

Shuttle Flight Operations Manual

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Volume 4D
Television (CCTV)

Mission Operations Directorate
Training Division

Basic, Rev-A, PCN-3
November 1986



National Aeronautics and
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2.5 WIDE ANGLE LENS ASSEMBLY

The Wide Angle Lens Assembly (WLA) is similar to the CLA, except that it has a shorter focal length. This provides the wide angle field-of-view necessary for interior scenes.

2.6 CLOSEUP LENS ASSEMBLY

Stowed separately in the cabin is the closeup lens assembly (fig. 2-4). It consists of retainer and adapter rings and typically one +3 diopter lens. This assembly attaches to the WLA camera lens to provide closeup views necessary for finely detailed experiment ops, IFM, etc. (fig. 2-5). Also available (by special request prior to flight) is a second lens which would attach to the retainer ring of the closeup lens assembly. Lenses available are +1, +2, or +3 diopters in any combination of two (fig. 2-5). This would provide an even closer image.

2.7 VIEWFINDER MONITOR

The viewfinder monitor (VFM) (fig. 2-6) is a monochrome mini-monitor. The VFM can be connected via detachable cable to either of the two interior TV cameras. Its purpose is to provide a visual presentation to the crewmember for camera setup and adjustment. It allows the crewmember to evaluate a TV scene without the inconvenience of moving to the aft station monitors.

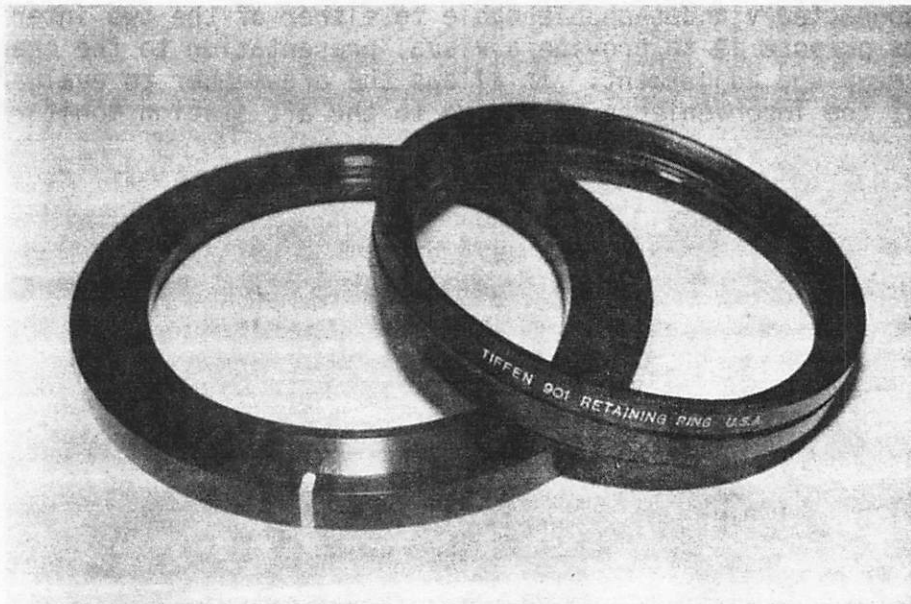
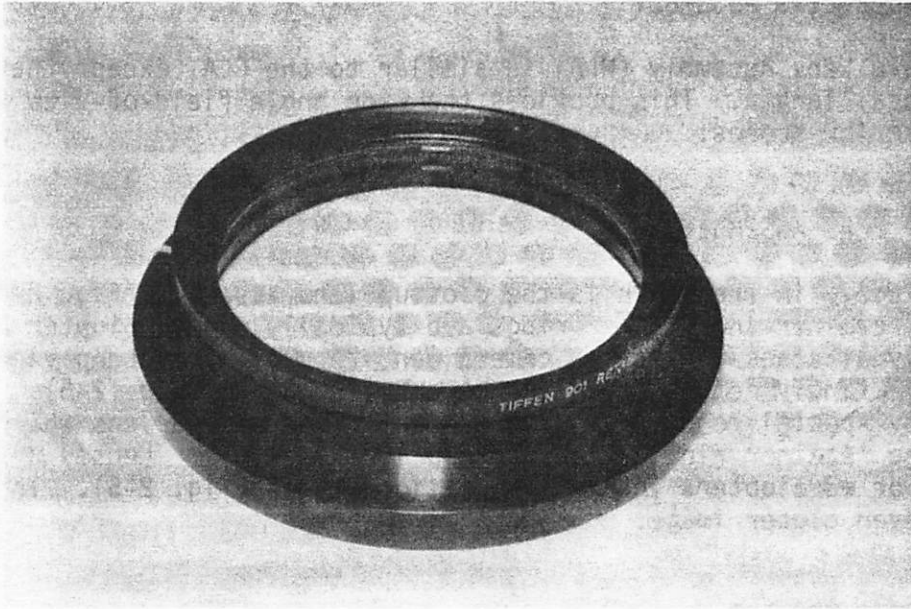


Figure 2-4.- Closeup lens assembly.

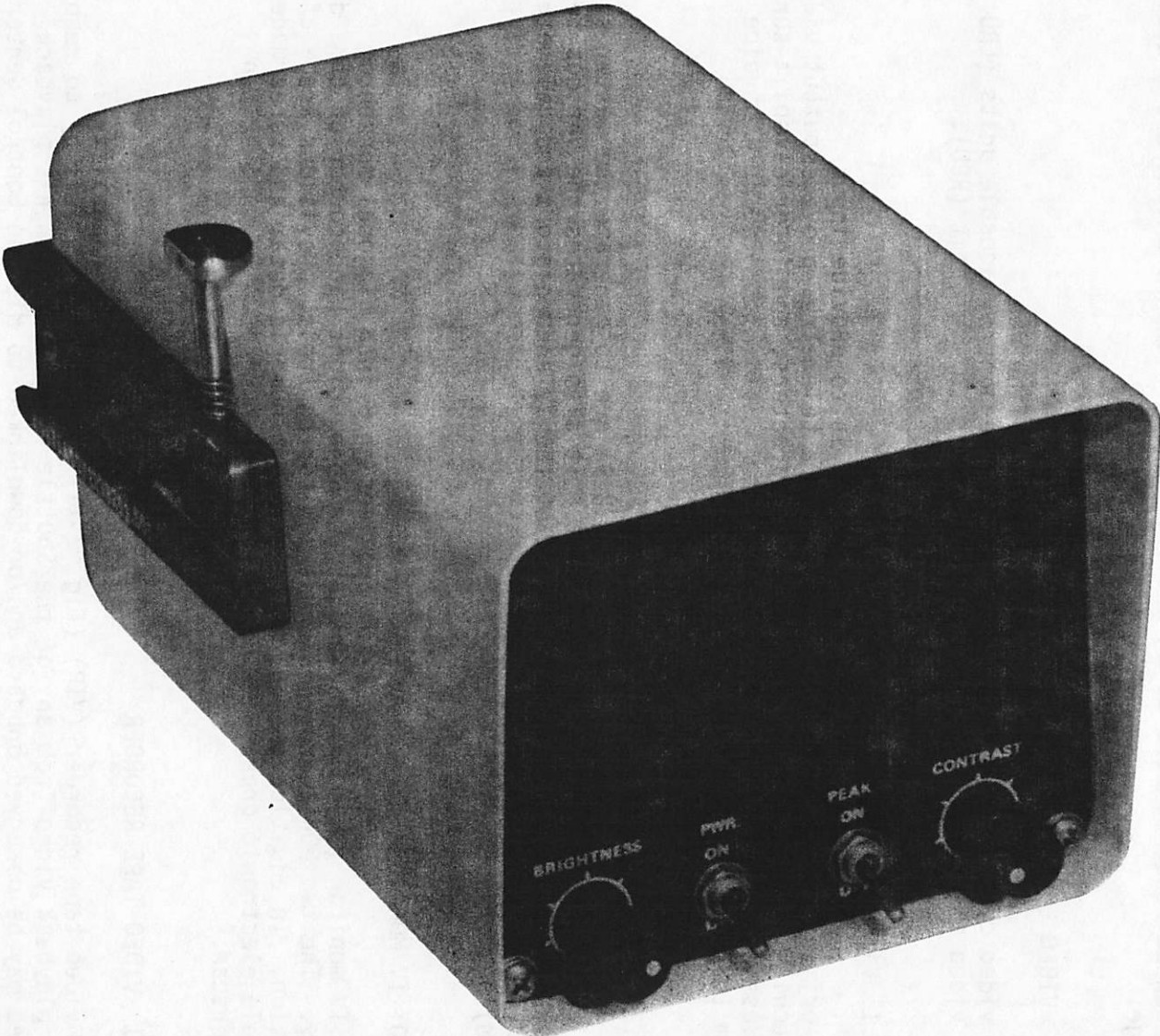


Figure 2-5.- Viewfinder monitor.

2.8 PAN-TILT UNIT

The pan-tilt unit (PTU) (fig. 2-7) provides remotely-controlled pan and tilt capability for cameras located within the payload bay. The PTU's can be controlled either from the aft crew station or via ground commands. Pan and tilt angles are available to the crew via on-screen alphanumeric displays, and can be reset to zero at an arbitrary point within the camera's travel range.

2.9 VIDEO CONTROL UNIT

The video control unit (VCU) consists of two line replaceable units (LRU's): the video switching unit (VSU) and the remote control unit (RCU).

2.9.1 Video Switching Unit

The primary function of the VSU (fig. 2-8) is to provide input/output video switching. Additionally, it decodes camera telemetry, provides split-screen processing, generates the alphanumeric characters, and interleaves voice from ICOM A or B with TV signal.

2.9.2 Remote Control Unit

The primary functions of the RCU (fig. 2-9) are to generate the master sync signals and to process system commands. It also generates the various test signals and provides outputs for most of the TV annunciators and telemetry (TLM) outputs.

2.10 TV MONITOR

The TV monitor (MON) (fig. 2-10) provides an 8-inch diagonal monochrome display. The two MON's are located at the upper right hand corner of the aft station. In addition to the normal monitor controls, provisions are made to enable electronic crosshairs, on-screen alphanumeric data, and screen underscan.

2.11 VIDEO TAPE RECORDER

The video tape recorder (VTR) (fig. 2-11) provides the capability to record and playback video from any of the Shuttle CCTV cameras. This playback video may be observed onboard and/or downlinked to Mission Control Center (MCC). A headset connector is provided for VTR voice input/output, if desired.

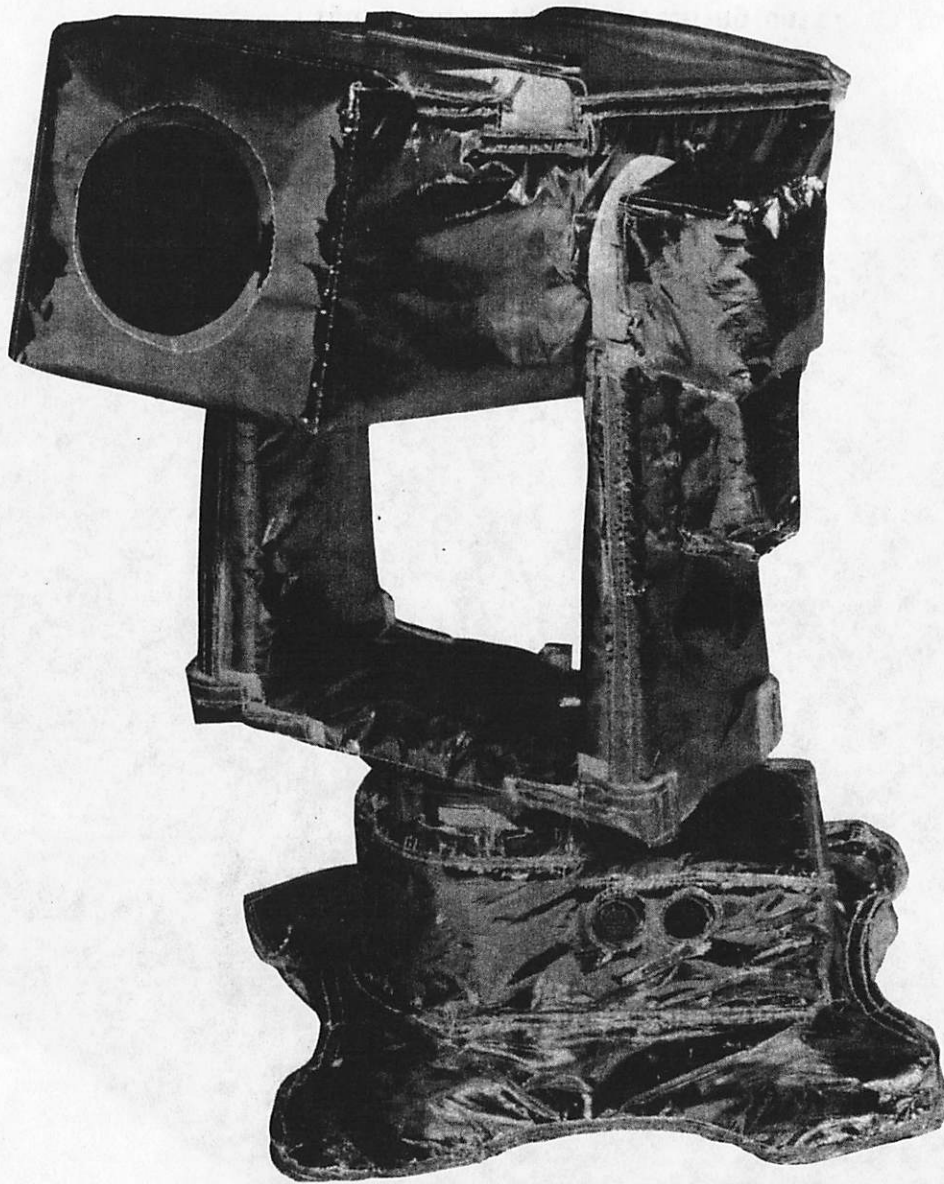


Figure 2-6.- Pan-tilt unit (with camera and thermal cover).

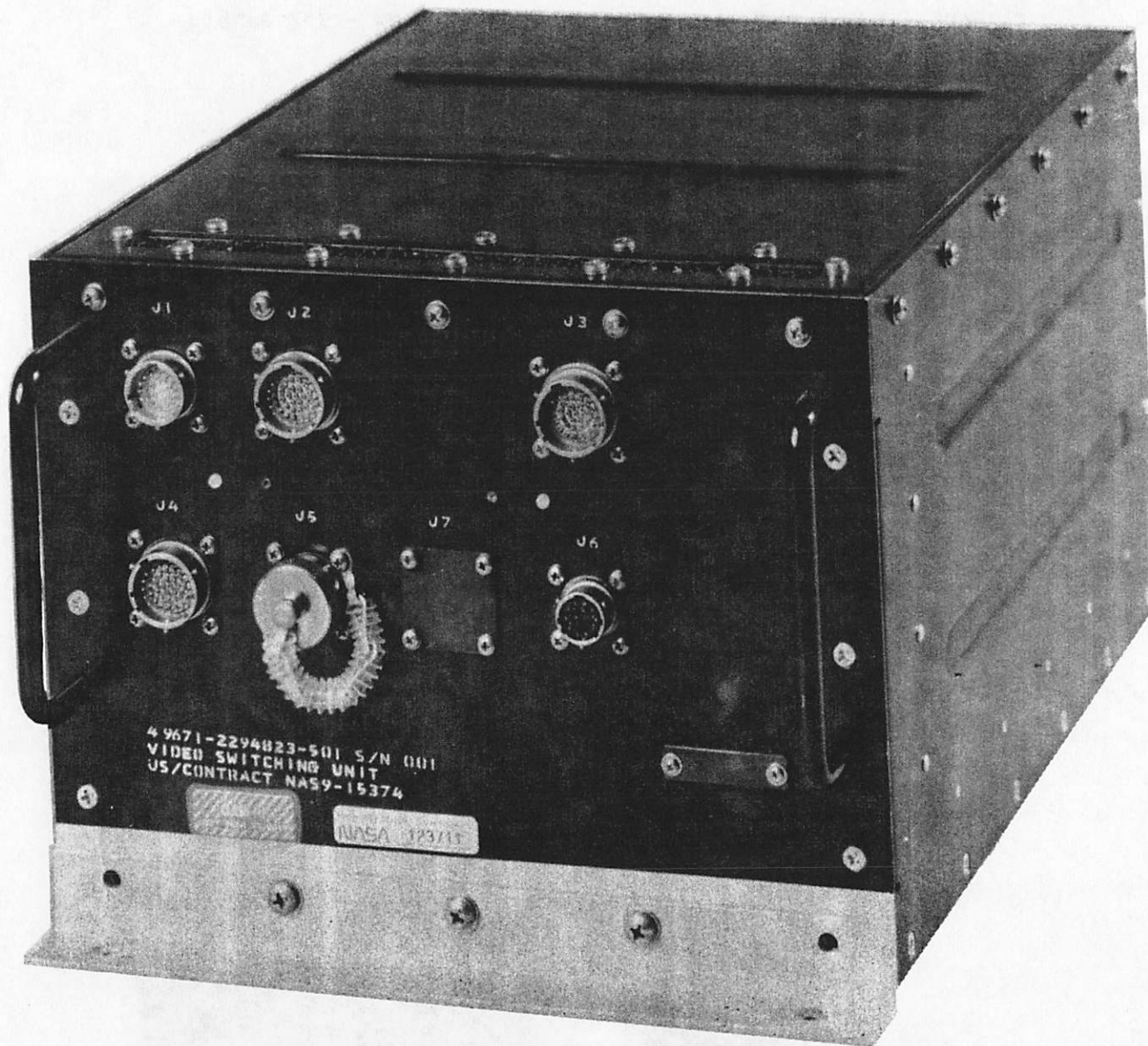


Figure 2-7.- Video switching unit.

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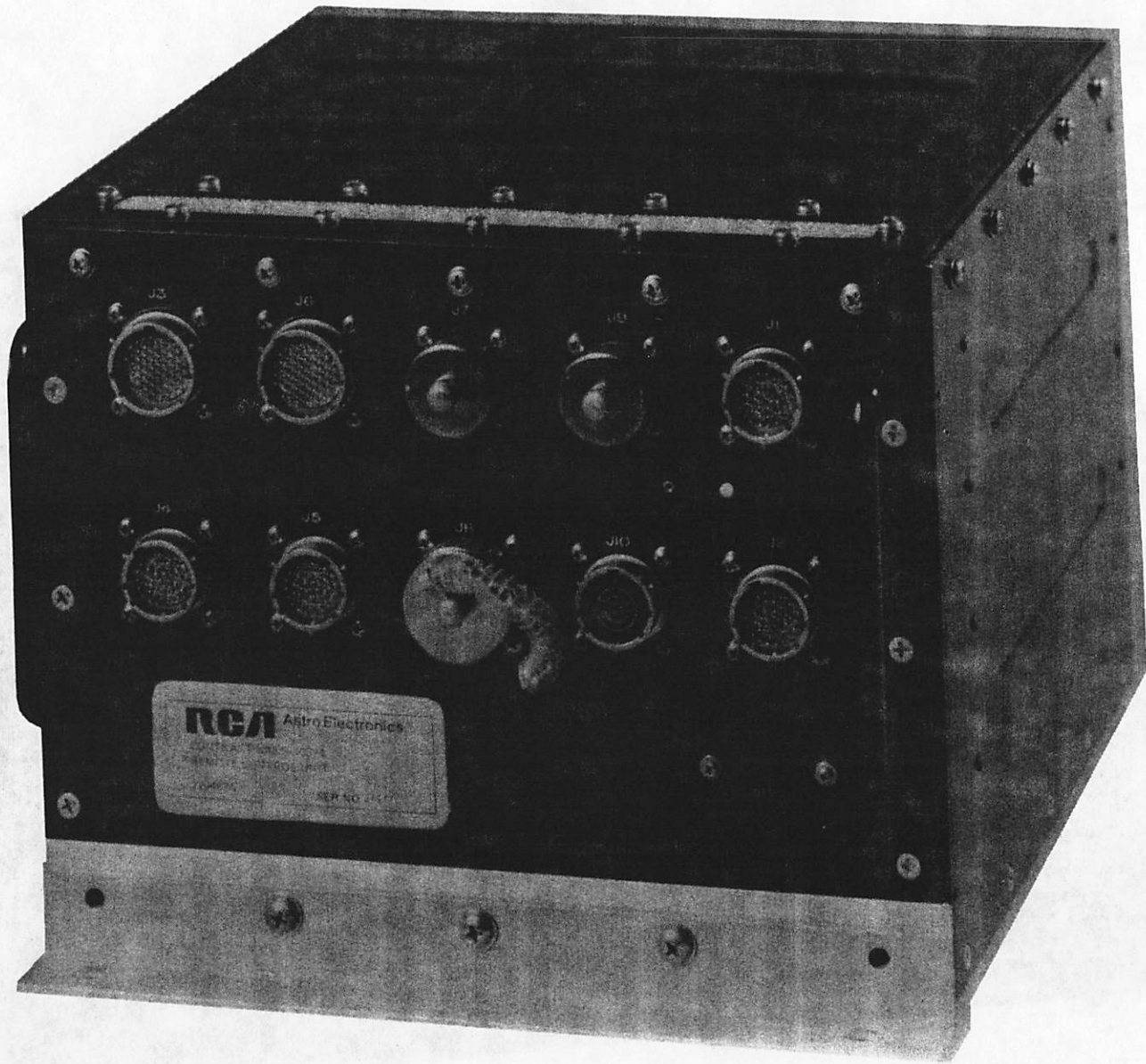


Figure 2-8.- Remote control unit.

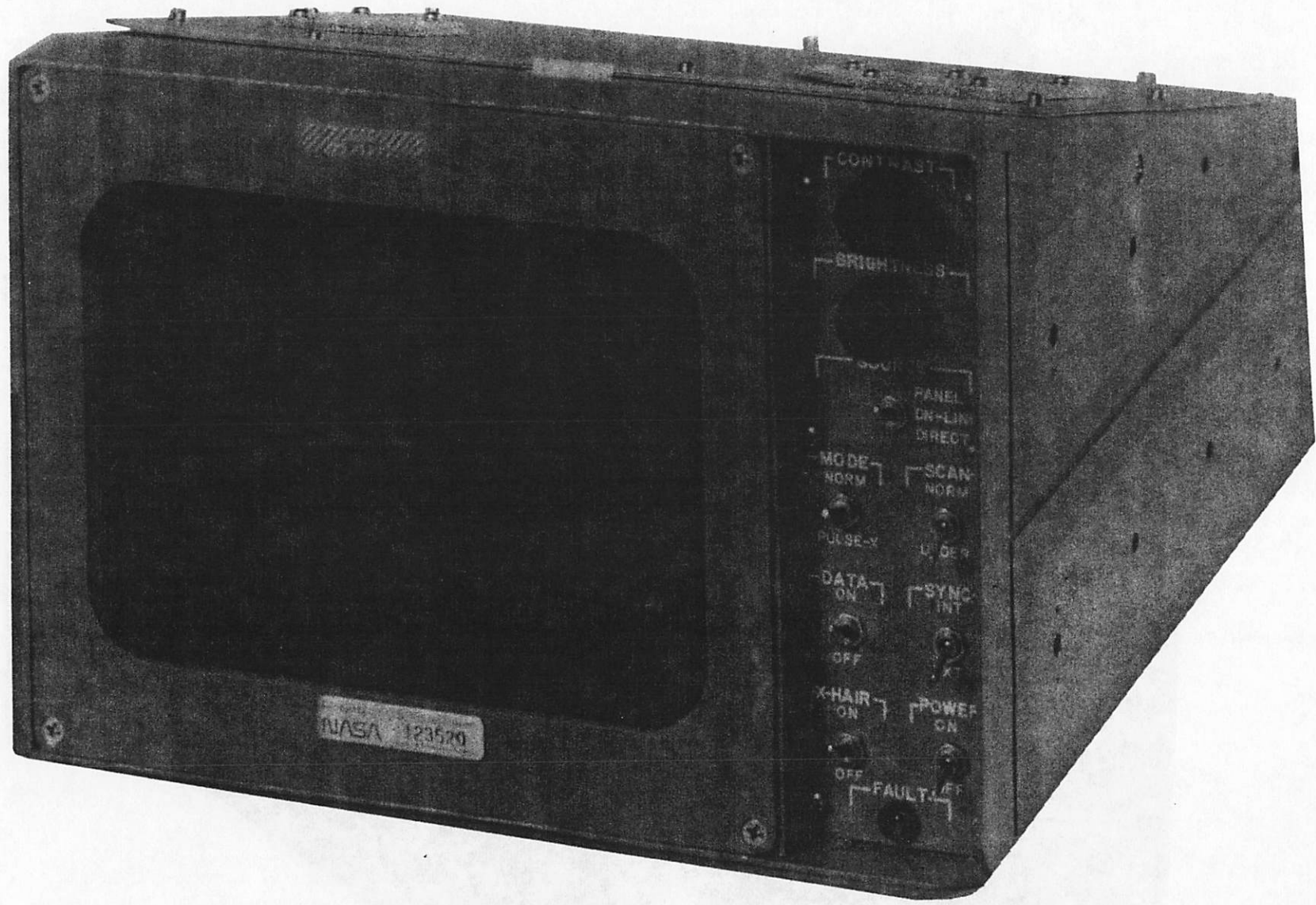


Figure 2-9 .- TV monitor.

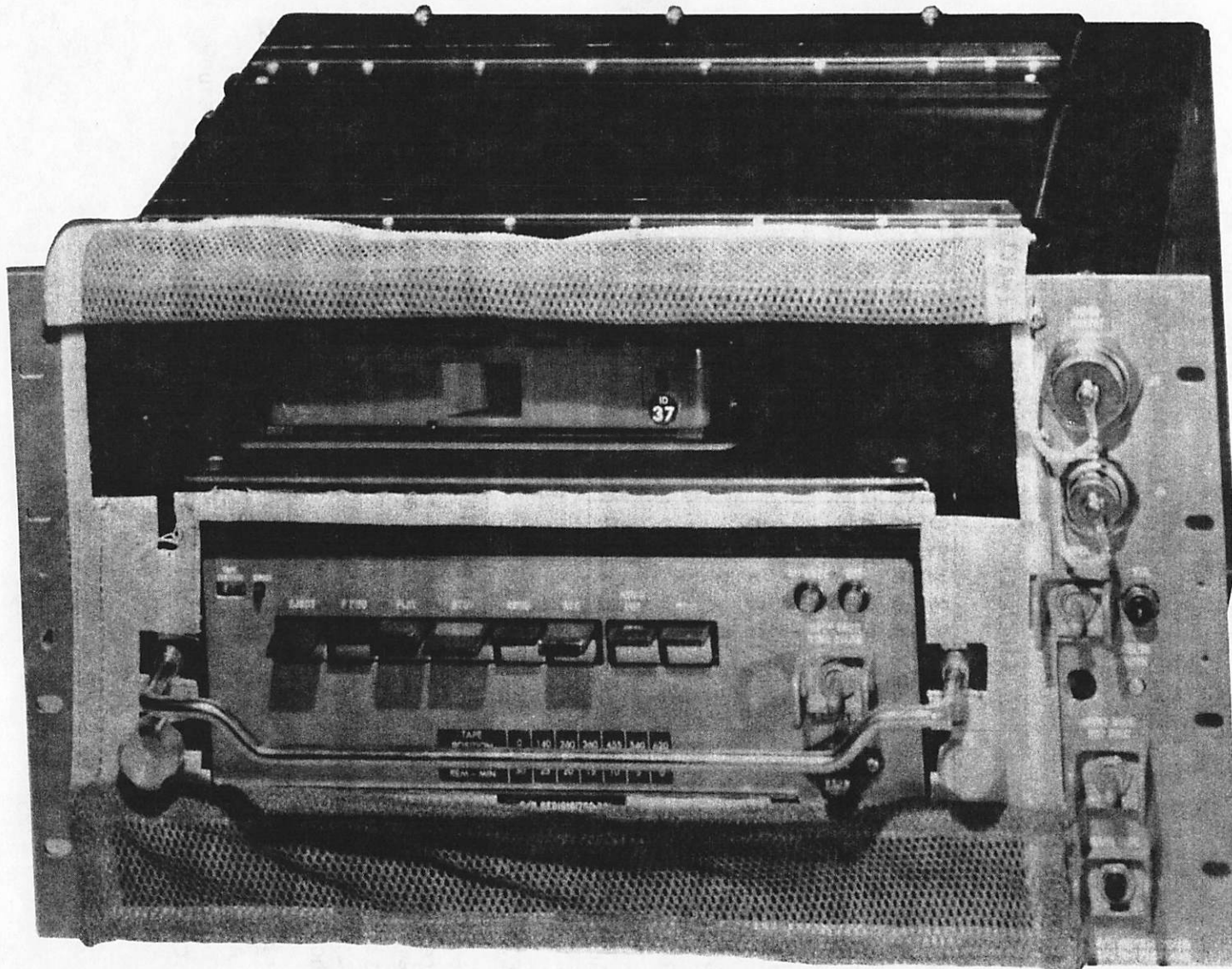


Figure 2-10.- Video tape recorder.

2.12 MECHANICAL AND ELECTRICAL SPECIFICATIONS

The size, weight, and power specifications for major components of the CCTV subsystem are defined in table 2-I. NOTE: The maximum weight allowable on the Orbiter's bulkhead mounting bracket is 37.2 pounds (this value is total weight, including P/T unit, camera/lens, and any other device).

TABLE 2-I.- GENERAL MECHANICAL/ELECTRICAL SPECIFICATIONS

| Item | Size (inches) | Weight (lb) | Power (watts) | Heater power (watts) |
|----------------------|-----------------|-------------|---------------|----------------------|
| Camera | 9.1 x 6.3 x 5.8 | 9.7 | 24.0+ | 26.1+ |
| Color Lens | 7.4 x 5.8 x 5.4 | 7.75 | 6.6 | |
| B&W Lens | 7.4 x 5.8 x 5.4 | 6.75 | 0.6 | |
| Viewfinder Monitor | 8 x 4.3 x 3.6 | 4.0 | 7.0 | |
| Pan-Tilt Unit | 16 x 11 x 11 | 9.0 | 0.6 | 16.4 |
| Video Switching Unit | 13 x 10.5 x 7.8 | 39.0 | 21.0 | |
| Remote Control Unit | 10 x 10 x 7.7 | 39.0 | 46.0 | |
| TV Monitor | 12.5 x 10 x 7 | 21.0 | 36.4 | |
| Video Tape Recorder | 15 x 19 x 10 | 49.8 | 42.6 max | |
| Wide Angle Lens Assy | 7.4 x 5.8 x 5.4 | 8.25 | | |

2.13 COMPONENT LOCATIONS

Most of the CCTV equipment is located within the cabin environment, as illustrated in figure 2-12. Not shown in the figure are the two cabin cameras and viewfinder monitors. These cameras and monitors are stowed in middeck lockers for launch and entry. During on-orbit operations, they may be located throughout the cabin at crew option, utilizing mounting shoes located throughout the cabin.

Potential camera locations within the payload bay are illustrated in figure 2-13. All X, Y, Z coordinate dimensions are in inches and represent the center of the pivotal axes points for each of the CCTV cameras. The elbow camera coordinates assume use of the 25° wedge on the pan/tilt unit.

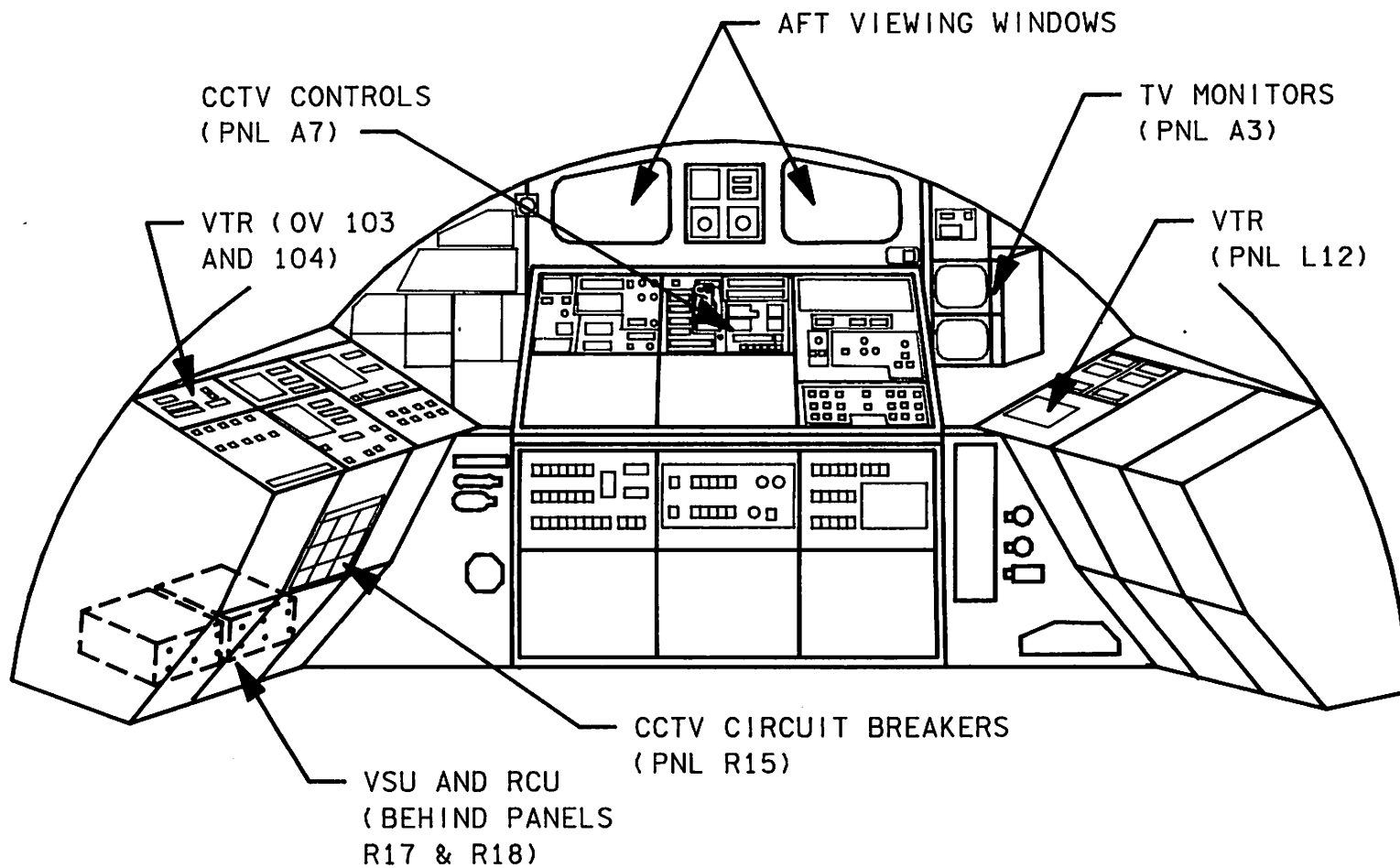


Figure 2-11.- CCTV Components locations (cabin).

