's)

RID's shall be submitted to the review control station as soon as they are written to allow as much time as possible for processing. Every attempt will be made to resolve problems via the review teams during the team meetings.

Screening Group, Pre-Board and Board Operations

Screening Group. The screening group will screen all RID's submitted to avoid redundancy, duplication, or other programmatic problems that may be generated. This group will review the disposition of all RID's and categorize them for review by the pre-board.

Pre-Board. The pre-board will be responsible for reviewing all RID's, with primary emphasis on those items requiring further deliberation or resolution. After the pre-board review, RID's of major importance will be forwarded to the board for final review and disposition.

Board. The board is the final dispositioning authority. All RID's of major importance to the program will be dispositioned at this level. Board presentations will consist of project summaries by each project manager and individual summaries by the team leaders of review accomplishments, problems, matters of significant importance and RID's.

TABLE I

JSC SYSTEMS INTEGRATION OFFICE FUNCTIONS

PRIME

ASCENT & ENTRY PERFORMANCE
LOADS & STRUCTURAL DYNAMICS
FLIGHT CONTROL
INTEGRATED AVIONICS
INTEGRATED PROPULSION & FLUIDS
MECHANICAL SYSTEMS
COMPUTER SYSTEMS AND SOFTWARE
SUPPORTING TECHNOLOGY
PERFORMANCE & DESIGN SPECIFICATION
FLIGHT TEST REQUIREMENTS
SYSTEMS INTERFACES
MASS PROPERTIES
SYSTEM/OPS DATA BOOKS
INTEGRATED SCHEMATICS
MATERIALS & PROCESSES
GROUND SYSTEMS INTEGRATION
MAINTAINABILITY
INTEGRATED LOGISTICS
TEST & VERIFICATION
GSE REQUIREMENTS & ANALYSIS
MANUFACTURING
RELIABILITY
SAFETY
QUALITY ASSURANCE
SCA PROJECT MANAGEMENT
SCA ENGINEERING AND INTEGRATION
SCA SYSTEMS
SCA SYSTEMS SUPPORT

SUPPORT

ANCILLARY HARDWARE REQUIREMENTS
COMMONALITY
CHANGE ASSESSMENT
CONFIGURATION MANAGEMENT
CHANGE INTEGRATION
OPERATIONAL REQUIREMENTS
DESIGN REVIEWS
APPROACH & LANDING FLIGHT TEST

TABLE II

PANELS AND WORKING GROUPS

MANAGEMENT

- PERFORMANCE MANAGEMENT PANEL
- CONFIGURATION MANAGEMENT SYSTEMS PANEL
- MIC INTEGRATION PANEL
- INFORMATION MANAGEMENT SYSTEMS PANEL
- INTEGRATED LOGISTICS WORKING GROUP
- COST PER FLIGHT COMMITTEE
- SCHEDULE/LOGIC INTEGRATION WORKING GROUP

TECHNICAL

- SYSTEM INTERFACES PANEL
- FLIGHT PERFORMANCE PANEL
- LOADS/STRUCTURAL DYNAMICS PANEL
- INTEGRATED PROPULSION & FLUIDS PANEL
- FLIGHT CONTROL SYSTEM PANEL
  - ORBIT & ENTRY FCS SUBPANEL
  - GUIDANCE NAVIGATION & CONTROL SYSTEMS SUBPANEL
  - ASCENT FCS/STRUCTURES SUBPANEL
- INTEGRATED AVIONICS PANEL
- MECHANICAL SYSTEMS PANEL
  - SPACECRAFT SYSTEMS SUBPANEL
  - AIRCRAFT SYSTEMS SUBPANEL
- GROUND SYSTEMS INTEGRATION PANEL

TABLE III

ROCKWELL INTERNATIONAL'S SYSTEMS INTEGRATION TASKS

SHUTTLE PROGRAM DEFINITION AND REQUIREMENTS
SYSTEM INTERFACE CONTROL
MASS PROPERTIES
FLIGHT SYSTEM DESIGN PERFORMANCE
GROUND OPERATIONS ANALYSIS
COST PER FLIGHT
INTEGRATED SCHEMATICS
MASTER MEASUREMENT LIST
INTEGRATED VEHICLE ANALYSIS
INTEGRATED GROUND TEST
CONFIGURATION MANAGEMENT
PROGRAM SCHEDULE
MANAGEMENT INFORMATION CENTERS
COMMONALITY PROGRAM
LOGISTICS
QUALITY MANAGEMENT
SAFETY AND RELIABILITY
PREFLIGHT AND FLIGHT TEST SUPPORT
INTERFACE TOOLING
SYSTEMS MATERIALS AND PROCESS CONTROL
PAYLOAD INTERFACE
MISSION PLANNING
REPRESENTATIVES AT ELEMENT CONTRACTORS
SYSTEM LEVEL WORKING GROUPS
REPRESENTATIVES AT NASA CENTERS
SPECIAL STUDIES

