

Space Program Operations Contract

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SM TM 21002

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Final Version

**This document has been reviewed and updated.
No subsequent updates to this document are anticipated or required due to the
approaching shuttle program closure.**

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**Systems Management
Training Manual
SM TM 21002**

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<u>Page No.</u>	<u>Change No.</u>
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i - iii	Rev. B
1-1 – 1-3	Rev. B
2-1 – 2-4	Rev. B
3-1 – 3-2	Rev. B
4-1 – 4-7	Rev. B
5-1 – 5-21	Rev. B
6-1 – 6-8	Rev. B
A-1 – A-4	Rev. B
B-1	Rev. B

FOREWORD

The content of this document was provided by the Systems Training Group, Vehicle Systems Branch, Space Transportation Vehicle Division, Mission Operations Directorate (MOD), Lyndon B. Johnson Space Center (JSC), National Aeronautics and Space Administration (NASA). Technical documentation support was provided by Bastion Technologies Inc. Any questions concerning this training manual or any recommendations should be directed to Shuttle Systems Document Controller, Tina Weber, at USH-4713, 281-244-7679, or the training manual Book Manager, John Kennard, at USH-4713, 281-244-2334.

This material is for training purposes only and should not be used as a source of operational data. All numerical data, displays, and checklist references are intended as examples. To determine any prerequisites before using this document, consult the applicable Certification Plan. For shuttle manuals, consult the Flight Operations Support Personnel Training Guide (Blue Book) or the Crew Training Catalog. For International Space Station (ISS) manuals, consult the appropriate Space Station Certification Training Guide or Training Administration Management System (TAMS). The applicable training package should be studied before attending any classroom session or lesson for which this is a prerequisite.

A Training Materials Evaluation is included at the end of this document. Inputs on this sheet will be used to evaluate the lesson material. You do not need to sign the sheet.

CONTENTS

Section	Page
1.0 INTRODUCTION	1-1
2.0 SYSTEMS MANAGEMENT SOFTWARE	2-1
2.1 GPC SOFTWARE OVERVIEW	2-1
2.2 ASCENT AND ENTRY	2-3
2.3 ORBIT	2-3
3.0 SM COMMAND AND DATA INTERFACES.....	3-1
4.0 BASIC SM PROCESSES.....	4-1
4.1 FAULT DETECTION ANNUNCIATION	4-1
4.2 PRECONDITION PROCESSING	4-3
4.2.1 BFS SM Precondition Processing	4-3
4.2.2 PASS SM Precondition Processing.....	4-5
5.0 SPECIAL/MISSION-SELECTABLE PROCESSES.....	5-1
5.1 SPECIAL PROCESSING	5-2
5.1.1 BFS SM Special Processing	5-2
5.2 PASS SM SPECIAL PROCESSES.....	5-4
5.2.1 Fuel Cell Auto Purge Sequence	5-4
5.2.2 Hydraulic Fluid On-orbit Temperature Control Sequence	5-6
5.2.3 O ₂ /N ₂ Quantity Computation	5-9
5.2.4 Standby Water Coolant Loop Temperature Control	5-10
5.3 FREON COOLANT LOOP RADIATOR ISOLATION.....	5-11
5.4 BFS AND PASS SM SPECIAL PROCESSES	5-11
5.4.1 Antenna Management.....	5-11
5.4.2 Auxiliary Power Unit Fuel Quantity Calculation	5-14
5.4.3 Fuel Cell Total Current and Power Computation.....	5-14
5.4.4 Hydraulic Water Boiler Quantity	5-15
5.4.5 Payload Bay Door Sequence	5-16
5.5 MISSION-SELECTABLE PROCESSES	5-19
5.5.1 SSUS Sequence Control Process.....	5-19
5.5.2 IUS GNC Data Transfer	5-20
5.5.3 Standard GNC Data Transfer.....	5-21

Section		Page
6.0	DISPLAY AND UPLINK CONTROLLED PROCESSES	6-1
6.1	BFS AND PASS SM DISPLAY- AND UPLINK-CONTROLLED PROCESSES.....	6-1
6.1.1	PCMMU Telemetry Format Load	6-1
6.1.2	SM System Summary Displays.....	6-2
6.2	PASS SM DISPLAY- AND UPLINK-CONTROLLED PROCESSES.....	6-4
6.2.1	Checkpoint	6-4
6.2.2	MMU Read/Write	6-4
6.2.3	Payload Data Interleaver Format Load	6-6
6.2.4	Payload Data Uplink Processing	6-7
6.2.5	Payload Signal Processor Communication	6-7
6.2.6	Remote Manipulator System Control	6-7
6.2.7	Table Maintenance SPEC.....	6-8
 Appendix		
A	ACRONYMS AND ABBREVIATIONS	A-1
B	SUGGESTED REFERENCE DOCUMENTS	B-1

TABLES

Table		Page
5-1	SM special/mission-selectable processing	5-1
6-1	Display and uplink controlled processes.....	6-1

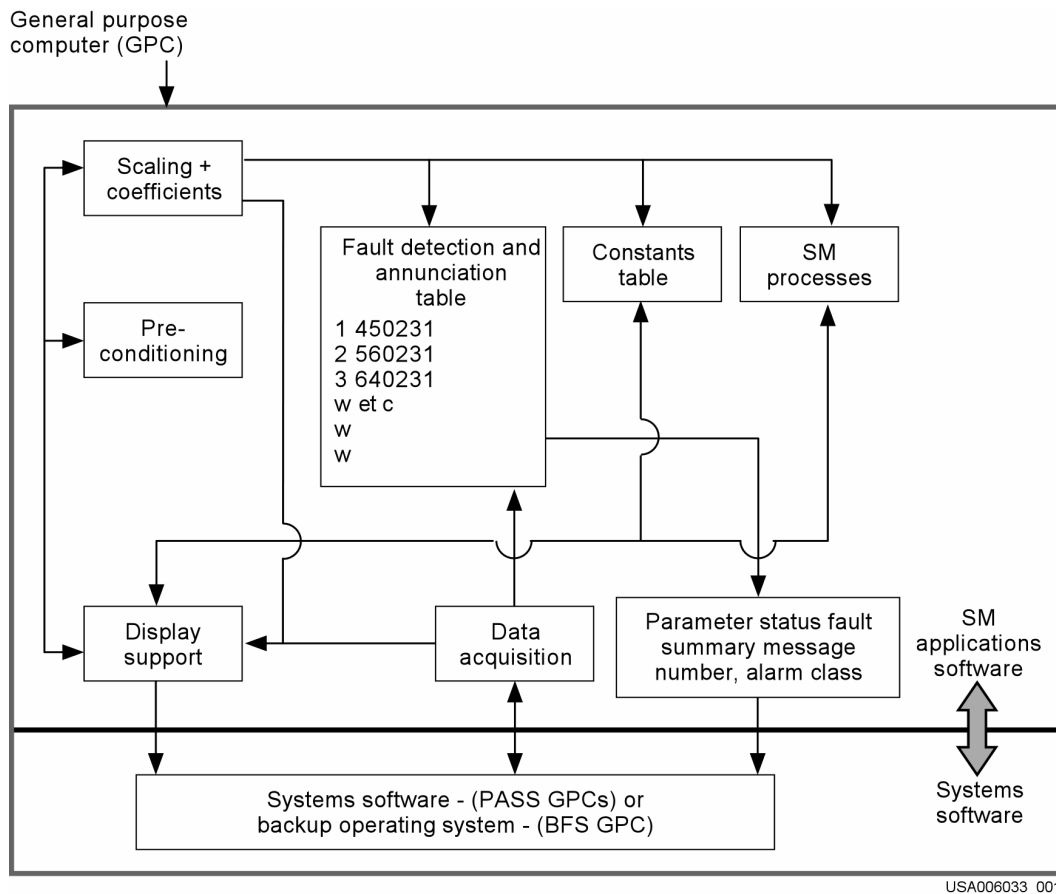
FIGURES

Figure		
1-1	SM software overview	1-1
1-2	SM structure	1-2
2-1	BFS SM display summary	2-3
2-2	SM major mode transitions and display summary (PASS)	2-4
3-1	SM control and data interfaces	3-2
5-1	SM SYS SUMM 1 display	5-2
5-2	Panel L1	5-4
5-3	Hydraulic circ pump switches on Panel R2.....	5-7
5-4	S-band designated steering.....	5-12
5-5	Ku-band designated steering.....	5-12
5-6	PL BAY DOORS display (OPS 202, 402, or BFS SPEC 63)	5-16
5-7	PLBD close auto sequence	5-18
5-8	IUS transfer path	5-21
6-1	PCMMU/PL COMM display	6-2
6-2	SM SYS SUMM 1 display	6-3
6-3	SM SYS SUMM 2 display	6-3
6-4	MASS MEMORY R/W display	6-5
6-5	MMU roll-in buffers	6-6
6-6	SM TABLE MAINT typical display	6-8

1.0 INTRODUCTION

The successful performance of a complicated space flight depends heavily on the use of a computerized system for controlling and monitoring the entire space vehicle. On the space shuttle, the computerized system consists of two groups of applications software: Systems Management (SM) and Guidance, Navigation, and Control (GNC). These two groups of applications software are called Major Functions (MFs).

The shuttle software has a third MF called Payload, but at this time, the Payload MF is not used in flight. This workbook covers the SM applications software (see the SM software overview, Figure 1-1, and the SM structure, Figure 1-2).



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Figure 1-1. SM software overview

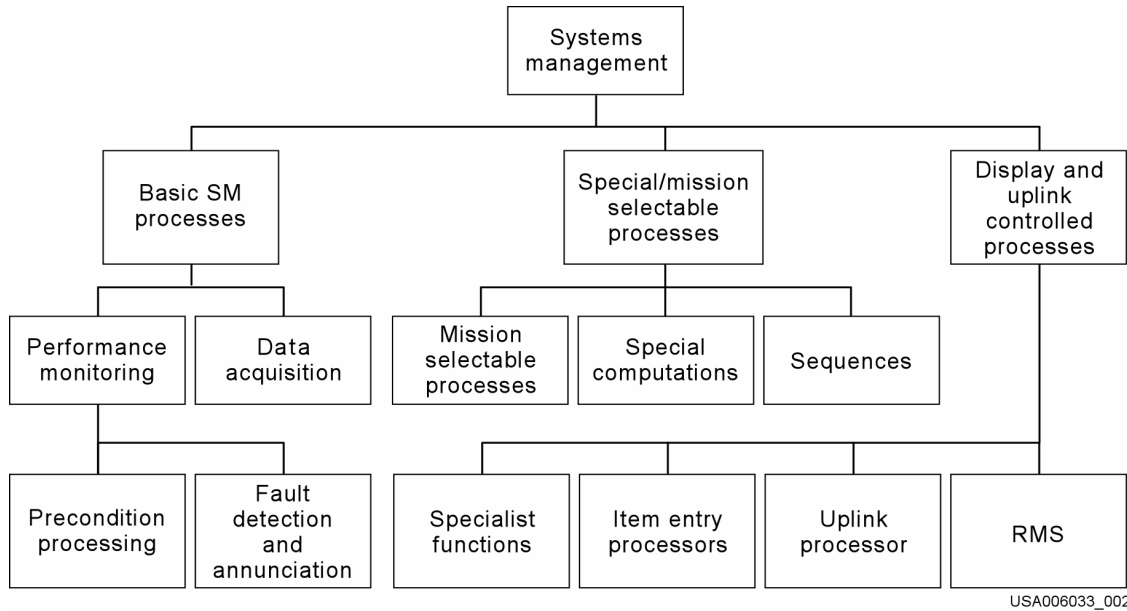


Figure 1-2. SM structure

SM, an MF of applications software, monitors and provides interfaces to the crew on orbiter support systems, payloads, and the Remote Manipulator System (RMS). The SM structure consists of three primary functions: basic SM processes, special/mission selectable processes, and display- and uplink-controlled processes. Basic SM processes acquire data from the various vehicle and payload subsystems and monitor these data to provide fault detection and warning in the event of a vehicle or payload anomaly. Special processes and mission selectable processes provide specialized computations and processing sequences to determine and control the status and performance of various vehicle subsystems and payloads. Display- and uplink-controlled processes provide functions that can be used to initiate, alter, or terminate certain processing within basic SM processes and special processes. Some of these functions provide the onboard capability to modify certain tables used by SM processes.

All three primary functions of SM require computer operating systems software support (like a Personal Computer (PC) operating system), with respect to input data acquisition, and outputs from the General Purpose Computer (GPC) to external hardware. The Backup Flight System (BFS) GPC has its own specialized computer operating systems software called the Backup Operating System (BOS). SM MF software is active during all mission phases in either Primary Avionics Software System (PASS) or BFS.

Note: The operating system should not be confused with the orbiter system.

Fault Detection and Annunciation (FDA) and scaling/displaying provide information on vehicle subsystem health and status through automatic fault detection, performance data readouts, and configuration status displays. Subsystem management of the vehicle is then accomplished by user assessment of this information provided by SM and subsequent user actions to effect vehicle configuration. SM also performs special computations and sequences called Special Processing (SP) that provide additional information and provide assistance in the maintenance of vehicle subsystems. SM, through SP, controls selected functions onboard the vehicle, such as turning pumps off and on, etc. In addition to monitoring the vehicle subsystems, SM provides the capability for the user to update parameters that control SM processing.

2.0 SYSTEMS MANAGEMENT SOFTWARE

2.1 GPC SOFTWARE OVERVIEW

To understand how SM software fits into the overall GPC software, the student must be familiar with the software configuration of the GPCs. In this section, these software configurations are reviewed. The software within each PASS GPC is divided into two parts, System Software (SS/W) and applications software (GNC, SM, or Payload).

The SS/W is common to all PASS GPCs, regardless of what applications software is present. SS/W deals with running the GPCs themselves, as opposed to applications software, which runs the vehicle systems. SS/W provides timing, display support, input/output, sync, etc. Additionally, it is capable of functioning with or without applications software being present in the GPC.

The applications software is further broken down into various MF Operations Sequence (OPS) combinations. The combination of SS/W and application software within a GPC is termed a Memory Configuration (MC). These combinations can be one of eight varieties that determine the GPC's MC. These combinations are as follows:

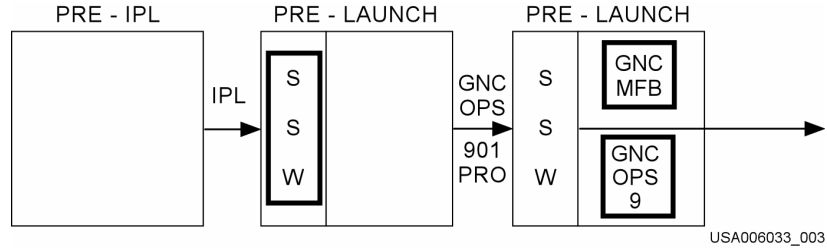
MC	OPS	Function
1	GNC OPS 1 and 6	ASCENT AND RTLS GNC
2	GNC OPS 2	ORBIT GNC
3	GNC OPS 3	ENTRY GNC
4	SM OPS 2	ORBIT SM
5	SM OPS 4	ORBIT SM (no longer supported)
6	PL OPS 9	ORBIT VEHICLE UTILITIES
8	GNC OPS 8	ORBIT FLIGHT CONTROL CHECKOUT
9	GNC OPS 9	PRELAUNCH and POSTLANDING

Going from one MC to another requires that new software be brought (overlaid) into the GPC from the Mass Memory Units (MMUs). Only one MC (MC1) contains more than one OPS because there would be insufficient time to load in GNC OPS 6 from an MMU when it is needed.