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2-16

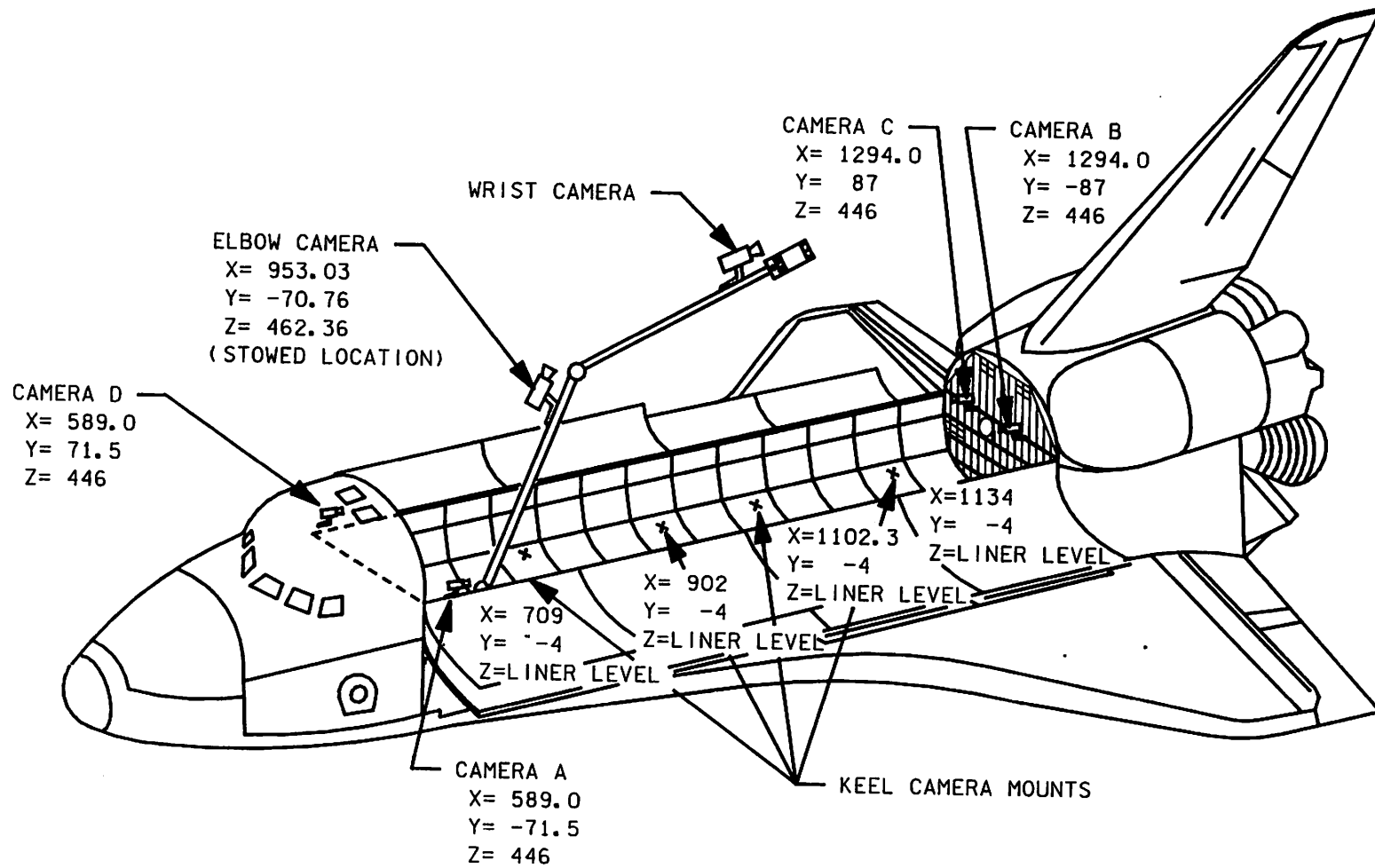


Figure 2-12.- Possible CCTV locations (payload bay).

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For interior operation, a Viewfinder Monitor (VFM) may be attached to the camera to assist the crewmember in camera positioning and setup. The VFM will display a black-and-white picture regardless of which lens assembly is being utilized. However, if the color lens assembly is in use, a 20-cycle flicker will be present on any onboard monitor viewing this scene. This flicker is due to the sequential or serial nature of the color reproduction and transmission. The ground color conversion process, of course, eliminates this flicker by essentially converting from a serial to a parallel color format.

The exterior cameras are equipped with Pan-Tilt Units (PTU's), which reposition the cameras in response to crew and/or ground commands. Crew control of the exterior cameras and the pan-tilt units is accomplished from aft station panel A7.

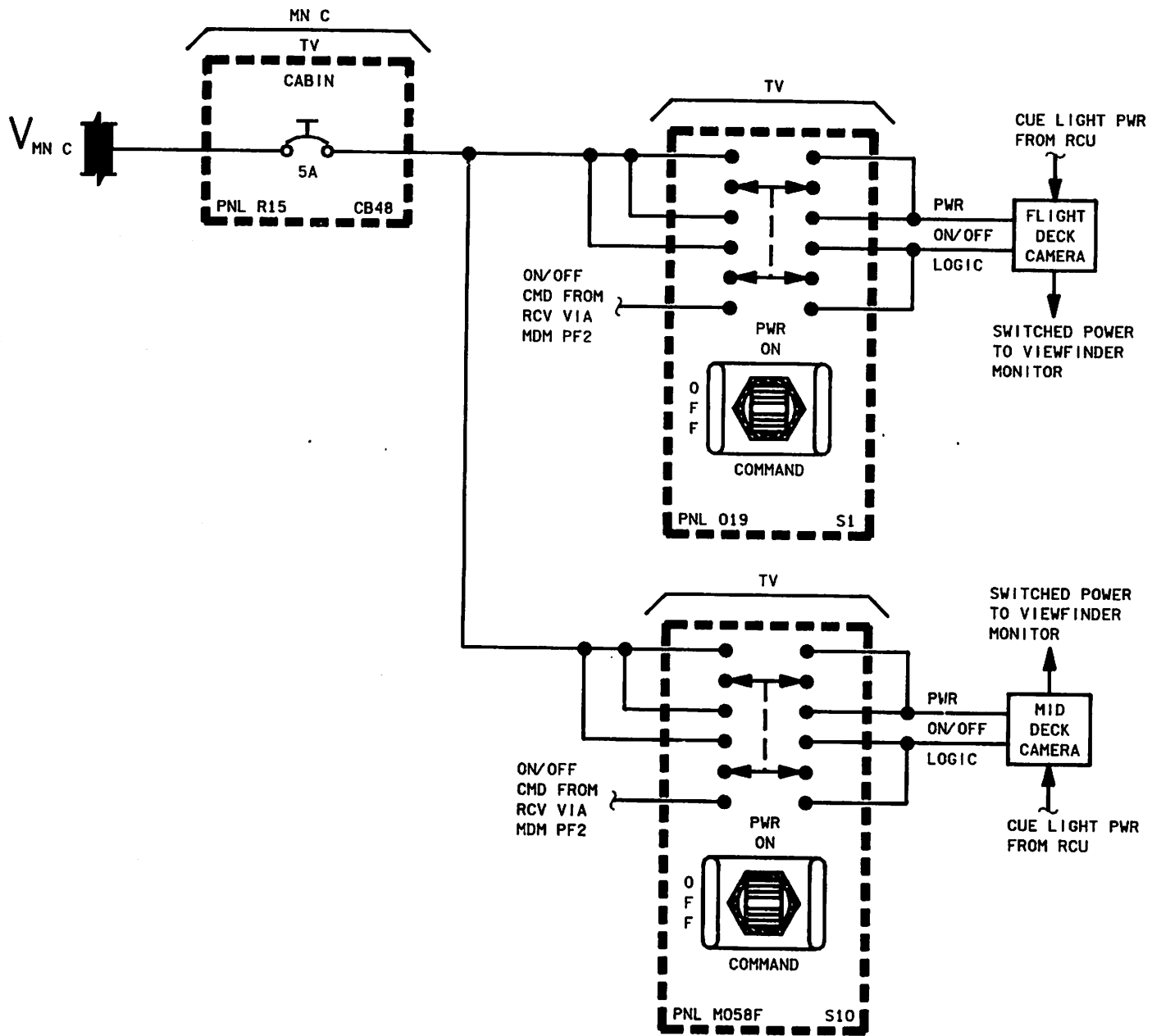
Panel A7 also has controls for video input and output selection via the VSU. The VSU is essentially a video distribution device, and all video signals, including downlink video, are routed through it. Power for the VSU is provided from the RCU. The primary function of the RCU is to process commands (whether from the crew or from the ground). However, it is the RCU which generates the system synchronization signal.

Also at the aft station, on panel A3, are located two TV Monitors (MON's). These are black-and-white monitors, and provide CCTV viewing capability for the flight crew. By using the unique split-screen function, a crewmember may simultaneously display as many as four independent scenes on the two monitors.

The downlinking of CCTV is accomplished via the S-band FM or Ku-band downlink (on later flights). Except for the split-screen case, only one video source may be downlinked at any given time. In the case of a real-time CCTV scene, intercom voice may be interleaved with the video signal, thereby maintaining video and voice synchronization regardless of ground processing and routing (see section 4.5.1.5). Additionally, voice from any loop is available to the Video Tape Recorder (VTR) via the Audio Distribution System (ADS)/VTR audio cable. This same cable provides for VTR voice playback into the Orbiter audio system for downlinking.

3.2 POWER DISTRIBUTION OVERVIEW

All CCTV equipment utilizes 28-volt bus power. Provisions are made such that the critical elements of the system (such as the VSU and RCU) are protected from bus failures by bus switching. No single bus failure can cause the loss of the entire CCTV system. Of course, any bus loss will disable portions of the CCTV equipment. A tabulation of equipment versus power bus is shown in table 3-I. Details of power distribution for individual components are covered in subsequent paragraphs of this document.



4-7

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Figure 4-5.- TV Camera power (cabin cameras).

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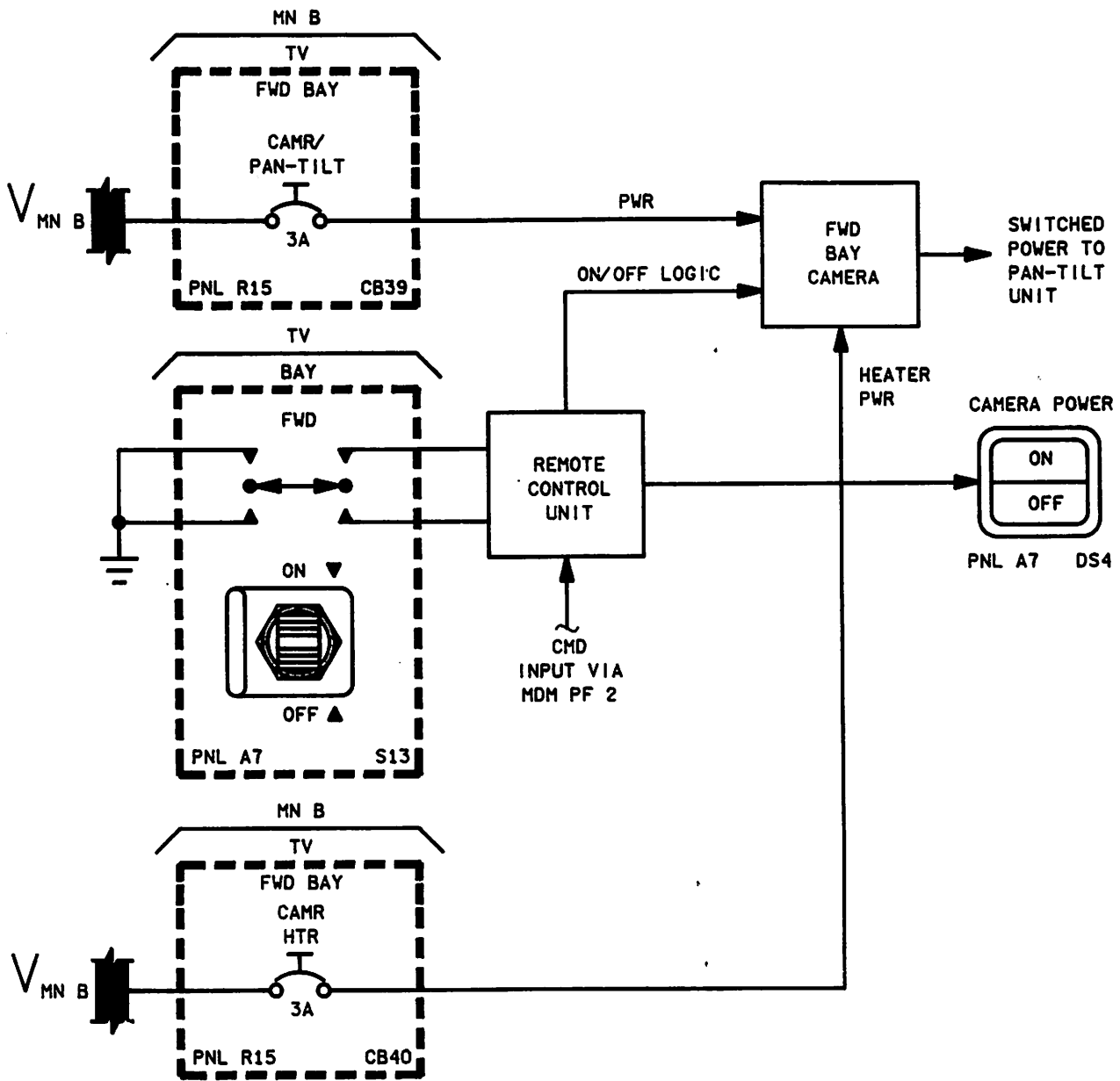
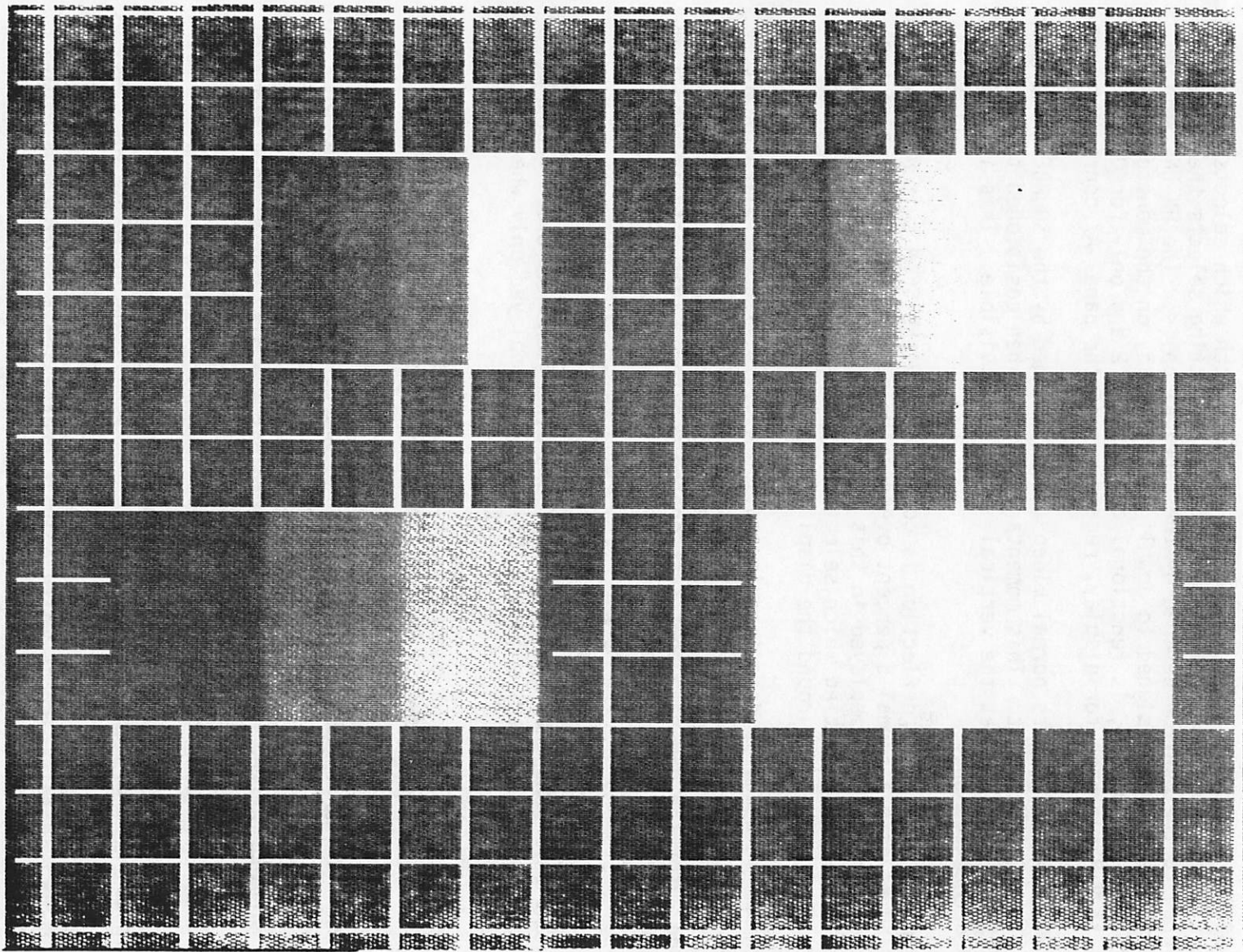


Figure 4-6.- Forward bay camera power (typical of all payload bay cameras).

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4-59

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Figure 4-36.- TV test pattern.

The SOURCE switch is a three-position toggle switch which selects the source of the video input to the monitor. The PANEL setting selects the source assigned to the monitor defined by the panel A7 pbi's. The DN-LNK setting selects the source assigned to downlink for display on the monitor. The third setting, DIRECT, is functional only on MON 2 and only for OV-102. It selects VTR playback for display, regardless of the panel A7 configuration.

The MODE switch selects normal video (as determined by the SOURCE switch) or an internal test input. This momentary switch, when positioned to PULSE-X, shifts the scan so that the vertical interval is visible. This is used for ground checkout only.

The amount of monitor deflection is controlled by the SCAN switch. The NORM setting selects a normal 5 percent overscan mode. The fringe areas of the camera scan are not displayed in this position. Total camera image can be seen in the UNDER setting which selects a 7.5 percent underscan mode and gives a black border around the displayed image.

Alphanumeric data, as described in section 4.5.1.4, is controlled by the DATA switch. When in the ON position, a signal is sent to the control unit's character generator. This superimposes an alphanumeric data of camera data for the camera output seen on the monitor. This data is displayed on the bottom of the monitor screen in the following order:

- First two characters - CAMERA ID (see table 4-III)
- Next seven characters - PAN ANGLE and DIRECTION (+ = RIGHT, - = LEFT)
- Next seven characters - TILT ANGLE and DIRECTION (+ = UP, - = DOWN)
- Last four characters - CAMERA TEMPERATURE (displayed only when an over-temp condition exists)

If the DATA switch is ON during split-screen or MUX operations, only the camera ID's are displayed. When a camera is powered OFF, the PAN and TILT angles automatically reset to zero.

The SYNC switch selects the synchronizing source for monitor operations. In the EXT position, the control unit sync generator is chosen. The monitors also have internal sync generators, which are selected in the INT setting. This setting must be used when VTR recordings are played back to a monitor, since the VTR is an asynchronous source (not synchronized with the CCTV system). Therefore, INT is the nominal switch position.

A crosshair is superimposed on the monitor picture when the X-HAIR switch is activated. The crosshair output includes extended tic marks at the edges of the FOV. Since the crosshair outputs are white with a black border, they can be seen no matter what the background is. (This is not true of the alphanumeric data, which is white only). Crosshairs are used as a camera alignment aid, especially for RMS operations.

The POWER switch controls power to the monitor. When switched ON, main bus power is applied to the monitor power supply.

The FAULT light, when lit (bright red), indicates there is an overtemp or undervoltage condition in the associated monitor.

4.7 VIDEO TAPE RECORDER

The Shuttle Video Cassette Tape Recorder (VTR), located in panel L12 (OV-102) or R11 (OV-103 and OV-104), provides the capability to record video from any of the selectable input sources and can playback video to the onboard monitors and/or MCC. Additionally, audio may be recorded along with the video or it may be dubbed onto previously recorded video. The VTR Crewman Communication Unit (CCU) receptacle provides the voice input/output capability for VTR audio operations. For recording or dubbing audio, it is necessary to either connect a handheld mike, the Audio Distribution System (ADS)/VTR audio cable, or a headset to the CCU receptacle. A headset must always be used with a Headset Interface Unit (HIU) or Wireless Crewman Communication Unit (WCCU) since by itself, the headset has no amplifier. Recorded audio on a video tape may be played back to MCC provided the ADS/VTR audio cable is connected from VTR CCU to an ADS orbiter panel. A simplified block diagram of the VTR is provided in figure 4-37.

Currently, cassette tapes for the VTR provide a record time of 30 minutes (fig. 4-39). The ADS/VTR cable contains an in-line toggle switch (fig. 4-39-A). During recording operations this switch should be in RCD position. During playback it should be positioned to PLBK. The switch is designed to prevent feedback 'squeal'.

4.7.1 VTR Power

Power to the Shuttle VTR can only be controlled by crewmembers; that is, no uplink commands are available. Power distribution is shown in figure 4-38. On OV-102, the VTR's power supply is controlled from panel L12 by a POWER switch and two serial circuit breakers. (One circuit breaker is next to the POWER switch and the other is above the VTR unit.) On OV-099 and subs, the VTR, with POWER switch and circuit breaker, will move to panel R11. The second circuit breaker (above the VTR) will be deleted.

4.7.2 VTR Thermal Control and Constraints

Currently, there are no special thermal control components available during flight for the VTR. Conduction provides some cooling. Because of the thermal constraints, the VTR should be powered down (POWER switch - OFF) when it is not in use. The VTR will reach 120° F (the upper limit specification temperature) after about 4 hours of continuous use. It then takes 4 more hours to return the VTR to cabin temperature.

4.7.3 VTR Displays and Controls, with Functions

All necessary VTR displays and controls are found on panels A7 and L12 (or R11), some on the VTR itself (fig. 4-40). This includes the POWER switch and VTR circuit breakers mentioned previously. Tape decals are shown in figure 4-29.

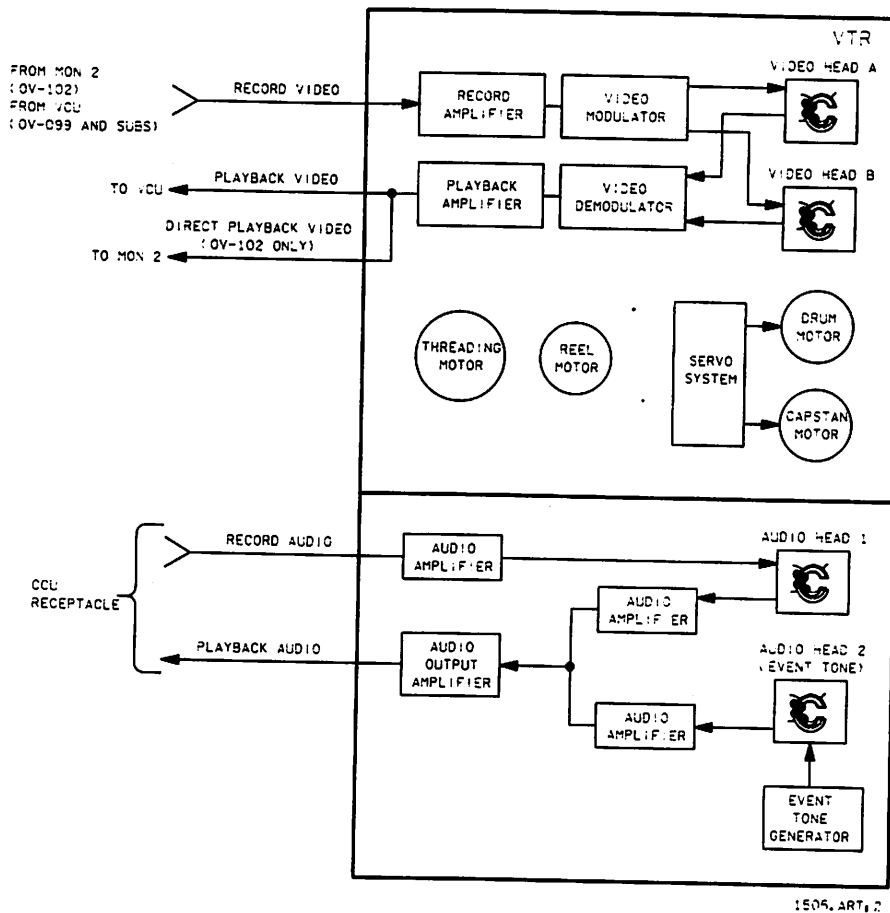


Figure 4-37.- VTR block diagram.

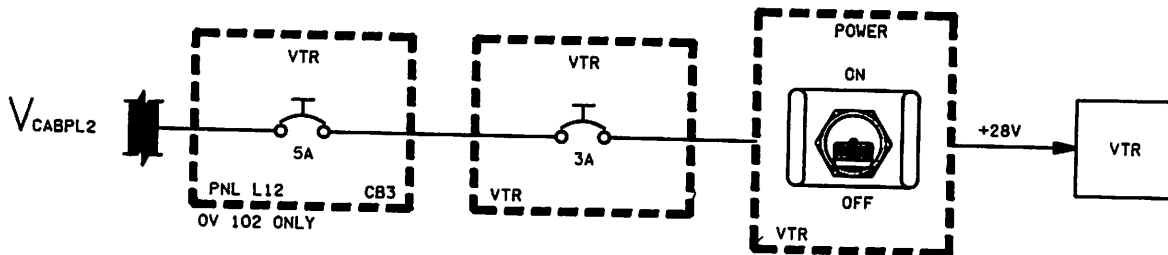


Figure 4-38.- VTR power distribution.

The voice record mode is controlled by the AUDIO MODE switch. When switched to HOT MIKE, the audio interface is configured for constant audio. A Push-to-Talk (PTT) setting is also available, which configures the audio so that the appropriate PTT switch must be pushed for audio recording.

In addition, a crewmember can record voice on previously recorded video. This is done by simultaneously depressing the AUDIO DUB and PLAY pushbuttons. This enables voice recording on track 1 and event marking on track 2 and erases any previously recorded audio without erasing video.

The VIDEO OUTPUT receptacle provides direct access to the VTR video output but is not used in flight.

The COLOR LOCK control is used to adjust the National Television System Committee (NTSC) color electronics so it will match recorder electronics. This is a ground adjustment and is normally not changed in flight.

The VIDEO MODE switch configures the VTR to record either black-and-white video (also field-sequential color video) or NTSC color video. For normal operations, the VIDEO MODE switch may be left in NTSC.

The TAPE POSITION indicator gives a numerical representation of the tape's position. There are 640 revolutions between BOT and EOT, corresponding to 30 minutes of run time.

The RESET pushbutton resets the TAPE POSITION indicator to zero when pressed.

The F FWD (fast forward) pushbutton moves the tape in the forward direction at ten times the normal speed (3 vs. 30 minutes from BOT to EOT).

The REWIND pushbutton moves the tape in the reverse direction also at ten times the normal speed.

The STOP pushbutton stops the tape's motion and unthreads the tape from the tape head. It is also used to release any depressed pushbuttons.

An unthreaded, motionless tape cassette can be ejected by pressing the EJECT pushbutton. If the VTR is in PLAY, RCD, STBY (threaded modes), RWND, or F FWD (motion modes), the EJECT pushbutton is interlocked and will not eject the cassette. Since the EJECT pushbutton can be used when the VTR is not powered whether the head is threaded or not, it is important to use the STOP pushbutton, then wait 10 seconds before unpowering the VTR.

In order to stop a tape without unthreading and/or to freeze a single frame in the playback mode, the STBY (standby) pushbutton should be depressed. When this button stops the tape, it also releases the tension around the head. To get out of the STANDBY mode, the STBY pushbutton is depressed again.

The RECORD mode is accomplished by simultaneously depressing both the RCD and PLAY pushbuttons. Input for recording must be assigned by the appropriate panel A7 pushbuttons as well.

The PLAY pushbutton threads the cassette tape on the tape head drum and starts it moving for the RECORD and PLAYBACK modes. There are two different ways to access monitors for playback: a configuration to use either monitor and a configuration for payloads and downlink.

- On panel A7, either monitor can be assigned as the output for the VTR and thereby display recorded video. In this configuration the SOURCE switch should be in PANEL, the SYNC switch in INT, and the system in the ASYNC mode to prevent false camera OVERTEMP alerts.
- Should the VTR playback signal be selected for downlink, it can be viewed on either monitor by placing the desired SOURCE switch to the DN-LINK position. Again, the system will be in the ASYNC mode to prevent false camera OVERTEMP alerts.

The MARK TAPE pushbutton helps the user return to specific data after recording. When pressed, it inserts a 1 KHz tone onto the tape as an event marker on track 2.

Total RECORD and PLAYBACK time (i.e., head wheel motion) on the VTR is shown on the HOURS and TENTHS indicator. It has a maximum of 999.9 hours. This is primarily for maintenance purposes.

There are two yellow indicator lights on the VTR. The NO VIDEO light shows that there is no video present at the input. The EOT light indicates that a cassette is at the end-of-tape. The recorder will stop automatically in this case.

SECTION 5 COMMAND CAPABILITY

In addition to commands that are performed on panel A7, the Orbiter CCTV system can be commanded from the ground or by crew inputs to the keyboard through the DPS UTILITY display.

5.1 UPLINK COMMANDS

In order for the ground (i.e., INCO in the MCC) to have uplink capability, the TV POWER CONTROL switch must be in the CMD position.

5.1.1 VCU Related Commands

The ground has the following VCU related command capability:

- VCU - MNA, OFF, and MNB
- TV Input - FLT DECK, MID DECK, A, B, C, D, RMS, VTR PLAY, PL 2, PL 3, PL 1, MUX 1, MUX 2, and TEST
- TV Output - DOWNLINK, PAYLOAD (VTR RCD), MUX 1 L, MUX 1 R, MUX 2 L, MUX 2 R. (Monitors cannot be controlled by uplink)
- VSU - SYNC and ASYNC (operating modes of the CONTR unit)
- Audio INLV - A, B, AB, and OFF.

The audio interleaver takes audio data from either ICOM A and/or B channels and interleaves them with video downlink signals. The audio is controlled through panel A1 PL BAY ICOM A&B switches.

The ASYNC and audio INLV functions cannot be performed with nominal onboard D&C (keyboard commands are available). SYNC is the normal configuration of the VSU since this causes the video data to be sampled synchronously. However, to prevent erroneous SM alerts, the ASYNC configuration must be used when playing back recorded data since the VTR is an asynchronous source.

5.1.2 Camera, Lens, and PTU Power and Configuration Commands

The ground has the following command capability for the TV cameras, lenses, and PTU's:

- TV Camera Power - ON and OFF
- TV ALC - PEAK, NORM, and AVG
- TV GAMMA - WHITE, NORM, and BLACK
- TV FOCUS - NEAR, FAR, and STOP
- TV ZOOM - IN, OUT, and STOP
- TV IRIS - OPEN, CLOSE, and STOP
- TV PAN/TILT - FAST, SLOW, and RESET
- TV PAN - LEFT, RIGHT, and STOP
- TV TILT - UP, DOWN, and STOP

5.2 KEYBOARD COMMANDS AND INTERFACES

As mentioned previously, the CCTV system can be controlled by keyboard commands via SPEC 01, the DPS UTILITY display. In this mode the TV POWER CONTROL switch must be in CMD (in order to accept commands to control the system), and the GPC MEMORY SPEC must be controlled by the same major function controlling the payload data buses.