TABLE IV

PRESENT ORBITER BASELINE FUNCTION/CRITICALITY SUMMARY

DOOR	FUNCTION	TIMELINE FOR OPERATION	FAILURE	CRIT OF FUNCTION	REMARKS
STAR TRACKER	OPEN TO EXPOSE STAR TRACKER CLOSE FOR THERMAL PROTECTION	OPEN ON ORBIT	TO OPEN	2	ABORT MISSION - NO IMU UPDATE
		CLOSE PRIOR TO DEORBIT BURN	TO CLOSE	1	AERO/THERMAL PROBLEM (BASELINE). INWARD OPENING DOOR MAY CHANGE TO CRIT 2
PAYLOAD BAY (OPEN & CLOSE TIME - CRITICAL FOR MISSIONS 3a, 3b)	OPEN TO EXPOSE PAYLOAD & RADIATOR CLOSE FOR STRUCTURAL INTEGRITY THERMAL PROTECTION	OPEN ON ORBIT	TO OPEN	2	ABORT MISSION
		CLOSE PRIOR TO DEORBIT BURN	TO CLOSE	1	THERMAL/STRUCTURAL PROBLEM DURING ENTRY/DESCENT. RESCUE, OR CREW WORKAROUND
VENT (ONLY)	OPEN ASCENT/DESCENT PRESSURE EQUAL CLOSE LIFTOFF - ACOUSTICAL ENTRY - THERMAL	CLOSE AT T-4	TO CLOSE	2	LAUNCH DELAY
		OPEN AT T+10	TO OPEN	2	REDUNDANCY PROVIDED
		CLOSE PRIOR TO DEORBIT BURN	TO CLOSE	1	THERMAL RPOBLEM - ENTRY. RESCUE, OR CREW WORKAROUND
		OPEN 70K FT	TO OPEN	2	REDUNDANCY PROVIDED
EXTERNAL TANK UMBILICAL	CLOSE FOR THERMAL PROTECTION	CLOSE AT MECO PLUS 12	TO CLOSE	1	AERO/THERMAL PROBLEM DURING ENTRY/DESCENT. RESCUE, OR CREW WORKAROUND

TABLE V

ORBITER OPERATIONAL MODES

Manual Direct

The crew manually controls the vehicle. No feed-back signals from vehicle-motion sensors are used for stabilization and control. The crew's command signal is applied to the appropriate force effector via the GNSC computer. Required compensation and logic for effector selection are accomplished within the GN&C computer. Vehicle-motion signals are displayed as required for crew operation. Automatic GSN commands are inhibited.

Manual Command Augmentation

The crew manually controls the vehicle as in manual direct. However, the crew's command is augmented by feedback signals from vehicle-motion sensors to improve response or augment stability, or both. Required compensation and logic for effector selection are accomplished within the GN&C computer. Vehicle-motion signals are displayed as required for the crew. Automatic G&N commands are inhibited.

Hold

The controlled vehicle parameter is held at the value existing when the hold function is engaged. This reference signal is not alterable by the automatic guidance system except by disengagement and reengagement of the hold function. The old function may be manually disengaged by moving the associated manual hand controller from the detent position. Reengagement is accomplished by returning the hand controller to the detent position.

Select

The controlled vehicle parameter converges to and holds the value selected or preselected by the crew.

Automatic

The guidance function provides automatic control of the vehicle. Manual command signals are inhibited and cannot act to sum with or override the automatic commands from the guidance system. Vehicle motions signals are displayed to permit crew monitoring of the G&N function. The crew has the option of manually engaging or disengaging the automatic function.

TABLE VI

ATMOSPHERIC REVITALIZATION SUBSYSTEM

FUNCTIONS

CARBON DIOXIDE, ODOR, AND WATER VAPOR CONTROL IN PRESSURIZED CABIN

CABIN PRESSURE MAINTENANCE AND CONTROL

CABIN ATMOSPHERE THERMAL CONTROL

CABIN AND AFT SECTION AVIONICS THERMAL CONTROL

ATMOSPHERIC REVITALIZATION FOR HABITABLE PAYLOADS (WHEN REQUIRED)

DESIGN/PERFORMANCE REQUIREMENTS

MISSION

- NOMINAL: 42 MAN-DAYS
- EXTRAVEHICULAR ACTIVITY: 3 TWO-MAN PERIODS
- CONTINGENCIES: 16-MAN DAYS OR 1 CABIN REPRESSURIZATION OR MAINTAIN PRESSURE WITH CABIN LEAK
- PERSONNEL (CREW/PASSENGERS)
- CABIN :DESIGN OPERATION, 3 to 10
  :NORMAL, 3 to 7
  :RESCUE, 6 to 10
- CABIN PRESSURE: 101,354 N/m^2 (14.7 psia)
- ATMOSPHERIC COMPOSITION: 21,374 N/m^2 (3.1 PSIA) OXYGEN:
  79,980 N/m^2 (11.6 PSIA) NITROGEN