Applications software within a GPC is divided into two parts, the OPS overlay and the Major Function Base (MFB). The MFB is not overlaid when a transition is made to a new MC that is of the same MF (for example, GNC OPS 2 to GNC OPS 3). The MFB carries to the new MC that intelligence from the old MC that must be passed along for proper applications software functioning. Line Replaceable Unit (LRU) failure status, state vector, and FDA limit changes are some examples of the intelligence resident in the MFB.

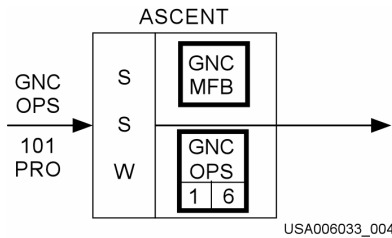
The following illustrates how the OPS overlay and MFBs take place in the GPC. The examples take GPC 4 through a typical flight scenario.

Preflight, the SS/W is loaded into GPC 4 via a process known as the Initial Program Load (IPL). Then GNC OPS 9 is added via overlay with an OPS 901 PRO:

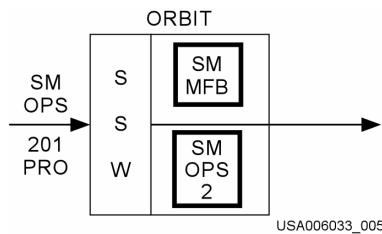


A box around a software segment indicates that it was overlaid during that step.

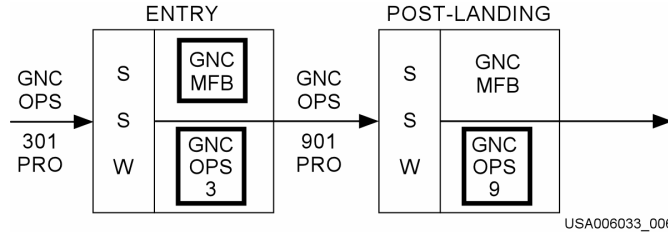
Next, GPC 4 is taken to MC1 for launch with a GNC OPS 101 PRO. Notice that the MFB is not overlaid in the transition; only OPS 1 and 6 are overlaid.



After the ascent phase, GPC 4 is taken to SM OPS 2 (which is MC4) with an SM OPS 201 PRO. In this case, both the MFB and the SM OPS 2 are overlaid.



Finally, GPC 4 is taken to GNC OPS 3 (MC3) for entry and then back to GNC OPS 9 (MC9) postlanding.



The source of an OPS overlay and MFB can be either the MMU (as previously mentioned) or a GPC that already contains the requested software. The OPS overlay and the MFB are considered separately.

The BFS is different from the PASS in that all of its software is present within the computer all the time. This includes SS/W, SM, and GNC OPS 1, 3, and 6. Therefore, no overlays from the MMUs are required.

2.2 ASCENT AND ENTRY

During the ascent and entry phases of the mission, the SM program is managed by the BFS GPC with the BFS program. Activation of the BFS program also activates the BOS data acquisition for SM and enables the scaling/display function. The FDA function is always enabled. When the BFS MODE switch is in RUN, it has control of the Payload data buses. It is through these Payload buses that the BFS SM special processes operate. BFS is always considered to be in SM OPS 0, and its SM is always available, which is different from PASS OPS 0 (see the BFS SM display summary, Figure 2-1).

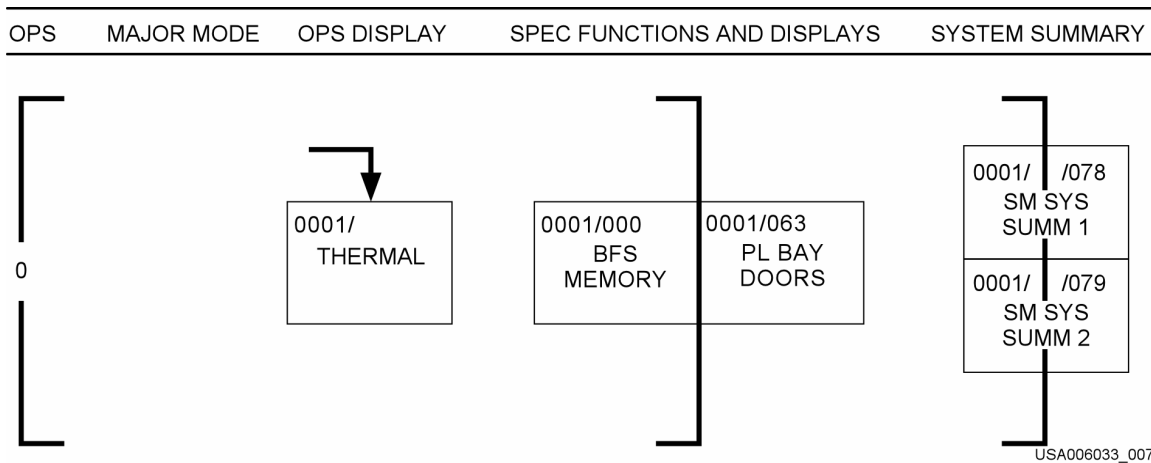


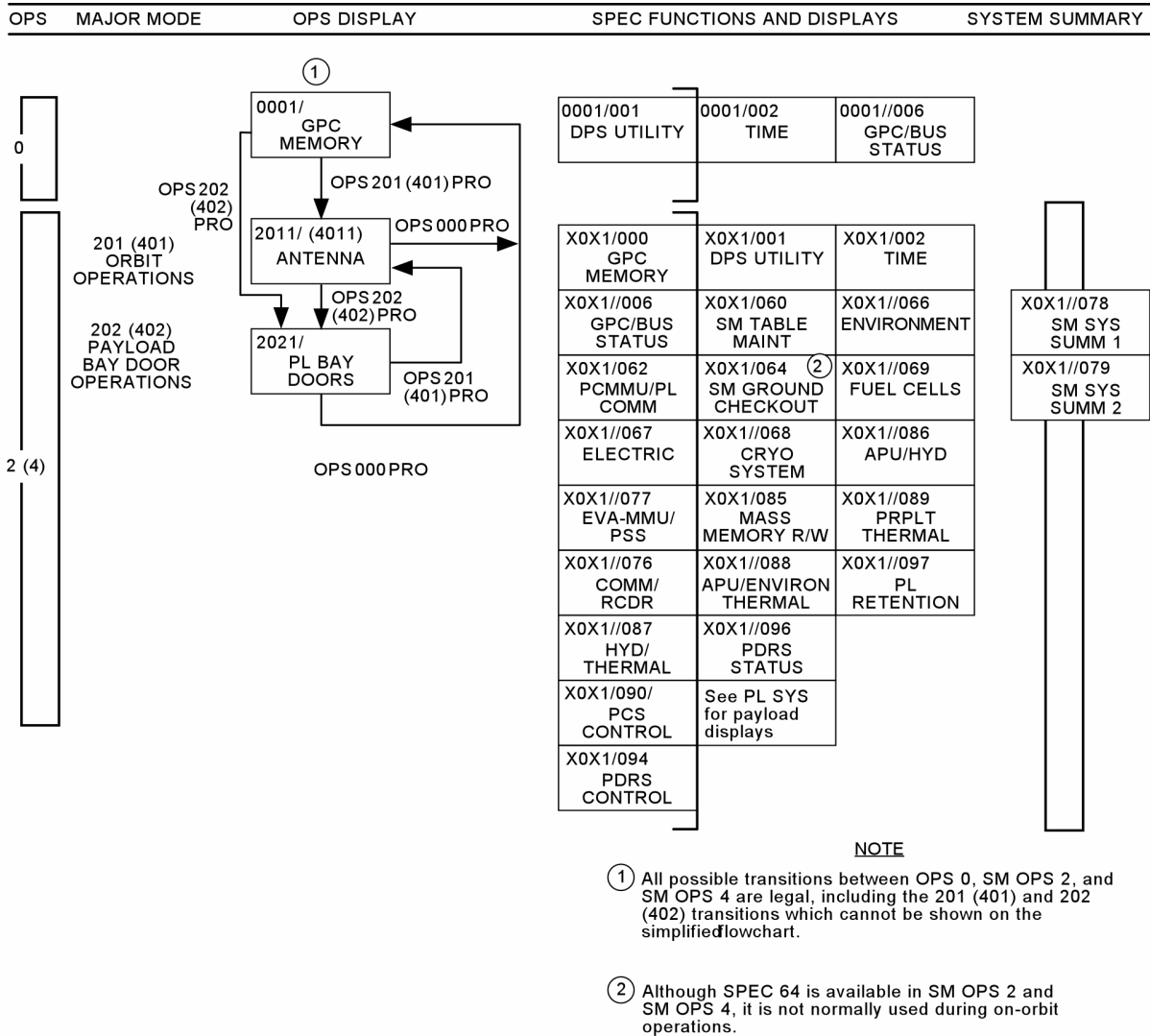
Figure 2-1. BFS SM display summary

2.3 ORBIT

During the orbit phase of the mission, SM is available in a PASS GPC via SM OPS 2. PASS SM OPS 2 and 4 are basically the same. The primary difference is that they contain different payload capabilities. In general, a shuttle mission required only SM OPS 2. However, if all the required payload capabilities could not be put in the OPS 2

software, then it was split between SM OPS 2 and 4. SM OPS 4 is no longer supported (it was rarely used), though many OPS documents still make reference to it.

On-orbit SM software is executed in a common set GPC, which is usually GPC 4. For an outline of all on-orbit displays, see Figure 2-2, the SM Major Mode (MM) transitions and display summary. For a description of all SM displays, see the Data Processing System (DPS) Dictionary.



USA006033_008

Figure 2-2. SM major mode transitions and display summary (PASS)

3.0 SM COMMAND AND DATA INTERFACES

The SM GPC receives Commands (CMDs) from the ground or directly by the crew via the Multifunction Electronic Display System (MEDS). Uplinked CMDs from the ground go through either the Ku-band or S-band signal processor to the Network Signal Processor (NSP). The uplinked CMDs are then sent to the Flight Forward (FF) Multiplexer/Demultiplexers (MDMs) and on to the GNC GPCs via the flight-critical buses. The GNC GPC recognizes that the command is for SM and sends it to the SM GPC via the Inter Computer Communication (ICC) data bus.

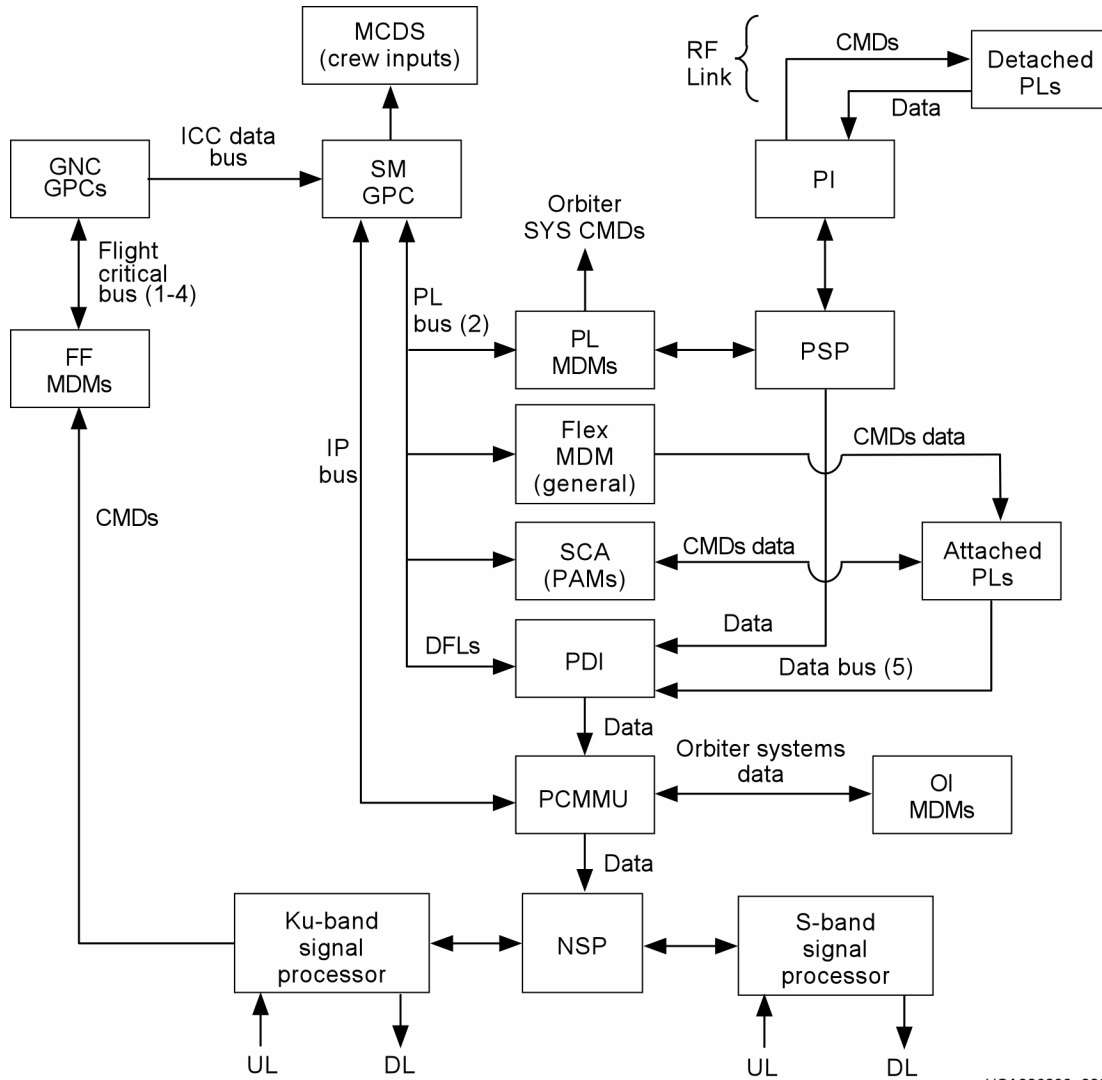
Once a CMD is at the SM GPC, it is acted upon internally or sent out over one of two payload buses to either an orbiter system or a payload. Orbiter systems CMDs are sent to the systems via the Payload (PL) MDMs. Data are sent from the Pulse Code Modulation Master Unit (PCMMU) to the GPC via the Intermediate Processor (IP) data bus for processing and display. In addition, the NSP receives and sends the data to the ground.

Detached payload CMDs are routed to the PL MDM, the Payload Signal Processor (PSP), the Payload Interrogator (PI), and then to the detached payload. Data from the detached payload are then routed back in the reverse direction, to the SM GPC and also to the Payload Data Interleaver (PDI).

Attached payload CMDs are routed either to the flex MDMs or, in the case of a Payload Assist Module (PAM), to the Sequence Control Assembly (SCA) and then to the payload.

Data from the payload are then routed back in the reverse direction to the SM GPC and like detached payloads, to the PDI.

Data sent to the PDI are then sent to the PCMMU. Data sent to the PCMMU can be sent back to the SM GPC and/or the NSP and then to the S-band or Ku-band signal processor for downlink to the ground. The SM command and data flow is illustrated in Figure 3-1.



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Figure 3-1. SM control and data interfaces

4.0 BASIC SM PROCESSES

Basic SM processes acquire data from the various vehicle and payload subsystems and monitor these data to provide FDA in the event of a vehicle or payload anomaly.

4.1 FAULT DETECTION ANNUNCIATION

SM software contains the computer application program that provides a partial backup capability to the orbiter alarm system (additional alarm backup functions reside in the GNC GPC). FDA provides this backup capability in SM.