At this point, the crewmember is ready to call up the DPS UTILITY display (fig. 5-1) on the CRT by inputting SPEC 1 PRO. TV commands will be made by the Real-Time Command (RTC) function available in ITEMS 13 and 14. An eight-character hexadecimal code is entered in ITEM 13, and ITEM 14 executes this data. This system requires that two separate codes be input to activate the desired command. The first ITEM 13 entry resets the MDM channels associated with the CCTV commands to zero. The second entry sets the command. The reset and set command inputs are listed on table 5-I. The starred functions are those commands most likely to be used since they are not available through the onboard displays and controls (audio interleaver and SYNC/ASYNCR functions.) The double-starred functions are those least likely to be used since they control motions that cannot be easily stopped by keyboard commands, especially when good vernier control is necessary (the focus, zoom, iris, pan, and tilt functions).

| XXXX/001/ | | DPS UTILITY | | XX X DDD/HH:MM:SS | |
|----------------|-----------|-------------------|------------|-------------------|----------|
| | | | | DDD/HH:MM:SS | |
| MMU ASSIGN | | PORT ASSIGN | | UL CNTL | |
| 1 | 2 | | <u>PRI</u> | <u>SEC</u> | |
| GNC 1X | 2X | STRING 1 | 15X | 16X | AUTO 35X |
| SM 3X | 4X | 2 | 17X | 18X | ENA 36X |
| PL 5X | 6X | 3 | 19X | 20X | INH 37X |
| OPS 0 | 7X 8X | 4 | 21X | 22X | |
| | | PL 1/2 | 23X | 24X | |
| MMU STATUS | | VAR PARAM ID LIST | | | |
| 1 | XXX | 25 | X.XXX | | |
| 2 | XXX | 26 | XXXX | | |
| MMU SOURCE/BUS | | 27 | XXXX | | |
| GPC/MMU 9X | | 28 | XXXX | | |
| MMU/MMU 10X | | 29 | XXXX | | |
| GPC/LDB 11X | | 30 | XXXX | | |
| CKPT RETRV | | 31 | XXXX | | |
| ENA 12X | | 32 | XXXX | | |
| RTC | | 33 | XXXX | | |
| 13 | XXXX XXXX | 34 | XXXX | | |
| CMD | 14 | | | | |

Figure 5-1.- DPS UTILITY display.

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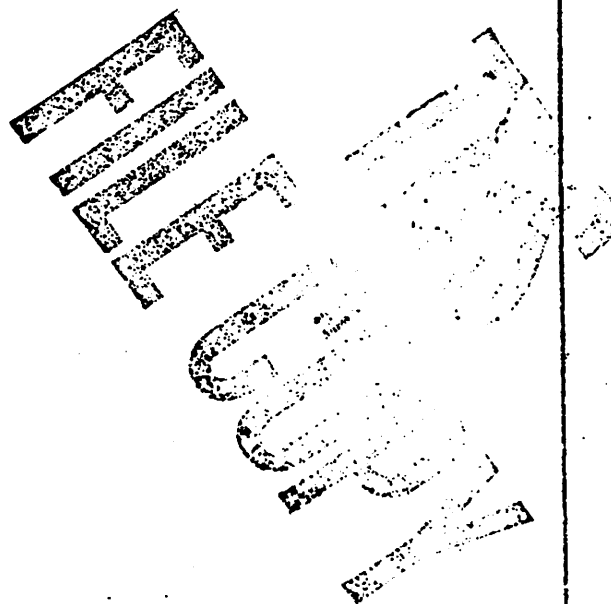
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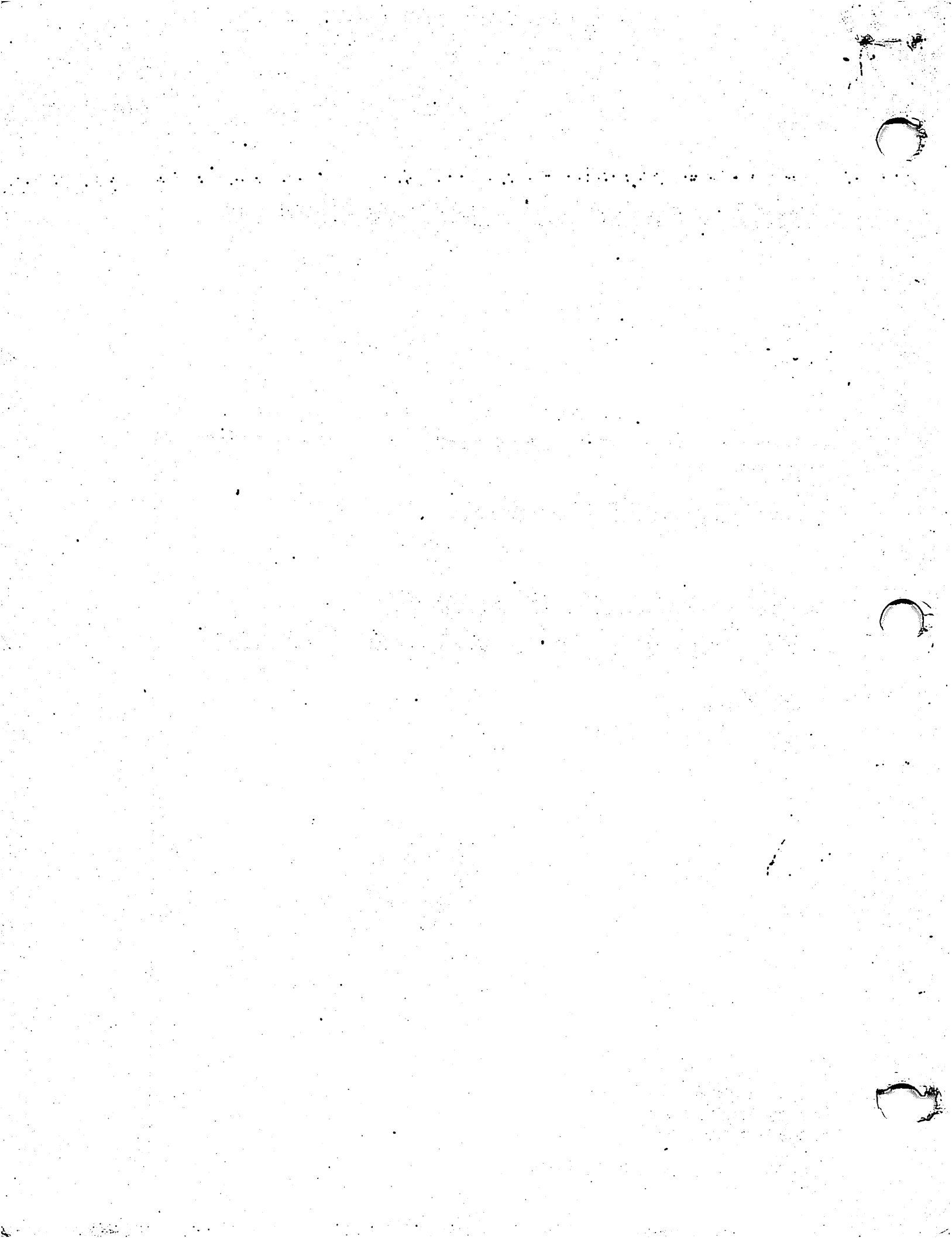
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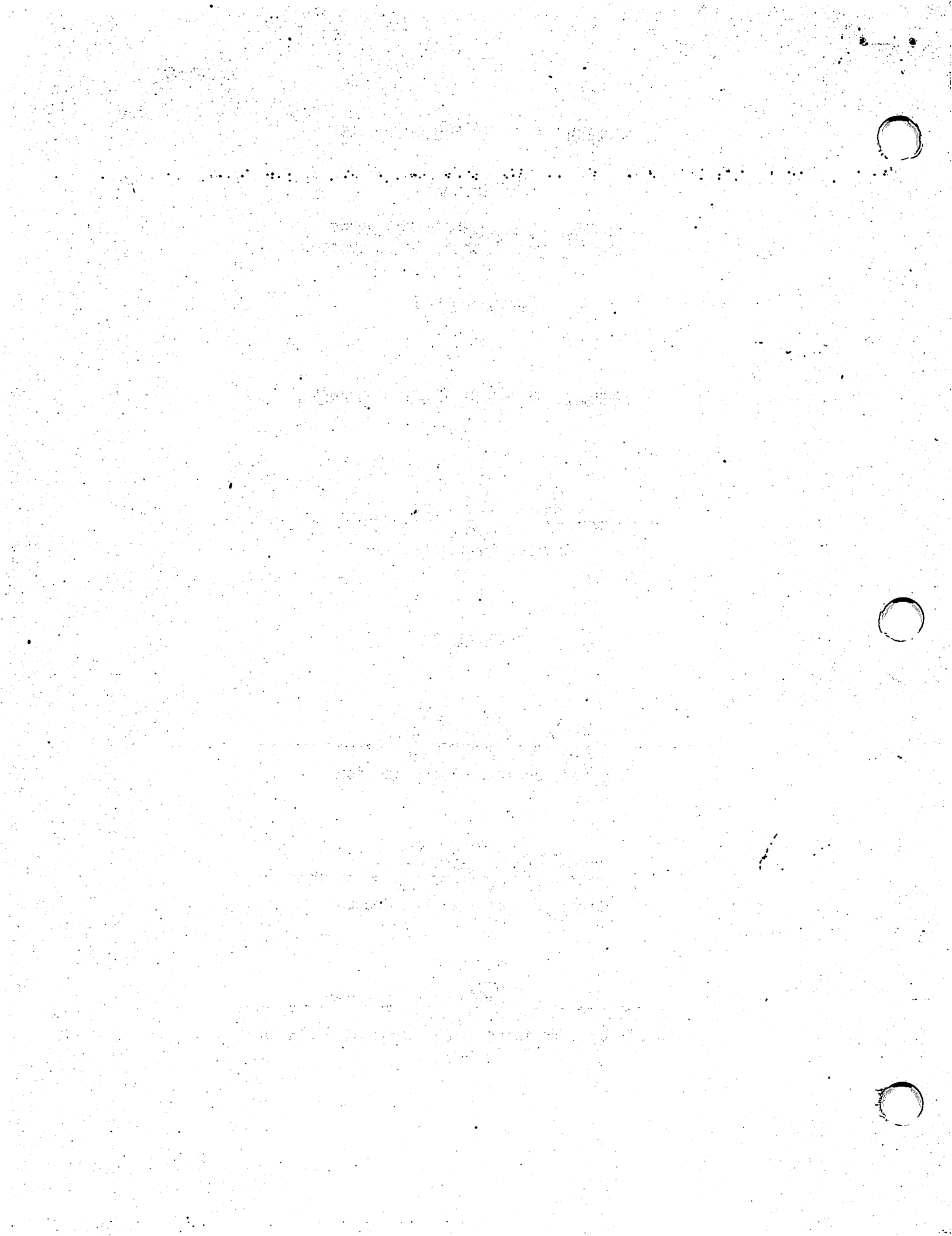
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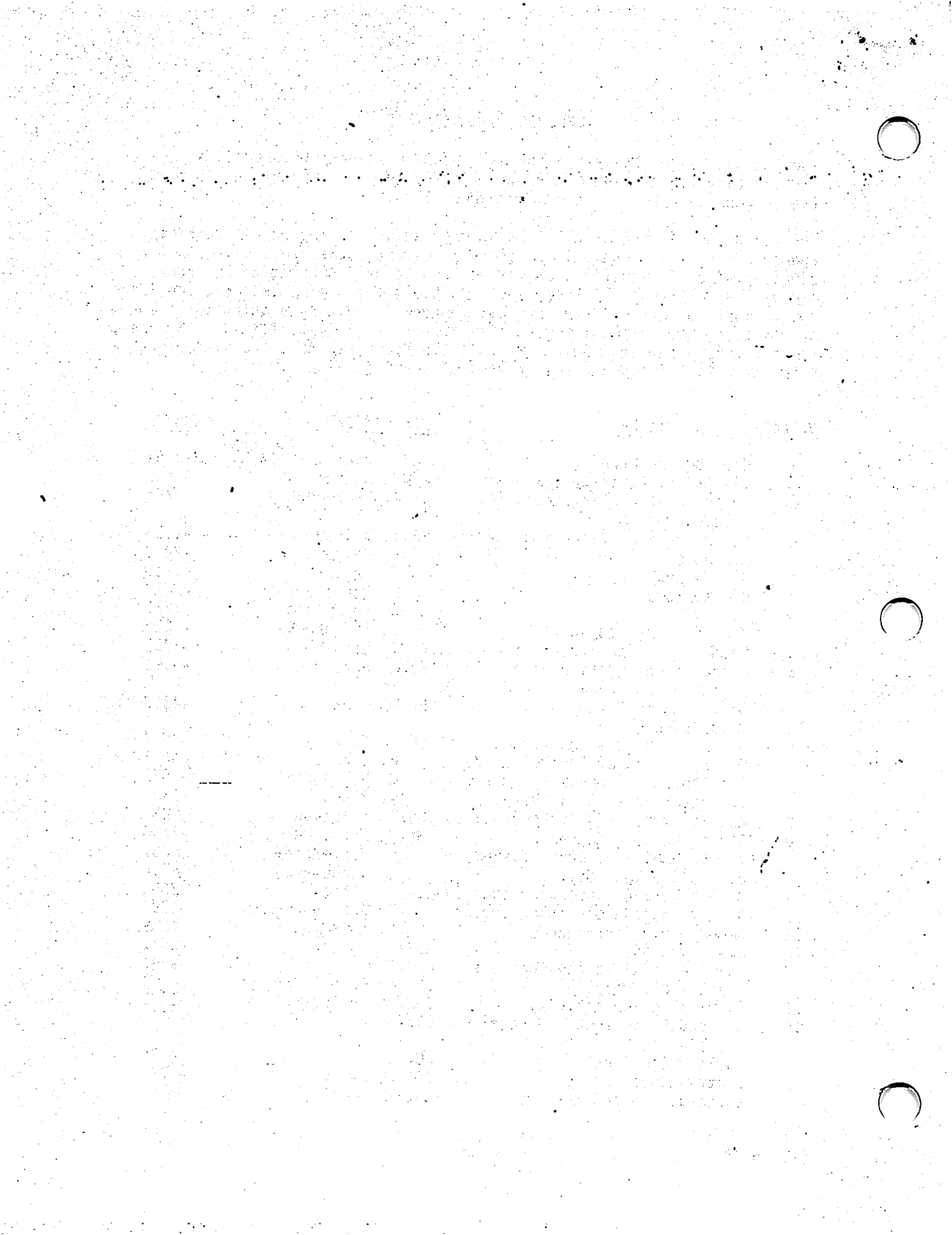
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SECTION 1 INTRODUCTION

1.1 PURPOSE

The successful performance of a complicated spaceflight depends heavily on the use of a computerized system for controlling and monitoring the entire space vehicle. The Data Processing System (DPS), through the use of its various hardware components and its self-contained computer programming (software), provides the vehicle with this monitoring and control support. Some of the functions of the DPS are as follows:

- Supports the Guidance, Navigation, and Control (GNC) requirements of the vehicle, including calculation of trajectories, engine burn data, and vehicle attitude control data.
- Provides for the monitoring and control of vehicle subsystems such as electrical power and environmental control.
- Processes vehicle data, and provides this data for transmission to the ground. It also allows for ground control of the vehicle via transmitted commands.
- Provides for checking of data transmission errors and crew control input errors, and supports the annunciation of vehicle systems failures and out-of-tolerance conditions.

The purpose of the Shuttle Flight Operations Manual (SFOM), Vol 5 - Data Processing Subsystem, is to provide a compilation of the functional description of the Orbital Flight Test/Operations (OFT/OPS) DPS, including hardware, system software, crew station controls and displays pertaining to the DPS, and Cathode Ray Tube (CRT) displays affecting or affected by any of the above. The CRT displays will be explained as required to support functional aspects of the DPS. Explanation of each area of a particular CRT display can be found in SFOM, Volume 14 and are not contained herein. More detail concerning the DPS can also be found in SD 74-SH-0230C, DATA PROCESSING SUBSYSTEM, PRINCIPLES OF OPERATION, as published by Rockwell International, April 1978.

1.2 SCOPE

This SFOM provides DPS hardware and systems software reference information specifically for the flight crew and flight operations personnel. It is comprised of the following sections:

- SECTION 1.0, INTRODUCTION - This section describes the purpose, scope, authority, control, publication and revisions of this volume.
- SECTION 2.0 - DPS HARDWARE - This section provides a functional description of the operational aspects and the interfaces for the following Shuttle hardware: General Purpose Computer (GPC), Mass Memory Unit (MMU), Computer Data Bus Network, Master Events Controller (MEC),

Backup Flight Controller (BFC), Multiplexer/Demultiplexer (MDM), Display Electronics Unit (DEU), Display Unit (DU), and Keyboard Unit (KBU). A brief description is also provided for the Computer Interface Conditioning Unit (CICU), Annunciator Display Unit (ADU), Data Bus Coupler (DBC), and Data Bus Isolation Amplifier (DBIA). Although the Engine Interface Unit (EIU), Pulse-Code Modulation Master Unit/Master Timing Unit (PCMMU/MTU) and Caution and Warning (C&W) Electronics Unit (EU) process data, they will be described in SFOM Volumes 8A, 4B and 4D, respectively.

- SECTION 3.0, DISPLAYS AND CONTROLS - The crew station displays and controls pertaining to the DPS are functionally described according to designed usage and results to the system if used non-nominally.
- SECTION 4.0, SYSTEM SOFTWARE - This section provide a functional description of system software terms (e.g., Memory Configuration table, freeze-dried), GPC synchronization and Reduncancy Management (RM), Input/Output (I/O) Management, time management, memory modification, downlist and uplink.
- SECTION 5.0, BFS SYSTEM SOFTWARE - The Backup Flight System (BFS) system Software modules are functionally described with emphasis on capabilities provided in various BFS modes of operation (e.g., OPS 0, disengaged-stand alone).

1.3 AUTHORITY

The Crew Training and Procedures Division (CTPD) within the Flight Operations directorate (FOD) has the responsibility to develop crew procedures and to provide documentation necessary to support training operations as defined in the Flight Operations Directorate Program Support and Management Plan (JSC 10750).

This document, SFOM Volume 5, is CTPD's partial fulfillment of this responsibility for OFT/OPS in the Data Processing Subsystem (DPS) area.

1.4 CONTROL

The OFT/OPS Shuttle Flight Operations Manual (SFOM) is controlled by the Training Control Board as defined in the Space Shuttle Training Management Plan (JSC 0993L).

1.5 PUBLICATIONS AND REVISIONS

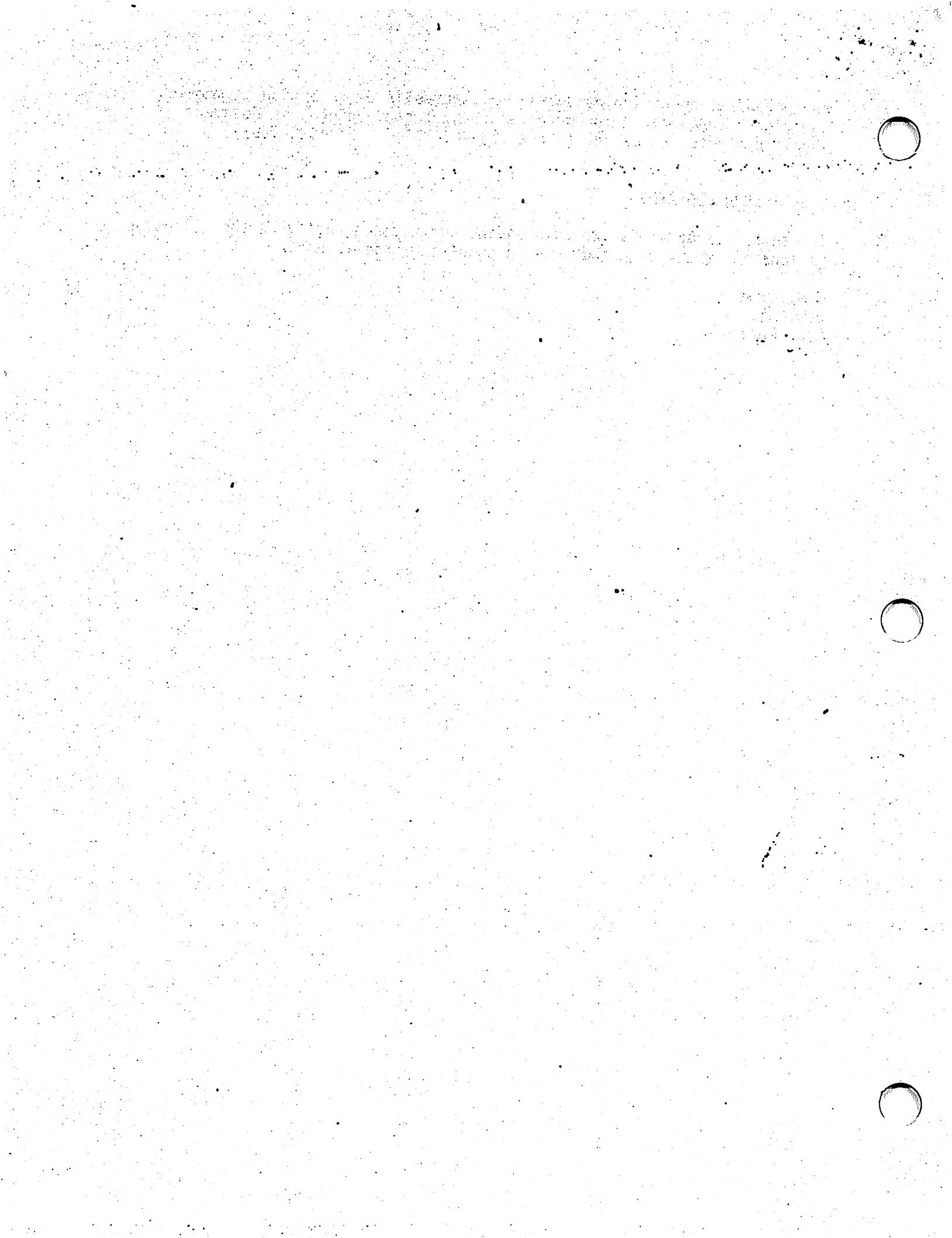
This document will be published in Preliminary, Basic and Final editions. Each edition will be revised as required via Page Change Notices (PCN's) or, if extensive changes are required to a milestone edition, the document will be issued again as a Revision. The Flight Training Branch of the CTPD has the responsibility for preparing, coordinating and maintaining this document.

Any organization having requests for changes in distribution, comments, questions, suggestions, or proposal changes concerning this document should contact R.R. Lanier (phone 713-483-3291 or FTS 525-3291).

1.6 ACKNOWLEDGEMENTS

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SECTION 2 DATA PROCESSING SUBSYSTEM HARDWARE

The Shuttle Data Processing Subsystem (DPS) hardware consists of several Line Replaceable Units (LRU's) as illustrated in figure 2-1. Although there are several devices onboard the Shuttle Orbiter which "process data," categorization of such hardware is made with respect to the type of data processed and to the principal use of the processed data. The DPS hardware elements not included in this SFOM will be included in other SFOM's relating to this categorization, and are outlined with dashed lines in figure 2-1.

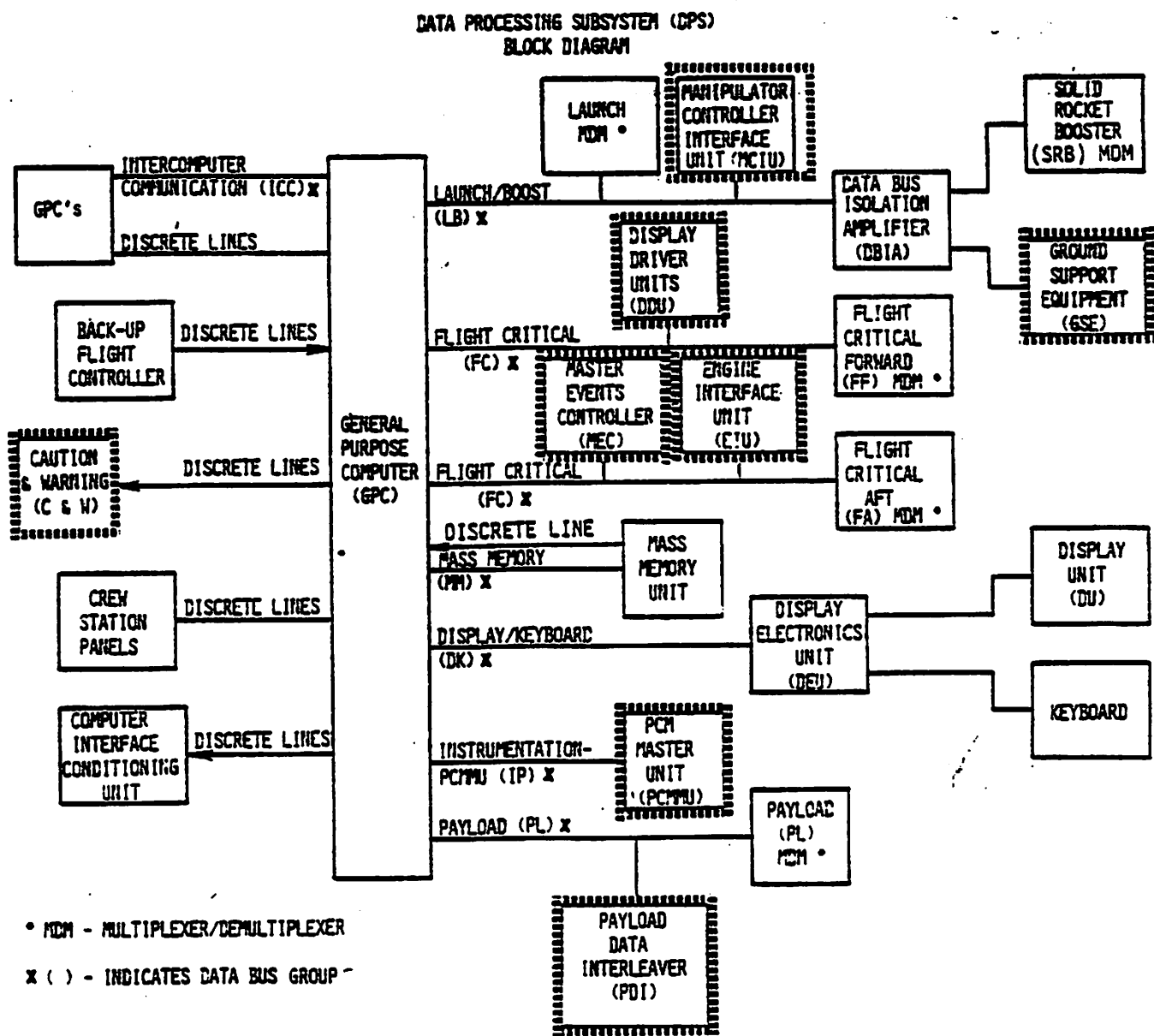


Figure 2-1.- DPS block diagram.

2.1 GENERAL PURPOSE COMPUTER (GPC)

Each of the five GPC's onboard the Orbiter is composed of two separate units: an IBM AP-1C1 Central Processing Unit (CPU) and an IBM 4PI Input/Output Processor (IOP). Each of these units contains a memory area for storage of software and data. These two memory areas are collectively referred to as the GPC's main memory.

2.1.1 GPC Power and Cooling Interfaces

The GPC power switches are two-position (ON, OFF) toggle switches which, when placed in the ON position, allow essential bus power (from three essential buses) to flow to three pairs of Remote Power Controllers (RPC's). The essential bus power provided by each of the power switches' three contacts is first applied to a circuit driver. Each circuit driver allows the Ground Support Equipment (GSE) to turn the GPC power on or off as long as the GPC power switch is in the ON position. This circuitry is designed such that when the GSE is disconnected, the circuit drivers do nothing more than act as a pathway for the essential bus power to be transferred "on" from the GPC power switch to the RPC's. The RPC's allow main bus power from the three main buses to flow to the GPC's. Main bus power from each of the main buses flows from one of each of the RPC pairs and is "diode'd" together to form the power source for the GPC's IOP power supply. Main bus power from each of the other RPC's is "diode'd" together and becomes the source for the GPC's CPU power supply. This power is also supplied to the GPC's associated Backup Flight Controller (BFC) module and the BFC switch input circuitry. The design of the power flow to the GPC's is such that a GPC will still be able to function normally in the event of a loss of two of the three main bus power inputs.

Both the CPU and IOP receive forced air cooling from the avionics bay fans.

2.1.2 GPC Discrete Interfaces

There are discrete data lines between each GPC and the other GPC's, crew station panels, a BFC, the Caution and Warning (C&W) electronics, the Computer Interface Conditioning Unit (CICU) and the Mass Memory Units (MMU's).

2.1.2.1 GPC discrete inputs.-

- MMU Discrettes: Each GPC receives a single discrete from each of the two MMU's which indicates whether that MMU is READY or OFF/BUSY.
- GPC Discrettes: Each GPC receives five discrettes from each of the other GPC's: Three synchronization discrettes, a FAIL VOTE discrete, and a BFS RUN discrete.
- The BFC sends six discrete signals to the GPC (see section 2.6.2).

- **Crew Station Control Discrettes:** Each GPC receives discrete signals from its associated crew station controls on Panel O6. There is a RUN and a STANDBY discrete from the GPC's MODE switch, an Initial Program Load (IPL) discrete from the IPL pushbutton, and two IPL source discrettes from the IPL SOURCE switch which tells the GPC which MMU to access for the IPL sequence. The GPC also receives a HALT command from its GPC MODE switch. This discrete is separated from the other MODE switch discrettes because it is relayed to the GPC via its BFC as discussed in section 2.6.2.

Figure 2-2 illustrates the GPC discrete inputs. A summary of all GPC discrete inputs is contained in table 2-1.

2.1.2.2 GPC discrete outputs.

- **Crew Station Display Discrettes:** Each GPC issues a single discrete to its OUTPUT talkback on Panel O6. This talkback, which is either barberpole (not energized) or gray (energized), is normally gray when the designated GPC is either processing Primary Avionics Software System (PASS) software and maintaining Input/Output (I/O) operations on the computer data bus network, or when the designated GPC is processing Backup Flight System (BFS) software after BFS is engaged. Each GPC also issues two discrete outputs to its respective GPC MODE talkback on Panel O6. These discrettes drive this talkback to one of three positions: barberpole (not energized), IPL (when the designated GPC is involved in an IPL sequence) or RUN (when the designated GPC is processing software).
- **GPC Discrettes:** Each GPC outputs five specific discrettes to each of the other GPC's. These discrettes, which consist of three synchronization discrettes, a BFS RUN discrete, and a GPC FAIL discrete (or FAIL VOTE), will be discussed in sections 4.2 and 5.2.
- **GPC STATUS MATRIX Discrettes:** Each GPC transmits its GPC FAIL discrettes via the CICU to the GPC STATUS matrix on Panel O1. The GPC STATUS matrix is a five-by-five light matrix (consisting of 20 white lights, and five yellow lights on the main diagonal) which is used to annunciate these GPC discrettes. The yellow diagonal lights are illuminated when a GPC determines itself failed via voter hardware and/or synchronization, or GPC Redundancy Management (RM) software. One of the remaining white lights (referred to as non-diagonal lights) is illuminated when a GPC determines another GPC has failed via synchronization or GPC RM software.
- **GPC SELF-FAIL Discrete:** When a GPC issues a SELF-FAIL discrete, this signal is also transmitted to the vehicle's C&W electronics. This signal is used to illuminate the red GPC light on the 40-light C&W light matrix (Panel F7), as well as a GPC SELF-FAIL indication on the C&W 120-status light matrix on Panel R13. The five lights on this 120-light matrix correspond to the diagonal (yellow) lights on the GPC STATUS matrix (Channels 5, 15, 25, 35 and 45: GPC's 1-5). When a GPC's software has determined that either a self-failure or a failure in another GPC has occurred, a BACKUP C/W ALARM light located in the lower left-hand corner of the 40-light C&W matrix on Panel F7 will be illuminated.

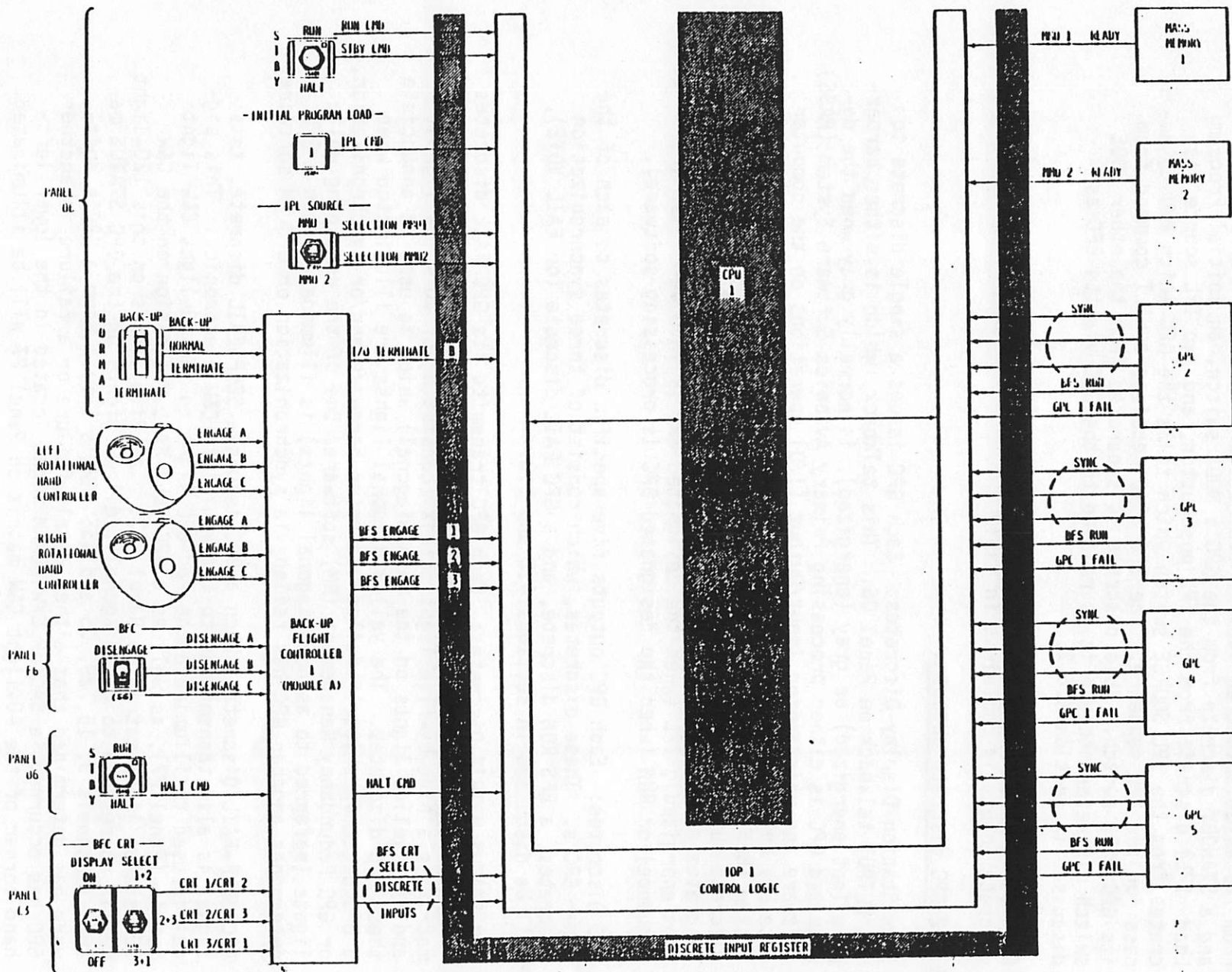


Figure 2-2.- GPC discrete input lines (typical of all 5 GPC's).