TABLE VII

SUBASSEMBLY RELIABILITY PREDICTION BREAKDOWN

	Total	I	II	III
Input Electronics	3.4313	1.2524	.1028	2.0761
Computer Interface Electronics	2.8360			2.8360
Output Electronics	3.3191			3.3191
Power Supply Electronics	3.7732			3.7732
Chassis Electronics	3.2708	.6032		2.6676
Digital Computer Unit	21.1272			21.1272
(%/1,000 hours) TOTAL	37.7576	1.8556	.1028	35.7992
(Hours) MTBF	2648	53,891	972,763	2765

I = Electronics for flight recording and/or maintenance data

II = Electronics for ground operation not required for mainstage

III = Electronics required for mainstage

TABLE VIII

TYPICAL CONTROLLER ELECTRONICS CARD FAILURE RATES

Nomenclature	Quantity	Failure Rate (%/1000 hr.)	Percent of Controller Failure Rate
Output electronics	1	0.597	1.7
Power supply	1	0.455	1.3
Input electronics	1	0.310	0.88
Computer interface electronics	2	0.208	0.59

TABLE IX

CONTROLLER RELIABILITY PREDICTION

Assembly	Failure Rate % per 1000 hrs.
Input Electronics	3.96
Interface Electronics	2.87
Output Electronics	3.32
Power Supply and Chassis	2.30
DCU	21.18
Controller	33.63
	3,000 hours MTFF

TABLE X

SRB BASELINE REVIEW
PARACHUTE DESIGN FACTORS

$$D.\ F. = \frac{(j)\ (c)}{(u)\ (o)(e)(k)\ (r)\ (m)}$$

APPLICATION	SAFETY FACTOR	STRENGTH REDUCING FACTOR ($A_p = \frac{c}{u\text{-}o\text{-}e\text{-}k\text{-}r\text{-}m}$)							OVERALL DESIGN FACTOR (D. F. = $j\text{-}A_p$)
	j	CON — FLUENCE ANGLE FACTOR (c)	JOINT EFFICIENCY FACTOR (u)	WATER FACTOR (o)	ABRASION FACTOR (e)	FATIGUE FACTOR (k)	REUSE FACTOR (r)	CLUSTER FACTOR (m)	
DROGUE	1.91	1.025	.8	.95	.95	.95	.95	1	3.00
MAIN	1.54	1.055	.8	.95	.95	.95	.95	.833	3.00

PRECEDENTS

	j	D.F.	
PERSONNEL		3	(F-111 2.54)
"AEROSPACE"	1.9	2.9	(APOLLO 1.9, VIKING 2.08)
CARGO (NO REUSE)	1.5	2.2	
CARGO (REUSE)	1.5	3.0	

TABLE XI

SHUTTLE SYSTEM CONCERNS

1 - FIRE/TOXICITY REQUIREMENTS
2 - HAZARDOUS GAS DETECTION
3 - PROPELLANT LOADING HAZARDS ON PAD
4 - EMERGENCY DRAIN OF EXTERNAL TANK
5 - EMERGENCY INGRESS/EGRESS ON GROUND
6 - DAMAGE TO ORBITER FROM ET ICING
7 - PREMATURE SEPARATION OF ET TO INTERTANK GROUND UMBILICAL
8 - ET TPS/LO_2 INCOMPATIBILITY DURING PRELAUNCH & EARLY BOOST PHASE
9 - SRB IGNITION OVERPRESSURE
10 - LATE IGNITION OF ONE SRB
11 - SHUTTLE COLLISION WITH TOWER ON LIFTOFF
12 - SRB SEPARATION SYSTEM PLUME IMPINGEMENT
13 - FAILURE OF FORE OR AFT SEPARATION MOTOR
14 - POGO
15 - EXCESSIVE ET AERO HEATING
16 - FIRE IN ET INTERTANK AREA BELOW 80,000 FT
17 - SSME UNSCHEDULED SHUTDOWN DURING BOOST
18 - HYDROGEN INGESTION IN THE ORBITER DURING BOOST
19 - SSME FUEL AND OXIDIZER LEAKAGE
20 - SSME HEAT EXCHANGER LEAKAGE
21 - EFFECTS OF ET ABLATIVE PRODUCTS ON ORBITER TPS
22 - LH_2 & LO_2 HAZARDS AT ET/ORBITER SEPARATION
23 - ORBITER/ET SEPARATION WITH FAILED RCS
24 - POST SEPARATION IMPACTS OF ORBITER BY ET
25 - PUBLIC HAZARD FROM SRB IMPACT
26 - PUBLIC HAZARD FROM ET IMPACT
27 - INTACT ABORT CAPABILITY
28 - CONTINGENCY ABORT CAPABILITY
29 - EMERGENCY ESCAPE IN FLIGHT
30 - CREW RESCUE FROM ORBIT
31 - HYDROGEN & OXYGEN RELIEF FROM A CRYOGENIC PAYLOAD

PUBLISHED IN "SHUTTLE SYSTEM PDR-SAFETY ANALYSIS REPORT," SD 75-SH-0064 28 FEBRUARY 1975.