The FDA is a software module within the SM software that detects and initiates annunciation of out-of-tolerance subsystem conditions. Warnings provided are Class 2 and Class 3, which are the backup Caution and Warning (C&W) and alert systems, respectively. A third minor alarm class contained in the SM software module, Class 0 Limit Sensing, provides indications if an out-of-limits condition is detected by showing either \uparrow or \downarrow . The processes involved in the FDA function include the following: precondition processing, limit sensing, false alarm avoidance, and fault annunciation output.

Precondition processing is the capability to provide configuration-dependent limit sensing. A parameter may have one, two, or three limit sets available for limit sensing. Limit sets 2 and 3 have a corresponding logical statement; i.e., a logical combination that defines the configuration for which the limit set is used. If one of the logical conditions is not met (the combination can include up to four discretely or limit-sensing analogs), the software defaults to limit set 1. Both PASS SM and BFS SM software have numerous examples of precondition processing, as outlined in Section 5.

The capability exists to limit-sense analog parameter values, single-precision floating-point parameters, and discrete parameters. The limit-sense test compares the parameter value with one set of two limits, either simple or multiple. A simple limit set for an analog parameter is one high-limit and one low-limit constant value. A multiple set is a set, which contains two or three simple limit sets, from which one set is selected by preconditions. Alarm Class 2 limit sets are simple limit sets only, whereas alarm Class 0 and 3 limit sets may be simple or multiple. The capability exists to change limit-sense values by keyboard input on the Table Maintenance Specialist Function (SPEC) (PASS SM SPEC 60) or via Table Maintenance Block Update (TMBU) commands from the ground.

False alarm avoidance is the capability to change the time a parameter must be out of limits in order to trip an alarm. If a parameter has been out of a limit set for N consecutive software samples, a fault annunciation, as specified for that parameter, is enabled. The parameter will not annunciate the out-of-limits again for at least N times. The in- and out-of-limits count will be reinitialized if the parameter value has been within limits N consecutive times, or a different limit set is selected by preconditions. The value of N is an integer constant, called the filter value, as specified for each parameter.

The value can be changed by a keyboard entry via the Table Maintenance SPEC or TMBU command.

For example, if a parameter has a filter value of 2 and a software process rate of once a second, that parameter will annunciate an alarm after being out of limits 2 seconds. If a parameter has a filter value of 2 and a software process rate of 0.5 times a second (once every 2 seconds), that parameter annunciates an alarm in 4 seconds.

Fault annunciation output from SM is defined as follows:

- a. Class 2 Backup C&W - Backup C&W light, Master Alarm (MA), and fault messages
- b. Class 3 Alert - Alert light, alert tone, and fault messages
- c. Class 0 - No annunciation, preconditioning, or special purpose limit sensing; status characters (or) for out-of-limits conditions only (↑ or ↓)

SM is a major part of the crew warning system. SM software monitors a large number of parameters associated with the backup C&W system and the SM alert system.

The SM software contains an FDA table made up of a large number of parameters (see Figure 1-1). The job of the SM software is to monitor these parameters and alert Systems software if an out-of-limits condition is found. If an out-of-limits condition is found, SM software sets the out-of-limits flag and tells SS/W what fault message to use and what the alarm class will be. Then SS/W generates the appropriate message, alarm, and tone.

All backup C&Ws are Class 2. Only those SM backup C&W alarms that are produced by FDA can be changed and displayed in engineering units. These limits are accessed through the SM Table Maintenance SPEC (PASS SM SPEC 60) or via TMBU command. The remaining backup C&W alarms, produced by the GNC program, are accessed through the GPC mass memory read/write procedure. A backup C&W out-of-tolerance condition will trigger a C&W MA, illuminate the backup C&W alarm light on Panel F7, and display a message on the Fault Message Line and Fault Summary Page. GNC detected that Class 2 C&W limit violations also drive an additional command out the flight MDM to annunciate a hardware C&W condition.

Another portion of the SM program, which operates similarly to the backup C&W system, is the SM alert program. The alert program is designed to inform the crew of a situation that may be leading up to a C&W, or a situation that may require additional procedures. The alert program was intended to be used for parameters that are not as critical as those covered by hardware C&W (exceptions are fuel cell delta volts, equivalent dP/dT, etc.). The alert program is different from the backup C&W system in that it has subroutines that accomplish precondition steering and can compare up to three limit sets for a parameter. The precondition steering selects which set of limits is in effect, as discussed earlier. When an SM alert parameter exceeds its limits, three actions occur: the SM light is illuminated; a discrete is sent to the primary C&W system

to turn on the alert tone; and the SS/W displays a message on the Fault Message Line and the Fault Summary Page.

SM also contains the capability to perform scaling on all data acquired in order that the parameter values and states may be displayed in calibrated engineering units.

In comparison to the PASS SM software, the BFS SM software has several limitations.

- a. A reduced number of alert parameters
- b. Only five BFS displays compared to over 30 PASS SM displays
- c. Only one value for the N-counter filter associated with false alarm avoidance (N = two samples)
- d. The limit sense capability is not adjustable, except by TMBU
- e. A reduced number of precondition processes

4.2 PRECONDITION PROCESSING

Precondition steering is a software function that selects limit sets for FDA. The difference between PASS and BFS preconditioning is that the PASS has one large block of software, which performs all preconditioning, as opposed to the BFS SM software, which has small subroutines that perform each preconditioning function.

4.2.1 BFS SM Precondition Processing

The BFS SM software contains the following preconditioning processing functions:

- a. FC STACK T (Fuel Cell Stack Cool Out Temperature) - The stack cool out temperature parameters of the three fuel cells have multiple limits for FC STACK T high. These variable upper limits depend on the power output of the fuel cell (see Section 5.4.3). An SM alert, Class 3 alarm, is generated when these limits are exceeded. This precondition processing is the same in the SM PASS software, except that the PASS also has variable lower limits.

Precondition (power output)	SM alert limit (high limit) (deg F)
<3.5 kW output	212
3.5 to 7.5 kW output	222
>7.5 kW output	238

- b. APU SPEED (Auxiliary Power Unit (APU) Turbine Speed) - The three APU speeds will have two upper alarm limits, depending on whether or not the cockpit switch setting for APU speed is high or normal. There is only one lower limit. If the APU speed is set to normal, an SM alert, Class 3 alarm, is generated if the speed exceeds 112 percent; a backup C&W, Class 2 alarm, is generated if the APU speed is set to high and the speed violates 122 percent. This precondition processing is not in the PASS SM software.
- c. Inertial Measurement Unit (IMU) Fan Preconditioning - Because only one of three IMU fans is on at a time, the three IMU fan speed measurements are preconditioned so as to FDA only the fan that is turned on. This precondition processing is different in the PASS SM software (see Page 4-5).
- d. Gearbox Lube Oil Pressure Preconditioning - The three gearbox lube oil out pressure measurements are preconditioned so that the FDA alarm is inhibited when the APUs are off. An APU shall be regarded as off if its turbine speed is less than 40 percent. A time delay of 10 seconds elapses after each precondition change before limit testing begins. This precondition processing is the same in the PASS SM software.
- e. Power Reaction Storage And Distribution (PRSD) Fuel Cell Powerplant (FCP) Reactant Valve Preconditioning - Each of the three Reactant Valve (REAC VLV) discrettes for the SM SYS SUMM 1 display is derived from the oxygen (O₂) and hydrogen (H₂) valve positions. An open display indicator reflects that both the O₂ and H₂ valves are open. A closed display indicator reflects that either one or both valves are closed. This precondition processing is the same in the PASS SM software.
- f. Partial Pressure O₂ (PPO₂) - During the postlanding BFS transition to OPS 0, the backup C&W (Class 2) lower limit on PPO₂ is lowered from 2.7 to 2.4. This precondition processing is not in the PASS SM software.
- g. Tire Pressure Monitoring - Each of the six orbiter tires contains two pressure sensors. The output from these sensors is displayed on the BFS THERMAL display SM0. If any of these 12 sensors detects a tire pressure below 50 Pulse Code Modulation (PCM) counts (256 psi), an SM Class 3 FDA occurs. Since the crew cannot take protective actions once touchdown has occurred, these tire pressure sensors are inhibited for FDA when the LANDING GEAR DOWN discrete is activated. This precondition processing is not in the PASS SM software. This process is scaled and displayed in OPS 0, 1, 3, and 6, but the FDA is performed in OPS 3 and 6 only. Tire pressures are also available on orbit in SM OPS 2 and 4 via HYD THERMAL display (SPEC 87).
- h. SM Brake Pressure Monitoring - There are two brake skid/control modules for each of the four main gear tires (left outboard, left inboard, right outboard, and right inboard) for a total of eight modules. Each of these 8 modules contains 2 brake pressure sensors for a total of 16 sensors. The output from these sensors is

displayed to the BFS THERMAL display (SM0). If any of the 16 sensors detects a brake pressure above 180 psia, an SM Class 3 FDA occurs. Preconditioning inhibits the 16 brake pressure sensors from FDA when the LANDING GEAR DOWN discrete is activated. The landing gear deploy sequence is performed approximately 10 seconds from touchdown. The FDA is inhibited prior to touchdown due to the hydraulic spike caused by main gear touchdown, which would cause alarms if the FDA were not inhibited. This precondition processing is not in PASS SM software. This process is scaled and displayed in OPS 0, 1, 3, and 6, but the FDA is performed in OPS 3 and 6 only.

4.2.2 PASS SM Precondition Processing

The PASS SM software uses precondition processing to perform the following operations:

- a. APU OIL OUT P (APU Oil Out Pressure) - Preconditioning sets two low alarm limits for APU OIL OUT P, one for when the APU is OFF (P = Off Scale Low (OSL)) and one for when the APU is ON (P = 25).
- b. CRYO TANK PRESSURE - Preconditioning sets to low alarm limits for cryo O₂ and cryo H₂ tank pressures, one for when the cryogenic heaters are in ON or AUTO and a different limit for when the heaters are OFF. The cryo heaters are designed to work in a single-phase fluid, and if the pressure gets too low, pockets of gas will form in the tanks. This preconditioning sets the low-pressure limit so that a warning appears if the tank pressure goes below the critical pressure of the cryo, which would indicate a tank leak.

CRYO TANK P LOWER LIMITS

O ₂ tank P		H ₂ tank P	
HTR OFF	HTR ON or AUTO	HTR OFF	HTR ON or AUTO
575	740	165	189.8

The upper limit for O₂ tank pressure is always 960 psia, and the upper limit for H₂ tank pressure is always 283 psia.

- c. EVAP TEMP HI LOAD INBD DUCT - Preconditioning sets two low alarm limits for this parameter, one for when the HI LOAD DUCT HTR is ON (T = 150) and one for when the HI LOAD DUCT HTR is OFF (no low limit).
- d. FC STACK T - Fuel Cell Stack Coolant Out Temperature - The three fuel cells have variable upper and lower SM alerts depending on the fuel cell power outputs (see Section 5.4.3).

Precondition (power output)	SM alert limits (deg F)	
	Low	High
<3.5 kW output	180	212
3.5 to 7.5 kW output	190	222
>7.5 kW output	198	238

- e. FREON FLOW - Preconditioning sets two low alarm limits for the Freon flow depending on the position of the FLOW PROP VLV. If the valve is in INTERCHANGER, the low limit is 1950 lb/hr, and if the valve is in PAYLOAD, the low limit is 1300 lb/hr.
- f. FREON LOOP PL HX FLOW (Payload Heat Exchanger) - Preconditioning sets two low alarm limits for the Freon flow through the Payload Heat Exchanger (HX) depending on the position of the FLOW PROP VLV. If the valve is in INTERCHANGER, the low limit is 159.5 (OSL) lb/hr, and if the valve is in PAYLOAD, the low limit is 500 lb/hr.
- g. H₂O LOOP ICH FLOW (Interchanger) - Preconditioning allows any position of the H₂O loop pump switch to be selected (ON, GPC, OFF) and still have the same low limit for the H₂O LOOP ICH FLOW (550 lb/hr).
- h. H₂O LOOP PUMP OUT P AND PUMP OUT Δ P - Preconditioning allows the C&W SM alert system to give different alarms depending on the switch position the H₂O loops are in.

SM Alert Limits

	PUMP OUT P		PUMP OUT Δ P	
	Low	High	Low	High
Loop 1 pump switch ON or GPC and either pump commanded ON	50	70	33	46
Loop 1 pump switch OFF	20	None	None	5
Loop 1 pump switch GPC and neither pump running	20	None	None	5
Loop 2 pump switch ON or GPC and pump commanded ON	50	75	33	46
Loop 2 pump switch OFF or GPC and pump not commanded ON	20	None	33	46

- i. HUM SEP (Humidity Separator) - Preconditioning sets up variable SM alert alarm indications for the two different switch positions of the two humidity separators (ON and OFF).
 - 1. If both humidity separators are OFF, preconditioning generates an alarm.
 - 2. If any humidity separator is ON but not operating at the correct speed, an alarm is generated.
 - 3. If either humidity separator is OFF but the speed indication is still good, an alarm will be generated.
- j. HYD CIRC PMP P (Hydraulic Circulation Pump Pressure) - Each of the three hydraulic systems has two limit sets depending on whether the CIRC pump is ON or OFF. If the CIRC pump is ON or commanded ON by the GPC, an SM alert will be generated if the HYD CIRC PMP P drops below 100 psi. If the CIRC pump is OFF or commanded OFF by the GPC, an SM alert will be generated if the HYD CIRC PMP P is above 100 psi.
- k. IMU Fan - Preconditioning sets up variable SM alert alarm indications for the different switch positions of the IMU fans.
 - 1. If all three fans are OFF, preconditioning selects limits that generate an alarm.
 - 2. If any IMU fan is on but not operating at the correct speed, an alarm will be generated.
 - 3. If any IMU fan is OFF but still has a good speed indication, an alarm will be generated.
- l. W/B BLR T - Preconditioning sets two upper limits for the water spray boiler temperature (W/B BLR T) depending on the switch position of the BOILER CNTLR PWR/HTR (A, OFF, or B). If the switch is in A or B, the upper limit is 185°; if the switch is in OFF, the upper limit is Off Scale High (OSH).
- m. W/B REG P and W/B TANK T - Preconditioning sets two SM alert alarm limits for these parameters depending on the switch position of the BOILER CNTLR PWR/HTR. If the switch position is in A or B, these parameters have set upper and lower limits. If the switch is in OFF, these parameters do not have any limits.

5.0 SPECIAL/MISSION-SELECTABLE PROCESSES

Special processes and Mission-Selectable Processes (MSPs) provide specialized computations and processing sequences to determine and control the status and performance of various vehicle subsystems and payloads. Table 5-1 contains a list of all the SM special processes, MSPs, and their software locations. The table shows us that different SM special/MSPs will be available depending on the flight phase and the corresponding GPC software that is functioning. There are three categories of special processing software.