TABLE 2-1:- GPC DISCRETE INPUT SUMMARY (TYPICAL OF 5)

| DISCRETE INPUT SOURCE | DISCRETE INPUTS | GPC ACTION |
|---|--|--|
| MASS MEMORY 1 | Ready | MMU 1 is ready to respond to GPC commands; not powered OFF |
| MASS MEMORY 2 | Ready | MMU 2 is ready to respond to GPC commands; not powered OFF |
| GPC's 2-5 | GPC-1 FAIL 3 sync discretes from each GPC | Directs inputs to voter and main memory Processed by systems software to maintain synchronized GPC operations |
| | BFS RUN | <ul style="list-style-type: none"> ● PASS GPC'S inhibit MIA transmitters on PL data buses ● BFS assumes command of PL data buses |
| Backup Flight Controller | BFS ENGAGE 1 BFS ENGAGE 2 BFS ENGAGE 3 | <ul style="list-style-type: none"> ● If all=1 and I/O TERMINATE B=1 PASS GPC'S inhibit MIA transmitters on FC data buses. Halt software and set GPC self-fail discrete output ● BFS GPC assumes command of FC data buses if 2 of 1,2, or 3=1 and I/O TERMINATE B=1 |
| | 2 BFS CRT SELECT discretes | <ul style="list-style-type: none"> ● PASS GPC's inhibit MIA transmitters on DK data buses selected by BFC CRT SELECT switch ● BFS GPC assumes command of DK data buses selected by BFC CRT SELECT switch |
| | I/O TERMINATE B | <ul style="list-style-type: none"> ● Force PASS software to fail-to-sync ● Inhibit MIA transmitters on all FC data buses |
| | HALT | see MODE switch below |
| INITIAL PROGRAM LOAD pushbutton (momentary) | IPL CMD | Initiates IPL sequence if <ul style="list-style-type: none"> ● POWER = ON ● MODE = HALT ● An MMU is selected and ready |
| MODE switch (3 positions) | RUN | <ul style="list-style-type: none"> ● Allows nominal GPC operations |
| | STANDBY | <ul style="list-style-type: none"> ● Transition to "STBY" from "RUN" or from "RUN" to "STBY" cancels any application software execution |
| | HALT (from BFC) | <ul style="list-style-type: none"> ● Inhibits software execution ● Resets hardware logic and discrete outputs ● Permits IPL to occur |
| IPL SOURCE (3 positions) | MM-1 | Directs GPC to select MMU 1 for IPL |
| | MM-2 | Directs GPC to select MMU 2 for IPL |

be illuminated. Depending upon the failure case, either or both the GPC light and BACKUP C/W ALARM light can be illuminated at any one time.

Figure 2-3 illustrates the GPC discrete outputs. The only discrete output which has not been mentioned is the BFS RUN discrete. The BFS GPC is the only GPC to issue this discrete, which is used to tell the other GPC'S to release control of the Payload (PL) data buses.

There are some specifics about each of the other discrete outputs where the BFS GPC differs from the PASS GPC'S. These specifics will be discussed in the software portion of this SFOM (sections 4.0 and 5.0).

A summary of all of the GPC-1's OUTPUT discrettes is presented in table 2-2.

2.1.2.3 Computer Interface Conditioning Unit (CICU) and the Annunciator Display Unit (ADU).- The CICU receives the GPC FAIL VOTE discrettes, conditions them, and passes them on to the ADU. The ADU uses these discrettes (or the annunciator lamp test inputs from the lamp test switches on Panels 06 and 08) to illuminate the appropriate GPC STATUS light(s). The intensity of these lights can be controlled via intensity control inputs from switches on Panel 06 to intensity control circuitry in the ADU. When a GPC is powered off, that GPC will reset its discrete outputs and will inhibit FAIL VOTE discrete inputs from other GPC'S to itself (i.e., that GPC'S GPC STATUS matrix row and column will not illuminate).

2.1.3 Central Processing Unit (CPU) Functional Description

The CPU has the following purposes:

- Assigns DPS resources to process data and perform systems control tasks.
- Controls access to GPC main memory for data storage and software execution.
- Executes instructions to perform vehicle systems control and data manipulation.

Figure 2-4 illustrates a functional block diagram of a GPC CPU.

2.1.3.1 CPU control logic.- The CPU control logic schedules, supports, and maintains the status of GPC hardware and software tasks. It also allocates the use of DPS hardware to accomplish scheduled tasks. It executes hardwired (microprogram) and software instructions and maintains two clocks (one for Greenwich Mean Time/Mission Elapsed Time (GMT/MET) and one for simultaneous GPC operations). A 20-MHZ oscillator within each CPU supplies timing signals to the CPU components.

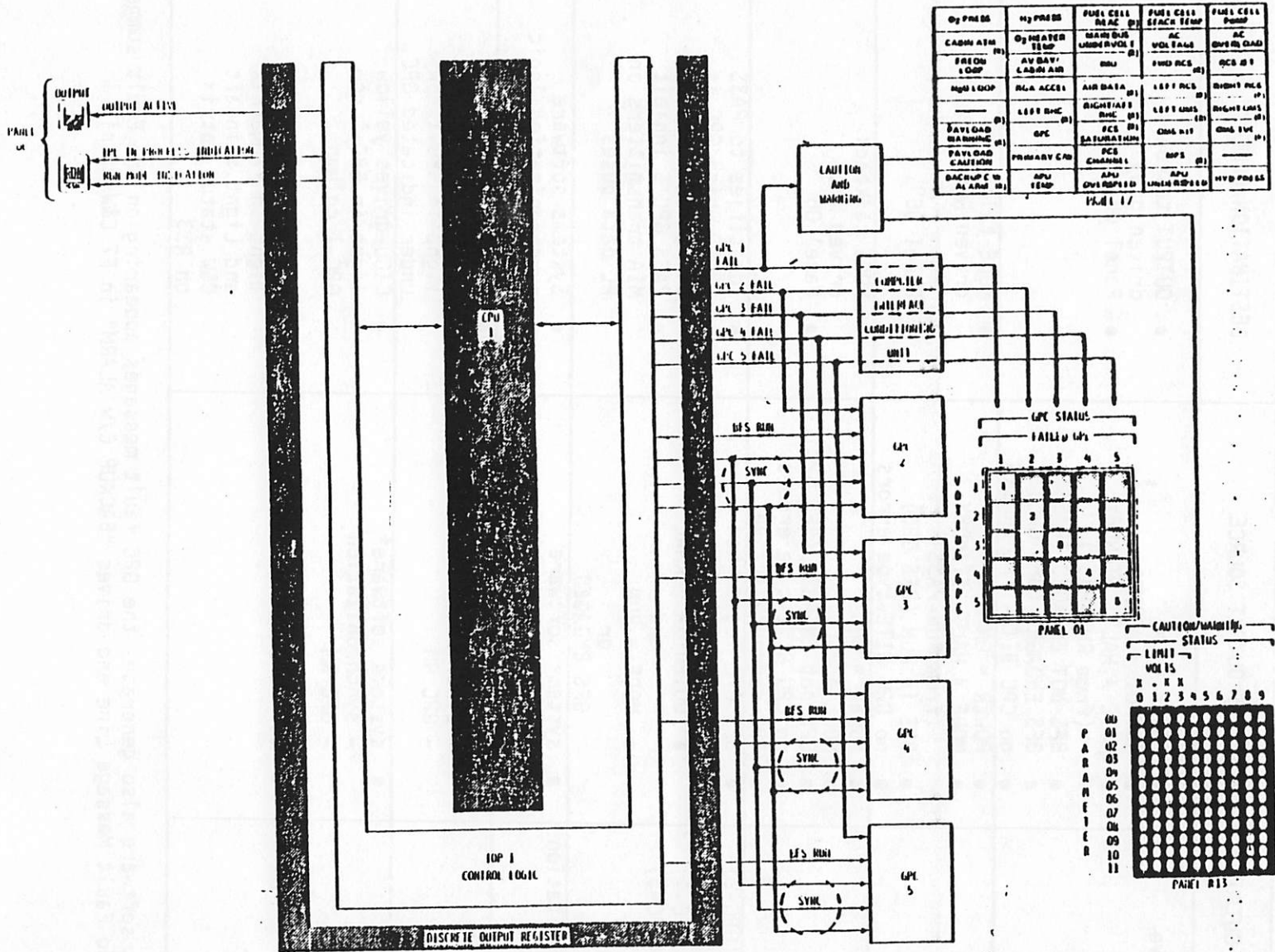


Figure 2-3.- GPC 1 discrete output lines (typical of all 5 GPC's).

TABLE 2-2.- GPC DISCRETE OUTPUT SUMMARY (TYPICAL OF 5).

| DISCRETE OUTPUT | DISCRETE OUTPUT SOURCE | DESTINATION/EFFECT |
|--|---|---|
| I/O active | <ul style="list-style-type: none"> ● POWER = ON ● OUTPUT = NORMAL ● MODE ≠ HALT, STANDBY (from RUN-PASS) ● BFS NOT ENGAGED (PASS) ● BFS ENGAGED (BFS GPC) ● no CPU BITE-TYPE ERRORS | <ul style="list-style-type: none"> ● OUTPUT talkback driven gray ● Panel 06 |
| RUN | <ul style="list-style-type: none"> ● POWER = ON ● MODE ≠ HALT, STANDBY (from RUN-PASS) ● BFS in RUN (BFS GPC) ● no CPU BITE-type errors | <ul style="list-style-type: none"> ● MODE talkback driven RUN ● Panel 06 |
| IPL | <ul style="list-style-type: none"> ● POWER = ON ● MODE = HALT ● BFS not ENGAGED (BFS GPC) ● no CPU BITE-type errors ● IPL sequence active | <ul style="list-style-type: none"> ● MODE talkback driven IPL ● Panel 06 |
| BFS RUN (GPC-2) BFS RUN (GPC-3) BFS RUN (GPC-4) BFS RUN (GPC-5) | <ul style="list-style-type: none"> ● BFS GPC logic when <ul style="list-style-type: none"> ● POWER = ON ● OUTPUT = NORMAL and ● MODE = RUN or ● BFS ENGAGED | <ul style="list-style-type: none"> ● Identifies to PASS GPC'S which GPC is designated BFS GPC ● PASS GPC'S inhibit MIA transmitters on PL data buses |
| 3 synchronization discretes | <ul style="list-style-type: none"> ● systems software synchronization logic | <ul style="list-style-type: none"> ● Systems software synchronization logic in other PASS GPC'S. |
| GPC-2 FAIL GPC-3 FAIL GPC-4 FAIL GPC-5 FAIL | <ul style="list-style-type: none"> ● systems software* <ul style="list-style-type: none"> - synchronization - GPC RM | <ul style="list-style-type: none"> ● Indicated GPC ● CICU - drives white light in GPC-1 row under indicated GPC. |
| GPC-1 FAIL | <ul style="list-style-type: none"> ● systems software* <ul style="list-style-type: none"> - synchronization - GPC RM ● IOP hardware voter | <ul style="list-style-type: none"> ● CICU-drives yellow light in GPC-1 row GPC-1 column ● C&W-drives GPC light in F7 matrix and Light 5 in aft C&W status matrix on R13 |

* systems software also generates the GPC fault messages appearing on the Fault summary page and Fault Message Line and drives "BACKUP C/W ALARM" in F7 C&W matrix

2.1.3.2 CPU main memory.- The CPU's main memory section uses nonvolatile (bit structure is maintained when power is interrupted) iron ferrite cores, arranged in five modularized "two-page" sections. Each section can store 32,768 18-bit data words for a total storage capability of 212,992 18-bit words. The terminology used in reference to GPC data words is to call an 18-bit word a "half-word" and two consecutive "half-words" a GPC "full-word." Each half-word is composed of 16 data bits, a "parity" bit which is used to ensure data is read properly, and a "storage protect" bit which is used to prevent an unintentional alteration of that half-word. Main memory is addressable and accessed by the IOP control logic and the CPU control logic regardless of location.

2.1.3.3 Main memory control logic.- The CPU main memory control logic controls access to main memory by the CPU and IOP control logic and commands the power supply to place main memory sections in a minimum-power-usage stage when data is not being accessed.

2.1.3.4 CPU Built-In Test Equipment (BITE) status and error logging.- Built-in test equipment within each CPU continuously checks the CPU operations for errors such as timing problems, erroneous data requests, power problems, etc. Some of these errors (called critical BITE errors), such as attempting to execute data as if it were program code, and main memory data word errors, cause software halt. In this case, the CPU control logic will only execute hardware instructions and monitor discrete inputs. When a noncritical problem is detected by GPC hardware or software, the condition is logged in what is known as a GPC error log. This BITE-type error along with this GPC's four previous errors, the latest BITE-type error for each common set GPC, and the accumulated number of BITE-type errors for each common set GPC, are then sent to the Pulse-Code Modulation Master Unit (PCMMU) for eventual transmission to the ground every second. The fault message "GPC BITE" will also be generated to alert the crew of this condition.

2.1.3.5 CPU power supply.- The CPU power supply converts input main bus power (28 Vdc) into +5 Vdc, +12 Vdc, +6 Vdc and +40 Vdc, and has the capability to independently inhibit both the 5 and 12 Vdc in the event of an overcurrent situation (more than 50 amps). The power supply also will initiate a self-powerdown sequence should it sense a drop in the input voltage below 17.5 Vdc or an undervoltage condition in the converted voltages. It also exchanges power-off discretely with its IOP power supply in order to coordinate a total GPC powerdown. Therefore, should the GPC's IOP initiate its own powerdown sequence, the CPU would also initiate a powerdown sequence in response to the IOP's discrete. Power input less than +17.5 Vdc is logged as a GPC error. If the converted voltage varies more than 5 percent from nominal, a mechanical flag is driven on the CPU (not seen in flight) and the condition is logged as a GPC error.

2.1.3.6 Timing.- The CPU components receive signals derived from a 20 MHz crystal oscillator-driven timing network. Failure of the frequency output of the network drives a mechanical flag on the outside of the CPU (not seen in flight) and is logged in the GPC error log which is part of the GPC's downlist.

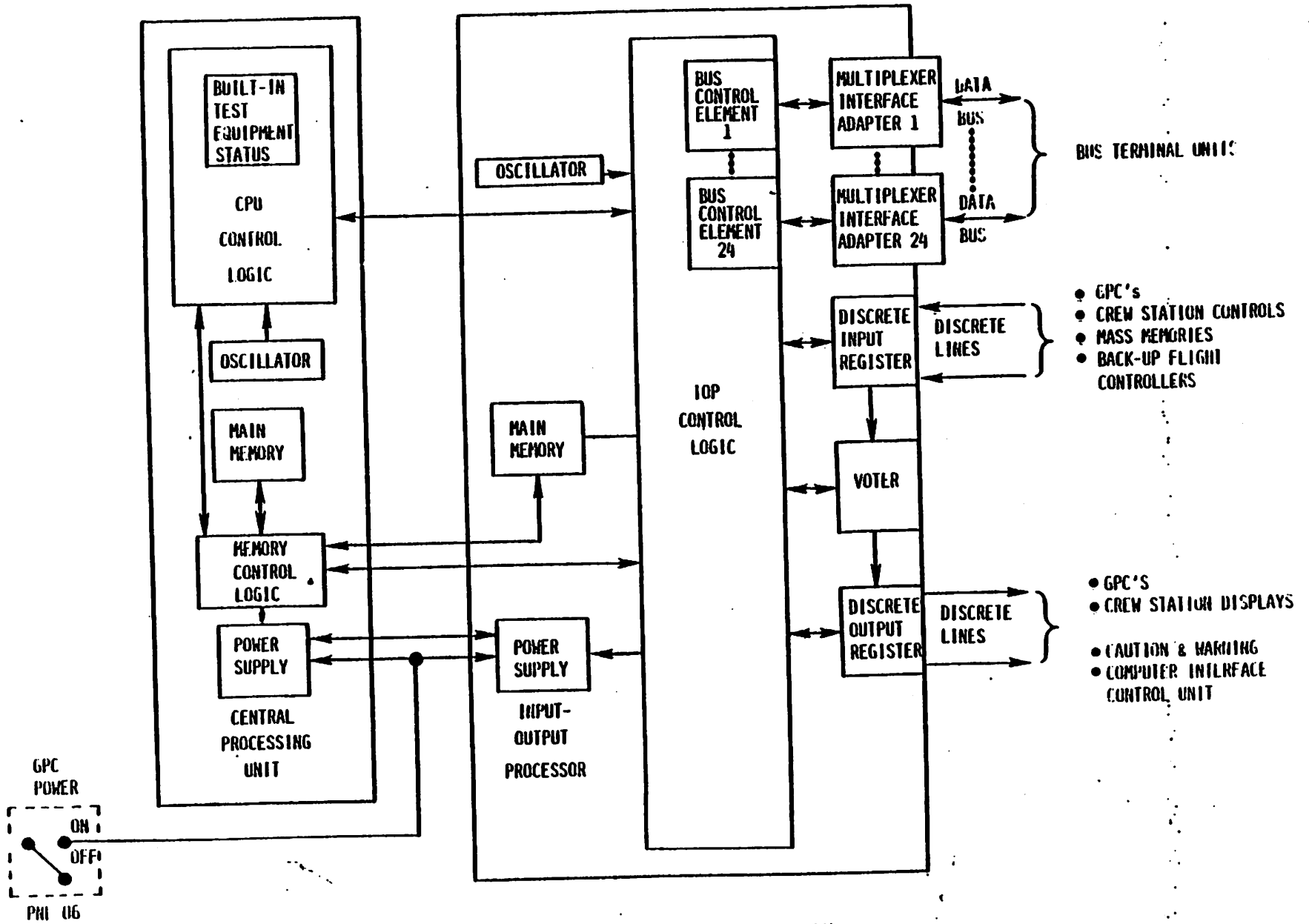


Figure 2-4.- GPC functional block diagram.

2.1.4 Input/Output Processor (IOP) Functional Description

The purpose of each IOP is to:

- Format and transmit commands to the vehicle systems.
- Receive and validate response data from the vehicle systems.
- Maintain the status of the interfaces with the CPU and the other GPC's.

Figure 2-4 illustrates a functional block diagram of a GPC IOP.

2.1.4.1 IOP control logic.- The IOP control logic schedules the use of IOP hardware components through execution of hardwired (microprogram) instructions, schedules the use of instructions stored in main memory, and sets/resets discrete outputs from the GPC.

2.1.4.2 IOP main memory.- The IOP main memory, like the CPU main memory, uses nonvolatile iron ferrite cores. The IOP main memory is arranged in three sections and has a total storage area for 49,152 half-words. The IOP main memory is also hardwired to the CPU's memory control logic. This allows the CPU and the IOP to address both memory areas as if they were a single unit.

2.1.4.3 IOP power supply.- The IOP power supply, like that of the CPU, converts 28 Vdc main bus input power into +5, +12, +6, and +40 Vdc. It also can inhibit its 5 and 12 volt outputs in the event of an overcurrent situation and can initiate a powerdown sequence when its input power drops below 17.5 Vdc, or when it senses an undervoltage condition in the dc/dc converted voltages. It also sends power-off discretes to its companion CPU to coordinate a total GPC powerdown. The IOP power supply will initiate a powerdown sequence if it receives a power-off discrete from the CPU. If the internally converted voltages vary more than 5 percent from nominal, a mechanical flag (not seen inflight) is driven on the IOP.

2.1.4.4 Timing.- IOP components receive signals derived from a 16 MHz oscillator-driven timing network. The signals are the basis for timesharing of the software processing components in the IOP control logic.

2.1.4.5 IOP voter.- The IOP contains a hardware "voter." The function of this voter is to monitor discrete inputs from the other GPC's. Should it receive a FAIL VOTE from two other GPC's, it will cause the GPC to consider itself failed, and that GPC will cease any attempt to vote against the other GPC's.

2.1.4.6 IOP discrete input and output registers.- The IOP discrete input register accepts and buffers discrete inputs from the other GPC's, crew station controls, the MMU's, and the BFC's. The discrete output register sets or resets discrete outputs (as directed by the control logic and voter) to the other GPC's, crew station displays, the C&W subsystem, and the CICU.

Under certain GPC failure conditions, a GPC's discrete outputs will be reset to "zero". If a condition to set the discrete output persists via hardware (e.g. VOTER), the discrete output will be set to "1".

2.1.4.7 IOP serial digital data bus interface.- The IOP interfaces with the serial digital data buses via two sets of hardware components: Bus Control Elements (BCE's) and Multiplexer Interface Adapters (MIA's). The BCE's execute instructions to transmit commands to and receive data from other vehicle hardware items called Bus Terminal Units (BTU's). A BTU can be considered to be any piece of hardware which communicates over a data bus through an MIA. The BCE's add the appropriate BTU address and a special bit pattern to words scheduled for transmission prior to shipping the data to its associated MIA. The BCE's also validate data received from and transmitted to their associated MIA's and notify the IOP control logic in the event an error is detected.

MIA's, which are commonly referred to as "ports," have two modes of operation: TRANSMIT and RECEIVE. During the RECEIVE mode, a MIA validates the received data (notifying the IOP control logic when an error is detected), reformats the data, and sends it to the BCE. During a RECEIVE operation, the MIA's transmitter is inhibited unless that particular GPC is "in command" of that data bus.

During the TRANSMIT mode, a MIA, which always transmits and receives 28-bit words over the computer data buses, adds the appropriate parity and SYNC code bits to the data word, reformats the data, and sends the data out over the data bus. In this mode, both the MIA's receiver and transmitter are enabled.

Any BTU on the other end of the data bus also has its own MIA whose functions are the same as those of the IOP MIA.

2.2 COMPUTER DATA BUS NETWORK

The Orbiter computer data bus network consists of a group of twisted, shielded wire pairs (data buses) which support the transfer of serial digital commands from the GPC's to vehicle hardware and the transfer of vehicle systems data to the GPC's. The computer data bus network is divided into specific groups which perform specific functions. These groups are as follows:

- Inter-Computer Communication (IC or ICC) data buses for GPC to GPC transactions.
- Display/Keyboard (DK) data buses for GPC/Display Electronics Unit (DEU) transactions.
- Mass Memory (MM) data buses for GPC/MM Unit transactions.
- Instrumentation/PCMMU (IP) data buses for GPC/PCMMU transactions.
- Flight Critical (FC) data buses which tie the GPC's to the FC Multiplexer/Demultiplexers (MDM), Display Driver Units (DDU), Engine Interface Units (EIU), and Master Events Controllers (MEC).
- PL data buses which tie the GPC's to the PL MDM's and the Payload Data Interleaver (PDI).

- Launch/Boost (LB) data buses which tie the GPC's to the GSE. Launch Forward (LF) and Aft (LA) MDM's, Solid Rocket Booster (SRB) MDM's and the Manipulator Controller Interface Unit (MCIU).

Figure 2-5 illustrates the GPC/data bus network interface.

2.2.1 Inter-Computer Communication (IC or ICC) Data Buses (Ports 1-5)

There are five ICC data buses on the Orbiter. Each GPC transmits data over one data bus and receives data over a separate ICC data bus from each of the other GPC's. All GPC's which are processing PASS software (PASS GPC's) and which are members of the common set exchange status information over the ICC data buses. During on-orbit operations, the Systems Management (SM) GPC will receive Guidance, Navigation, and Control (GNC) data from the GNC GPC's. The GPC which is processing BFS software (BFS GPC) will not transmit or receive data over the ICC data buses.

Communications over the ICC data buses is unique in respect to the data "traffic", which is transmitted over the other types of computer data buses. ICC data bus traffic occurs in one direction only. A GPC transmits over its own ICC bus, and receives data from the other GPC's over each of their dedicated IC buses. The commands and data, which are carried on the other types of computer data buses, are of the "command-response" type. A GPC "requests" data over a specific data bus before the data is sent from the appropriate hardware device back to the GPC over the same data bus.

2.2.2 Display/Keyboard (DK) Data Buses (Ports 6-9)

There are four DK data buses onboard the Orbiter. Each DK data bus connects one of the four DEU's to the five GPC's. The GPC's provide serial digital data and commands to the DEU's via these data buses, and receive inputs from the Orbiter keyboards on these data buses via the DEU's.

2.2.3 Mass Memory (MM) Data Buses (Ports 18,19)

There are two MM data buses onboard the Orbiter. Each MM bus connects one of the MMU's to the five GPC's. The GPC's, via these MM buses, can command the MMU's to read data from, or write data to the MMU's magnetic tape. In addition, the MMU's can be commanded to position their tapes, send tape position data or MMU BITE data, and control the amount of data which can be transferred to the GPC's.

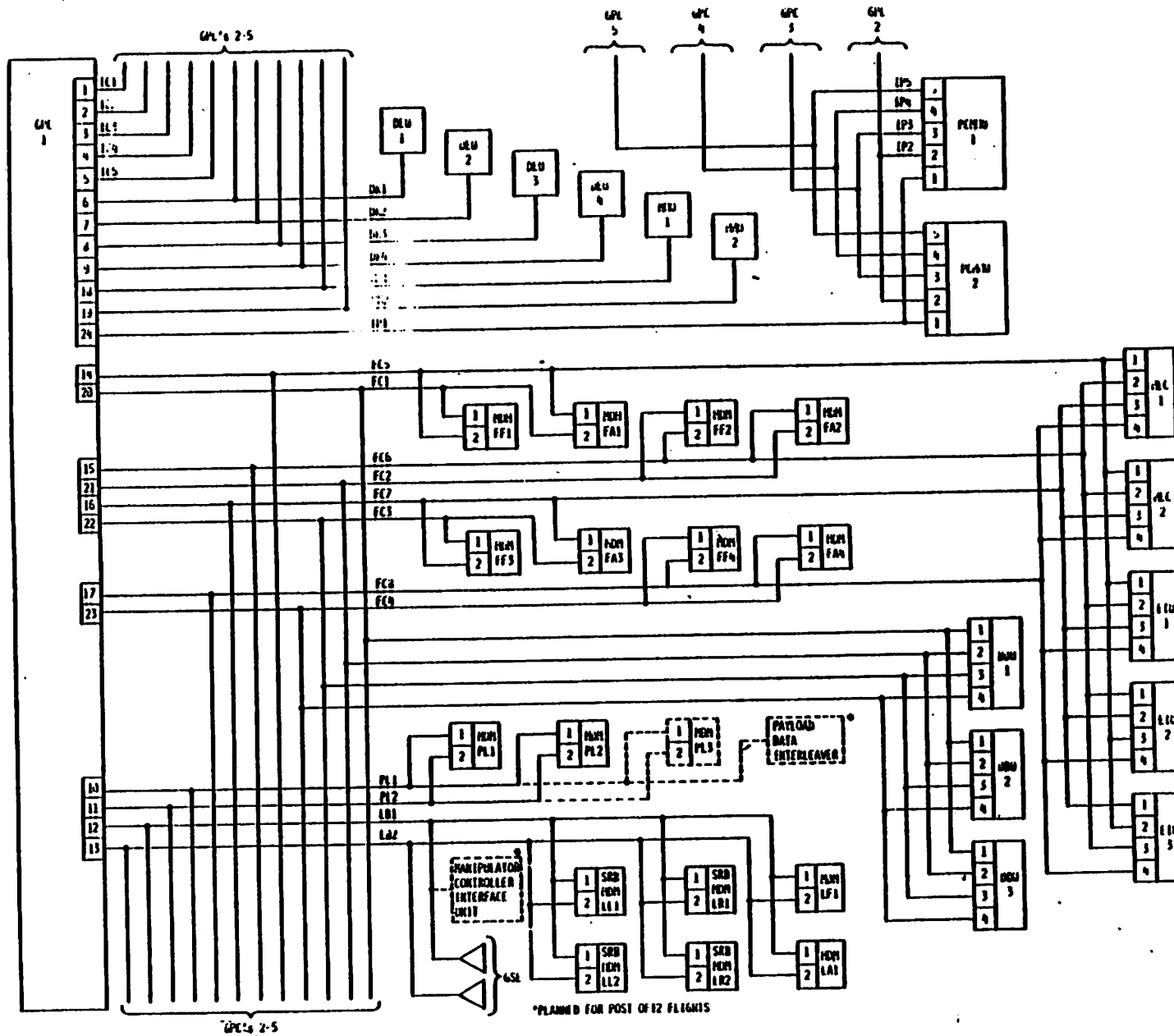


Figure 2-5.- Computer data bus network.

2.2.4 Instrumentation/PCMMU (IP) Data Buses (Port 24)

There are five IP data buses onboard the Orbiter. Each GPC commands a unique data bus to both PCMMU's. Each GPC transmits its downlist data to the active PCMMU via its IP data bus. As required by software, a GPC receives instrumentation data and PCMMU BITE status from the active PCMMU over its IP data bus. When commanded by the crew, a GPC will transmit the required downlink telemetry format to the PCMMU's over the IP data bus. During GPC/PCMMU communications over the IP data buses, only one PCMMU will be powered at any one time to respond to GPC commands.

2.2.5 Flight Critical (FC) Data Buses (Ports 20-23, 14-17)

There are eight FC data buses onboard the Orbiter. Four of these FC buses (FC1-4) connect the GPC's with the four Flight Critical Forward (FF) MDM's, the four Flight Critical Aft (FA) MDM's and the three DDU's. The other four FC buses (FC5-8) connect the GPC's to the four FF MDM's, the four FA MDM's, the two MEC's, and the three EIU's. The specific manner in which these units are interfaced is referred to by the term "string." A string is composed of two FC data buses (one of the first group and one of the second group), the BTU's connected to them (DDU's, MDM's, MEC's, and EIU's) and all of the hardware which is hardwired to those BTU's. For example, String 1 consists of FC data buses 1 and 5, MDM's FF1 and FA1 and their hardwired hardware, controls, and displays, the three EIU's, the two MEC's, the three DDU's, and their associated displays. There are four strings defined in this way. The functional purpose of the string concept is to provide failure protection capability during dynamic phases by allowing exclusive command of a specific group of Shuttle vehicle hardware by one GPC.

2.2.6 Payload (PL) Data Buses (Ports 10,11)

There are two PL data buses onboard the Orbiter. Their function is to interface the five GPC's with the two PL MDM's presently planned for the Orbiter and a third PL MDM which is planned for later OFT Orbiter flights. A PDI, which is also planned for later OFT flights, will interface with the GPC's over PL Data Bus 1.

2.2.7 Launch/Boost (LB) Data Buses (Ports 12,13)

There are two LB data buses onboard the Orbiter (also referred to as Launch Data Buses or LDB's). Each GPC can interface with the GSE, the two launch MDM's (LF1 and LA1), and the four SRB MDM's (LL1, LL2, LR1, and LR2) via these two data buses. In addition, the GPC's can interface with the MCIU via LB Data Bus 1. The GSE can also interface with this hardware via these two data buses when the GPC's are not executing software. There are two hardware items which serve to interface the two LB data buses with the GSE and the SRB MDM's. These are called Data Bus Isolation Amplifiers (DBIA's).

2.2.8 Data Bus Isolation Amplifier (DBIA)

There are two DBIA's onboard the Orbiter. The purpose of these units is to isolate data bus stubs which are left open by the GSE (T-0) disconnect and the SRB disconnect. This isolation protects the LB data buses from unwanted interference and "noise." Each DBIA consists of two independently powered and controlled channels - a GSE channel and an SRB channel. Upon receipt of a signal at one receiver, the control logic inhibits the other receiver (to avoid a "wrap-around" effect), validates the input data, improves the signal strength of the received data, and then transmits the data to the appropriate destination. Since the GSE channel receives its power through the preflight test buses (via the T-0 umbilical), it becomes inoperative when the T-0 disconnect occurs at launch. The SRB channels receive main bus power via the MEC switching circuitry and power switches located on Panel 017. Each MEC power switch permits control bus power to activate a RPC which then allows main bus power to flow to the SRB channels in both DBIA's. Therefore, both SRB channels receive main bus power via either one of the two MEC switches. Power flow to the DBIA's is illustrated in figure 2-6.

2.2.9 Data Bus Coupler (DBC)

A DBC is a small device which provides DC isolation and transformer coupling between a data bus and a MIA.

2.3 MASS MEMORY UNIT (MMU)

Onboard the Orbiter, there are two BTU's which are known as Mass Memory Units (MMU's). Each of these MMU's is a coaxially-mounted reel-to-reel digital magnetic tape storage device which provides storage for computer software and Orbiter systems data, and which can be accessed by the flight crew as required.