TABLE XII

FLUID HAZARDS VS MISSION PROFILE

ORBITER FLUID	MISSION PROFILE					
	PRE-LAUNCH	ASCENT	ORBIT	REENTRY	LANDING	SAFING & MAINTENANCE
AMMONIA (NH_3)	F&T	(IP)	-	F	F	F&T
HYDROGEN (H_2)	F	(IP)	-	F	F	F
HYDRAZINE (N_2H_4)	F&T	(IP)	-	F	F	F&T
MONOMETHYLHYDRAZINE (5606)	F&T	(IP)	-	F	F	F
*NITROGEN TETROXIDE (N_2O_4) AND/OR OXYGEN (O_2)	F&T	(IP)	-	F	F	F&T

<u>LEGEND:</u> F = FIRE HAZARD
T = TOXIC HAZARD
IP = PAD INERT GAS (GN_2) PURGE

*NITROGEN TEXTROXIDE & O_2 CAN BE FIRE HAZARDS IN COMBINATION WITH FUELS WHEN AIR IS NOT PRESENT

- NECESSITY FOR GROUND DETECTION AFFIRMED - CLEARS FOR ASCENTS
- ENTRY HAZARD POTENTIAL BEING EVALUATED - ON-BOARD DETECTION (TBD)

TABLE XIII

ALT MISSION OBJECTIVES DOCUMENT

ORBITER FREE FLIGHT TESTS

TEST NO.	ORBITER GW/CG	OBJECTIVES	REMARKS
1	OPT/OPT	SIMULATED APPROACH AT ALTITUDE	TAILCONE ON
2	OPT/OPT	STAB AND CONT AT NEAR V_{MSO}, V_{APP}	TAILCONE OFF
3	INTERMEDIATE I	STAB AND CONT AT V_{MAX} ALLOWABLE	MONITOR AUTO COMMANDS
4	OFT/OFT	STAB AND CONT AT V_{MSO}, V_{APP}	MONITOR AUTO COMMANDS
5	OFT/OFT	BANKS, SIDESLIPS AT V_{MSO}, V_{APP}	AUTO ROLLOUT AT 30 kt
6	OFT/OFT	MANUALLY FLY AUTO COMMANDS	SWITCH IN/OUT OF AUTOMODE IN FLIGHT AUTO ROLLOUT AT ABOUT 90 kt
7	OFT/OFT	AUTOTAEM/AUTOLOAD DEMONSTRATION	
8	OFT/OFT	OFFSET AUTOTAEM/AUTOLOAD DEMONSTRATION	$\approx 30^\circ$ OFFSET SEPARATION
9	IMMEDIATE II	STAB AND CONT AT V_{MAX} ALLOWABLE	MONITOR AUTO COMMANDS
10	NVY/AFT	STAB AND CONT AT NEAR V_{MSO}, V_{APP}	MONITOR AUTO COMMANDS
11	NVY/AFT	$\approx 2_g$ TURN, BANKS, SIDESLIPS AT V_{APP}	$\approx 50^\circ$ OFFSET SEPARATION

OPT - OPTIMUM CONFIGURATION FOR APPROACH AND LANDING
OFT - FIRST ORBITAL FLIGHT TEST CONFIGURATION
NVY/AFT - AN OFT/OPERATIONAL CONFIGURATION MORE EXTREME THAN OFT
V_{MSO} - MINIMUM SAFE OPERATING VELOCITY
V_{APP} - NOMINAL APPROACH VELOCITY
V_{MAX} - MAXIMUM VELOCITY