- a. BFS SM special processing
- b. PASS SM special processing
- c. Both BFS and PASS SM special processing

Table 5-1. SM special/mission-selectable processing

	BFS SM	PAS S SM	Both BFS and PASS SM
Special processes			
Cabin pressure monitor	X	-	-
Flash EVAP/NH ₃ boiler ACT/DEACT	X	-	-
Fuel cell auto purge sequence	-	X	X
Hydraulic fluid on-orbit temperature control sequence	-	X	-
O ₂ /N ₂ quantity computation	-	X	-
Recorder tape position	-	X	-
Standby water coolant loop temperature control	-	X	-
Remote Manipulator System (RMS) control	-	X	-
Antenna management	-	-	X
APU fuel quantity computation	-	-	X
Fuel cell total current and power computation	-	-	X
Hydraulic water boiler quantity	-	-	X
Payload bay door sequence	-	-	X
MSPs			
Spinning Solid Upper Stage (SSUS) sequence control process	-	X	-
Inertial Upper Stage (IUS) GNC data transfer	-	X	-
Payload control supervisor sequence control	-	X	-
Standard GNC data transfer	-	-	X

5.1 SPECIAL PROCESSING

5.1.1 BFS SM Special Processing

The BFS has the following SM software special processes:

- Cabin pressure monitor
- Flash evaporator/ammonia boiler activation/deactivation
- Freon pump power management

These processes are in the BFS SM software only. Other special processes that are in both the PASS and BFS will be discussed later (see Section 5.4).

Cabin Pressure Monitor (Backup dP/dT)

The cabin pressure monitor is used to determine the cabin pressure change rate. The change rate will be displayed on the BFS SM SYS SUMM 1 display, and if out of limits, a Class 3 alarm and Fault Summary Message (FSM) will be issued. Figure 5-1 is an example SM SYS SUMM 1 display.

000L/ /078 SM SYS SUMM 1			S 004/00# 41# LB				
			BFS 000/00# 00# 00				
SMOKE	L/A	2/B	DC VOLTS	1/A	2/B	3/C	
CABIN	-0.0	-0.0	FC	30.6	30.6	30.6	
L/R FD	-0.0	-0.0	MAIN	30.4	30.5	30.5	
AV BAY 1	-0.0	-0.0	CNTL AB	28.8	28.8	28.8	
2	-0.0	-0.0	BC	28.8	28.8	28.8	
3	-0.0	-0.0	CA	28.8	28.8	28.8	
CABIN			ESS	29.2	29.3	29.3	
PRESS	14.7		AC				
dP/dT	-0.00		VOLT Φ A	116	116	116	
BU/EO	-0.00	-0.0	Φ B	116	116	116	
PPQ2	3.13	3.13	Φ C	116	116	116	
FAN ΔP	5.83		AMPS Φ A	2.3	4.3	2.4	
HX QUT T	47		Φ B	2.4	4.6	2.5	
O2 FLOW	0.0L	0.0L	Φ C	3.7	4.8	3.8	
N2 FLOW	0.0L	0.0L	FUEL CELL PH				
IMU FAN A	B*	C	AMPS	218	211	213	
ΔV FC1	FC2	FC3	REAC VLV	OP	OP	OP	
SS1	18	21	21	STACK 7	+206	+206	
SS2	18	22	13	EXIT T	150	149	150
SS3	16	20	20	COOL P	60	60	60
TOTAL AMPS	642		PUMP				
KW	19						
SYS SUMM							

TD379022, CRT, 2

Figure 5-1. SM SYS SUMM 1 display

The cabin pressure monitor is initiated anytime the BFS GPC is in STANDBY or RUN. This means that the Backup dP/dT calculation is available no matter what OPS mode the BFS is in. The cabin pressure monitor is scheduled to run in OPS 0 on the pad, in OPS 1 during ascent, and OPS 3 or 6 during entry. It operates both pre- and post-engaged. This process is also available in BFS OPS 0 on orbit by simply taking the BFS GPC to STANDBY. The process generates the cabin pressure change rate using cabin pressure readings over a 30-second time period. This change rate is sent to the BFS SYS SUMM 1 display. This change rate is also compared to a high limit value (I-Load, nominal to 0.12 psi/min). If the change rate exceeds this limit for two

consecutive cycles of the program, fault annunciation for that parameter will be enabled. The process monitors the input parameters and performs the calculation at least once every five major cycles (for this SM process, a major cycle is performed once a second). Therefore, after the first calculation, an updated backup dP/dT calculation will be performed every 5 seconds.

Flash Evaporator/Ammonia Boiler Activation/Deactivation

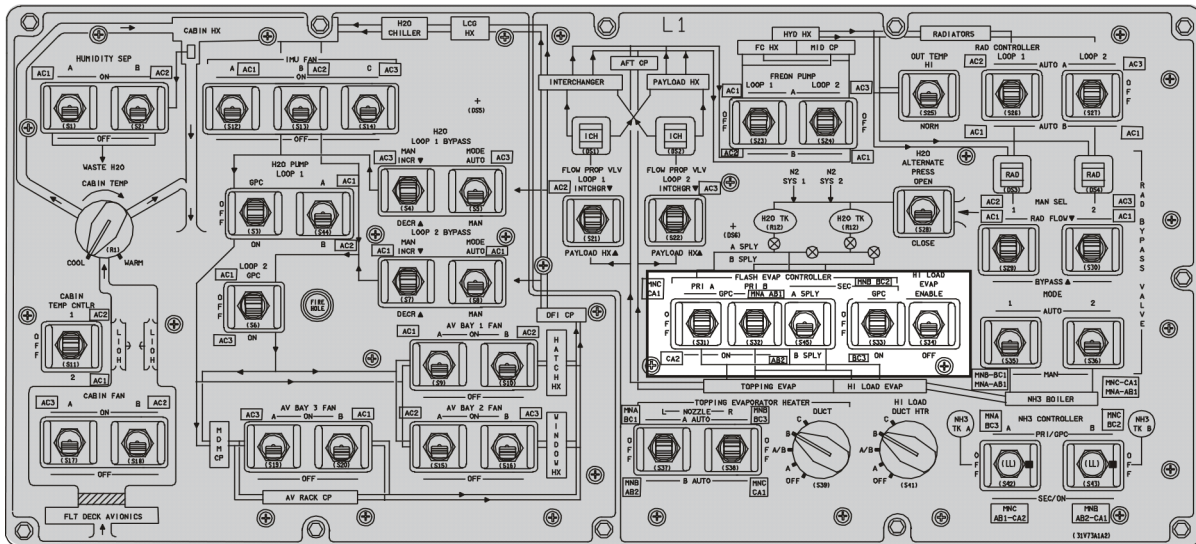
The Active Thermal Control System (ATCS) contains two Freon loops that operate simultaneously throughout the mission. The flash evaporator and the ammonia boiler are two of the heat sinks that provide cooling to these Freon loops during different portions of the mission (Ground Support Equipment (GSE) and the radiators also provide cooling to the Freon loops).

The flash evaporator requires a vacuum in order to operate. Therefore, this BFS SM process activates the flash evaporator during ascent at MM 103 transition and Solid Rocket Booster (SRB) separation, and deactivates it during entry at MM 305 transition (603 for Return to Launch Site (RTLS)). The flash evaporator has three controllers that regulate water flow. Only one controller is used at a time, and it can service both evaporators. When the orbiter reaches the appropriate phase during ascent, commands are issued to all three flash evaporator controllers. Only the controller, with its respective panel switch in the GPC position, is activated. The commands are terminated during the appropriate phase during entry or RTLS.

The software during entry does not nominally activate the ammonia boiler, but the GPC has the capability to turn it on for RTLS, Transoceanic Abort Landing (TAL), and Abort Once Around (AOA) aborts, as cooling requirements dictate. For an RTLS, this BFS SM process activates the ammonia boiler (if switch is in GPC) during entry at MM 602 transition. For a TAL, AOA, or a situation in which radiator cooling is not available, the ammonia boiler is activated during entry by this BFS SM process when the specified altitude (usually 120,000 ft) is reached in MM 304 or at MM 305 transition, whichever occurs first. If the orbiter is above the MM 305 transition, activation of the ammonia boiler causes the flash evaporator system to shut itself down. There are two ammonia systems, each with a controller to regulate the ammonia flow. Both systems operate independently and service both Freon loops (only one system is used at a time; i.e., like the Flash Evaporator System (FES), only one controller has its switch in the GPC position).

Each controller for the flash evaporator and the ammonia boiler has a panel switch with an ON, OFF, and GPC position. When the controllers are in the GPC position, this BFS SM process automatically controls these systems (see Figure 5-2, Panel L1).

Both the flash evaporator and the ammonia boiler are initialized to OFF in OPS 1. In OPS 3 or 6, the flash evaporator is initialized to ON, and the ammonia boiler is initialized OFF. In OPS 0, the flash evaporator is initialized OFF. Also, in OPS 0, the ammonia boiler is initialized OFF, unless the OPS transition is from OPS 3 (MM 305) or OPS 6 (MM 603), in which case it is initialized ON. This was done to allow ammonia boiler activation on the ground.



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Figure 5-2. Panel L1

5.2 PASS SM SPECIAL PROCESSES

PASS SM special processes include

- a. Fuel cell auto purge sequence
- b. Hydraulic fluid on-orbit temperature control sequence
- c. O₂/N₂ quantity computations
- d. Recorder tape position
- e. Standby water coolant loop temperature control
- f. Freon coolant loop radiator isolation

These are the SM processes that are only in the PASS SM OPS 2 software. Other special processes that are in both the BFS and the PASS are discussed in Section 5.4.

5.2.1 Fuel Cell Auto Purge Sequence

The fuel cell auto purge sequence is used during the orbit phase to maintain fuel cell operating efficiency. The auto purge sequence is available in PASS SM OPS 2 software. The fuel cells are normally purged for 2 minutes every 72 hours in order to minimize the drop in fuel cell efficiency. The fuel cell auto purge sequence is provided to release the crewmembers' attention from purge activity and permit the performance of other functions. The auto purge program turns on the purge line heaters, provides for sequential purging of each fuel cell, and then turns off the purge line heaters. This auto sequence does not allow OPS transitions. If an auto purge is started in OPS 2, the orbiter software should remain in that OPS until the purge is completed. Any change in

the OPS modes results in the cancellation of the entire auto purge commands. One possible result of an OPS transition during a purge could be a frozen purge line because the purge line heaters are commanded off when an OPS transition occurs.

To purge the fuel cells, the crew selects the GPC position for the purge control heaters. The fuel cells to be purged are selected by setting the respective purge valve switch to GPC. To start the purge sequence, the crewmember selects and holds the momentary START position of the PURGE SEQ START switch until verification of GPC ON event indication, which occurs only if one or more purge valve switches are in GPC. If the procedure is done incorrectly and the software detects that the auto purge-on line signal has been lost after the GPC auto sequence has been initiated, an FC PURGE SEQ FSM occurs. Upon satisfying the start conditions, the GPC issues the purge control heater ON commands and begins monitoring the O₂/H₂ vent line heater temperatures. This sequence allows a maximum time of 27 minutes for the vent lines to reach the proper temperature. If the temperatures are below the specified limits, after 27 minutes have elapsed, the crew receives the FSM FC PURGE TEMP FAIL, a Class 3 alarm is generated, and the sequence stops the purge.

After the vent temperatures have reached the prescribed limits, the GPC determines which fuel cell is selected for purging and issues O₂/H₂ purge valve open commands for the selected fuel cells. The fuel cells are purged sequentially 1, 2, and then 3 if their purge switches are in the GPC position. A flow computation is performed to verify that the valves have opened. If a valve fails to open, a FSM FC PURGE and a Class 3 SM alert are generated; commands are issued to close the valves, but the purge heaters will remain on to permit the next selected fuel cell to be purged. When the valves open, the selected fuel cell is purged for a minimum of 2 minutes. The purge valves are then commanded closed. Another flow computation is performed to verify that the valves have closed. If a valve fails to close, a FSM "FC PURGE" and a Class 3 SM alert are generated, all purge valve open commands are terminated, and the purge vent line heater ON commands remain for 30 minutes to bake out the lines. When the valves close, the sequence proceeds to the next selected fuel cell to be purged.

However, in the present configuration, the flow checks mentioned above have been negated (overridden) because of the unreliability of the O₂/H₂ flow transducers.

The duration of the purge sequence is a changeable constant via the table maintenance function. Its normal value is 2 minutes.

After all the selected fuel cells have been purged, the vent line heaters remain on for 30 additional minutes and then are commanded off by the GPC. The program then recycles back to start and looks for the next fuel cell auto initiation by the crew.

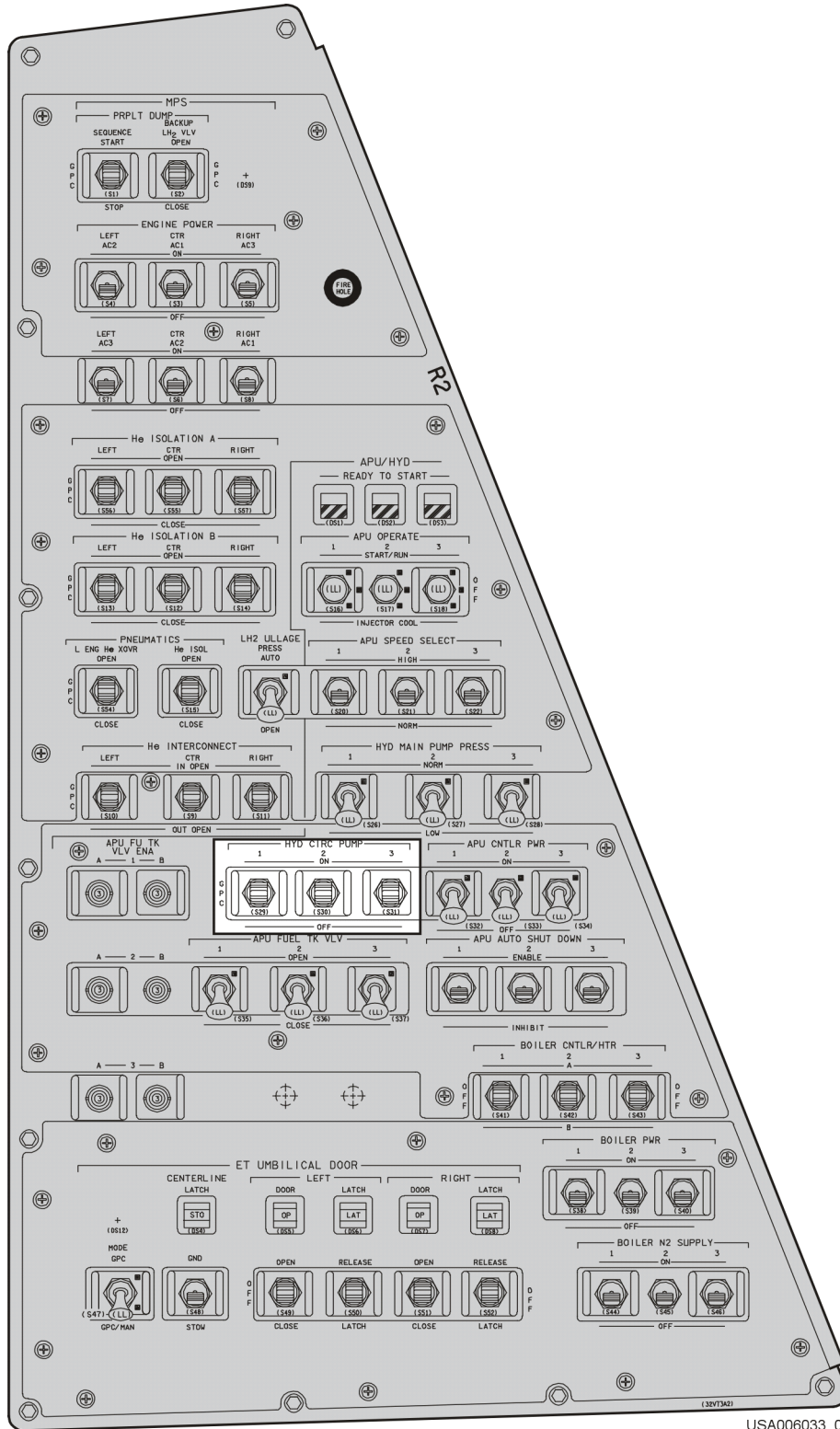
5.2.2 Hydraulic Fluid On-orbit Temperature Control Sequence

During the on-orbit phase, the three hydraulic systems will be subject to periods of prolonged cold. In order to maintain the hydraulic fluids at acceptable operating temperatures, the hydraulic system circulation pumps (circ pumps) will be turned on, and the hydraulic fluid will be circulated through the ATCS/hydraulics heat exchanger where heat will be added. The hydraulic fluid on-orbit temperature control sequence is the primary mechanism for cycling the circ pumps on and off. This sequence is available only in SM OPS 2. A transition to any other OPS will result in termination of all sequence commands. The circ pump control parameters can be monitored on the HYD THERMAL display (DISP 87).