2.3.1 MMU Interfaces

2.3.1.1 MMU power/cooling interfaces. - Each MMU receives electrical power via separate MMU power switches on Panels 014 (MMU 1) and 015 (MMU 2). Each MMU power switch is a two-position toggle switch which permits control bus power to activate a RPC. The RPC allows main bus power to flow to the designated MMU power supply. The status of the power switch is made available for downlink through the Operational Instrumentation Forward (OF) MDM's.

Each MMU is cooled via the water loop coldplates in the forward avionics bays.

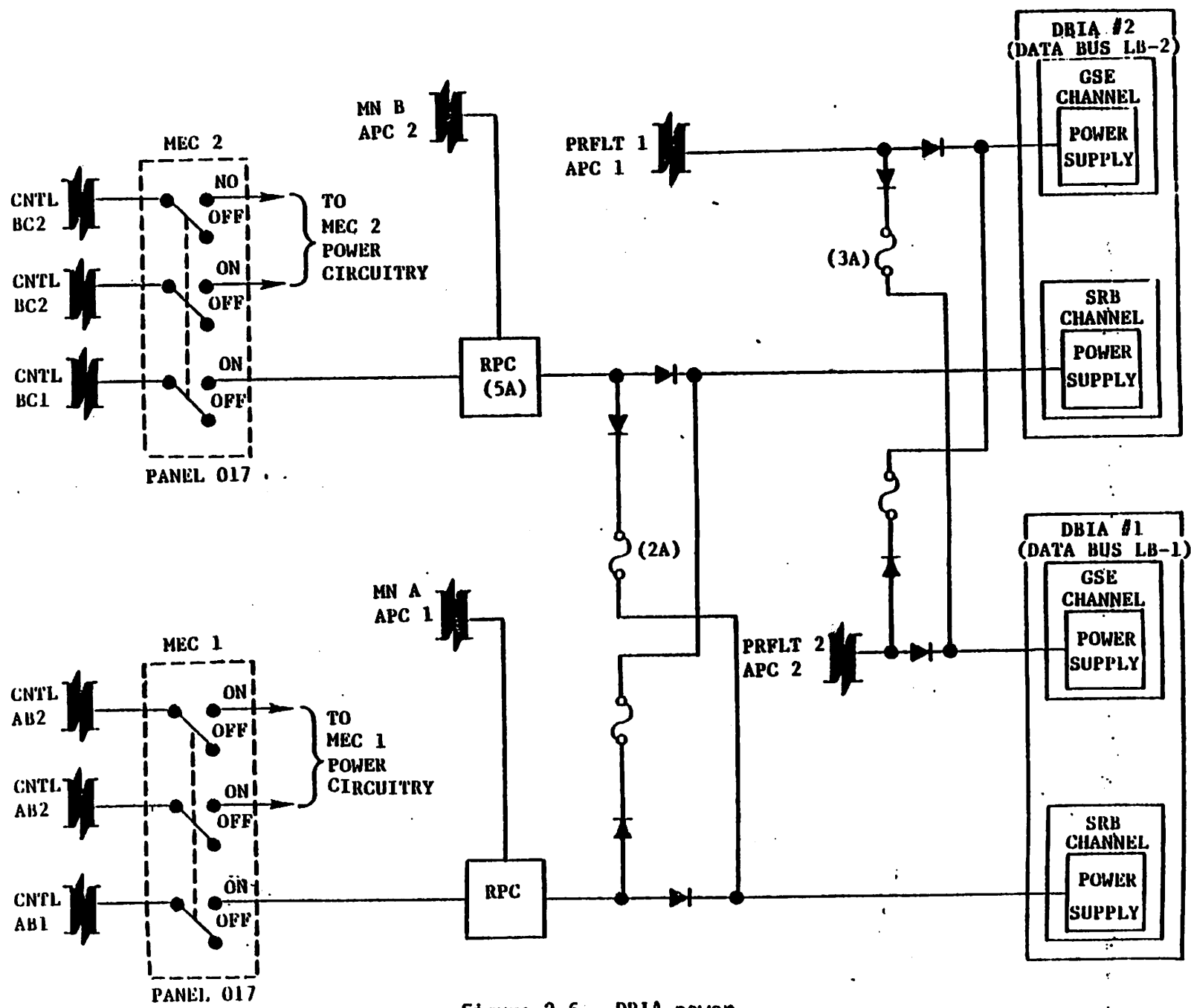


Figure 2-6.- DBIA power.

2.3.1.2 MMU/GPC interface.- Each MMU interfaces with all five GPC's via a separate MM data bus. In addition, each MMU has a separate discrete interface line to each of the GPC's to inform the GPC's of the state of the MMU (busy or ready to accept command inputs).

The GPC's, via the MM data buses, can command the MMU's to read data from or write data to the MMU's magnetic tape. In addition, the MMU's can be commanded to position their tapes, to send the GPC's BITE data or tape position data, and to extend the limit on the amount of data which can be transferred by a factor of eight. (The normal amount is 2,048 16-bit words in SM OPS 2).

2.3.2 MMU Functional Description

The following is an analysis of the components of a MMU and the functions of these components. Figure 2-7 illustrates a functional block diagram of an MMU.

2.3.2.1 Multiplexer Interface Adapter (MIA).- Each MMU interfaces with its MM data bus via an MIA. The functions of the MMU MIA are the same as those listed for the IOP MIA; that is, GPC command validation, data format conversion, and the addition of SYNC codes and parity bits to MMU response data to the GPC's.

2.3.2.2 Control logic.- The MMU control logic decodes and performs additional GPC command validation. It also issues command signals to the other MMU components and sends the READY discretes to the GPC's when it is not responding to GPC commands. It is responsible for maintaining tape position, providing data format conversion prior to issuing the data to the tape heads, and adding address and status bits to response words to the GPC's. It also places various MMU components in a standby state when the MMU is not responding to GPC commands.

2.3.2.3 Read electronics.- The MMU read electronics activate the appropriate read heads for the selected data track and control track, validates data read from the tape, and converts data read from the track (which is in an analog format) into digital data. The MMU tape is subdivided into eight data tracks and one "control" track which run the length of the entire tape. Data is read from each of these tracks via a separate read head and is written to each track via individual write/erase heads. These heads are activated individually by the Read and Write electronics.

2.3.2.4 Read/write electronics.- The MMU write electronics activate the appropriate write/erase heads for the selected data track and control track read head, transmits an erase signal to the head selected for the erase function, and transmits write data to the head selected to write the data on the tape. Prior to writing on a portion of the tape, that portion is erased (actually a continuous operation) to insure that the tape is "clean."

2.3.2.5 Tape transport mechanism.- The tape transport mechanism houses the nine-track magnetic tape, the tape heads, and the motor and its control mechanism. It physically moves the tape, retains proper tape

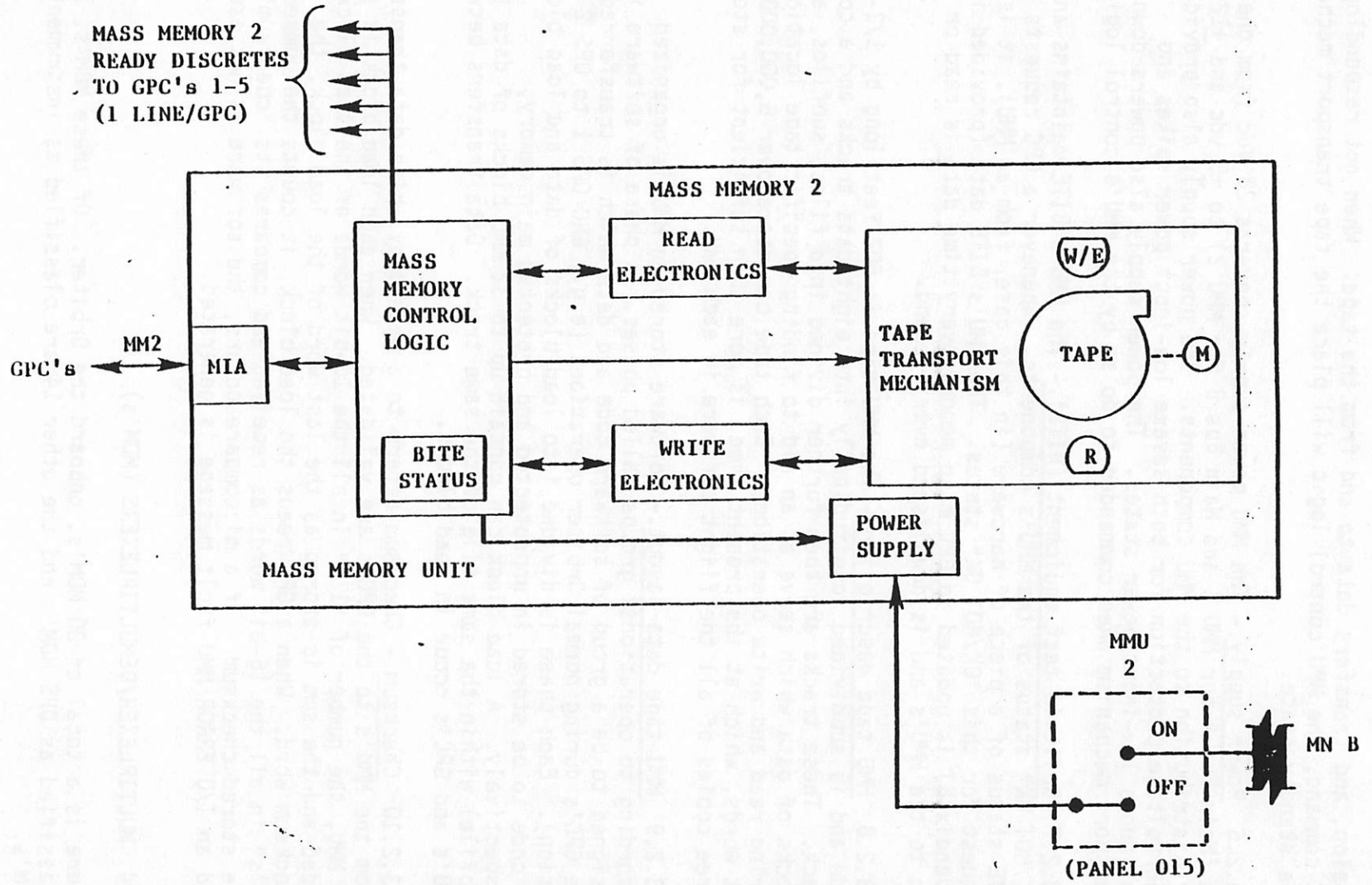


Figure 2-7.- MMU functional block diagram.

tension, and transfers data to and from the tape. When not responding to GPC command, the MMU control logic will place the tape transport mechanism in a standby state.

2.3.2.6 Power supply.- The MMU power supply converts 28 Vdc from one main bus (Main Bus A for MMU 1 and Main Bus B for MMU 2) to +5 vdc and +12 vdc for distribution to the MMU components. The power supply also provides undervoltage protection for both severe low-input power spikes and continuous low-input power states. The power supply also powers down the transport mechanism when commanded to do so by the MMU's control logic.

2.3.2.7 Built-in test equipment (BITE).- The MMU's BITE maintains an "OK/NOT OK" status of the MMU's components. Whenever a GPC requests the BITE status of a piece of hardware (in this case, from an MMU), it is a request for this "OK/NOT OK" status. The MMU's BITE data (provided in appendix B) is updated in GPC main memory every time data is read or written to the MMU's and is downlisted every second.

2.3.2.8 MMU tape description.- The MMU tape is 602 feet long by 1/2-inch wide and is subdivided longitudinally into eight data tracks and a control track. These tracks are then further divided into files, subfiles, and blocks of data which serve as an aid to finding specific tape locations during read and write operations. Each tape can store over 8,000,000 16-bit words, which at the present time, is more than sufficient for storing three copies of all the flight software in each MMU.

2.3.2.9 MMU tape data layout.- Software stored on MMU is organized according to operational groups called phases. A phase of software is designed to be a group of software code and data which is transferred to the GPC's during normal Orbiter operations (e.g., GNC OPS 1 to OPS 2 transition). Each phase is divided into load blocks of data and load blocks of code to be stored in unprotected and protected main memory, respectively. A load block can contain up to 32 MMU blocks of data (one subfile) within the same file of the same track. Data transfers between MMU's and GPC's occur in load blocks.

2.3.2.10 Checksum.- Checksum refers to a method by which data transfers from the MMU's to the GPC's are validated. When each load block is stored on MMU, the number of "1's" in all the 16-bit words of the load block are added and the sum is stored as the last word of the load block, the checksum word. When a GPC reads the load block, it counts the number of "1's" in all the 16-bit words as received and compares its "checksum" to the stored checksum. If a miscompare occurs, the software is not executed and an I/O ERROR MMU fault message is generated.

2.4 MULTIPLEXER/DEMULTIPLEXERS (MDM's)

There is a total of 30 MDM's, onboard the Orbiter. Of these MDM's, 16 are classified as DPS MDM's and the other 14 are classified as instrumentation MDM's.

The 16 DPS MDM's have names which are derived from their locations and their hardware interfaces. They are the:

- Flight Critical Forward (FF) MDM's - (4)
- Flight Critical Aft (FA) MDM's - (4)
- Payload (PL) MDM's - (2)
- Launch-SRB LEFT (LL) MDM's - (2)
- Launch-SRB Right (LR) MDM's - (2)
- Launch-Forward (LF) MDM - (1)
- Launch-Aft (LA) MDM - (1)

The 14 instrumentation MDM's have names which are derived from the instrumentation systems and their locations. They are the:

- Operational Instrumentation Forward (OF) - (4)
- Operational Instrumentation Aft (OA) - (3)
- Developmental Instrumentation Center (DC) - (2)
- Developmental Instrumentation Forward (DF) - (1)
- Developmental Instrumentation Left (DL) - (2)
- Developmental Instrumentation Right (DR) - (2)

The DPS MDM's serve the following purposes: they convert and format serial digital GPC commands into parallel discrete, digital, and analog commands for transfer to vehicle subsystem hardware. This operation is commonly referred to as an MDM's demultiplexing function. The other function of the MDM, which is known as the multiplexing operation, is to convert and format parallel discrete, digital, and analog data from vehicle systems into serial digital data for transmission to the GPC's.

2.4.1 MDM Interfaces

The several MDM interfaces are as follows:

- Cooling - Water-loop coldplate cooling to those MDM's in the forward avionics bays (the FF, PL, and LF1 MDM's); Freon-loop coldplate cooling to the MDM's in the aft avionics bays (the FA and LA1 MDM's), and passive coldplate cooling to the SRB MDM's (LL1, LL2, LR1, and LR2).
- The MDM's interface with the GPC's via serial digital data buses and with Orbiter systems hardware via hardwired lines. For a complete description of MDM/LRU interfaces see the MDM Tables in appendix A.
- Power - Main bus power (28 Vdc) to the FF, FA, and PL MDM's, preflight test bus power to the LF and LA MDM's, and SRB bus power to the SRB MDM's (LL1, LL2, LR1, LR2). There are 11 FC and PL MDM power switches on Panel 06. The function of these two-position, dual-contact toggle switches (with the exception of the PL3 switch which is unwired for OSS 1 and 2) is to permit control bus power to activate two RPC's which in turn allow power from two main buses to flow to the designated MDM's. The MDM power switch status is made available for downlink via the OF and OA MDM's (FF1-4, FA1-4, PL1-3). The LF and the LA MDM's receive their power through the preflight test buses, (there is no crew station control for these MDM's). The four SRB MDM's receive power through SRB Buses A and B. These buses are tied to the Orbiter main buses and controlled by the MEC.

2.4.2 MDM Functional Description

The typical DPS MDM is redundant in several ways. Each MDM can communicate on one of two different data buses via two separate MIA's. Each MDM has two separate power supplies, each fed by a different main bus power source. Furthermore, each power supply can provide power to all components within the MDM; therefore, a power supply failure will not inhibit the operation of either MDM "channel." Each MDM has two analog-to-digital converters. Inputs from each of the I/O modules (there can be up to 16 I/O modules in each MDM) are available to both MDM "channels." Since each MDM has two MIA's or "ports" and the other redundant components, the loss of a MIA would not mean the permanent loss of data to the GPC's since the data can be accessed through the other port on the other data bus upon action of the crew. "Switchover" is not automatic. The I/O modules which reside in an MDM are based on the hardware components and types of data that the particular MDM is required to access. Therefore, a FF MDM and an SRB MDM, for example, would not be interchangeable.

Figure 2-8 illustrates a functional block diagram of an MDM.

2.4.2.1 MDM MIA.- Each of the two MIA's within an MDM are functionally identical with the GPC's IOP MIA.

2.4.2.2 Sequence Control Unit (SCU).- Either of the MDM SCU's validates GPC commands (for proper address, operation, and time between words) and decodes those commands into instructions to control MDM operations. They also execute instructions which are stored in a programmable read-only memory (PROM) if required, and maintain the BITE status of the MDM components. MDM BITE is updated in GPC main memory only when requested by crew or uplink command and is not nominally downlisted. MDM BITE status data is available in appendix B. Self-check tasks are cyclically performed to terminate MDM operations if invalid. Cycling MDM power will restore normal MDM functions.

2.4.2.3 Analog-to-digital (A/D) converter.- The function of the A/D converter is to convert analog data inputs from the input modules into serial digital data for transfer to the SCU. The reverse process (digital-to-analog conversion) is not performed by this device, but is accomplished instead in the appropriate MDM output module.

2.4.2.4 MDM power supply.- Each of the MDM power supplies convert 28 Vdc main bus input power into regulated 18.6 Vdc power, and then converts the 18.6 Vdc into +5 Vdc, +10 Vdc, +12 Vdc and -20 Vdc, as required. These power supplies also provide undervoltage detection and their power inputs are "diode'd" together to supply all the MDM components. Failure of one power supply will not effect MDM operations. Failure of both power supplies will cause the MDM to reset all discrete outputs, to reset all analog outputs, and, when power is reapplied, to invalidate the first MDM response to GPC commands.

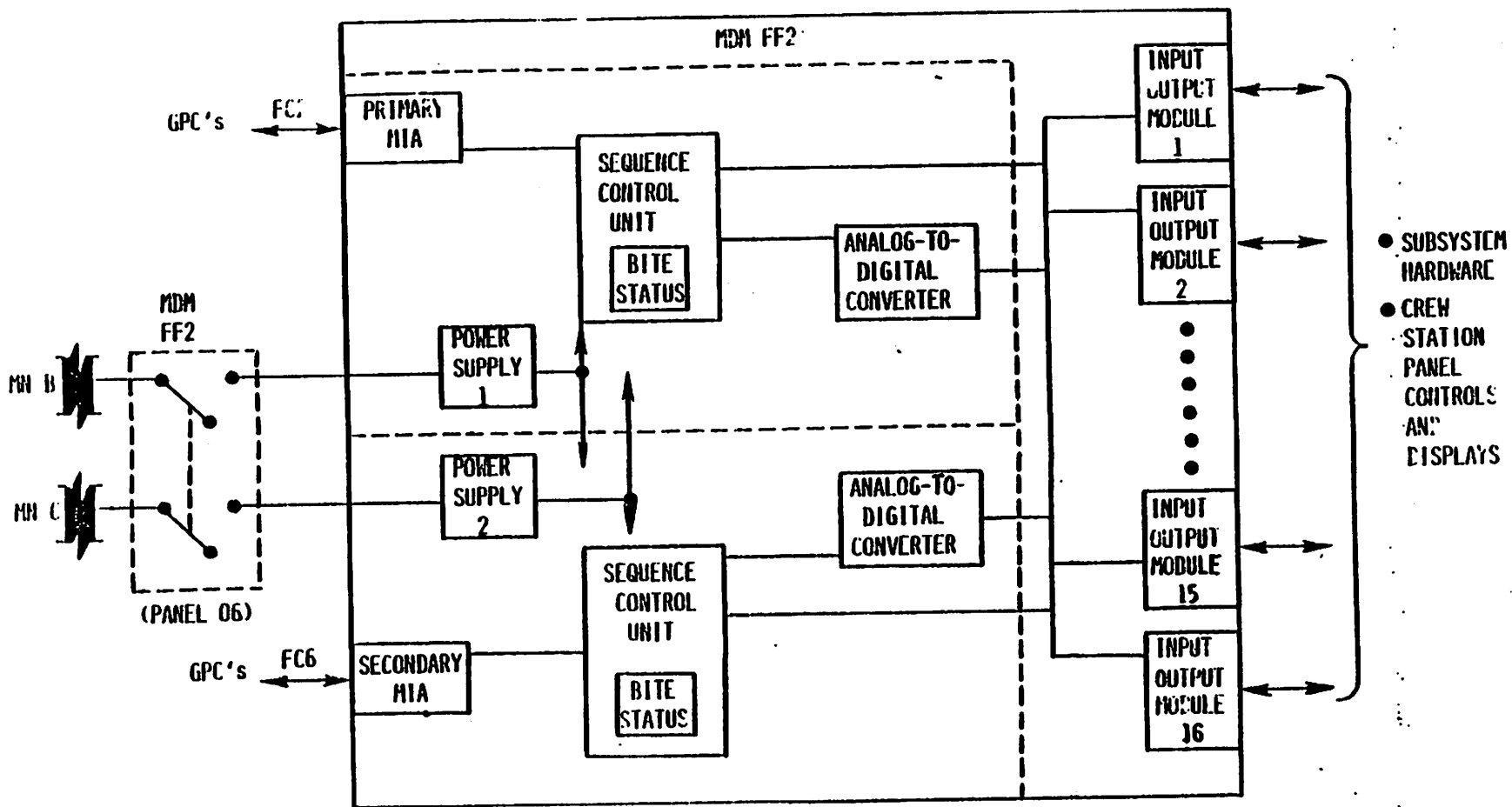


Figure 2-8.- MDM functional block diagram.

2.4.2.5 MDM Input/Output (I/O) modules - There are six basic types of I/O modules which may be installed in an MDM. They are as follows:

- Discrete input module converts up to 48 parallel +5 Vdc inputs or up to 48 +28 Vdc inputs into three serial, 16-bit data words.
- Discrete output module converts serial, digital commands into parallel discrete signals to Orbiter systems hardware.
- Analog input module conditions +5.11 Vdc to -5.12 Vdc analog inputs from Orbiter systems hardware for digital conversion by A/D.
- Analog output module converts 10-bit digital commands into +5.11 Vdc to -5.12 Vdc analog outputs to Orbiter systems hardware.
- Serial, digital input/output module:
 - Notifies Orbiter systems hardware to receive commands or to send data.
 - Converts "NRZ" commands into "Manchester II" commands for transmission to Orbiter systems hardware (waveform conversion).
 - Adds SYNC code and parity bits to commands for systems hardware.
 - Converts "Manchester II" data into "NRZ" data from systems hardware (waveform conversion).
- TACAN/RADAR altimeter module (applicable to FF MDM's only):
 - Continuously transfers control panel inputs or GPC commands to TACAN.
 - Continuously requests, receives and buffers radar altimeter data.
 - Continuously receives and buffers TACAN and TACAN control panel data.
 - Converts buffered data to NRZ for transmission to GPC when requested.

2.5 MULTI-FUNCTION CRT DISPLAY SYSTEM (MCDS)

The MCDS onboard the Orbiter is the system which allows for onboard monitoring of Orbiter systems and computer software processing, and provides the flight crew with manual control for data and software manipulation. The MCDS consists of three types of hardware the DEU's, the Display Units (DU's), and the Keyboard Units (KBU's), which communicate with the GPC's over the KBU's data bus network. Figure 2-9 illustrates the KBU's and the DU's and their locations in the Orbiter crew stations. Additional KBU's, DEU's and DU's may be added to the vehicle as the Shuttle program develops.

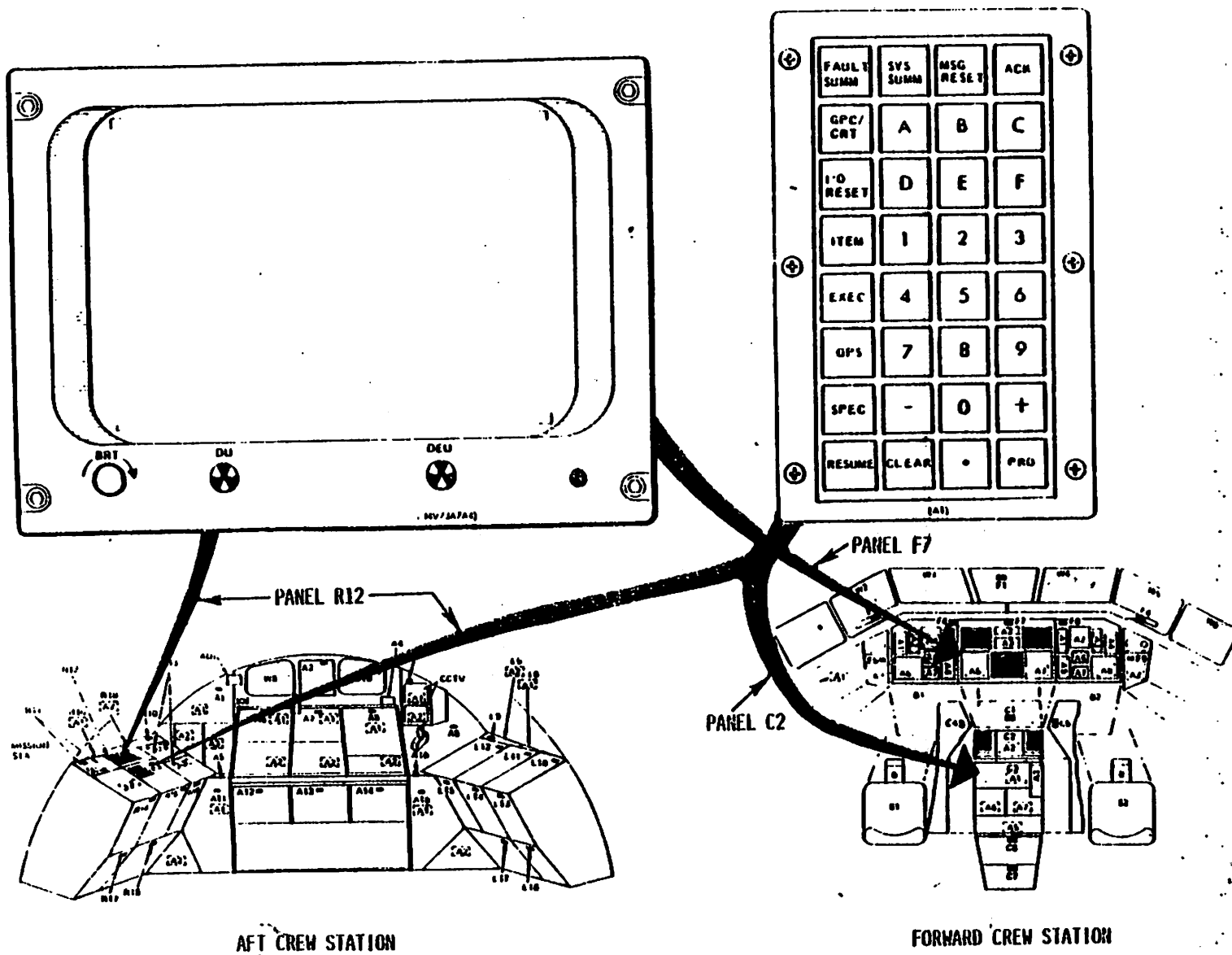


Figure 2-9.- DPS Keyboard and CRT locations.

2.5.1 MCDS Interfaces

2.5.1.1 Power/cooling. - The CRT POWER switch has two contacts for three positions: OFF, STBY, and ON. The STBY position activates two RPC's to allow main bus power from one bus to the DEU and DU power supplies. Only the DU high-voltage power supply is activated to use for CRT filament heaters. In the ON position, the DEU power supply receives a POWER UP signal discrete input to activate its logic circuitry and send a POWER UP signal to the DU voltage power supply to activate its logic circuitry. A 3-amp circuit breaker allows the 115 Vac input to the respective instrumentation lamp potentiometer to control lamp intensity via dimmer circuitry. The dimmer circuitry output is transformed to 5 Vac and protected by a 5-amp fuse for keyboard lamp power.

The DEU and DU pairs receive forced-air cooling via the cabin fans. The KBU's are cooled by convective heat dissipation.

2.5.1.2 Crew station controls - The following is a brief explanation of each of the MCDS controls.

- DEU LOAD switches: Prior to beginning normal operations, each DEU must receive a memory load from MMU through a GPC. This procedure is accomplished through the use of the DEU LOAD switches on Panel O6. Each of these four switches (one for each DEU) is a two-position momentary toggle switch which sets a "flag" which will initiate a GPC request for data stored in MMU. These data will be shipped from MMU to the GPC and then loaded from the GPC into the DEU's own memory. This DEU data load request will only be recognized immediately after GPC initialization. During this initialization sequence, the words DEU LOAD will appear on the appropriate Cathode Ray Tube (CRT). If the load is successful, the words IPL COMPLETE will appear on the CRT, followed shortly thereafter by the appropriate CRT display. IPL INCOMPLETE will appear on the CRT if the attempted load is unsuccessful.
- Major Function (MAJ FUNC) switches: On the basis of the phase of the Shuttle mission, there may be different functional groups of software being processed at the same time. These three-position toggle switches (one for each KBU) tell the GPC's which of these software groups is meant to process the KBU inputs and drive the data presented on the CRT: GNC, SM, PL.
- CRT SELECT switches: There are three CRT's (three DU's hardwired to three DEU's) in the forward station and only two KBU's. The forward station KBU's are each connected to two of these DEU/ DU pairs. The function of the CRT SELECT switches is to identify to the system which DEU/DU pair is to process keystrokes from each of the keyboards. The LEFT CRT SELECT switch allows the left keyboard to talk to either DEU/DU-1 (the left CRT) or DEU/DU-3 (the center CRT), and the RIGHT CRT SELECT switch allows the right keyboard to talk to either DEU/DU-2 (the right CRT) or DEU/DU-3.
- CRT POWER switches: Each DEU/DU pair has a DEU/DU POWER switch associated with it. Each of these is a three-position dual-contact toggle

switch which permits control bus power to activate a pair of RPC's, and allows main bus power to flow to the designated DEU and DU. Power allowed to flow through each of the forward station CRT POWER switches (in the STANDBY position) is "diode'd" together and supplied to the Panel C3 BFC CRT switches. The ON and STBY CRT POWER switch status is available through the OF MDM's.

- Keyboard Lamp Power Switches: Each set of keyboard lamps is part of an instrumentation lighting system which responds to crew station circuit breakers and potentiometers. Three 3-amp circuit breakers protect the ac phase power bus inputs to the left/center, right, and Mission Specialist (MS) instrumentation lamps (including keyboard lamps). The potentiometers permit variable control of instrumentation lamp intensity.

2.5.1.3 GPC interface. - Figure 2-10 illustrates the GPC/MCDS interfaces via the DK data buses. Note the inclusion of a proposed fifth DEU/DU pair and a fourth KBU (for the PL specialists station in the aft crew station). When and if a fifth DEU/DU pair is added to the vehicle, it will interface with the GPC's over DK-2, and provisions will be made to ensure that only DEU/DU-2 or DEU/DU-5 will be active at any one time. Only one GPC can command a specific DEU/DU pair at any one time. If two GPC's send commands to the DEU to drive different displays and data, frequently the viewer will see a flashing effect on the CRT.