JSC TPS MANAGEMENT ORGANIZATION

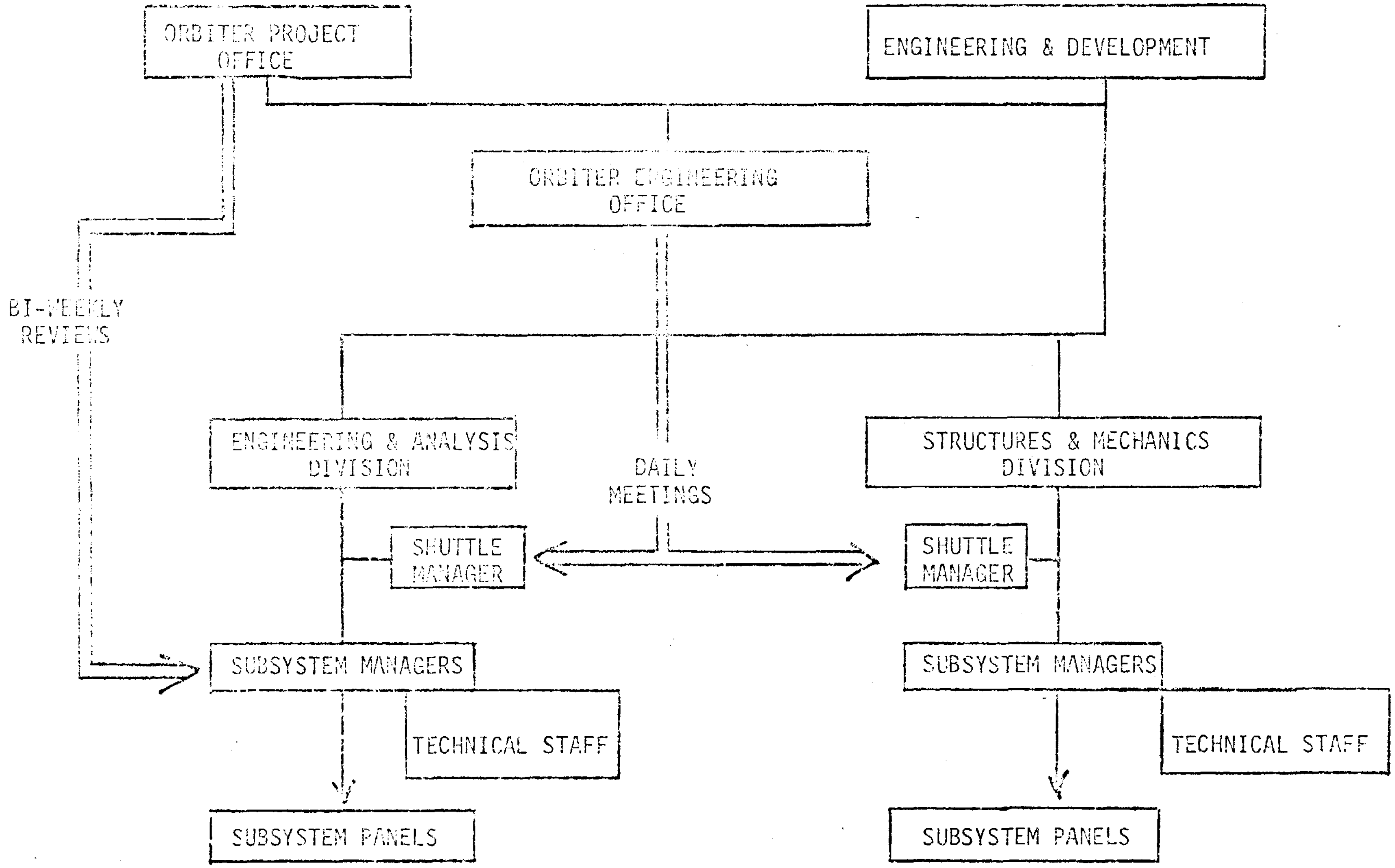


Figure 1

JSC TPS MANAGEMENT