Another responsibility of this sequence is to maintain the bootstrap accumulator pressure in the three hydraulic systems. The bootstrap accumulators are used to provide head pressure for the hydraulic main pumps. Circ pumps are used on orbit to automatically recharge the accumulators in the event of a pressure decrease in the bootstrap system. The accumulator pressure management software turns on a circ pump if the accumulator pressure for one of the three hydraulic systems is below a predefined low limit of 1960 psi and greater than 32 psi. The 32-psi low limit is to prevent a transducer loss from running a pump unnecessarily. The circ pump will be commanded on for accumulator recharging immediately with no time delay. The software will run the pump until the accumulator pressure timer (a changeable value set at 2 minutes) has elapsed and accumulator pressure is above 1960 psi.

The hydraulic fluid on-orbit temperature control sequence is enabled when the crew selects the GPC switch position for any of the three hydraulic system circ pumps. However, because of a software lockout, the APUs START/RUN switch must be off for this sequence to be enabled. The GPC monitors selected temperature sensors and the accumulator pressures for each hydraulic system under GPC control and commands the circ pumps on or off in the order that each hydraulic system requires activation. Manual ON/OFF positions are also available for the crew to manually cycle the circ pumps (see Figure 5-3).

Accumulator pressure management software takes priority over thermal conditioning software. The accumulator pressure management software will turn off any circ pump that the thermal conditioning software has been running. However, accumulator pressure management software may run up to all three circ pumps simultaneously, if required, to recharge more than one bootstrap system. Therefore, even if two circ pumps are manually on, the third system will come on if a hydraulic accumulator pressure below 1960 is detected.



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Figure 5-3. Hydraulic circ pump switches on Panel R2

The thermal conditioning software operates the circ pumps on orbit for circulating hydraulic fluid to keep fluid temperatures above low limits and maintains fluid viscosity at acceptable levels for hydraulic main pump startup.

The thermal conditioning software will run only one circ pump at a time. If the thermal conditioning software detects any circ pump pressure to be above 100 psi, it will not activate another circ pump. Therefore, if one of the circ pumps has been turned on either manually or by the SM GPC software, it will prevent the other two circ pumps from operating. The software will run pumps consecutively based on a priority system if more than one hydraulic system requires thermal conditioning.

The thermal conditioning software will set a circ pump to come on if one or more of the temperature control sensors in a system fall below the pump turn-on limit (either 0° or -10° F depending on the sensor). The thermal conditioning software features a startup time delay. After a circ pump has satisfied the turn-on requirements, the startup delay timer will have to expire before the circ pump is actually turned on. The start delay timer is set at 1 minute and is a changeable constant via the table maintenance function. A circ pump will therefore normally be turned on 1 minute after its temperatures fall below the turn-on limits. If circ pumps are running consecutively for thermal conditioning, their runs will be separated by the 1-minute startup time delay.

The GPC commands a circ pump OFF when the following conditions are satisfied:

- a. All temperature sensors in a hydraulic system are above the upper turnoff limit of 20° F
- b. A circ pump commanded ON for out-of-limit temperatures has been on in excess of a specified circ pump minimum run time (15 minutes for Hyd Sys 1, 10 minutes for Hyd Sys 2 and 3) and a second hydraulic system requires circulation
- c. One of the hydraulic systems has a low accumulator pressure (accumulator pressure low overrides minimum run time and temperature constraints)

The sequence is also capable of operation in a timer mode. The thermal conditioning software may be used to cycle two or three circ pumps at regular intervals for specified amounts of time. Changing turn-on/off limits does this for one sensor in each system, so the software thinks all three circ pumps need to run. The startup delay timer and thermal control timer values are then changed to regulate when and for how long the circ pumps cycle.

Temperature sensor low and high limit values, circ pump pressure low limit values, circ pump start delay time, and circ pump minimum run time are changeable through the Table Maintenance (TM) constants change capability available on SM SPEC 60.

The following examples are included to help clarify circ pump operations.

CASE 1:

Circ Pump Control
Switch Position

CIRC PUMP
1 2 3
ON GPC GPC

In this configuration, neither circ pump 2 nor 3 will come on for thermal conditioning of their respective system because the circ pump software pressure limit of 100 psi is exceeded by system 1, and the software will not command a second system on.

However, with circ pump 1 on, systems 2 and 3 can be commanded on by the GPC if its accumulator pressure falls below limits, regardless of a system already in operation. Low accumulator pressure is of a higher priority than running two circ pumps simultaneously.

CASE 2:

CIRC PUMP
1 2 3
GPC GPC GPC

If circ pump 1 is commanded on for low hydraulic temperatures and system 2 or 3 accumulator pressure begins to drop, then the GPC will command circ pump 1 off and turn 2 or 3 on. The bottom line is that maintaining accumulator pressure takes precedence over low hydraulic temperatures, and running one pump at a time is desired over commanding a second pump on simultaneously.

5.2.3 O₂/N₂ Quantity Computation

O₂ Quantity Computation

The O₂ quantity computation for the emergency O₂ tank is used during the orbit phase to determine the status of the high-pressure O₂ supply. This oxygen source is used as an emergency backup for cabin atmosphere in the event of excessive leakage of cabin pressure and emergency breathing.

The quantity of O₂ gas, in terms of weight, is computed by using the Pressure, Volume, and Temperature (PVT) relationship for the tank. The computation uses the measured tank temperature and the manifold pressure. The result of this computation, in pounds remaining, can be made available on the environmental display (SPEC 66) available in SM OPS 2 and 4. However, at the present time, the orbiter does not carry the emergency O₂ tank, but this O₂ computation capability is still available should the tank be put back on the orbiter.

N₂ Quantity Computation

The N₂ quantity computation for System 1 (SYS 1) and System 2 (SYS 2) N₂ tanks is used during the orbit phase to determine the status of the N₂ system. Both System 1 and System 2 have two N₂ tanks. N₂ is required to replenish the cabin atmosphere and maintain proper cabin air mixture, and also for pressurization of the water and waste tanks.

The quantity of N₂ gas, in terms of weight, is computed by using the PVT relationship of each tank. The amounts of N₂ of the two SYS 1 tanks are combined to provide a quantity for SYS 1, and the same is performed for SYS 2. The temperature is measured in each tank, and a manifold pressure common to the two tanks in each system is required to perform the computation for each tank. The results of these computations, SYS 1 supply quantity, and SYS 2 are on the environmental display (SPEC 66) available in SM OPS 2.

5.2.4 Standby Water Coolant Loop Temperature Control

The Atmospheric Revitalization System (ARS) has two water coolant loops. Loop 1 has two pumps (only one operates at any given time), and loop 2 has one pump. The function of the water coolant loops is to maintain equipment and cabin temperature throughout the mission.

Only one loop (loop 2) is needed for all phases of flight. For the on-orbit phase, only one loop (loop 2) is required for continuous operation with the other loop (loop 1) in the standby mode. To prevent the water in the standby loop from freezing, this sequence will periodically operate the loop 1 pump to circulate the water. Both H₂O loops have a GPC position and, therefore, can be operated by the standby temperature control sequence of the H₂O coolant loop.

In the nominal timeline, after the Payload Bay Doors (PLBDs) are opened, the crew will place water coolant loop 1 in the standby mode by changing the selected pump's panel switch position from OFF to the GPC position. When the PLBDs are closed, the standby loop is returned to the OFF position.

The sequence operates in SM OPS 2 and is initiated when OPS 2 is initiated. Each time SM OPS becomes active or when an X minute expires, commands are issued to all three pumps. Only the pump with its respective switch in the GPC position will turn on. The selected standby pump will operate for Y minutes. The computer then terminates the pump ON commands and adds X minutes to the Greenwich Mean Time (GMT). This value is stored and becomes the X minute timer. When the current GMT becomes equal to or greater than the stored GMT plus X minutes, the computer issues the pump ON commands and sets the Y minute timer. When the Y minute timer expires, the pump ON commands are terminated, and a new X minute timer value is set. The sequence continues to cycle until the selected SM OPS is terminated.

The X and Y minute timers are changeable constants via the TM function. Their values are subject to vehicle attitude. Their values as of January 1, 1988, are 240 minutes (4 hours) and 6 minutes, respectively.

The sequence will not verify that the standby pump responds to GPC commands, nor issue any crew alerts if it does not. Crew alerts will be provided by the SM FDA function through its evaluation of water loop temperatures and pump operating performance.

5.3 FREON COOLANT LOOP RADIATOR ISOLATION

The ATCS has two Freon Coolant Loops (FCLs) that remove heat from the orbiter systems and radiate that heat into space. The FCLs have been modified to allow the radiators to be isolated in the event of a Freon loop leak. On orbit, if the PASS SM software detects that the FCL accumulator quantity drops below 12 percent for more than 5 seconds, it will send out a command to isolate the radiator in an attempt to isolate the leak.

5.4 BFS AND PASS SM SPECIAL PROCESSES

The following SM special processes are in both the BFS software and PASS OPS 2 software:

- a. Antenna management
- b. APU fuel quantity computation
- c. Fuel cell end cell heater monitor
- d. Total current and power computation of fuel cells
- e. Hydraulic water boiler quantity
- f. Payload bay door sequence

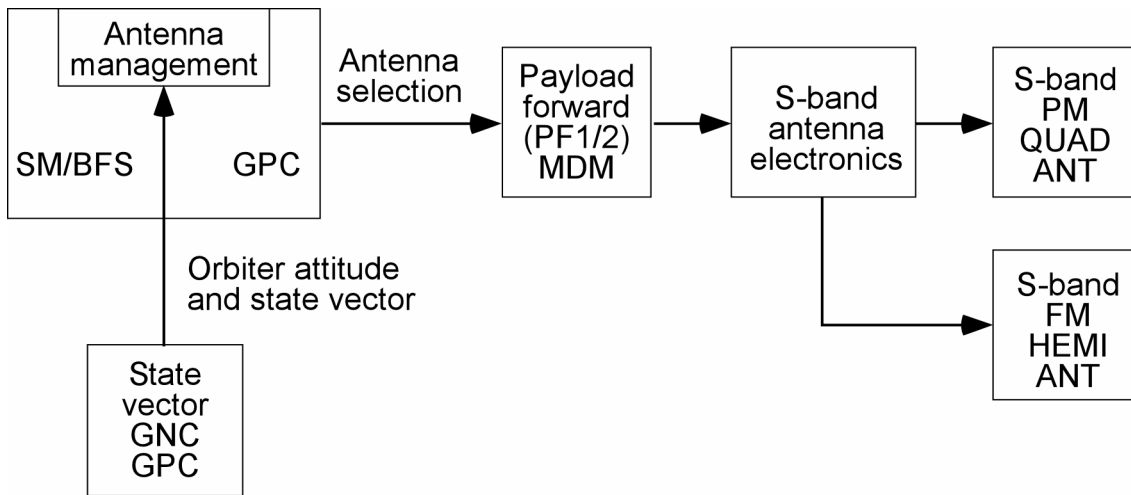
5.4.1 Antenna Management

The antenna management function, resident in the SM software, is used to automatically control the orbiter S-band and Ku-band antenna systems.

During the ascent and entry mission phases, the antenna management function program, resident in the BFS, controls the selection of the most effective S-band antenna based on the relative locations and attitude of the orbiter and the location of a receiving station. During the orbit phase, the antenna management function, resident in the PASS SM OPS 2 software, performs S-band antenna selection. After the Ku-band system has been deployed and activated, the antenna management function also directs the Ku-band antenna angles for Tracking and Data Relay Satellite (TDRS) operation. The Ku-band antenna functions strictly through TDRS, while the S-band antenna uses both ground stations and TDRS.

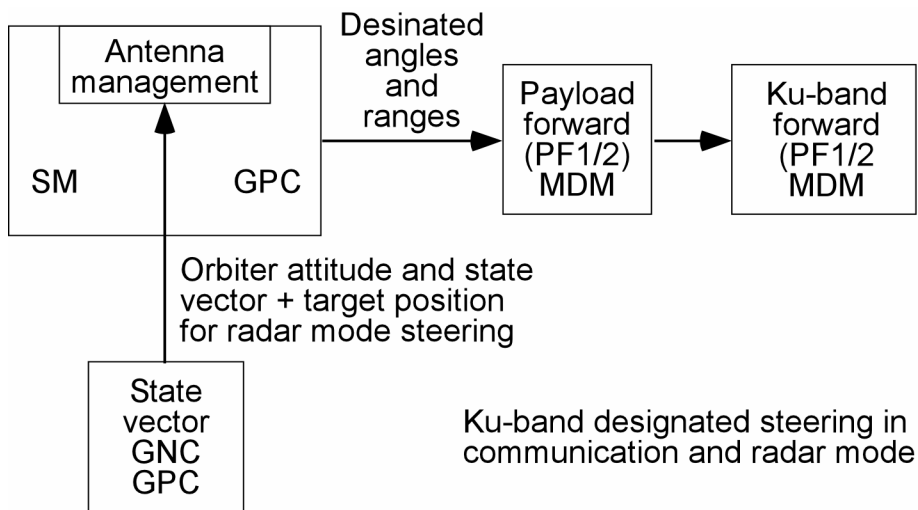
On orbit, the PASS SM antenna management software also provides the GNC flight software with a site-in-view flag that is used to provide uplink block for the orbiter. This computed site-in-view flag determines Acquisition of Signal (AOS) and Loss of Signal (LOS) time periods of the ground stations and of TDRS. The uplink block is used to prohibit unauthorized command sources from reaching the orbiter. (Note: The uplink block function is not required in the encrypted mode, which is the normal mode of operations.)

Figures 5-4 and 5-5 show how the S-band and Ku-band antenna systems interface with the antenna management software, the SM GPC, and payload MDMs.



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Figure 5-4. S-band designated steering



USA006033_014

Figure 5-5. Ku-band designated steering

S-Band Antenna Management

The antenna management program, depending on the commanded orbiter transponder mode (TDRS/Space Tracking and Data Network (STDN)/Space Ground Link Station (SGLS)), automatically selects one of the four S-band Phase Modulation (PM) antennas plus the forward and aft directivity of the antenna selected. The automatic selection can be overridden by

- Ground command (provided the GPC antenna command function is inhibited)
- Crew switch selection

One of the two S-band Frequency Modulation (FM) antennas is selected in the same manner as the S-band PM antenna, with the exception that only ground coverage is available. Indications of the antenna selection are visible to the crew on an orbit-dedicated antenna DPS display, OPS 20X (40X), and to Mission Control Center (MCC) flight controllers via the orbiter telemetry system.

The antenna management function attempts to make an S-band antenna selection once every 2 seconds.

Ku-Band Antenna Management

The Ku-band antenna management sequence consists of the following functions: selection of target (either TDRS or a satellite for rendezvous) available for use, computation of antenna pointing angles, and commanding the antenna to the selected target.