2.5.1.4 Fault Detection and Annunciation. - The DEU maintains a capability via software and hardware logic to detect and annunciate certain MCDS problems and keyboard input errors:

- BITE - Each CRT contains DEU and DU GO/NO-GO flags on its front panel. These flags go to a NO-GO state (black and white) when a BITE-detected condition exists for 6 seconds, but may be reset manually. If the problem is considered a critical situation (e.g. DEU memory parity error, power failure), the GPC DEU interface software will detect the appropriate BITE bits set and drive the CRT BITE fault message.
- Flashing ERR - The DEU control logic performs certain syntax checks on keyboard messages before transmission to the GPC's. Input of an unexpected character (e.g. letter in an OPS request) or termination of a sequence without the required previous keystrokes will result in a flashing ERR on the scratch pad line after the offending keystroke. Using the CLEAR key or starting the message again will recover from the error.
- Big X - When a DEU detects that a GPC has not sent CRT data for 3 seconds, a corner-to-corner "X" will be drawn on its associated CRT and freeze all data on the screen. This state remains until a CRT data update command is received.
- POLL FAILURE - When a DEU detects that a GPC has not polled it for 3 seconds, the words "POLL FAILURE" appear on the left of the scratch pad line. This state remains until the DEU is polled by a GPC.
- Stand-alone Self-Test Program (STP) - A special CRT display and DEU software can be used to verify the operation and interfaces involved

DISPLAY ELECTRONICS UNIT (DEU) - KEYBOARD
(DK) DATA BUS/GPC PORT
ASSIGNMENTS

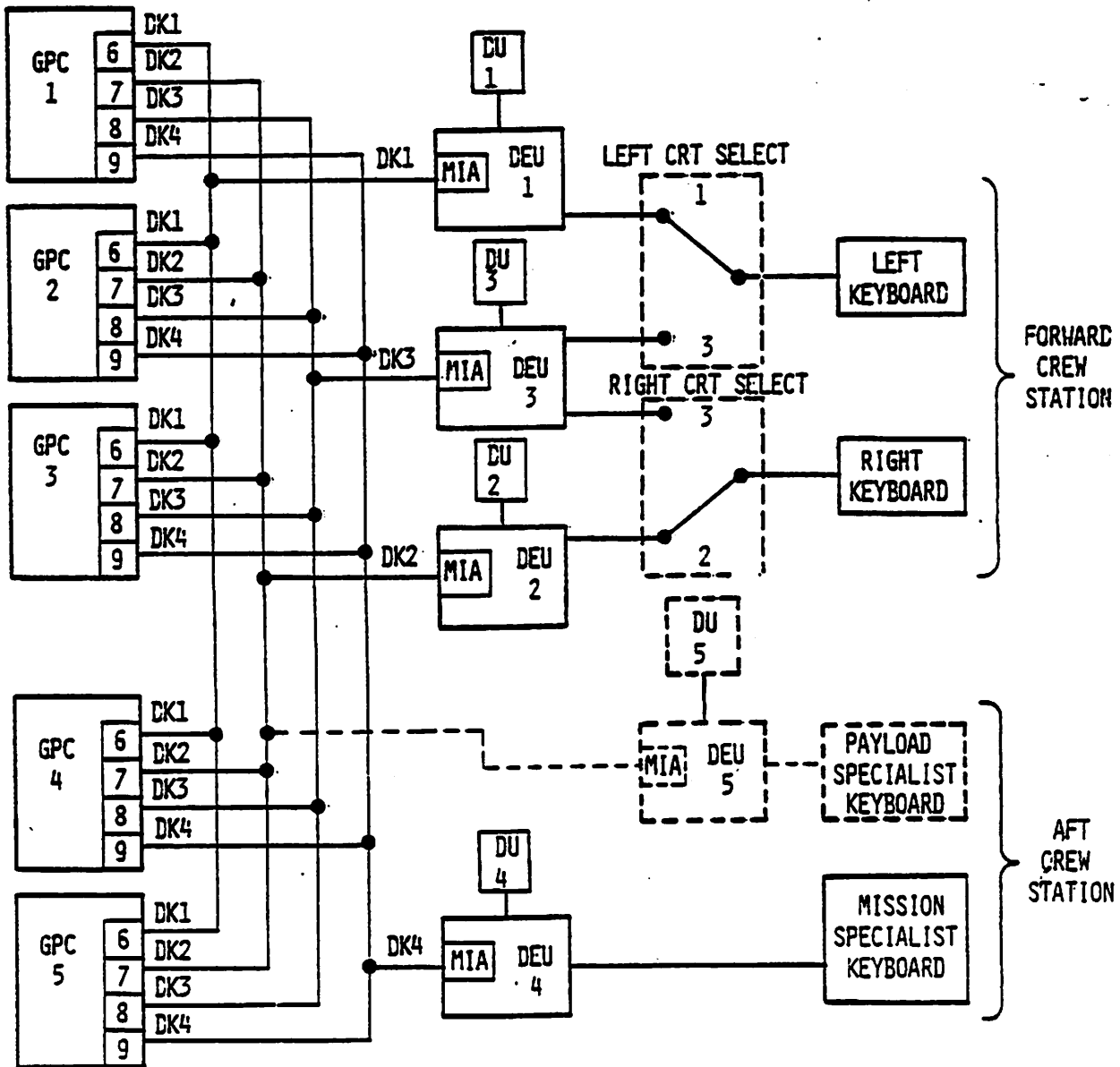


Figure 2-10.- GPC/MCDS interface.

in DEU operations immediately after GPC IPL and prior to initiating normal GPC/DEU operations.

2.5.2 Display Electronics Unit (DEU) Functional Description

Figure 2-11 illustrates a functional block diagram of an Orbiter DEU and the crew station control inputs to the DEU. The following is a functional description of these DEU components.

2.5.2.1 DEU MIA.- The functions of the DEU MIA are the same as those of the IOP MIA.

2.5.2.2 DEU control logic.- The DEU control logic validates GPC commands (address, operation, and word timing) and stores CRT display information from GPC commands in its own memory. The control logic also checks the crew station control discretes to determine which keyboard adapter to read, if a DEU memory load has been requested, and which major function software should be processing KBU's and processing display data. It also sends CRT display information to the symbol generator, provides timing signals for DEU operations and DU BITE, validates keyboard message inputs (syntax), and executes software to accomplish GPC command tasks.

2.5.2.3 DEU BITE.- The DEU BITE maintains an "OK/NOT OK" status of its components. The DEU and DU BITE status data are available in appendix B.

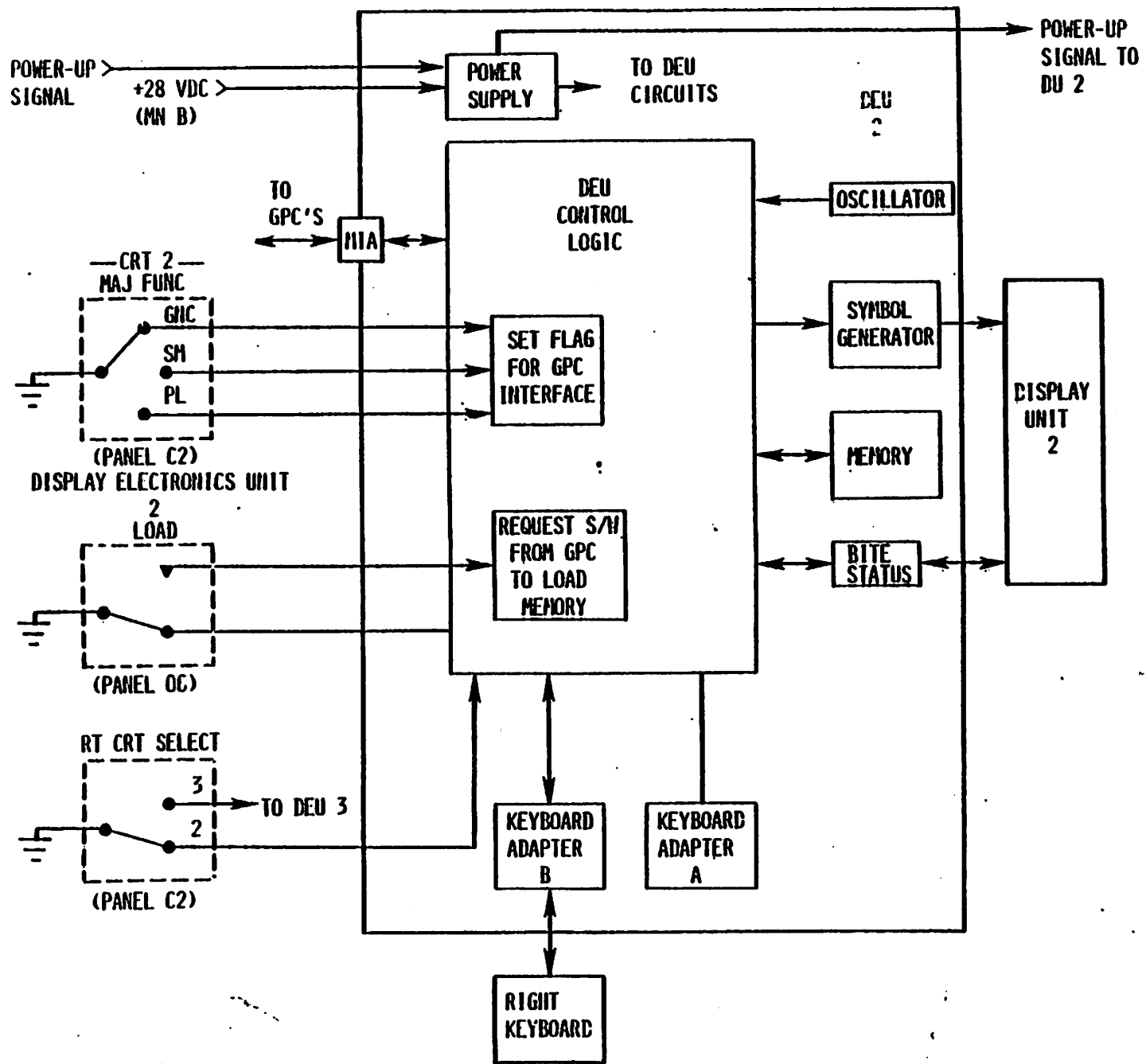
2.5.2.4 Symbol generator.- The symbol generator transforms data from the control logic into control signals which are then sent to the display unit.

2.5.2.5 DEU memory.- The DEU has a memory area which provides storage for 8192 17-bit words (16 data bits and parity). This memory area is used to buffer keyboard messages, GPC input and output data, the CRT scratch pad and fault message lines, and CRT refresh data. This memory area also stores critical background CRT display formats.

2.5.2.6 Keyboard adapter.- The DEU keyboard adapter (of which there are two in each DEU) notifies the DEU control logic when a keyboard input is made, and formats the status of all the keys for transmission to the control logic as requested.

2.5.2.7 Power supply.- The DEU power supply filters the main bus 28 Vdc input power and converts this power into +5 Vac, 12 Vdc, and +15 Vdc. It also provides undervoltage detection for converted voltages (when 5 percent below nominal) and initiates a powerdown sequence when the input power drops below 17.5 Vdc. The CRT attached to this DEU will blank should this powerdown sequence occur. It provides a POWER-UP discrete to the DU low-voltage power supply when its control logic circuitry is activated.

2.5.2.8 DEU oscillator.- The DEU oscillator provides 24 MHz timing signals to the DEU components, and also increments the time in DEU memory. Should the GPC stop sending time updates to the DEU, the time shown on the associated CRT will continue to update as a function of this oscillator.



2-30

Figure 2-11.- DEU functional block diagram.

2.5.3 Display Unit Functional Description

The functions of the DU components are outlined below. Figure 2-12 illustrates a functional block diagram of a DU.

2.5.3.1 X and Y deflection amplifier.- The X and Y deflection amplifier amplifies the X- and Y-direction deflection signals to drive the CRT beam to the correct screen location.

2.5.3.2 Video amplifier.- The video amplifier amplifies analog signals from the symbol generator to control CRT beam intensity. It also scales total CRT screen brightness on the basis of brightness control inputs. The brightness control unit bases its inputs to the video amplifier on signals from the manual brightness control dial and the ambient light sensor located just below the CRT screen.

2.5.3.3 CRT.- The CRT displays alphanumeric characters, graphic symbols, and vectors on a green-on-green phosphorus screen which is activated by a magnetically controlled beam.

2.5.3.4 DU BITE.- The DU BITE maintains an "OK/NOT OK" status of the DU components. The status of both the DU and DEU BITE is also reflected on a pair of mechanical "flags" located just below the CRT screen.

2.5.3.5 DEU power supply.- The DEU power supply converts 28 Vdc main bus power to +5, +15, +28, and +80 Vdc for DU logic and amplifier needs, to 16,000 Vdc to drive the CRT beam, and to 600 Vdc for focus control. It also provides overvoltage/undervoltage detection and overcurrent protection.

2.5.4 Keyboard Unit

Figure 2-13 is a schematic of an Orbiter keyboard and figure 2-9 indicates the locations of the three keyboards presently onboard the Orbiter vehicle. There are 10 number keys, 6 letter keys (used for hexadecimal data inputs), 2 algebraic-sign keys, a decimal key, and 13 special-function keys. Each keyboard consists of 32 momentary double-contact pushbutton keys. Each key utilizes its double contacts for communicating on separate signal paths to two DEU's (only one set of contacts on the aft station KBU keys is actually wired because this keyboard can only communicate with one DEU), and is illuminated by dual lamps driven by Orbiter ac power (5 Vac).

2.6 BACKUP FLIGHT CONTROLLERS (BFC'S)

There are three BFC's onboard the Orbiter. Each of these hardware devices contains two independently powered modules, and each of these modules provides the interface between one GPC and the crew station controls. The BFC interfaces are illustrated in figure 2-14. These interfaces consist of the GPC HALT command, the BFC ENGAGE discrettes, the BFC DISENGAGE discrettes, the BACKUP/NORMAL/TERMINATE discrettes, and those discrettes which control assignment of the forward DK bus(es) to the BFS GPC. Each BFC module is powered independently, with use of the same power source as

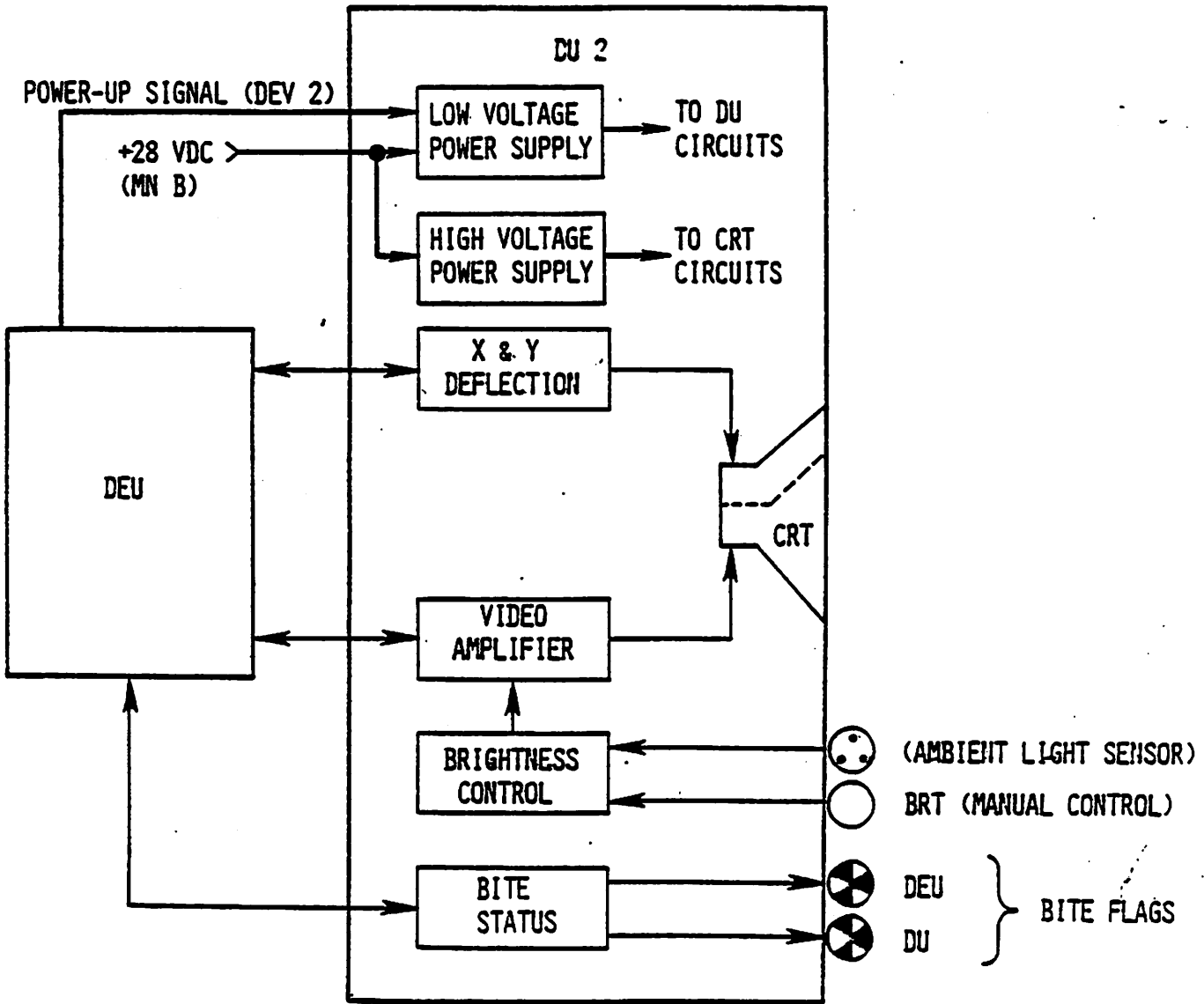


Figure 2-12.- DU functional block diagram.

RIGHT KEYBOARD SCHEMATIC

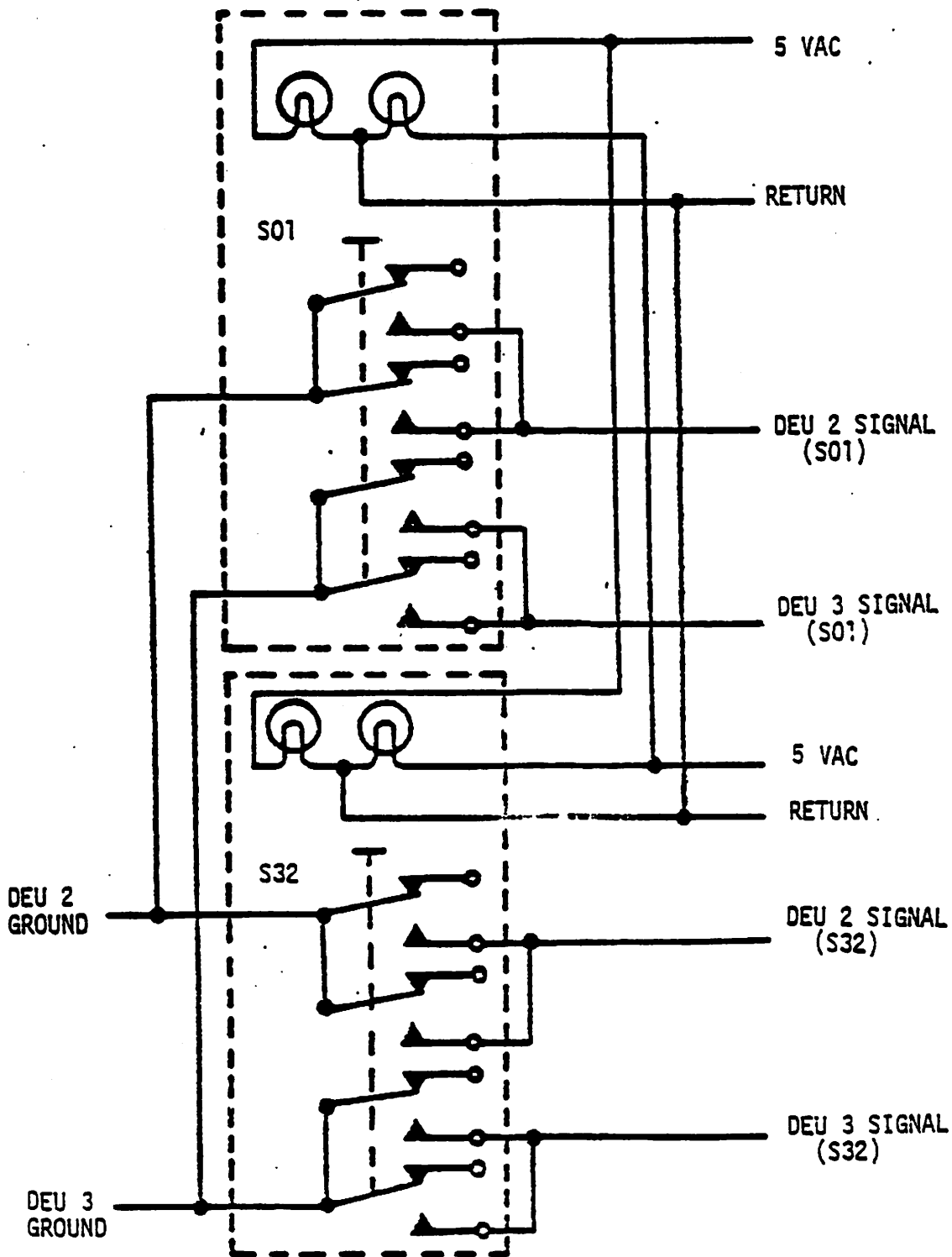


Figure 2-13.- Keyboard unit schematic.

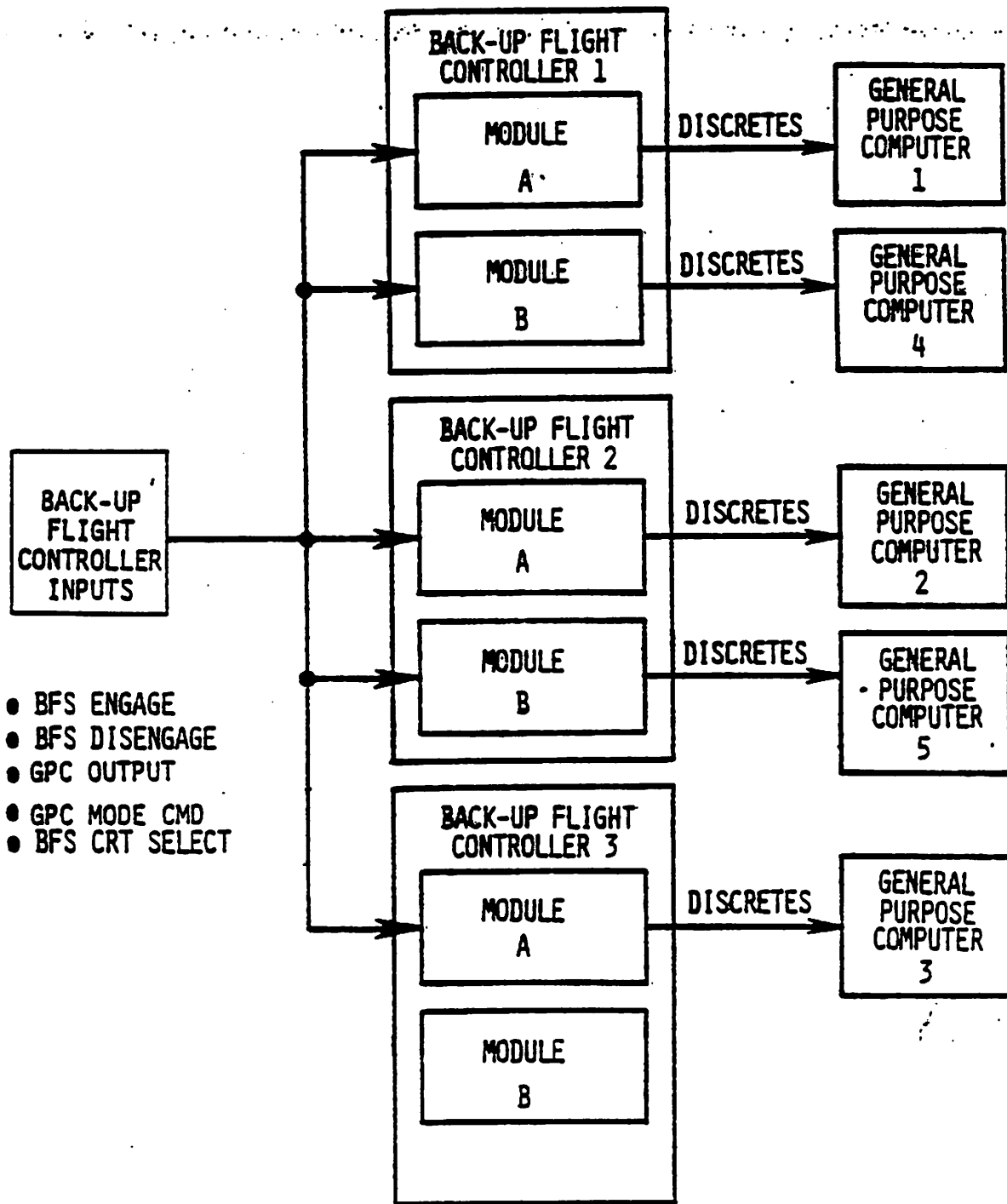


Figure 2-14.- BFC unit data interfaces.

the CPU of its associated GPC. For example, Module A of BFC 1, which transmits its discretes to GPC 1, receives its power from the same source as GPC 1's CPU.

2.6.1 GPC/BFC Power Flow

A GPC receives its power when its associated GPC POWER switch is moved to the ON position. The power that is supplied to the GPC's CPU power supply is also supplied to that GPC's BFC module and to the BFC switch input circuitry (to be discussed later on in this section). A total loss of power to a GPC's CPU would also result in a total loss of power to that GPC's associated BFC module. There is a 5-amp fuse in the power supply line to the BFC module. Destruction of this fuse could cause the loss of a BFC module even though the CPU is still receiving its required power.

2.6.2 BFC Discrete Inputs

2.6.2.1 BFC ENGAGE discretes.- The BFC ENGAGE pushbutton is a momentary pushbutton switch located on each of the two forward station Rotational Hand Controllers (RHC's). This pushbutton, when depressed, issues discrete signals to the BFC modules, which request that control of the vehicle be turned over to the BFS GPC. Although this pushbutton is momentary in physical design, the BFC ENGAGE discretes are "latched" inside the BFC modules and remain in that state unless the BFC DISENGAGE switch is toggled, power is removed from the BFC module, or no GPC's OUTPUT switch is in the "BACKUP" position.

2.6.2.2 BFC DISENGAGE discretes.- The BFC DISENGAGE switch is a single two-position momentary toggle switch, located on Panel F6. The purpose of this switch is to request that control of the vehicle be given back to the PASS GPC's. This switch resets the BFS ENGAGE discretes which were latched inside the BFC modules.

2.6.2.3 BFC CRT discretes.- There are two switches on Panel C3 which are known collectively as the BFC CRT switches. The left-hand switch, or BFC CRT DISPLAY switch, allows power from the CRT power switches in the forward station (diodeed together to form a single "source") to flow to the BFC CRT SELECT switch. The right-hand switch, or BFC CRT SELECT switch, is a three-position toggle switch which has its positions marked 1+2, 2+3, and 3+1. Assuming the BFC CRT DISPLAY switch is in the "ON" position, if the BFC CRT SELECT switch is in the 1+2 position, the BFS GPC will command CRT 1 when the BFS has not been engaged (the preengage state) and will command CRT 1 and CRT 2 after the BFS has been engaged (postengage state). The 2+3 position allows similar control of CRT 2 and 3, and the 3+1 position allows similar control of CRT 3 and 1. Preengage, should the BFC CRT DISPLAY switch be turned off, command of the single CRT (dedicated to the BFS) will be restored to the PASS. Postengage, if the BFC CRT DISPLAY switch was in the OFF position, the BFS GPC would default to commanding CRT's 1 and 2. A GPC/CRT keyboard message allows assignment of DK buses to the BFS in addition to those assigned via the BFC CRT switches.

2.6.2.4 BACKUP/NORMAL/TERMINATE discrettes.- The OUTPUT switch can be in either the BACKUP, NORMAL, or TERMINATE position. The BACKUP position identifies to the BFC Module if a GPC is intended to be the BFC GPC when the BFC ENGAGE pushbutton is depressed.

- If the OUTPUT switches of two or more GPC's are in the BACKUP position, the OUTPUT switch is wired such that any lower numbered GPC defaults to the NORMAL position.
- Preengage, if a GPC is in either the "true" BACKUP or TERMINATE position, the I/O Terminate B discrete will be sent to that GPC.
- If all five GPC's are in either the NORMAL or TERMINATE position (no GPC is in the BACKUP position) then the BFS ENGAGE discrettes will be forced to logical "zero's", and thus depression of the BFC ENGAGE pushbutton would be ineffective.

2.6.3 Backup Flight Controller (BFC) Input/Output (I/O) Logic

As can be seen from figure 2-14, the BFC receives inputs from the BFC ENGAGE pushbuttons, the BFC DISENGAGE switch, the OUTPUT switches, GPC MODE switch (HALT position only), and the BFC CRT DISPLAY and SELECT switches. The logic in the BFC module uses these inputs to develop the BFS ENGAGE discrettes (1, 2, and 3), the "I/O Terminate B" discrete, and the BFS CRT SELECT discrettes, which are then output by the BFC and transmitted to the associated GPC. The HALT position of the GPC MODE Switch is wired through the appropriate BFC to the GPC to reduce the effects of Electromagnetic Interference (EMI). The BFS GPC, in order to become ENGAGED, must recognize that at least two of the three ENGAGE discrettes have changed from "zero" to "1" and must receive an I/O Terminate B discrete equal to a logical "zero". The PASS GPC's, on the other hand, must receive all three BFS ENGAGE discrettes set to logical "1" and an I/O Terminate B discrete also equal to a logical "1". The PASS GPC's, upon receiving these discrettes, will give up control of their dedicated buses and enter a "software halt" state. These GPC's would have to be reinitialized with an IPL sequence before they could be used again with any guarantee of success.

Each GPC interrogates the ENGAGE discrettes and the "I/O Terminate B" discrete inputs to determine if a valid BFS Engage or Disengage condition exists. Also, the "I/O Terminate B" discrete provides for hardware control of the FC data bus transmitters; i.e., if a GPC detects its "I/O Terminate B" discrete = 1, it can not transmit on the FC data buses. Furthermore, a PASS GPC must receive an "I/O Terminate B" discrete = 1 as well as the BFS ENGAGE discrettes 1 = 2 = 3 = 1 to recognize the BFS ENGAGE condition.

The GPC OUTPUT switch logic shows that if the OUTPUT switch is in the TERMINATE position, or if the OUTPUT switch is in the BACKUP position and there is no higher numbered GPC with its OUTPUT switch in BACKUP, a logical "one" will be transmitted via a 1 second time delay to the BFC. Therefore, on the assumption that the three BFS ENGAGE discrettes are set to a logical "1" only the highest numbered GPC with its OUTPUT switch in

the BACKUP position will receive the correct discrete pattern in order to assume control as the BFS GPC. All the other GPC's, assuming no failures, will receive the correct discrete pattern which will tell them to surrender control of their buses.

2.7 MASTER EVENTS CONTROLLER TBS

2.8 DPS ACTIVATION

The following is a series of activation procedures, primarily taken from the Orbiter Systems Operating Procedures (OSOP), showing an acceptable order of activating the DPS. These procedures assume that the power and cooling subsystems have previously been activated.

2.8.1 MMU Activation

The only activation required for the MMU is to place the MMU 1 (2) POWER switches to ON on Panels 014 (015).

For non-IPL use, the IPL SOURCE switch for each MMU should be in the OFF position on Panel 06.

2.8.2 MDM Activation

The activation procedure for the DPS MDM's is to place the eleven POWER switches on Panel 06 to ON.

FLT CRIT AFT (four) - ON
FLT CRIT FWD (four) - ON
PL (three) - ON

Note: MDM's should be powered up before the GPC's are activated to prevent I/O errors from occurring.

2.8.3 MCDS Activation

The four MCDS's are normally activated by placing the appropriate CRT POWER switch to ON on Panels C2 and R12.

CRT 1 (2,3) Power - ON Panel C2
CRT 4 Power - ON Panel R12

Note: Approximately 1 minute is required for the CRT to become usable from an unpowered state.

If the DEU memories have never been loaded, then a DEU memory load is required; this can only be performed after a GPC has been activated and is in IPL OPS 0.

2.8.4 GPC Initialization and Activation

The information provided here concerns itself with the initialization and activation of the PASS GPC's as well as the BFS GPC. The first portion of the total procedure is known as GPC initialization and is equivalent for all GPC's. The first step in this initialization procedure is to turn a GPC's POWER switch to the ON position. At this point, the GPC is in a hardware-controlled state in which the GPC monitors its MODE discrete, the IPL SOURCE switch, and the IPL pushbutton. For an IPL request to be completed, the GPC's MODE switch must be in HALT and either MMU 1 or 2 must be selected as the IPL SOURCE. When the IPL pushbutton for that GPC is depressed, hardware initialization logic within the GPC checks the selected MMU's READY/BUSY discrete to determine whether or not the MMU is ready to respond with the initialization software load. If it is, and this is the first attempt at getting the MMU software load, the GPC will request the software from the selected MM and drive its own mode talkback (Panel 06) to the IPL position. If this software is received with no I/O errors and no checksum errors, the GPC will reset its mode talkback to barberpole and begin to monitor its discrete inputs for a signal to start the activation phase.

Should an I/O or checksum error be detected, the GPC will return to the hardware-controlled state and will wait for another IPL request via the IPL pushbutton. If the READY talkback has not returned to the barberpole state within 2 minutes, it will indicate that the load was not successful. The second and subsequent depressions of the IPL pushbutton will cause the GPC to retry the initialization software load from a second place on the same MM tape. If the other MMU is to be tried, the IPL SOURCE SELECT switch must be cycled to the other MMU, since there is no automatic MMU switching during this procedure. Figure 2-15 illustrates a functional GPC initialization logic flow.

At this point, the initialized GPC contains the system software loader and STP which will allow it to proceed with the activation sequence. Figure 2-16 illustrates this activation logic flow up to the point where a PASS systems software or a BFS software load is attempted.

At the start of this process, the GPC is monitoring its discrete inputs and remains in a "wait" state until it detects that the IPL SOURCE switch is OFF and its MODE switch is now in the STANDBY position. Prior to modifying these switches, it should be noted that additional steps must be implemented if this initialization/activation process is intended for the BFS GPC or if a GPC extended self-test is going to be performed. Both these processes require an active DEU because the GPC IPL MENU display (figure 2-18) is used to perform these functions. For either process, a CRT must be powered ON, and the associated DEU must be loaded with software via an input from the appropriate DEU LOAD switch (Panel 06). The BFC CRT DISPLAY switch must be turned ON, and the BFC CRT SELECT switch moved to the desired position (1+2, 2+3, or 3+1). The IPL is then initiated by depressing the GPC's IPL pushbutton on Panel 06. This will result in the GPC IPL MENU subsequently appearing on the selected CRT. At this point the IPL SOURCE switch can be turned to the OFF position and the GPC moded to STANDBY.