ORGANIZATION DETAIL

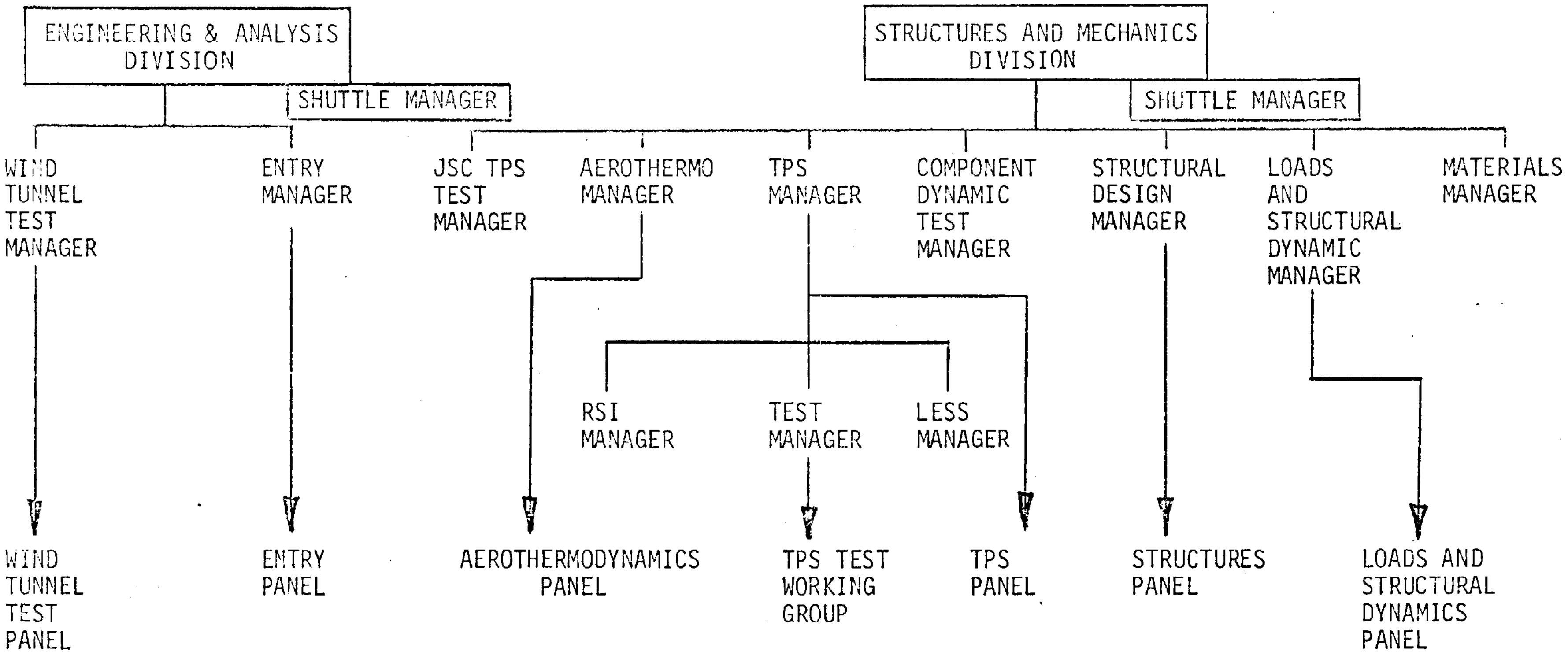
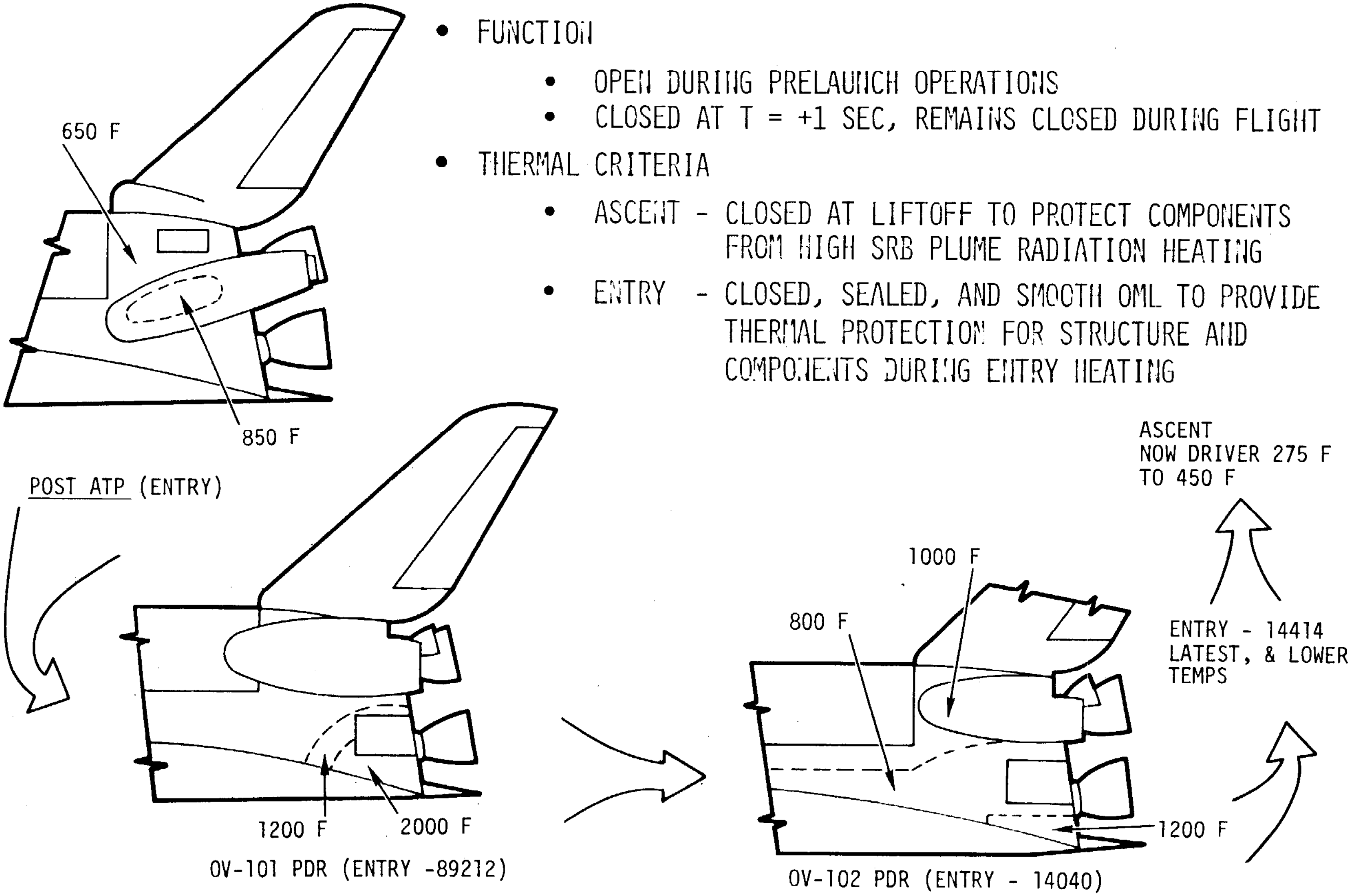