These functions shall be performed cyclically. In addition to the above functions, the capability exists to control the auto acquisition sequence of the Ku-band antenna for acquisition of either the selected TDRS (for communications) or the GNC designated target (for rendezvous operations).

Command data for Ku-band antenna management is transmitted via the PL MDM (PF1). The ground has the capability to bias the antenna management line-of-sight vector to compensate for errors in the antenna management processing. By biasing the antenna management line-of-sight vector, the ground can fine-tune the selected antenna angles. The crew can override the antenna management antenna selections via a switch throw. Indications of Ku-band antenna selection are visible to the crew on an orbit-dedicated display, OPS 20X (40X), and digital readout. MCC monitors antenna selection via the orbiter telemetry system.

The antenna management program routes antenna steering data to the Ku-band antenna system once every 2 seconds.

TDRS

Antenna management obtains the Tracking and Data Relay Satellite System (TDRSS) state vector and the orbiter state vector and attitude to make S-band antenna selections and to determine the Ku-band pointing angles.

The state vector referred to above is the location of an object with respect to the latitude, the longitude, and the center of the Earth.

5.4.2 Auxiliary Power Unit Fuel Quantity Calculation

The purpose of the APU fuel quantity calculation sequence is to calculate the quantity of the hydrazine fuel remaining in each of the three APU fuel tanks. The APU fuel is stored in a diaphragm-type tank with nitrogen used as the pressurant. The PVT method is used to determine the volume of nitrogen, which, in turn, is subtracted from the volume of the fuel tank to arrive at the quantity of fuel remaining. Fuel tank temperature and pressure are the primary parameters for calculating APU fuel quantity. To back up these parameters, uplink capabilities are provided to select an alternate fuel tank outlet pressure sensor and a best-predicted value for fuel tank temperature.

The sequence operates in all OPS modes of the BFS and in PASS SM OPS 2. The output from the APU fuel quantity calculation is displayed on the MEDS APU/HYD display and the APU/HYD display (SPEC 86) in SM OPS 2 and 4, and on SM SYS SUMM 2 (SPEC 79) during all flight phases (BFS and PASS SM).

The APU fuel quantity calculation is active during prelaunch and remains active during all flight phases. Sequence inputs are accessed at a rate sufficient to perform the calculations, once per two major cycles (2 seconds). Inputs to the sequence are the following for each APU: fuel tank temperature and pressure, fuel tank outlet pressure, and the constants specified in the detail requirements. The mass of nitrogen loaded into each APU tank is calculated prior to each flight by ground software and must be entered into the sequence via uplink in order to produce a correct calculation for APU fuel quantity. Prior to uplinking the actual value for nitrogen, mass I-Load values will be used. The sequence is not interrupted due to the detection of invalid data. In the case of invalid data, the sequence issues an "M" to be displayed next to the last good value of the parameters with invalid data and continues to perform the computations.

5.4.3 Fuel Cell Total Current and Power Computation

This sequence computes the total current and power of the three fuel cells and performs the fuel cell power-preconditioning limit setting for fuel cell stack cool out temperature (stack temp). The current and power computation of the fuel cells is active during all flight phases to provide the status of the electrical power subsystem. The computation is active in the BFS during all OPS modes, and it is active in SM OPS 2 on orbit.

The total current and power generated by the three fuel cells is computed by respectively summing the current and power (in kW) generated by the individual fuel cells. The measured value of current and voltage for each fuel cell is obtained from the orbiter instrumentation data. The results of the computations, total current and power, are then made available on the ELECTRIC display (SPEC 67) in SM OPS 2 and 4, and the total power load is made available on SYS SUMM 1 (SPEC 78) during all flight phases.

The sequence monitors the input parameters and also processes the computed outputs at a rate of once every two major cycles (a major cycle is performed once a second).

The precondition limit setting for each fuel cell is based on the power (in kW) generated by the individual fuel cell. Precondition limit sets for the individual fuel cell are established for three output ranges. The precondition limits sets are made available to FDA to status the measurement of the fuel cell stack cool out temperature. The three power output ranges are defined within two power levels. The power levels are changeable constants via the TM function (SPEC 60). The nominal values for levels 1 and 2 are less than 3.5 and greater than 7.5 kW, respectively.

Note: This SM special process is also referred to as the Fuel Cell Volts-Current-Temperature (V-I-T) program or the fuel cell performance monitor, not to be confused with Cell Performance Monitor (CPM), which is not a software function.

5.4.4 Hydraulic Water Boiler Quantity

The hydraulic water boiler quantity process computes the amount of water remaining in the three Water Spray Boiler (WSB) storage tanks for all flight phases. The WSB is part of the APU/hydraulics system and its purpose is to cool the hydraulic fluid and APU lube oil when the APUs are running. Water is stored in bellows-type tanks, which are pressurized by gaseous nitrogen. The storage tanks supply water to the spray boiler as demanded by the hydraulic fluid and APU lube oil temperatures. As the water is depleted, the amount of water remaining in each tank is computed.

The sequence operates in all OPS modes of the BFS and in PASS SM OPS 2. The output from the hydraulic water boiler quantity calculation is displayed on the MEDS APU/HYD display and the APU/HYD display (SPEC 86) in SM OPS 2 and on SM SYS SUMM 2 (SPEC 79) during all flight phases (BFS and PASS SM).

The hydraulic water boiler quantity calculation is active during prelaunch and remains active during all flight phases. Sequence inputs are accessed at a rate sufficient to perform the calculations once per two major cycles (2 seconds). Inputs to the sequence are the following for each WSB: H₂O tank temperature and pressure and GN₂ tank temperature and pressure. After the GN₂ and H₂O tanks are loaded, the process computes the initial total GN₂ quantity in the system. The computation is done by adding the quantity of GN₂ in the GN₂ tank to the GN₂ ullage volume in the H₂O tank. The GN₂ ullage volume is an I-Load value that determines the quantity of H₂O to which

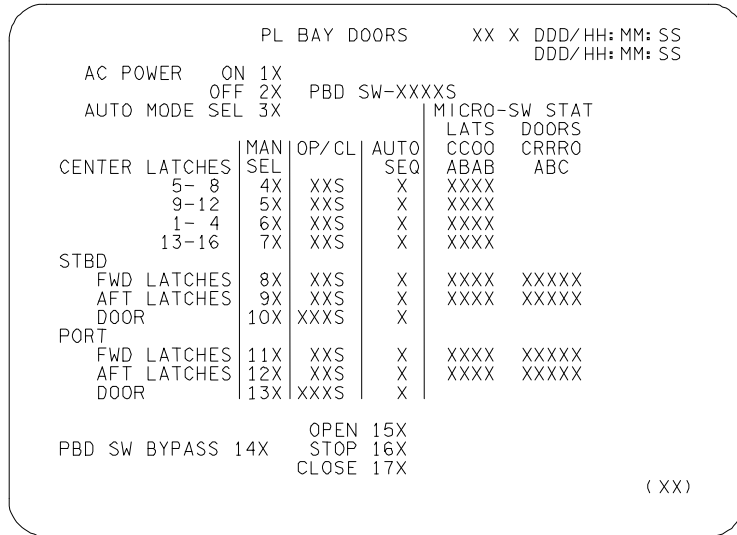
the software initializes (Kennedy Space Center loading is 83 percent and for Vandenberg Launch Site, loading is 94 percent). As water is used and GN₂ is transferred from the GN₂ tank to the H₂O tank, the process computes the resulting quantity of GN₂ in the H₂O tank. The total volume of GN₂ in the H₂O tank is subtracted from the volume of the H₂O tank to compute the volume and percentage of water remaining.

The process corrects for the GN₂ vented overboard during ascent (there is no venting during entry) by calculating the quantity vented overboard and subtracting this from the initial total computed quantity of GN₂ in the system.

5.4.5 Payload Bay Door Sequence

The PLBDs are opened on orbit for payload operations and for orbiter cooling via the radiators. The PLBDs are nominally opened by a PASS SM OPS 2 GPC. However, if orbiter cooling problems occur or some other contingency situation arises, the PLBDs can be opened via the BFS computer during ascent and during deorbit backout procedures. Without the SM software (PASS OPS 2 or the BFS software) the PLBDs cannot be opened.

The PLBDs display provides auto and manual modes for operating the doors and the latch groups and for monitoring the status of all limit switches (Figure 5-6). The BFS PLBD display (SPEC 63) operates exactly as the PASS SM OPS 202 display.



TD379016. CRT; 2

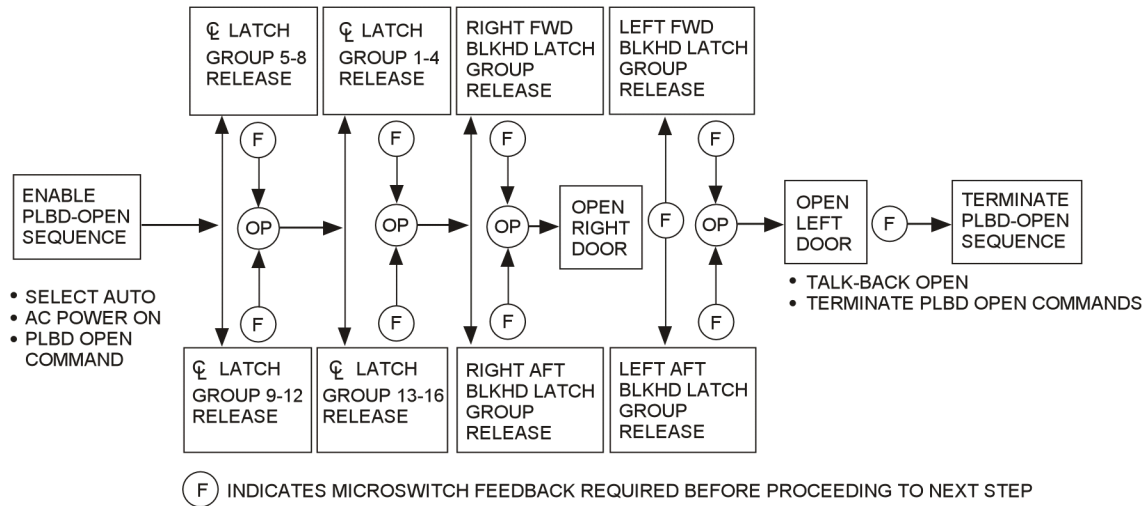
Figure 5-6. PL BAY DOORS display (OPS 202, 402, or BFS SPEC 63)

The auto mode provides for automatic sequencing of PLBD operations (see Figure 5-7). Referring to the display, once the OPEN/CLOSE selection is initiated, the software checks the status of all the PLBD microswitches, and if an improper configuration is detected, the auto sequence stops, PLBD ac power is removed, and a Class 3 alarm and message (PLBD CONFIG) are output. If all microswitch feedback indicates that the PLBDs and latches are properly configured, then the auto sequence

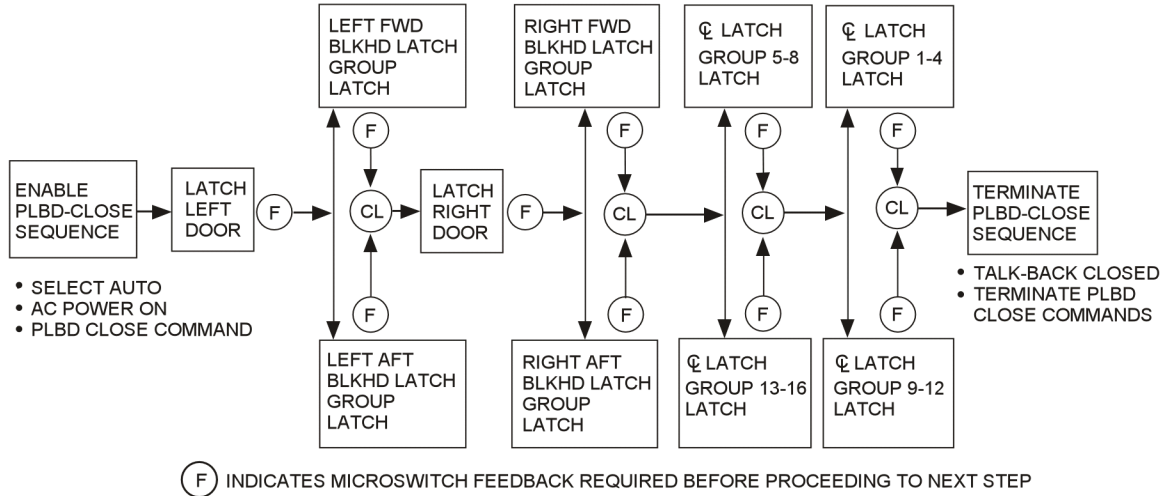
continues and the latches and doors are driven in a predefined sequence top to bottom for OPEN request and bottom to top for CLOSE request.

Microswitch status is verified for each step as the auto sequence proceeds. If any microswitches are invalid (only two out of three ready-to-latch microswitches are required for each door), the sequence holds at that point, PLBD ac power is removed, and a Class 3 alarm and message (PLBD SEQ FAIL) are output. The PLBD sequence can be interrupted during execution by terminating the OPEN (CLOSE) request. Reselection of the OPEN (CLOSE) request continues the sequence. The PLBD OPEN/STOP/CLOSE request can be made on the PLBD display or a switch on Panel R13.

PAYLOAD BAY DOOR **OPEN** SEQUENCE (AUTO)

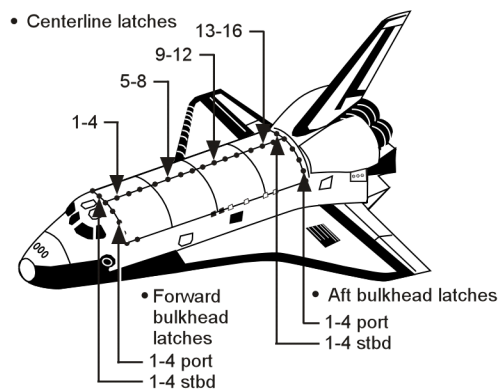


PAYLOAD BAY DOOR **CLOSE** SEQUENCE (AUTO)



PAYLOAD BAY DOOR **OPERATIONAL TIME**

	2 MOTORS (SEC)	1 MOTOR (SEC)
OPEN/CLOSE		
☉ LATCHES		
5-8	20	40
9-12	20	40
1-4	20	40
13-16	20	40
STBD BULKHEAD LATCHES		
FWD & AFT	30	60
STBD DOOR	63	126
PORT BULKHEAD LATCHES		
FWD & AFT	30	60
PORT DOOR	63	126
TOTAL OPEN/CLOSE TIME 226 SECONDS (3 MIN 46 SEC) NORMAL AUTO SEQUENCE		



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Figure 5-7. PLBD close auto sequence

Once the PLBD display has been called up on an Integrated Display Processor (IDP), a unique feature of the PLBD auto sequence will not permit the crew to call up another display on that IDP once the auto sequence has been initiated (selection of the OPEN/CLOSE request). If the crew attempts to call up another display, an ILLEGAL ENTRY message appears on the DPS display. Also, the crew cannot terminate the present OPS mode once the auto sequence is initiated without receiving an ILLEGAL ENTRY message. This means that if the crew is using SM OPS 202 to open the PLBDs, doing an "SM OPS 201" will be an illegal entry.

The manual mode can also be used to operate the PLBDs. The crew will then be able to select and move any component (items 4 to 13). Follow the sequence described above for the auto sequence (top to bottom to open, reverse to close). In the manual mode, it is possible to drive the latches and door motors in any order. However, any attempt to drive a door open while the latches are closed will fail and the door will not open.