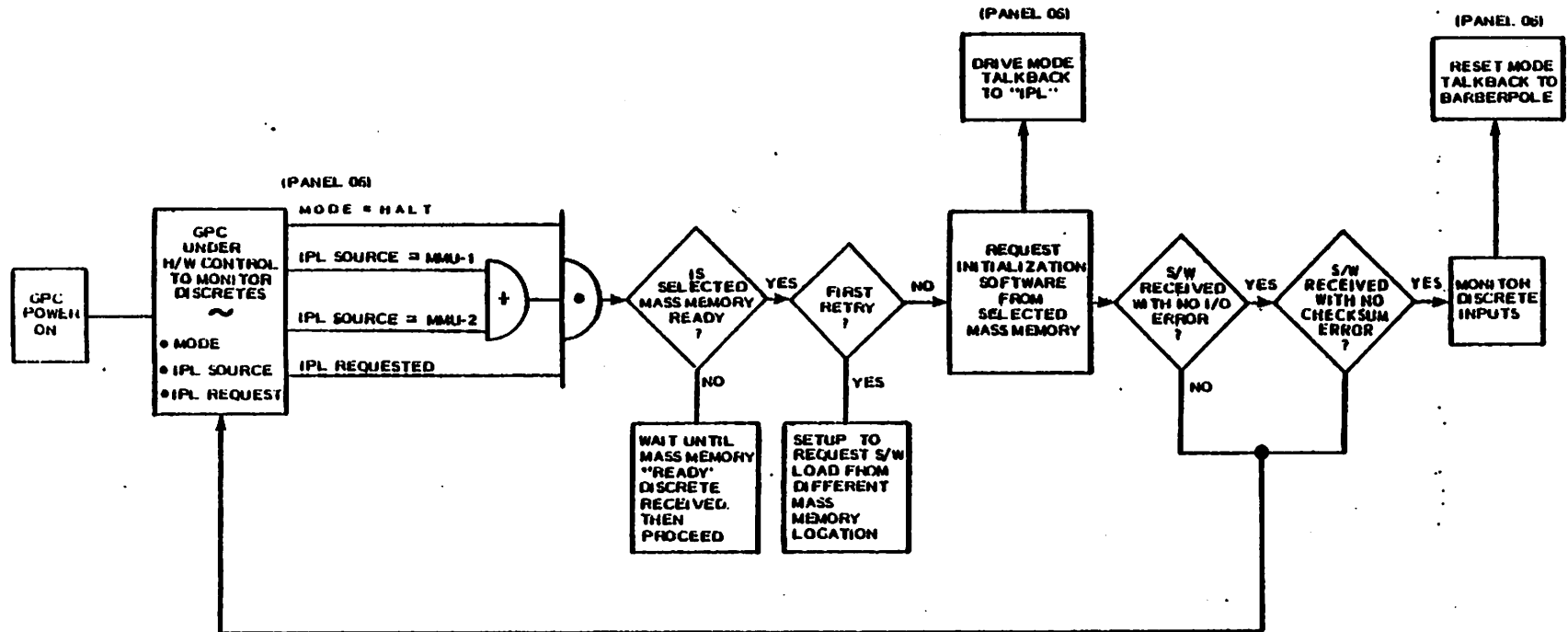


Figure 2-15.- GPC initialization.

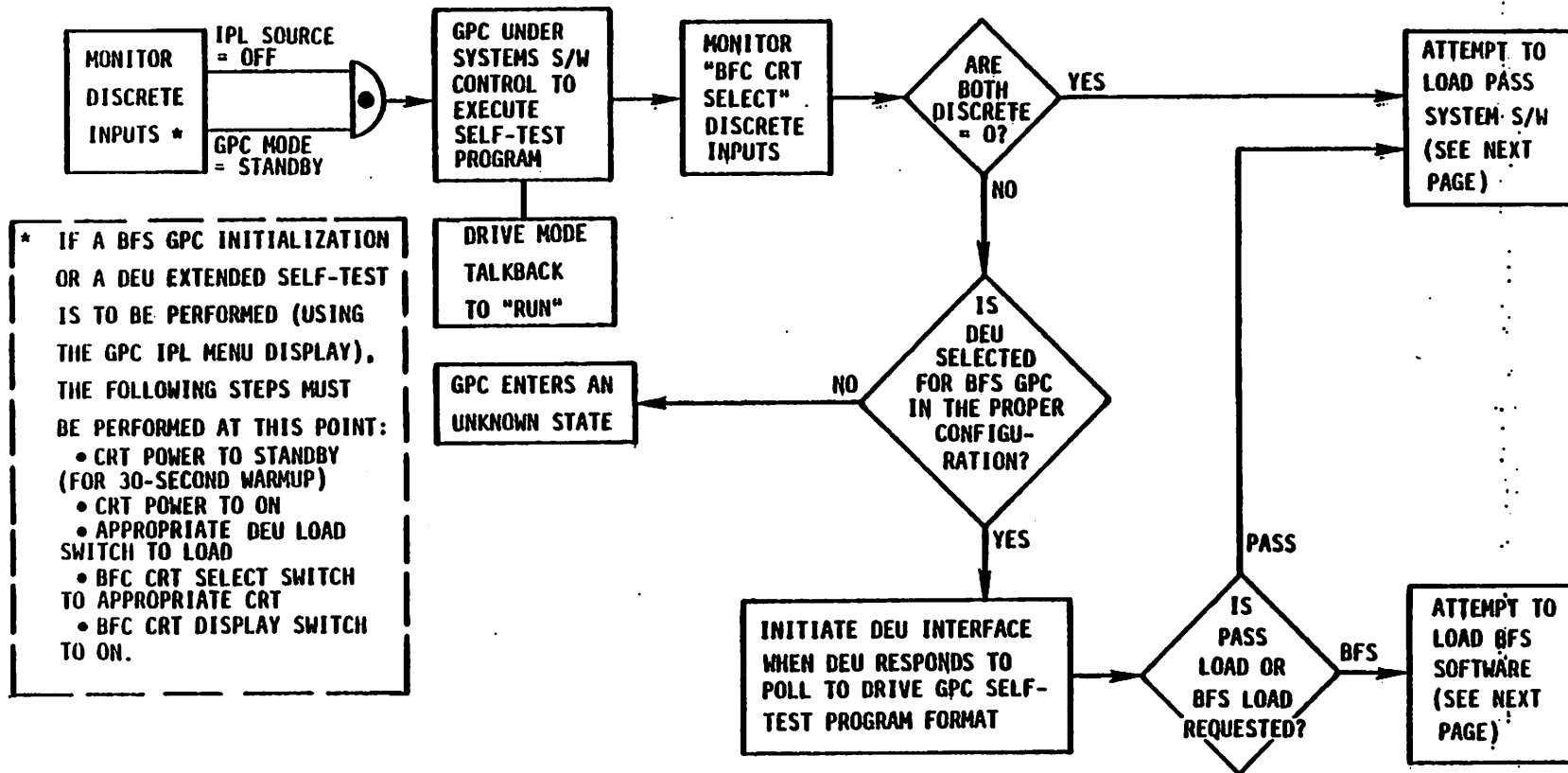
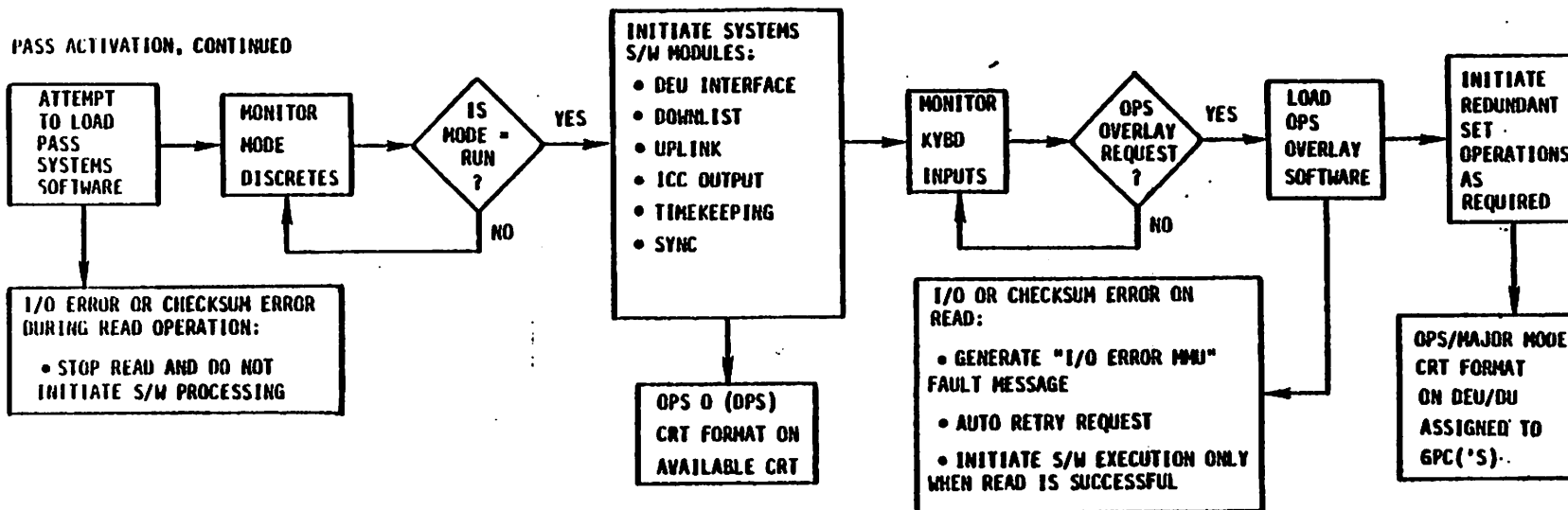


Figure 2-16.- GPC activation.

PASS ACTIVATION, CONTINUED



BFS ACTIVATION, CONTINUED

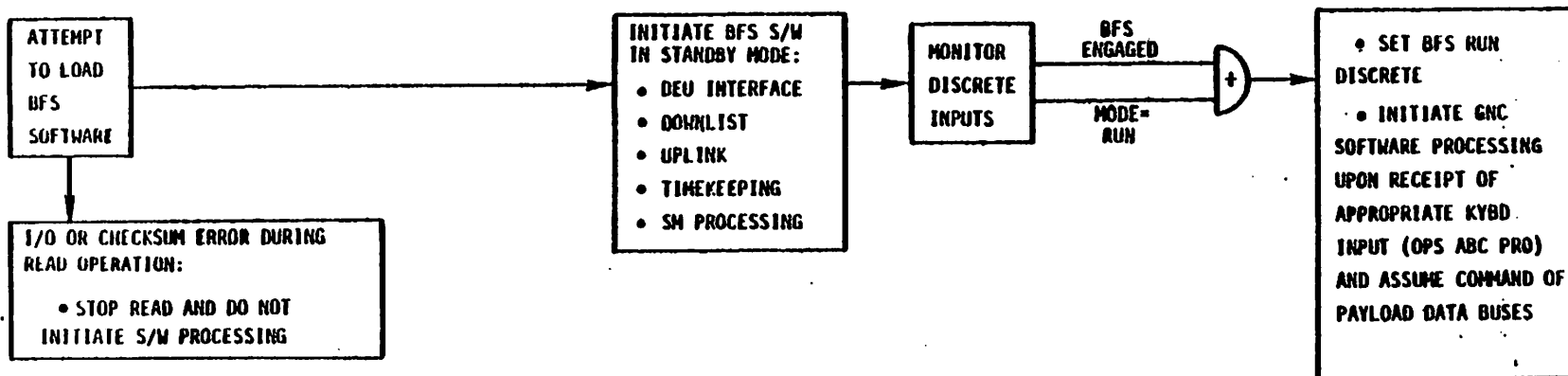


Figure 2-17.- PASS/BFS activation.

The GPC is now under software control to execute a STP, and it drives its mode talkback to RUN. The GPC then monitors the BFC CRT SELECT discrete inputs and if both of these discretés are "zero" (if the BFC CRT DISPLAY switch is in the OFF position), the GPC will attempt to load the PASS systems software.

However, if both these discretés are not "zero" the GPC checks to see if the DEU assigned to the BFS GPC is in the proper configuration as explained previously. If it is not, the GPC enters an unknown state (the results of this situation have not been defined). On the assumption the selected DEU has been properly configured, the GPC initiates the DEU interface and the DEU responds to the GPC poll. At this point, the GPC IPL MENU display is driven on the CRT. There are two item entries on this display which are used to select either a PASS software load request or a BFS software load request. When one of these item entries is initiated, the GPC branches off to attempt either the PASS or the BFS software load.

2.8.4.1 PASS activation.- At this point in the logic flow, the GPC attempts to load the PASS software from the MMU. The logic flows for both the PASS and BFS activations are illustrated in figure 2-17. If an I/O error or a checksum error is detected during this MMU read operation the read attempt is aborted. Since the read was unsuccessful, the software does not start processing and the IPL must be reinitiated. Assuming that the load has been completed successfully, the GPC monitors its MODE discrete and remains in this "wait" state until the MODE switch is moved to the RUN position. At this point, the PASS software begins processing. This software includes the DEU interface processing, the downlist and uplink processing, timekeeping, synchronization, and the GPC's ICC data bus output. At this time, the OPS 0 (GPC MEMORY) CRT format will be driven on the available CRT's. The GPC will then monitor inputs from the keyboard and, upon receiving an OPS overlay request, will attempt to read the OPS overlay software. If this software load is successfully read, redundant set operations will be initiated as required and the proper OPS/Major Mode CRT format will be displayed on the CRT assigned to the GPC('s). If this load is unsuccessful, the appropriate fault message will be generated and the transaction retried as described earlier. Execution of this software will only begin when the read is successful by at least one GPC required to execute the OPS.

2.8.4.2 BFS activation.- At this point in the logic flow, the GPC attempts to read the BFS software from the MMU. If an I/O or checksum error is detected, the read attempt is aborted. Assuming the software load is successful, BFS OPS 0 mode will be initiated. The BFS GPC now monitors its MODE discrete and the BFS ENGAGE discretés. Should the BFS ENGAGE discretés indicate that the BFS is engaged, or when the BFS GPC is moded to RUN, the BFS GPC sets its BFS RUN discrete. However, the BFS GPC does not perform any GNC software processing until a keyboard entry is made to activate the GNC software modules (which were included in the BFS software load).

Figure 2-18 illustrates the GPC IPL MENU CRT Display. In order to load the BFS software, the BFS LOAD ITEM must be entered (Item 16 EXECUTE). At this point, the PASS software could still have been loaded via an ITEM 15 EXEC entry.

```

                                GPC IPL MENU                                000/00:01:32
                                                                000/00:00:00
FUNCT1 01      FUNCT9  09      STP CYCLE COUNT                1
FUNCT2 02      FUNCT10 10      STP ERROR CODE                 049
FUNCT3 03      FUNCT11 11      ERROR CODE COUNT              1
FUNCT4 04      FUNCT12 12      TOTAL ERROR COUNT            7
FUNCT5 05      FUNCT13 13      ERRORS STILL IN LIST        4
FUNCT6 06      FUNCT14 14
FUNCT7 07      PASS        15
FUNCT8 08      BFS         16

                                MCDS BITE STATUS
                                MODE 3140
                                BSR1 8200
                                BSR2 8000
                                SWSW 0000

START FAST GPC TEST                17
STOP FAST GPC TEST                 18
START GPC SCREEN MEMORY TEST      19
STOP GPC SCREEN MEMORY TEST       20

                                PCN
                                BITE
                                STATUS
                                0000

START D/L OF TOGGLE BUFFER 1 21
START D/L OF TOGGLE BUFFER 5 22
STOP D/L                           23
STOP ON ERROR                       24
CONTINUE ON ERROR                   25*

UNEXPECTED CLOCK 2 INTERRUPT

```

Figure 2-18.- GPC IPL MENU CRT display.

If the BFS software is requested, the STP will load a software block from MMU called the Backup System Loader (BSL). After the load is complete, the STP will hand over control to the BSL which will then load the BFS software from MMU into the GPC. The BFS GPC will retain control of a CRT (the first CRT identified by the BFC CRT SELECT switch position).

The BFS GPC is now in the BFS OPS 0 state (as discussed in Section 5), and a display will appear on the CRT. If the DEU is in the GNC major function, the BFS MEMORY display will appear. If it is in the SM function, the HYD ACTR/PL display will appear. If the MAJ FUNC switch is in the PAYLOAD position, the CRT will become blank.

The BFS GPC is now listening on the FC data buses to see whether the PASS GPC's are in a Major Mode which supports the active PASS/BFS interface (currently GNC OPS 1 and OPS 3 phases). If so, the BFS will attempt to "TRACK" the PASS GPC's by listening on the FC data buses for the PASS "HIGH FREQUENCY EXECUTIVE" (25 Hz) listen commands and the PASS transfer data, and continue its processing using PASS data.

If the PASS is not operating in one of the appropriate Major Modes, the BFS GPC will ignore the PASS and enter the DISENGAGED-STAND ALONE mode in which no FC data bus inputs are considered valid.

If appropriate (depending upon the mission phase), the BFS GPC can be moded to RUN, at which time the PASS will surrender its control of the PL data buses and the BFS GPC will begin to command on the PL data buses.

If the BFS GPC is in the DISENGAGED-STAND ALONE state and it is desired to have the BFS GPC attempt to "TRACK" the PASS (such as after the PASS has been moded to OPS 101 or OPS 301), one of the following must be done: the BFS GPC MODE switch can be moded to HALT and back to STANDBY or RUN (placing the BFS GPC in BFS OPS 0); the keyboard entry of I/O RESET EXEC can be made via a BFS-controlled keyboard (the BFS GPC remains in its current OPS/Major Mode) or by moding the BFS GPC to the appropriate Major Mode (OPS 101 or OPS 301) via an OPS 101 PRO or OPS 301 PRO entry to the BFS keyboard.

At some point in this process, the OUTPUT switch for the BFS GPC will typically be placed in the BACKUP position to allow BFS Engagement.

SECTION 3
CREW STATIONS PANEL CONTROLS AND DISPLAYS

Each switch will be shown on its crew station accompanied by a functional description and operational limitations as necessary.

3.1 PANEL C2

3.1.1 CRT 1 (CRT 2, CRT 3)

3.1.1.1 POWER (3-position toggle switch).-

- ON: Allows 28 Vdc to designated Display Electronics Unit (DEU) and Display Unit (DU) power supplies.
- STBY: Allows 28 Vdc only to high-voltage power supply to warm-up Cathode Ray Tube (CRT) filament in designated DU (no CRT characters).
- OFF: Inhibits all power inputs to designated DEU and DU.
- NOTE: CRT warm-up occurs in ON or STBY position.

3.1.1.2 MAJ FUNC (3-position toggle switch).- Changes which major function software is to process keystrokes and to drive CRT data for the designated DEU/DU.

Operational Limitations

- The selected major function's Operational Sequence (OPS) display will appear on the designated CRT unless overlaid by a Specialist Function (SPEC).
- Moving the switch from one major function to another, then back to the original major function returns the underlying major mode or SPEC display to the CRT.
- Moving the switch to another major function in Primary Avionics Software System (PASS) causes that major function's major mode display to appear on the CRT unless:
 - A SPEC was active on the CRT the last time the major function was selected; then the SPEC appears on the CRT if an OPS transition has not occurred.

OR

- The new major function isn't active, then the display on the CRT goes blank and an error message is generated.

OR

- The selected major function already is in command-of three buses, then the display doesn't change and a fault message appears on the CRT.
- Moving a MAJ FUNC switch of a CRT assigned to the Backup Flight System (BFS) to "SM" will cause the HYD ACTR/PL display to appear on the CRT
 - "GNC" will cause the appropriate Guidance, Navigation and Control (GNC) major mode display to appear on the CRT unless a SPEC was active the last time GNC was selected; then the SPEC appears on the CRT if no OPS transition has occurred. If GNC is not active, the CRT display doesn't change.
 - "PL" will cause the display to blank.

3.1.2 LEFT CRT SEL (2-position toggle switch)

Directs DEU/DU 1 or DEU/DU 3 to process keystrokes from the left keyboard in the forward station.

3.1.3 RIGHT CRT SEL (2-position toggle switch)

Directs DEU/DU 2 or DEU/DU 3 to process keystrokes from the right keyboard in the forward station.

Operational Limitation: DEU/DU 3 will process keystrokes from both keyboards if both CRT SEL switches are in position "3". Hence, if the combined keyboard inputs pass DEU syntax checks, an unwanted message or command could be transmitted to GPC's listening to DEU 3 response messages.

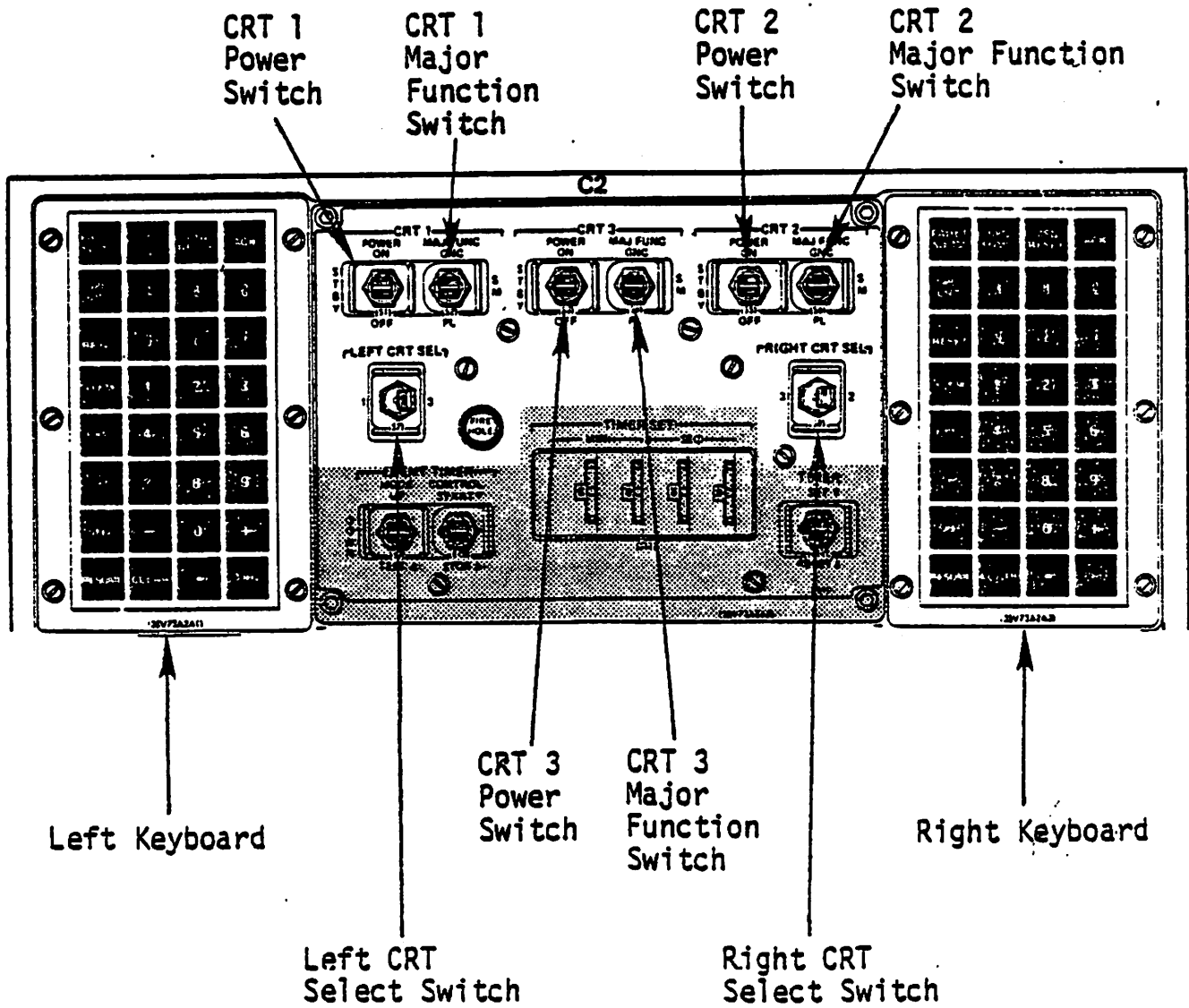


Figure 3-1.- Panel C2.

3.2 OFT KEYBOARD

- ① FAULT SUMM - A single keystroke message which includes the FAULT display in any OPS. SPEC 99 PRO invokes the FAULT display and clears all messages.
- ② GPC/CRT - The first keystroke of a keyboard message (e.g., GPC/CRT 43 EXEC) which assigns a specific Multifunction CRT Display System (MCDS) to a particular General Purpose Computer (GPC). A DEU/CRT may be isolated from the PASS GPC's by entering "0" for the GPC on a PASS keyboard. Isolation of a CRT from the BFS is similarly done via a BFS keyboard. The BFS responds to CRT reassignment via this keyboard message and the proper configuration of the BFC CRT DISPLAY and SELECT switches on Panel C3.
- ③ I/O RESET - The first key of a keyboard message (I/O RESET EXEC) which restores Bus Control Element (BCE) chains and resets any Bus Terminal Unit (BTU) port masks. PASS responds to inputs from a PASS keyboard while the BFS responds to inputs from a BFS keyboard or PASS keyboard when BFS is tracking the PASS (OPS land 3).
- ④ ITEM - The first key of a keyboard message which acts as a software switch (e.g., ITEM 14 EXEC), or allows data to be input for software processing (e.g., ITEM 13 + 1099 EXEC) for supporting SPEC's and OPS.
- ⑤ EXEC - The last key of a keyboard message to:
 - Enter data on SPEC'S and OPS displays (e.g., ITEM 13 + 7099 EXEC).
 - Assign a specific CRT to a particular GPC (e.g., GPC/CRT 43 EXEC).
 - Enable or inhibit software processes (e.g., ITEM 14 EXEC).
 - Restore BCE chains and reset BTU port masks (e.g., I/O RESET EXEC).
- ⑥ OPS - The first key of a keyboard message to initiate a new OPS (e.g., OPS 301 PRO), change major modes (e.g., OPS 302 PRO), or restart the current Ops major mode (only in GNC OPS major modes 201, 301, 801, and 901, and SM OPS major modes 201 and 202). The latter technique (OPS mode recall) also causes software to assign data buses according to the data bus assignment portion of the memory configuration table on GPC MEMORY. OPS 0 PRO cancels any Systems Management (SM) and Payload (PL) OPS when SM and PL, respectively, are selected via the Major Function switch, but cancels only GNC OPS 2 and 9 when GNC is selected.
- ⑦ SPEC - The first key of a keyboard message to invoke SPEC's or DISP's (e.g., SPEC 50 PRO). A major function can support a maximum of three CRT's with two SPEC's, three displays (DISP's), of any combination of three SPEC's and DISP's for the three CRT's. A SPEC may overlay an OPS while a DISP may overlay a SPEC or OPS. The same SPEC may be driven on two CRT's for the same major function (using the maximum of two SPEC's for the major function). Systems software SPEC's and DISP's count against the major function in which they were called.
- ⑧ SYS SUMM - A single keystroke message which invokes the System Summary (SYS SUMM) CRT display for the current OPS in the GPC. Only Ops 9 in all major functions do not have SYS SUMM displays. When SYS SUMM is entered for an OPS not having a SYS SUMM display, an ILLEGAL ENTRY fault message will be generated.

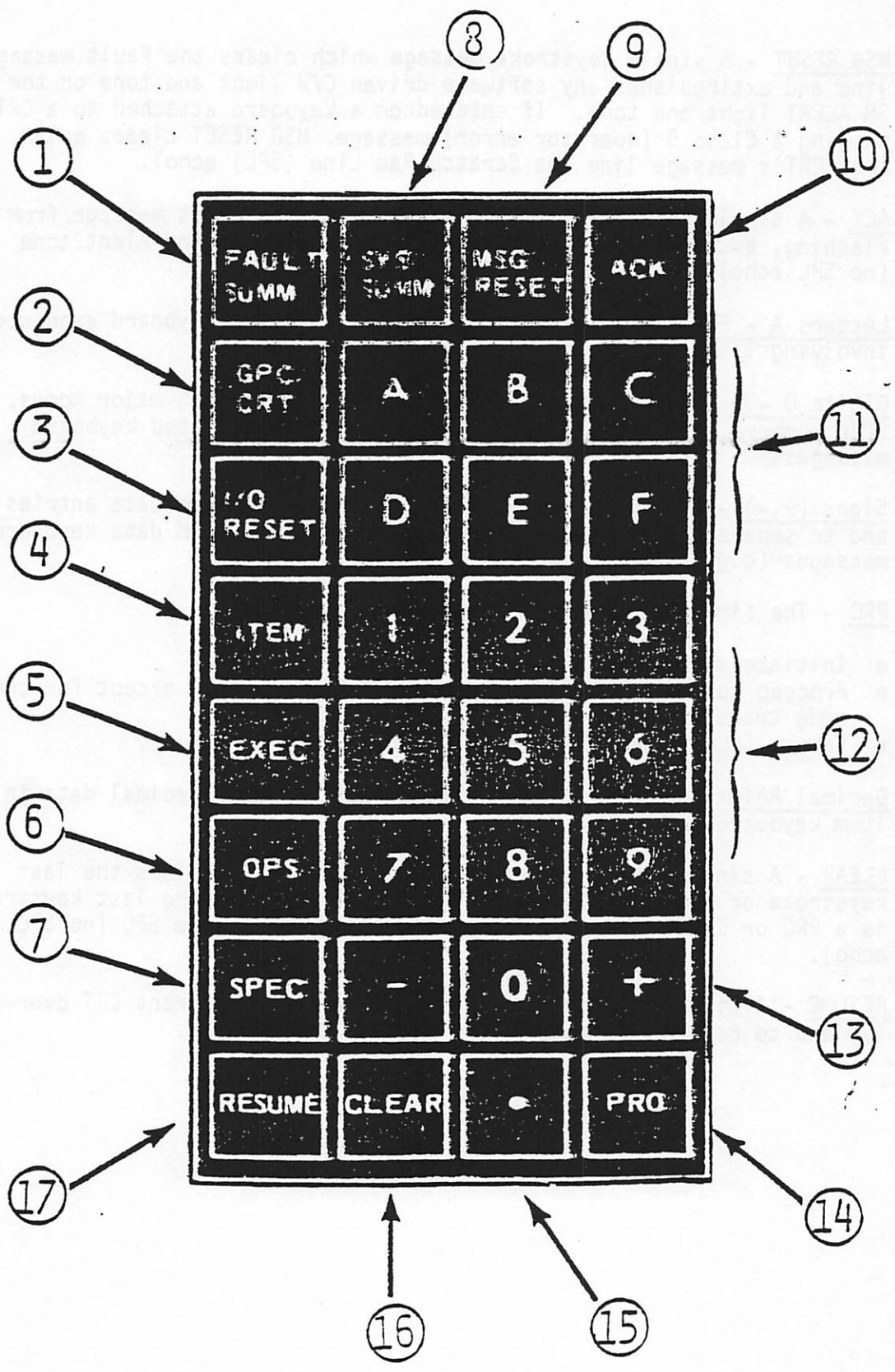


Figure 3-2.- OFT keyboard.

- ⑨ MSG RESET - A single keystroke message which clears the fault message line and extinguishes any software driven C/W light and tone or the SM ALERT light and tone. If entered on a keyboard attached to a CRT showing a Class 5 (operator error) message, MSG RESET clears only that CRT's message line (no Scratch Pad Line (SPL) echo).
- ⑩ ACK - A single keystroke message which stops the fault message from flashing, extinguishes the SM ALERT light and stops the Alert tone (no SPL echo).
- ⑪ Letters A - F - Allow hexadecimal data entries for keyboard sequences involving ITEM numbers.
- ⑫ Digits 0 - 9 - Used to specify ITEM numbers, data, OPS major modes, SPEC numbers, and GPC/CRT designation for the associated keyboard messages.
- ⑬ Signs (+,-) - Used to specify algebraic value for item data entries and to separate ITEM numbers from data entries on ITEM data keyboard messages (e.g., ITEM 1 + 6 + 14 + 12 EXEC).
- ⑭ PRO - The final keystroke in keyboard messages to:
- Initiate a new OPS (e.g., OPS 301 PRO).
 - Proceed to the next major mode (e.g., OPS 302 PRO) except for certain mode transitions in GNC OPS 1, OPS 6, and OPS 3.
 - Invoke SPEC's and DISP's (e.g., SPEC 50 PRO).
- ⑮ Decimal Point (.) - is used to enter floating point decimal data in item keyboard messages.
- ⑯ CLEAR - A single keystroke message which generally blanks the last keystroke or "ERR" and the erroneous keystroke. If the last keystroke is a PRO or EXEC, entering CLEAR will blank the entire SPL (no SPL echo).
- ⑰ RESUME - A single keystroke used to terminate the current CRT overlay and to return the underlying SPEC or OPS display.

3.3 FORWARD STATION ROTATIONAL HAND CONTROLLERS (RHC)

3.3.1 BFS Engage Pushbutton

BFS Engage Pushbutton engages the BFS and disengages the PASS if the BFS GPC's OUTPUT switch (Panel O6) is in BACKUP. If no GPC OUTPUT switch is in BACKUP, PASS remains in control of the vehicle. If a GPC OUTPUT switch is in BACKUP but no GPC contains BFS Software, the PASS GPC's with OUTPUT = NORMAL will give up vehicle control but the PASS GPC with OUTPUT = BACKUP remains in control of the vehicle.