Figure 2

T-0 UMBILICAL DOOR
THERMAL HISTORY



- FUNCTION
  - OPEN DURING PRELAUNCH OPERATIONS
  - CLOSED AT T = +1 SEC, REMAINS CLOSED DURING FLIGHT
- THERMAL CRITERIA
  - ASCENT - CLOSED AT LIFTOFF TO PROTECT COMPONENTS FROM HIGH SRB PLUME RADIATION HEATING
  - ENTRY - CLOSED, SEALED, AND SMOOTH OML TO PROVIDE THERMAL PROTECTION FOR STRUCTURE AND COMPONENTS DURING ENTRY HEATING

Figure 3

T-0 LAUNCH UMBILICAL PLATE

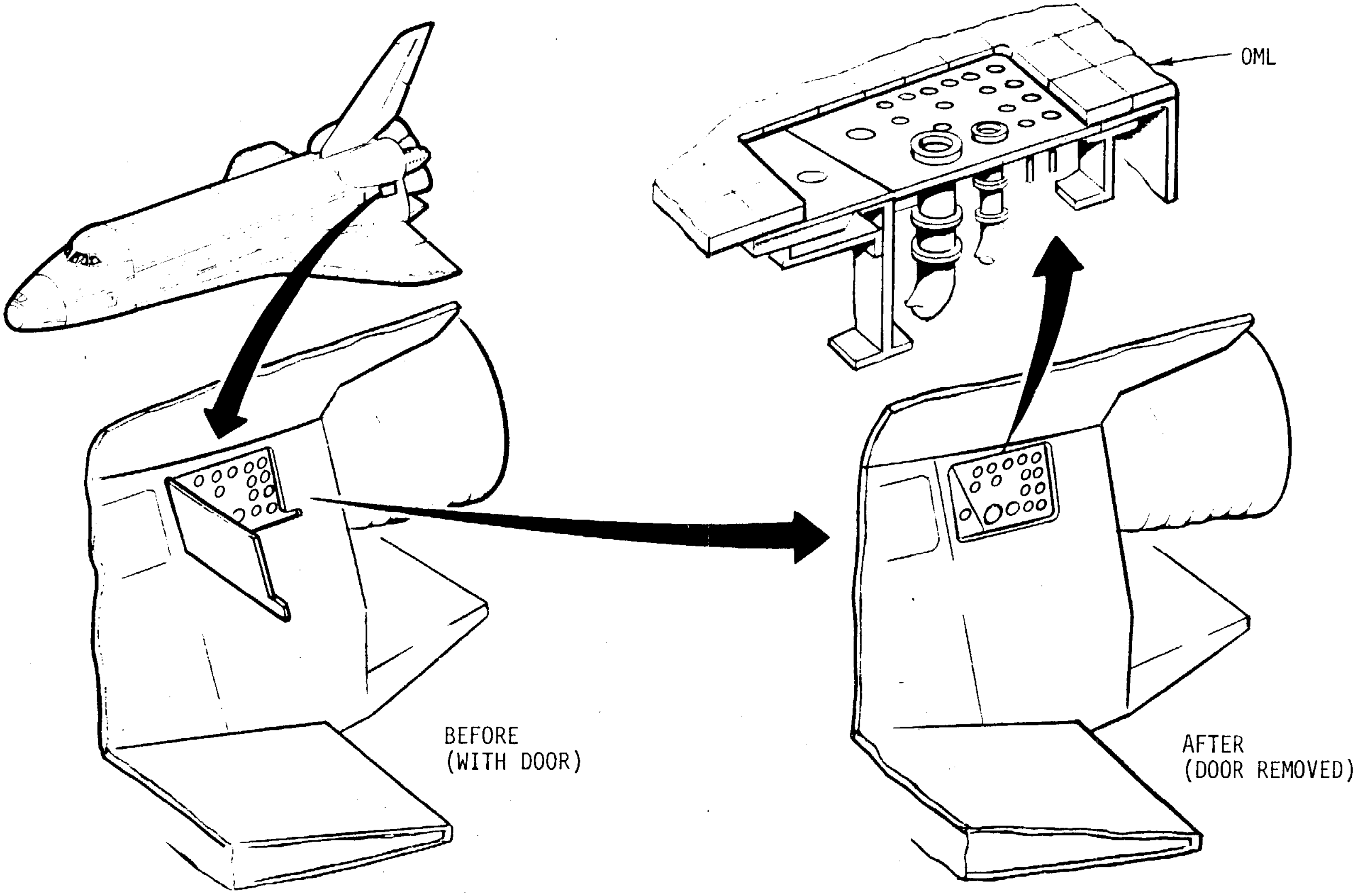


Figure 4

FORWARD RCS

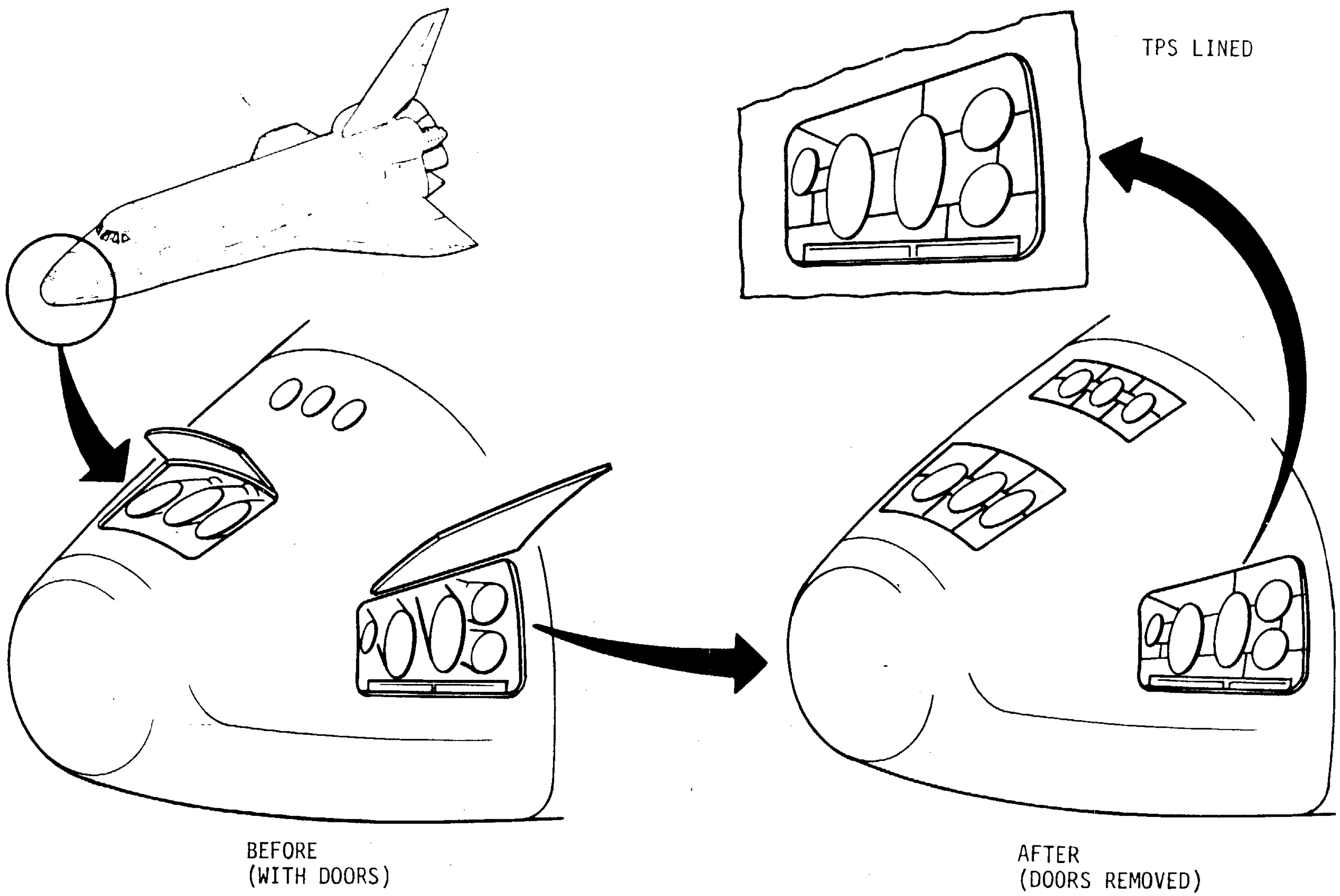


Figure 5