5.5 MISSION-SELECTABLE PROCESSES

The SM software also provides for the execution control of two types of MSPs in support of payloads: Mission-Dependent Processes (MDPs) and Mission-Unique Processes (MUPs). Any combination of MDPs and MUPs may be included in a mission as long as no more than eight MUPs are specified and the total computer resources used for all MSPs are compatible with the resources available.

The four MDPs include SSUS sequence control process, IUS GNC data transfer, Payload Control Supervisor (PCS) sequence control, and standard GNC data transfer. These processes exist in PASS SM OPS 2 software, except for the standard GNC data transfer capability, which is also in the BFS software (see Table 5-1)

5.5.1 SSUS Sequence Control Process

This software function is executed by the SM GPC in conjunction with the deployment of an SSUS, such as a Triana, from the orbiter. The deployer hardware, known as the Italian Research Interim Stage (IRIS), receives two commands from the orbiter GPCs during the nominal deployment sequence. The purpose of the Sequence Control Process (SCP) is to tell the SM GPC when to issue these commands. Currently, IRIS is the only user of the SSUS SCP.

The IRIS normally uses three displays to allow commanding and data monitoring of the SSUS and spacecraft. For Triana, for example, these SM displays are the Triana Deploy SPEC, Triana Monitor DISP, and Hubble Avionics Support Equipment (HASE) Control SPEC. HASE allows the crew to monitor/control the safety inhibits for the IRIS/Triana.

Following a crew item entry on the Triana Deploy SPEC (item 1, Countdown Start) the SCP is called by the SM software and processed. After the SCP is started, it checks for a valid deploy identification number (DEPLOY ID) and a valid deploy time. The SCP displays a countdown clock on each of the Triana displays and monitors Mission Elapsed Time (MET) to determine when to issue the two commands.

If the SCP is not active at this time, these commands are not issued and the Triana is not automatically deployed. If the SM GPC is not available, the crew has cockpit switches on the Standard Switch Panel (SSP) that will manually deploy the Triana.

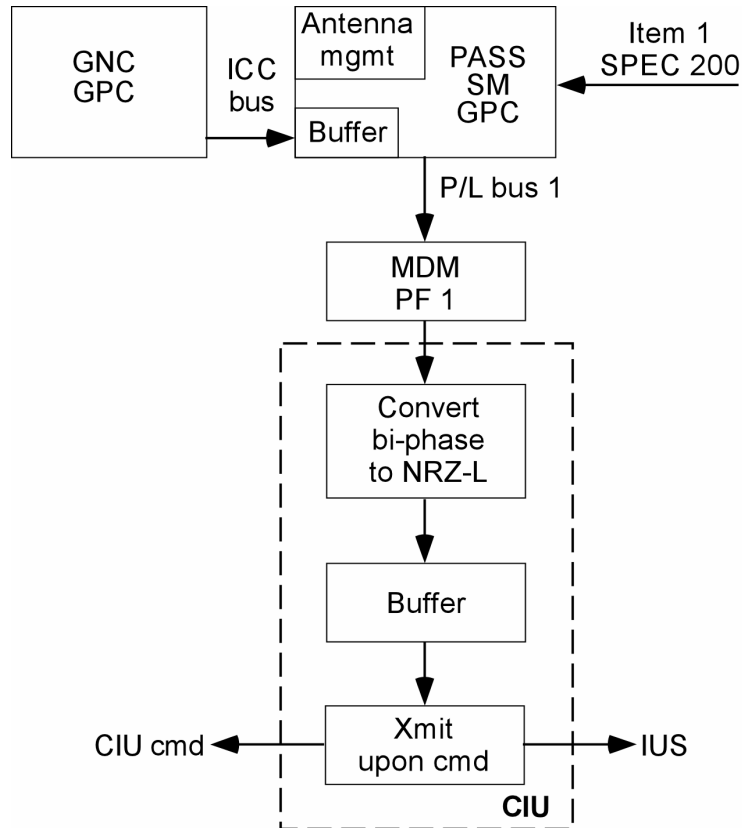
The crew will nominally verify the correct Deploy ID and deploy time prior to initiating the SCP. If these are incorrect, such as in the case of a deploy waveoff, they may be updated by the crew using SM SPEC 60, SM TABLE MAINT, or by the ground using a TMBU. The crew will reset the SCP as part of the nominal post-deploy procedures.

The SSUS SCP capability exists only for the PASS SM major function (PASS OPS 2).

5.5.2 IUS GNC Data Transfer

This function provides the capability to transfer orbiter GNC state vector and attitude data to the IUS. The PASS SM GPC obtains these GNC data points and through a SPEC item entry (SM SPEC 200) transfers the data, via a PL MDM serial Input/Output (I/O) channel, to the Communications Interface Unit (CIU) at a rate of once every 2 seconds. The crew then sends these data to the IUS via a CIU command. The GNC data shall be acquired via the ICC data bus. The two data sets (state vector data and attitude data) will each be processed as a time-homogeneous data set (snapshot) so that parameters from two different ICC updates for a set are not used in one IUS transfer.

The IUS GNC data transfer capability exists only for the SM major function (PASS OPS 2) (see Figure 5-8).



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Figure 5-8. IUS transfer path

5.5.3 Standard GNC Data Transfer

This function provides the capability to process orbiter state vector and attitude data, obtained via the ICC data bus from the GNC GPC for outputs to payloads and for the antenna management function discussed in Section 5.4.1, TDRS. The payload commands are sent via the PL MDM serial I/O card or the PSP function in response to payload processing control indicators. This GNC data transfer may be either cyclic via Standard Serial Interfaces (SSIs) or on demand via SSIs or the PSP. The transfer may consist of any one of the following time homogeneous data sets:

- Greenwich true of date state vectors
- Greenwich true of date attitude/attitude rate
- Orbiter state vector Mean of 1950 (M50) coordinates
- M50 attitude/attitude rate

The standard GNC data transfer capability exists in both BFS and PASS SM OPS software.

6.0 DISPLAY AND UPLINK CONTROLLED PROCESSES

Display and uplink controlled processes provide functions that can be used to initiate, alter, or terminate certain processing within basic SM processes and special processes. Table 6-1 contains a list of all the display and uplink controlled processes and their software locations. The table shows us that most display and uplink controlled processes are located only in the PASS SM software; the two exceptions to this are located in both the PASS SM software and the BFS software.

Table 6-1. Display and uplink controlled processes

	BFS SM	PASS SM	Both BFS and PASS SM
PCMMU telemetry format load	-	-	X
SM system summary displays	-	-	X
Checkpoint	-	X	-
Modular memory unit read/write	-	X	-
Payload data interleaver format load	-	X	-
Payload data uplink processing	-	X	-
Payload signal processor communications	-	X	-
Remote manipulator system control	-	X	-
Table maintenance SPEC	-	X	-

6.1 BFS AND PASS SM DISPLAY- AND UPLINK-CONTROLLED PROCESSES

- PCMMU telemetry format load
- SM systems summary displays

6.1.1 PCMMU Telemetry Format Load

The PCMMU is the device that accumulates the onboard instrumentation data. The data are made available for downlinking and to GPCs. The PCMMU via a fetch Programmable Read-Only Memory (PROM) polls the Operational Instrumentation (OI) MDMs for information then stores these data in a data Random Access Memory (RAM). The data are now accessible by the GPCs for processing and display and by the formatter for downlinking. Checks are made during this process to determine validity flagging with status of the data. If the data are flagged invalid on two consecutive reads of an LRU, OI MDM, PDI, or Spacelab, the GPC bypasses the element via FDA, no longer looking for data from the failed LRU.

Downlist data, and information accumulated by the GPC, are available and stored in a buffer in the PCMMU. The information is accessible by the formatter to be included with the OI telemetry for downlinking.

Telemetry Format Load (TFL) is the information available for setting up the PCMMU downlink data stream. The PCMMU TFL capability is a PASS SM OPS 2 process that is accessible via the PCMMU/PL COMM display SPEC 62 (Figure 6-1). The TFLs are stored on the MMU and upon request are transferred to the PCMMU, setting up processing of OI telemetry. TFLs are available in two data rates: 128 kilobits per second (kbps) high data rate and 64 kbps low data rate, each having its own formatter within the PCMMU and loaded independently of each other. The formatter then has the capability to request the desired information to be inserted into the downlink telemetry. Each PCMMU also has a hard-coded high data rate TFL (129). This precludes total loss of data in the event of failures, which will not allow access to the loading of TFLs. The PCMMU will retain only its hard-coded TFL in the event of an electrical power interruption.

```

XXXX/O62/          PCMMU/PL COMM  XX X  DDD/HH# MM# SS
SM CDM BUFF XXX   DDD/HH# MM# SS
PCMMU
BITE WORD XXXX
FM7
SEL FXD      LX5
  PGM       2XX
PGM ID 64 XXX
      128 XXX
3 SEL ID XXX
  LOAD 4 XXXX

I/O RESET
  PCM 5XX

PSP
I/O RESET
  PSP1 6XX
  PSP2 7XX
SYNC BIT XXXX
  FRAME XXXX
LOAD XXXX XXXX

PL INTRG
1 CHANNEL XXXX
2 CHANNEL XXXX
PHASE LOCK XXXX
ERR ±XXX
XMIT PWR XX.XXX
PL SIG STR X.XXX

PDI
I/O RESET 8XX
BITE WORD XXXX
9 SEL DECOM X
L0 SEL FMT XXX
  LOAD 1L XXXX
L2 SEL INPUT X
  LOAD 13
DECOM INPUT FMT
1 X XXXS
2 X XXXS
3 X XXXS
4 X XXXS
5-FPM XXX
DECOM ENA
FDA 1 14X
      2 15X
      3 16X
      4 17X
L8 TFL GPC SEL X

(XX)

```

TD37902L CRT# L

Figure 6-1. PCMMU/PL COMM display

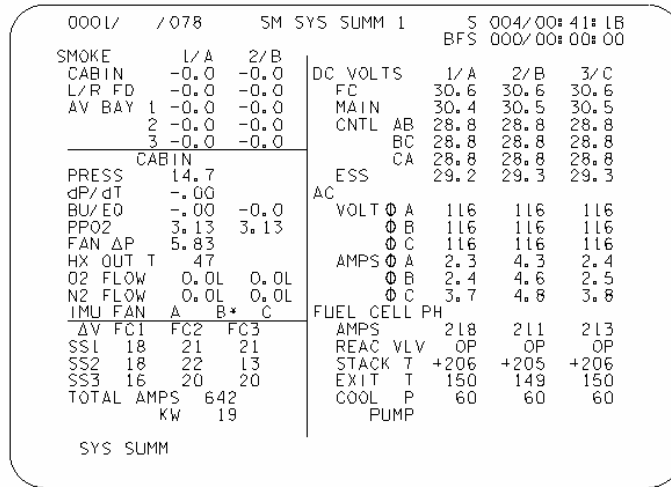
6.1.2 SM System Summary Displays

There are two key SM displays, SM SYS SUMM 1 and SM SYS SUMM 2. These displays are available during all flight phases and provide critical systems information in support of the orbiter.

SM System Summary 1 (see Figure 6-2), the first of two summary displays, contains status information on emergency parameters, electrical power and distribution, and basic orbiter atmospheric conditions. SM System Summary 2 (see Figure 6-3), the second of two summary displays, contains status information on cryogenics, APUs, hydraulics, and thermal control subsystems.

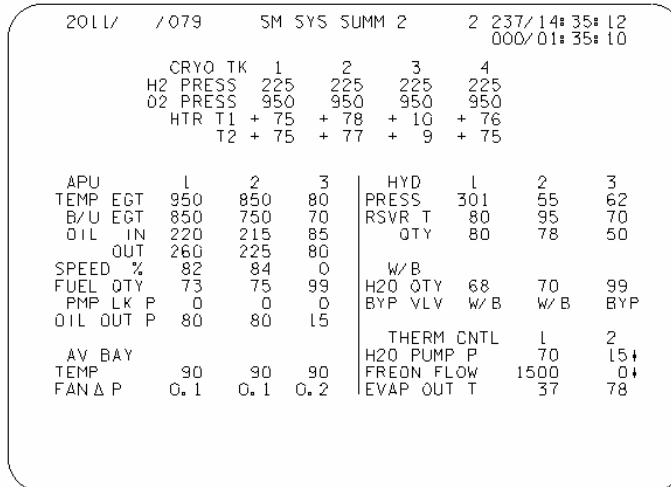
The BFS and PASS SYS SUMM 1 displays are the same. The BFS and PASS SYS SUMM 2 displays are slightly different (see the DPS Dictionary).

The SM SYS SUMM 1 display is called up by pushing the SYS SUMM key on an orbiter Keyboard Unit (KBU) assigned to either the BFS GPC (ascent or entry) or a PASS SM GPC (orbit). Successive depressions of the SYS SUMM key toggles between the two SYS SUMM displays.



TD379022. CRT, 2

Figure 6-2. SM SYS SUMM 1 display



TD379023. CRT, 1

Figure 6-3. SM SYS SUMM 2 display

6.2 PASS SM DISPLAY- AND UPLINK-CONTROLLED PROCESSES

- Checkpoint
- MMU read/write
- PDI format load
- Payload data uplink processing
- PSP communications
- RMS control
- Table maintenance SPEC

6.2.1 Checkpoint

A checkpoint is a record of system parameter values written to the MMUs at a specific instant in time and reserved for later use. Certain SM software control parameters (e.g., FDA status, limit values, constants, noise filter constants, parameter annunciation inhibits, state vectors, etc.) are preloaded, but may be changed during a mission's progress. These changes are maintained by the SM GPC. The most current values of these parameters are lost when a new load overrides the GPC software or when the SM GPC fails. Therefore, a function called Checkpoint Retrieval (CKPT RETRV) (on SPEC 1) enables or inhibits the retrieval and incorporation of SM checkpoint data from mass memory at SM OPS transitions.

Preparing a checkpoint allows the most recent version of system control data to be written to the MMUs. The checkpoint section of the MMU is located in a different place from the nominal SM software.

The checkpoint write capability currently exists only for the SM major function (PASS OPS 2), and is performed in conjunction with the SM TM display (PASS SM SPEC 60) and the DPS UTILITY display (SPEC 1). Only data that can be changed on SPEC 60 are captured by a checkpoint, and the data will be retrieved only during an OPS transition if enabled on SPEC 1.

6.2.2 MMU Read/Write

The MMU read/write capability is the most generic use of the MMU and provides the ability to access anything on the MMU except for the IPL software. This process is available in PASS SM OPS 2, on a display called MASS MEMORY R/W, (PASS SM SPEC 85), and in payload OPS 9 (PL 9) on the MASS MEMORY R/W display, or by ground uplink to the vehicle. Refer to Figure 6-4.

```

9011/085/      MASS MEMORY R/W   XX X DDD/HH:MM:SS
SM COM BUFF XXX DDD/HH:MM:SS
DESIRED ACTUAL  DESIRED ACTUAL
1 XXXX XXXX   21 XXXX XXXX      SELECT
2 XXXX XXXX   22 XXXX XXXX      MMU 1      40X
3 XXXX XXXX   23 XXXX XXXX      MMU 2      41X
4 XXXX XXXX   24 XXXX XXXX      42 S/W SYSTEM  X
5 XXXX XXXX   25 XXXX XXXX      43 PHASE      XXX
6 XXXX XXXX   26 XXXX XXXX      44 LOAD BLK   XXX
7 XXXX XXXX   27 XXXX XXXX      45 OFFSET7   XXXXX
8 XXXX XXXX   28 XXXX XXXX      46 NUMBER     XX
9 XXXX XXXX   29 XXXX XXXX      47 PATCH ID   XXXX
10 XXXX XXXX  30 XXXX XXXX      VIOLATE      XXX
11 XXXX XXXX  31 XXXX XXXX      READ LOAD BLK 48X
12 XXXX XXXX  32 XXXX XXXX      MERGE         49X
13 XXXX XXXX  33 XXXX XXXX      WRITE LOAD BLK 50X
14 XXXX XXXX  34 XXXX XXXX      COMPARE       51X
15 XXXX XXXX  35 XXXX XXXX      STATUS        XXXX
16 XXXX XXXX  36 XXXX XXXX      ERROR CODE    X
17 XXXX XXXX  37 XXXX XXXX      REGISTER A    XXXX
18 XXXX XXXX  38 XXXX XXXX      REGISTER B    XXXX
19 XXXX XXXX  39 XXXX XXXX      MM VERSION    XX.XX
20 XXXX XXXX  CHECKSUM XXXX      DUMP VIA DL   52X

(XX)

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TD379024. CRT, 1

Figure 6-4. MASS MEMORY R/W display

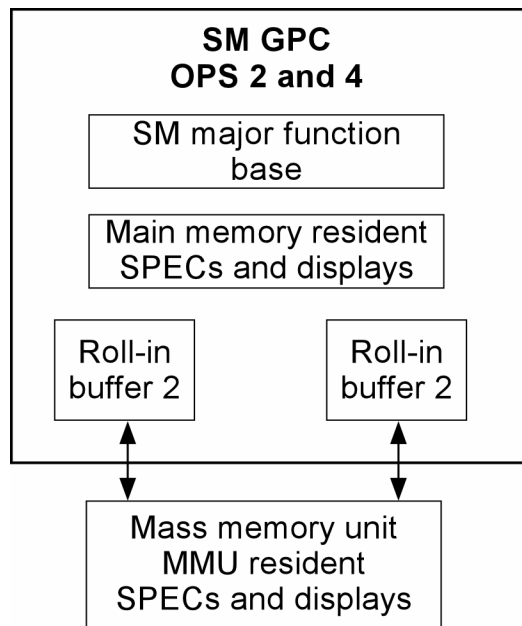
The display provides the capability to read from the MMU, write to the MMU, dump the MMU to the ground, and to compare a loadblock in one MMU to the same one in the other MMU. After a specific loadblock is selected, it may be read from either MMU into the GPC buffer. The data can then be dumped via downlist or displayed, 39 words at a time, on the MMU R/W display (SM SPEC 85). When a write is done, the changes are made to the displayed data; the data are merged into the buffer, and then written to either MMU. The following blocks of software are on each MMU and available for MMU read/write:

- Display text and graphics
- PASS 1
- PASS 2
- PASS 3
- BFS
- Display Electronics Unit (DEU) Control Program (DCP)
- DEU Standalone Self-Test Program (SASTP)
- DPS Critical Display Formats
- Space Shuttle Main Engine (SSME)
- Test Control Supervisor (TCS) sequence

The above list shows that there are three copies of PASS software available to the crew. Therefore, if PASS 1 has a software problem on orbit, the crew can access the mass memory and obtain PASS 2 software through a mass memory read. The MMU read/write capability allows the user to read or write to any of the above software blocks.

Another user of the MMU read/write capability is the crew text or Text Uplink Memory System (TUMS). The TUMS is available only in PASS SM OPS 2 or 4. The display pages available to this system are numbered from 900 to 999 and are roll-in displays. The text on these displays is written there by MMU read/write via uplink. A use of this system is to allow secure transmission of textual material for Department of Defense (DOD) flights. TUMS can also be used when all audio communications have been lost.

Probably the most common use of the MMU by the SM machine is that of roll-in displays. Since all SM displays cannot be held in mass memory at one time, the roll-in display capability allows the SM machine to use more displays than can fit in memory at one time by reserving two areas of memory (called buffers). Buffers can be used to store displays (a maximum of two at any one time) that have been called in from the MMU (see Figure 6-5).



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Figure 6-5. MMU roll-in buffers

6.2.3 Payload Data Interleaver Format Load

The PDI is the subsystem that processes selected payload data to either the PCMMU or the SM GPC. The data can be processed for monitoring onboard and/or available for downlinking in the OI telemetry. The PDI consists of a switch matrix allowing for six inputs, four decoms, and a Fetch Pointer Memory (FPM). Input selections, decom, and

FPM loading are accomplished via the SM GPC, which also performs FDA to determine the status of the PDI.

The PDI Decom Format Load (DFL) and FPM data are stored on the MMU. Upon demand, either via keyboard entry or uplink command, data are acquired, verified, and loaded into the applicable unit. Legal-format I-Loads in legal format range from 0 to 31 for the PDI DFLs and 1 to 999 for the FPM.

The PDI format load capability exists in SM OPS 2 (G9) and is accessible via the PCMMU/PL COMM display SPEC 62 (Figure 6-1).

6.2.4 Payload Data Uplink Processing

Payload data uplink processing is used as a means for the ground or the crew (via payload-specific displays) to communicate with various payloads via the SM GPC. The load is variable in length and consists of 1 to 33 command words (48-bit). These data should include a destination and the number of words to be included in the uplink. These commands include an operations code, which directs the data to the proper payload interface. Valid destinations shall include PSP communications, standard serial I/O, and the Spacelab serial data interface.

The payload data uplink processing capability exists in SM OPS 2.

6.2.5 Payload Signal Processor Communication

The PSP is a device used as an interface between the orbiter systems and its payloads. The PSP is configurable via the SM GPC, accepting commands, converting these commands into a compatible form to be sent either to the payload via hardline or to the PI for Radio Frequency (RF) transmission. The PSP also has the capability to accept detached payload telemetry via the PI, making this data available to the PDI for processing.

The SM computer communicates with the PSP via its corresponding payload MDM. The SM application has the capability to access five prestored configuration messages, a reinitialize configuration message, and output to the PSP via uplink command. These configuration messages consist of five 16-bit words. The PSP also outputs five 16-bit status words, indicating the current status of the unit available for display and downlist.

The PSP interface function is available in SM OPS 2 and is accessible via the PCMMU/PL COMM display SM SPEC 62 (Figure 6-1).

6.2.6 Remote Manipulator System Control

The RMS function is performed in SM OPS 2. It has the capability to monitor and control the RMS for payload deployment and retrieval. The SM GPC interface to the RMS is provided via dedicated SM displays. SPECs 94, 95, 96, and 169 are the pages dedicated to RMS operations. These displays allow the RMS operator to select flight-

specific payload parameters, monitor the status of the PDRS, override switches on the PDRS display and control panel, and enable/inhibit RMS software capabilities. These displays also provide commanded/actual translation and rotation rate information along with the RMS position and attitude. The SM GPC calculates this information with data provided from the RMS Manipulator Controller Interface Unit (MCIU).

6.2.7 Table Maintenance SPEC

The Table Maintenance SPEC (Figure 6-6), available in PASS SM OPS 2, is called up by entering SPEC 60 PRO on the IDP. This display provides the capability for the crew to interface directly with software in order to perform the following:

- a. View and change FDA limits
- b. View and change FDA filter values
- c. Inhibit or enable FDA parameter annunciation
- d. View and change telemetry TM constants
- e. Initiate a checkpoint
- f. Inhibit or enable all FDA annunciation

The procedures for using this display are in the Reference Data book.

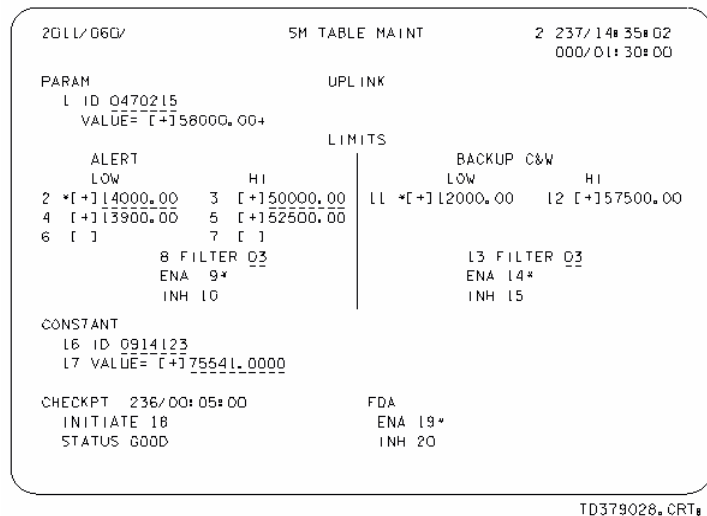


Figure 6-6. SM TABLE MAINT typical display

APPENDIX A ACRONYMS AND ABBREVIATIONS

AOA	Abort Once Around
AOS	Acquisition of Signal
APU	Auxiliary Power Unit
ARS	Atmospheric Revitalization System
ATCS	Active Thermal Control System
BFS	Backup Flight System
BOS	Backup Operating System
C&W	Caution and Warning
CIU	Communications Interface Unit
CKPT	Checkpoint
CMD	Command
CPDS	Computer Program Development Specification
CPM	Cell Performance Monitor
DCP	DEU Control Program
DEU	Display Electronics Unit
DFL	Decom Format Load
DOD	Department of Defense
dP/dT	delta Pressure/delta Temperature
DPS	Data Processing System
FC	Fuel Cell
FCL	Freon Coolant Loop
FCP	Fuel Cell Powerplant
FDA	Fault Detection And Annunciation
FDL	Flight Data File
FES	Flash Evaporator System
FF	Flight Forward
FM	Frequency Modulation
FPM	Fetch Pointer Memory
FSM	Fault Summary Message
FSSR	Functional Subsystem Software Requirements
GMT	Greenwich Mean Time
GNC	Guidance, Navigation, and Control
GPC	General Purpose Computer
GSE	Ground Support Equipment
H ₂	Hydrogen
HASE	Hubble Avionics Support Equipment
HX	Heat Exchanger

I/O	Input/Output
ICC	Inter Computer Communication
ID	Identification
IDP	Integrated Display Processor
IDS	Integrated Documentation Services
IMU	Inertial Measurement Unit
IP	Intermediate Processor
IPL	Initial Program Load
IRIS	Italian Research Interim Stage
ISS	International Space Station
IUS	Inertial Upper Stage
JSC	Lyndon B. Johnson Space Center
kbps	Kilobits Per Second
KBU	Keyboard Unit
kW	Kilowatt
LOS	Loss of Signal
LRU	Line Replaceable Unit
M50	Mean of 1950
MA	Master Alarm
MC	Memory Configuration
MCC	Mission Control Center
MEDS	Multifunction Electronic Display System
MCIU	Manipulator Controller Interface Unit
MDM	Multiplexer/Demultiplexer
MDP	Mission-Dependent Process
MET	Mission Elapsed Time
MF	Major Function
MFB	Major Function Base
MM	Major Mode
MMU	Mass Memory Unit
MOD	Mission Operations Directorate
MSP	Mission-Selectable Process
MUP	Mission-Unique Process
NASA	National Aeronautics and Space Administration
NSP	Network Signal Processor
O ₂	Oxygen
OFT	Operational Flight Test
OI	Operational Instrumentation
OPS	Operations Sequence
OSL	Off Scale Low

PAM	Payload Assist Module
PASS	Primary Avionics Software System
PC	Personal Computer
PCM	Pulse Code Modulation
PCMMU	Pulse Code Modulation Master Unit
PCS	Payload Control Supervisor
PDI	Payload Data Interleaver
PDRS	Payload Deployment and Retrieval System
PI	Payload Interrogator
PL	Payload
PLBD	Payload Bay Door
PM	Phase Modulation
PPO ₂	Partial Pressure O ₂
PRSD	Power Reaction Storage and Distribution
PROM	Programmable Read-Only Memory
psi	Pounds Per Square Inch
PSP	Payload Signal Processor
PVT	Pressure, Volume, and Temperature
RAM	Random Access Memory
REAC VLV	Reaction Valve
RETRV	Retrieval
RF	Radio Frequency
RMS	Remote Manipulator System
RTLS	Return to Launch Site
SASTP	Standalone Self-Test Program
SCA	Sequence Control Assembly
SCP	Sequence Control Process
SGLS	Space Ground Link Station
SM	Systems Management
SP	Special Processing
SPEC	Specialist Function
SPOC	Space Program Operations Contract
SRB	Solid Rocket Booster
SSME	Space Shuttle Main Engine
SS/W	System Software
SS	Subsystem
SSI	Standard Serial Interface
SSP	Standard Switch Panel
SSUS	Spinning Solid Upper Stage
STDN	Space Tracking and Data Network
TAL	Transoceanic Abort Landing
TAMS	Training Administration Management System
TCS	Test Control Supervisor

TDRS	Tracking and Data Relay Satellite
TDRSS	Tracking and Data Relay Satellite System
TFL	Telemetry Format Load
TM	Table Maintenance
TMBU	Table Maintenance Block Update
TUMS	Text Uplink Memory System
V dc	Volts, direct current
V-I-T	Volts-Current-Temperature
WSB	Water Spray Boiler

APPENDIX B SUGGESTED REFERENCE DOCUMENTS

- Space Shuttle Program Orbiter Project Computer Program Development Specification (CPDS), Volume V, Book 8, Systems Management Level B Software Requirements, SS-P-0002-580G. This document specifies the functional requirements for the computer program(s) of the SM function for the space shuttle orbiter vehicle.
- Space Shuttle Orbiter Flight Test, Level C, Functional Subsystem Software Requirements (FSSR), Systems Management. This document represents the SM detail software requirements for the space shuttle orbiter Operational Flight Test (OFT) program.
- Backup Flight System Management/Special Processes and Sequencing Program Requirements Document. This document describes all the BFS SM software requirements.
- Data Processing System (DPS) Dictionary. This Flight Data File (FDF) document contains a description of all the orbiter displays and SPECS.
- Data Processing System Familiarization Workbook, DPS FAM 21002.
- Environmental Systems Console Handbook, Systems Division, Electrical and Environmental Systems Branch, Basic, Rev. E, October 15, 2001.
- EGIL Console Handbook, Systems Division, Electrical and Environmental Systems Branch, Basic, Rev. F, January 31, 2002.
- Space Shuttle Programs, Orbiter Avionics Software, OPS DDS, Volume III, Applications, Part 2 SM.

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SIZE OF AUDIENCE/CLASS:

1. How well did this lesson meet its purpose?

For each statement below, mark one box on the scale:

	Strongly Disagree					Strongly Agree
a. <i>The lesson objectives are clearly stated.</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b. <i>The lesson objectives are clearly defined.</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c. <i>The lesson effectively teaches skills and information.</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
d. <i>The lesson meets its purpose and objectives.</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

2. How satisfying is the content of this lesson?

For each statement below, mark one box on the scale:

	Strongly Disagree					Strongly Agree
a. <i>The information is structured in a logical flow.</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b. <i>The content is clear.</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c. <i>The content is complete.</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
d. <i>The level of detail is correct for this information.</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
e. <i>The amount of information is effective.</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
f. <i>The graphics contribute to my understanding.</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

3. How appealing was the presentation of this lesson?

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	Strongly Disagree					Strongly Agree
a. <i>The overall presentation is appealing.</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b. <i>The visuals chosen are appropriate for the lesson.</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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4. How valuable is this information?

For each statement below, mark one box on the scale:

	Strongly Disagree					Strongly Agree
a. <i>The lesson teaches skills and information I need.</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b. <i>The lesson meets my expectations.</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c. <i>This information is useful for later reference.</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
d. <i>I would recommend this lesson to others.</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

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