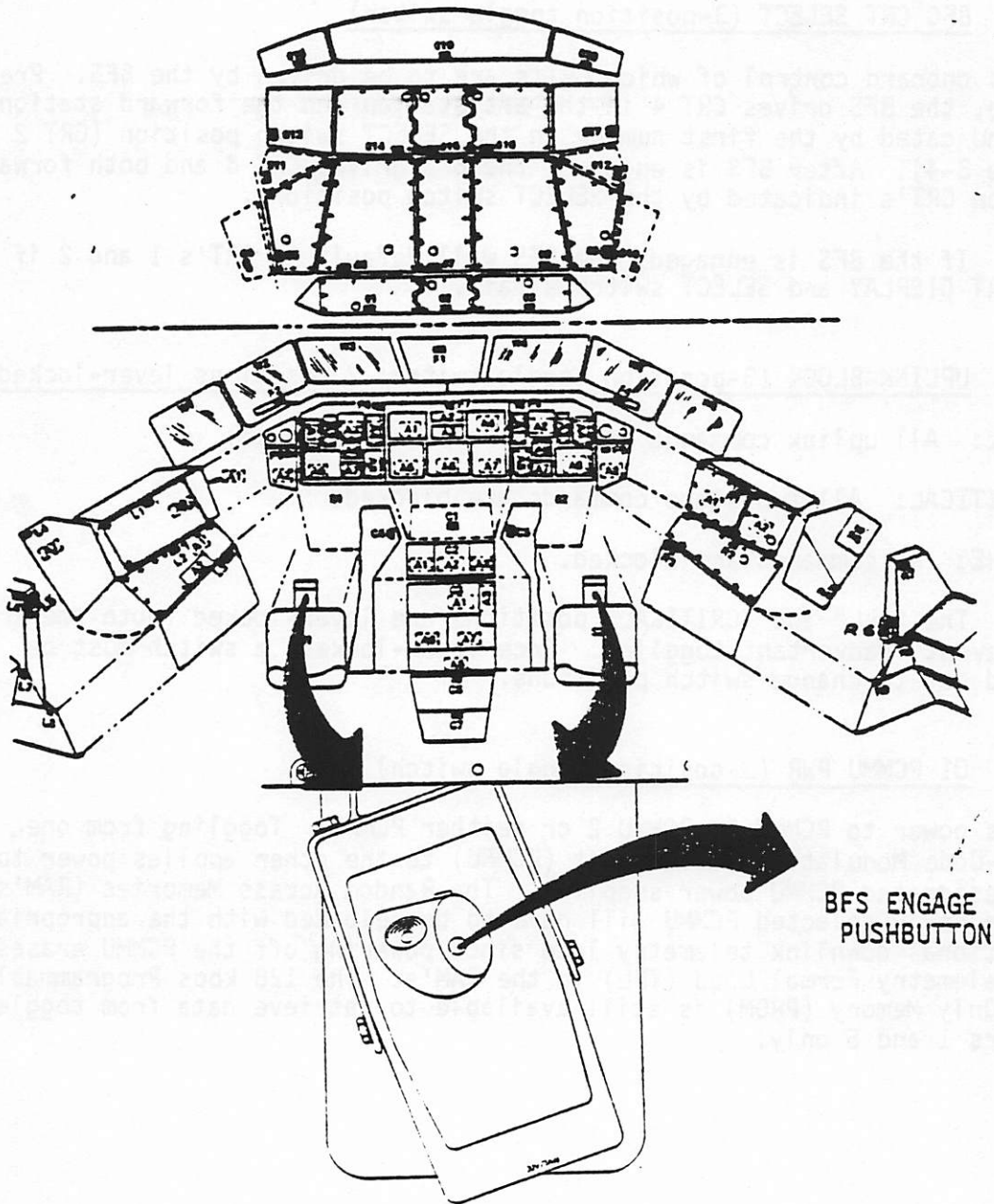


Figure 3-3.- Rotational hand controllers BFS ENGAGE pushbutton.

3.4 PANEL C3

3.4.1 BFC CRT DISPLAY (2-position toggle switch)

- ON: Provides power to the SELECT switch.
- OFF: BFS CRT selection can be accomplished with GPC/CRT key when the display switch is in OFF.

3.4.2 BFC CRT SELECT (3-position toggle switch)

Allows onboard control of which CRT's are to be driven by the BFS. Pre-engage, the BFS drives CRT 4 in the aft station and the forward station CRT indicated by the first number in the SELECT switch position (CRT 2 in figure 3-4). After BFS is engaged, the BFS drives CRT 4 and both forward station CRT's indicated by the SELECT switch positions.

NOTE: If the BFS is engaged, the BFS will default to CRT's 1 and 2 if the BFC CRT DISPLAY and SELECT switches fail.

3.4.3 UPLINK BLOCK (3-position toggle switch: 2 positions lever-locked)

- ALL: All uplink commands are not processed (blocked).
- CRITICAL: All two-stage commands are blocked.
- NONE: No commands are blocked.

NOTE: The "ALL" and "CRITICAL" positions are lever-locked (note the " ") to prevent inadvertant toggling. Once lower-locked, a switch must be pulled out to change switch positions.

3.4.4 OI PCMMU PWR (3-position toggle switch)

Allows power to PCMMU 1, PCMMU 2 or neither PCMMU. Toggling from one Pulse-Code Modulation Master Unit (PCMMU) to the other applies power to the designated PCMMU power supplies. The Random Access Memories (RAM's) in the newly selected PCMMU will have to be reloaded with the appropriate operational downlink telemetry load since powering off the PCMMU erases the Telemetry Formal Load (TFL) in the RAM's. The 128 kbps Programmable Read-Only Memory (PROM) is still available to retrieve data from toggle buffers 1 and 5 only.

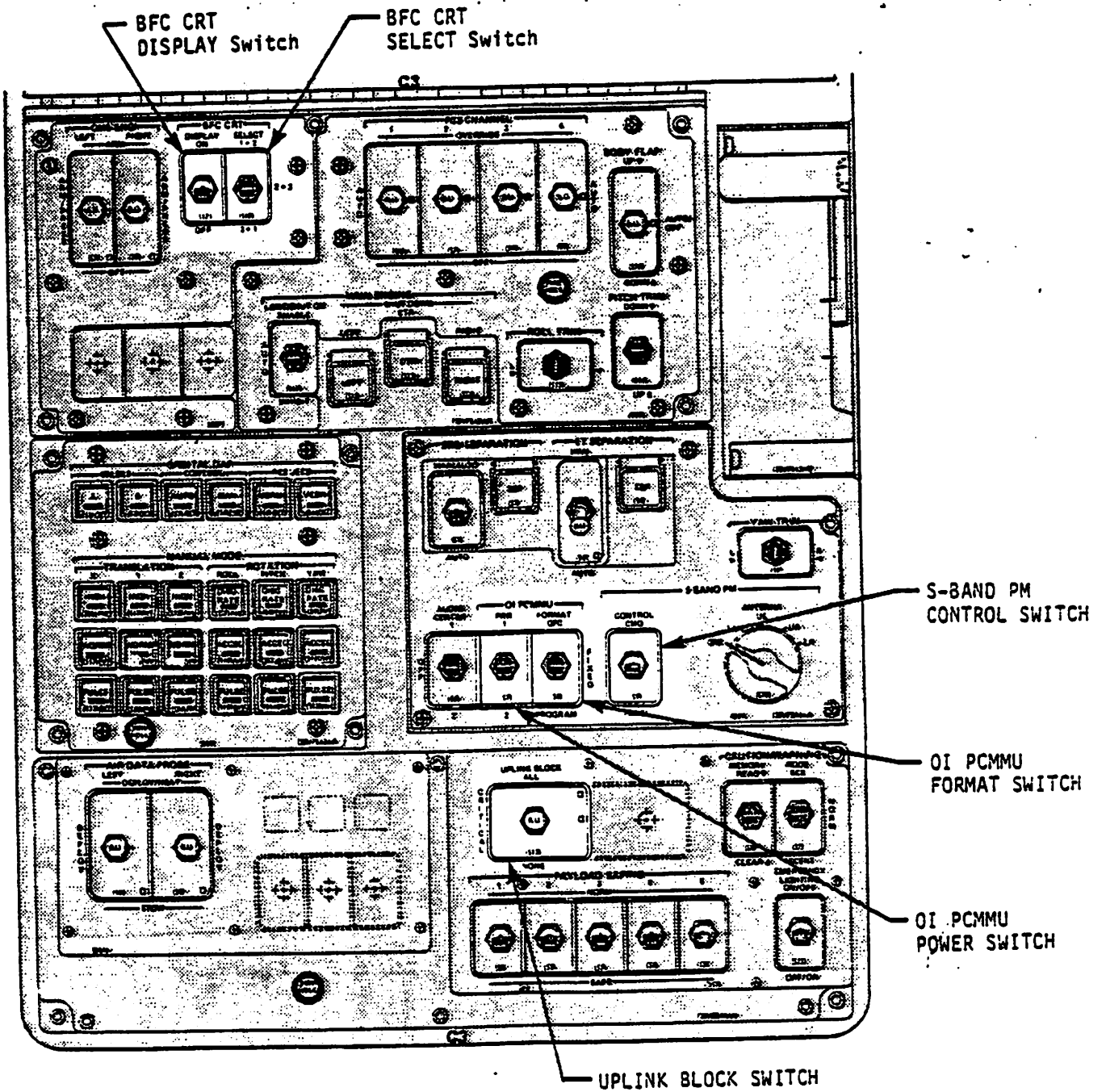


Figure 3-4.- Panel C3.

3.4.5 OI PCMMU FORMAT (3-position toggle switch)

Allows onboard control of the PCMMU telemetry formatter outputs.

- GPC: The PCMMU logic updates either the 128 kbps RAM or the 64 kbps RAM and selects which memory will be read by the 128 kbps telemetry formatter as directed by the GPC via keyboard inputs or uplink.
- FIXED: The 128 kbps telemetry formatter reads the fixed 128 kbps PROM format while the 64 kbps telemetry formatter reads the 64 kbps RAM format.
- PROGRAM: Both PCMMU telemetry formatters (64 and 128) read the program-mable TFL RAM formats to build the telemetry output to the Network Signal Processors (NSP's).

3.4.6 S-BAND PM CONTROL (2-position toggle switch)

Allows onboard control to direct the Ground Command Interface Logic (GCIL) to use uplink commands (CMD) or crew station panel switches for S-BAND PM hardware selection. When placed from "PANEL" to "CMD", the GCIL will control S-BAND PM hardware based on crew station switches until the GPC processes a valid uplink command to control S-BAND PM hardware (NSP's, pre-amps, power-amps and transponders).

3.5 PANELS F2, F4, M052J

3.5.1 MASTER ALARM (black letters on red background)

Illuminated by the Caution and Warning (C&W) electronics upon detection of a Class 2 problem. Data Processing Subsystem (DPS) Class 2 problems involve GPC fail-to-sync and sumword miscompare cases. Extinguished only by depression of any MASTER ALARM pushbutton indicator. Accompanied by a MASTER ALARM tone.

3.5.2 BFC (yellow letters on black background)

Illuminated by the BFS GPC when BFS is engaged.

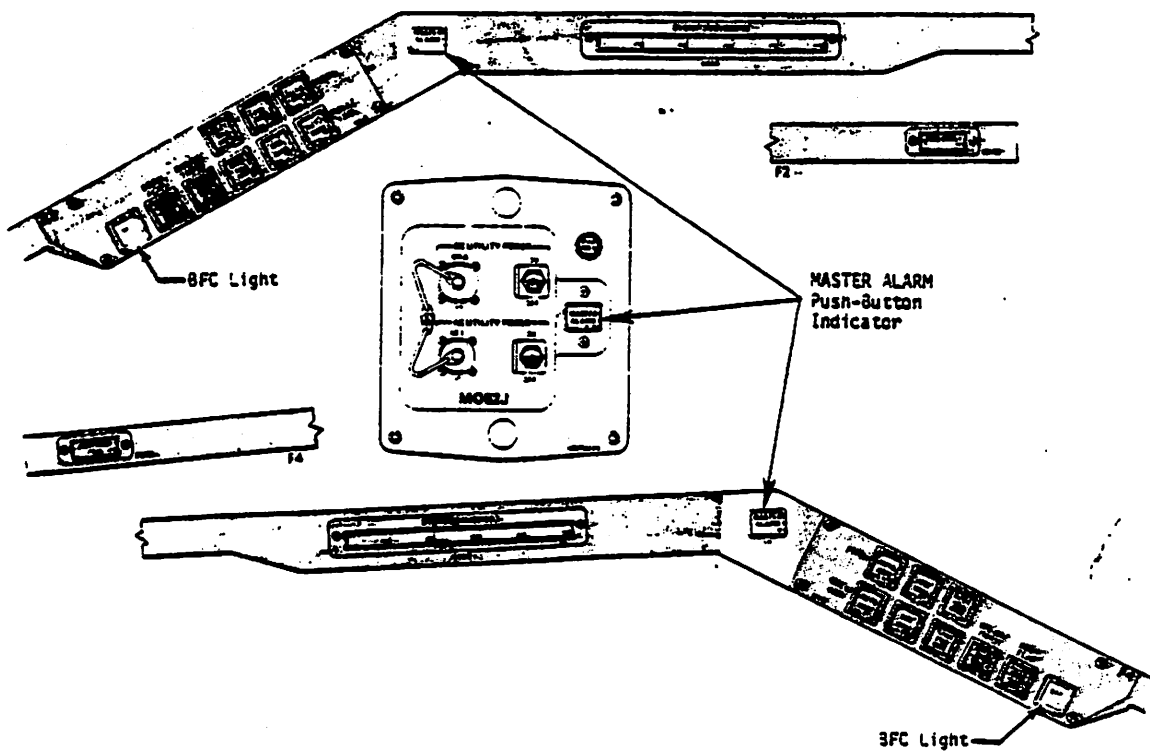


Figure 3-5.- Panels F2, F4 and M052J.

3.6 PANEL F6

3.6.1 BFC DISENGAGE (2-position, momentary, guarded toggle)

Sets three discrete inputs to all five Backup Flight Controller (BFC) modules to disengage the BFS.

NOTE: The PASS will not assume control of the vehicle without an overt action onboard to prepare the PASS for vehicle control (e.g., reinitialize and/or reformation of PASS redundant set).

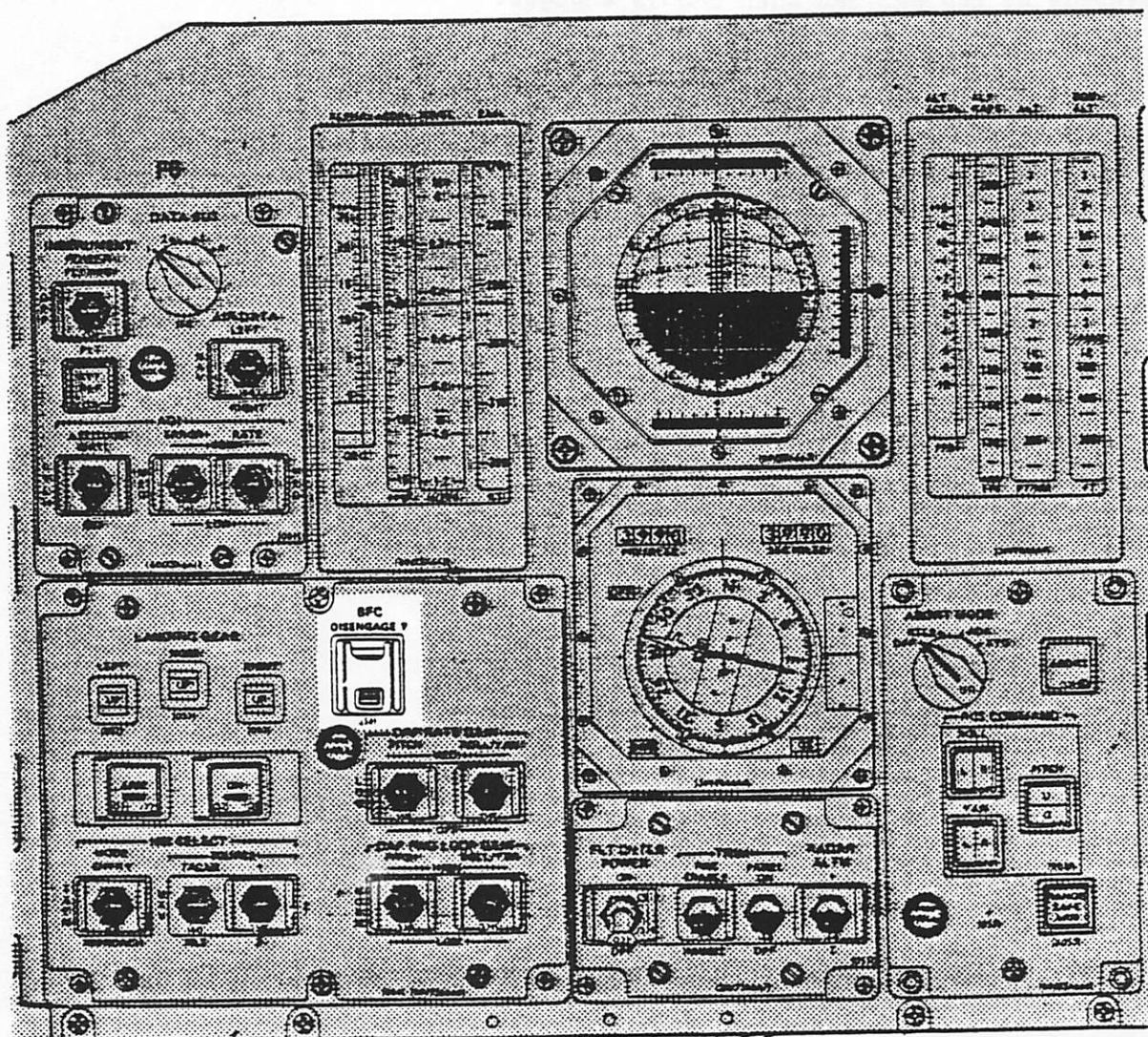


Figure 3-6.- Panel F6.

3.7 PANEL F7

3.7.1 CRT 1 (CRT 2, CRT 3)

(5" x 7" phosphorus screen activated by magnetically positioned electron beam) - Presents alphanumeric characters and graphics as directed by a GPC via a DEU.

3.7.1.1 BRT (potentiometer). - Allows onboard control of associated total CRT screen brightness from blackout to full brightness.

3.7.1.2 DEU, DU (2-position talkback). - Indicates illustrated "NO-GO" state when the BITE detects that a problem has existed for at least 6-seconds in the associated device. To return the flag to black (no problem detected), the flag must be manually twisted in a counterclockwise direction and released. If the problem still exists, the flag will return to illustrated "NO-GO" state. Accompanied by CRT BITE Class 3 fault message and associated annunciations if critical Built-In Test Equipment (BITE) problem.

3.7.2 SM ALERT (black letters on blue background)

Illuminates when a Class 3 alert problem is detected by software. DPS Class 3 problems include Input/Output (I/O) error, BCE chain bypass, GPC configuration, BITE, and timekeeping cases. Accompanied by alert tone, and fault message. LIGHT & TONE extinguished by depression of ACK or MSG RESET keys. Tone independently terminated by Software in 3 seconds.

3.7.3 GPC (red letters on black background)

Illuminated by C&W when any GPC issues its SELF-FAIL discrete output based on voter hardware, synchronization software, or sumword comparison logic. Normally accompanied by GPC STATUS matrix yellow diagonal light, MASTER ALARM lights and tone, Panel R12 CAUTION/WARNING STATUS matrix light (when status requested), BACK-UP C/W ALARM light on Panel F7 C&W matrix, and fault message. Extinguished by correction of problem or by powering-off faulty GPC.

3.7.4 BACKUP C/W ALARM (red letters on black background)

Illuminated by C&W via DPS MDM's when a Class 2 C&W problem is detected by software. DPS Class 2 problems include GPC fail-to-sync and sumword miscompare cases.

Normally accompanied by GPC STATUS matrix light, MASTER ALARM lights and tone, and fault message. Extinguished by MSG RESET key depression.

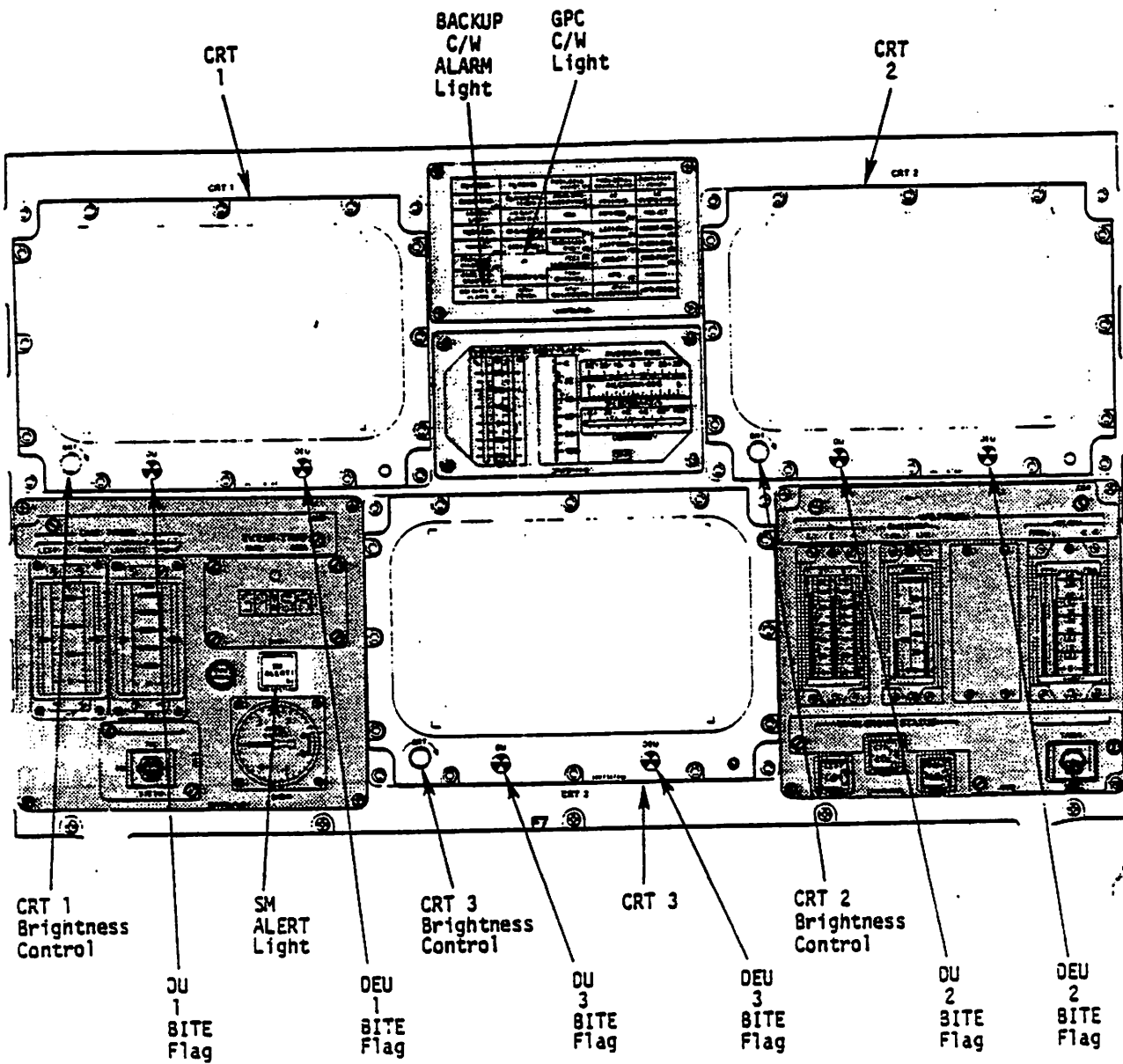


Figure 3-7.- Panel F7.

3.8 PANEL L4

3.8.1 INST R (cb)

Permits power to the Panel 08 potentiometer for instrumentation intensity control in the right forward station (e.g., right keyboard) instrumentation lamps.

3.8.2 INST L/CRT (cb)

Permits power to the Panel 06 potentiometer for instrumentation intensity control in the left and center forward stations (e.g., left keyboard) instrumentation lamps.

3.8.3 PANEL MS

Permits power to the Panel R10 potentiometer for intensity control in the mission specialist (MS) station (e.g., keyboard) panel lamps.

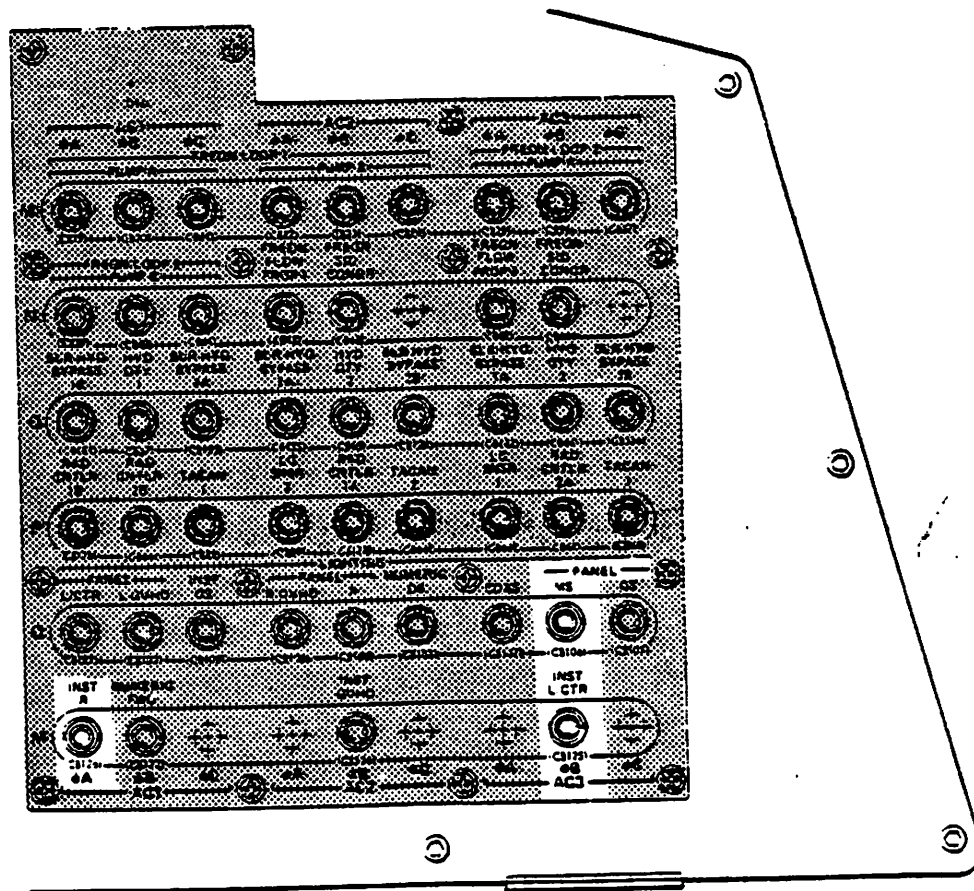


Figure 3-3.- Panel L4.

3.9 PANEL M042F .

3.9.1 GPC MEMORY DUMP (6 position rotary switch)

Identifies a GPC to be selected for a special Hardware Initiated Stand-Alone Memory (HISAM) dump capability. The selected GPC's OUTPUT switch (Panel O6) must be in TERMINATE, and the MODE switch must in HALT. When the MODE switch is moved to STBY, the GPC begins sending a 32 half-word frame downlist to the PCMMU's toggle buffer 4. If the PCMMU 128 kbps "fixed" format or a TFL which reads toggle buffer 4 is used, the contents of the selected GPC's memory will be included in the operational telemetry downlink until the selected GPC'S MODE switch is moved to HALT or power is turned off. A dump of a GPC main memory using this method will require about 5-10 minutes to complete.

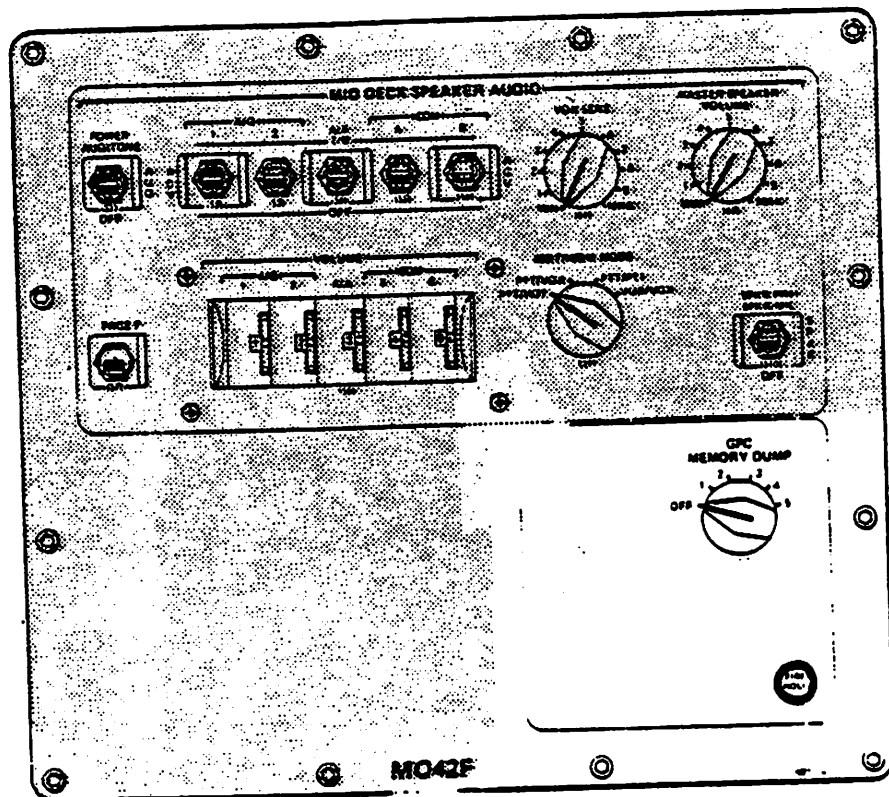


Figure 3-9.- Panel M042F.

3.10 Panel 01 - GPC STATUS Matrix

(5 x 5 light matrix with yellow lights on the main diagonal and white lights elsewhere).

Yellow, main diagonal light indicates a GPC has determined (i.e., voted) itself failed. A white light indicates a GPC has determined (i.e., voted) another GPC has failed. Normally, during Ascent and Entry phases, a failed PASS GPC will be indicated with its GPC STATUS matrix column, the GPC and BACKUP C/W ALARM lights (Panel F7), the MASTER ALARM lights (Panels F2, F4 and A7) and GPC fault messages on PASS driven CRT's. If the BFS GPC fails during Ascent or Entry, only its GPC STATUS yellow diagonal light, the GPC C&W light, and the MASTER ALARM lights will illuminate. During on-orbit operations, failure of one of the two GNC GPC's or the SM GPC may be indicated with the yellow GPC STATUS diagonal light, the GPC and BACKUP C/W ALARM lights, the MASTER ALARM lights, and/or GPC fault messages. In each instance, the C&W alarm will also occur. Different situations may involve different combinations of the annunciators mentioned above with other annunciators not mentioned (e.g. fault messages).

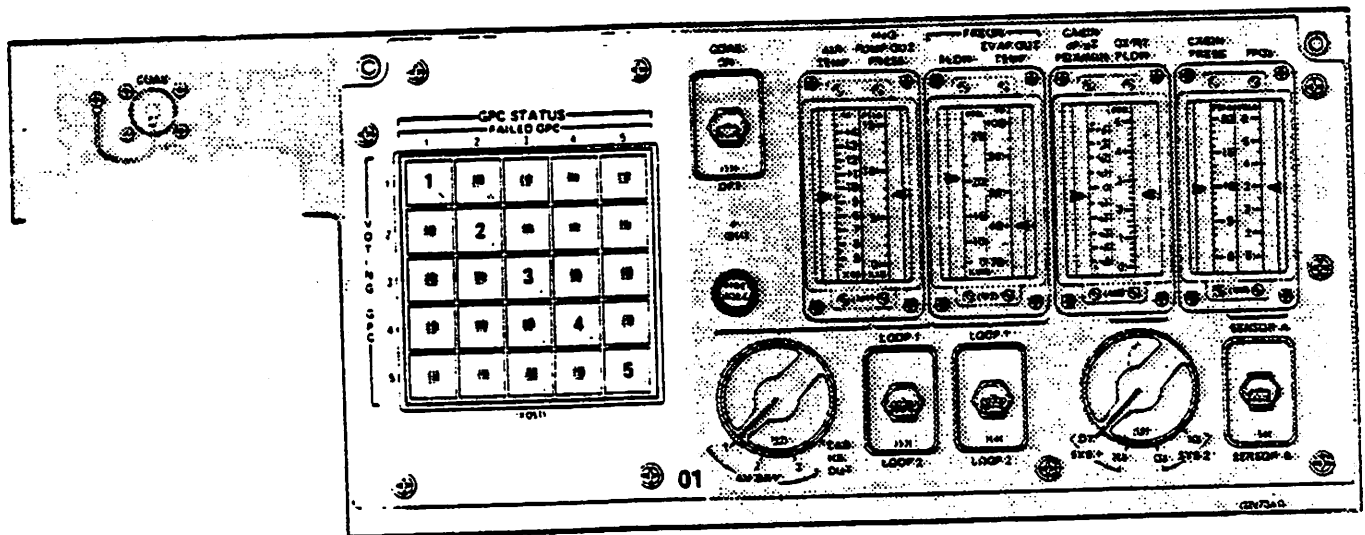


Figure 3-10.- Panel 01, GPC STATUS matrix.

3.11 PANEL 06

3.11.1 LEFT/CTR INSTRUMENT (potentiometer)

Permits variable input to control brightness of left/center instrumentation lamps in the forward station; e.g., left keyboard lamps.

3.11.2 ANNUNCIATOR LAMP TEST (3-position momentary toggle switch)

Permits power to the forward station annunciator lamps (including the Panel 01 GPC STATUS matrix when in the "LEFT" position) for bulb test.

3.11.3 ANNUNCIATOR INTENSITY (2-position toggle switch and potentiometer)

Permits onboard intensity control of annunciator lamps (including Panel 01 GPC STATUS matrix). When the INTENSITY toggle switch is in "BRIGHT", the forward station annunciator lamps are driven to full brightness. When the INTENSITY toggle switch is in "VAR", the LOW-MED potentiometer controls the variable annunciator lamp intensity level from low to medium.

3.11.4 MDM PL1 (PL2, PL3, FF1-4, FA1-4) (2 position toggle switch)

Permits power inputs to the designated multiplexer/demultiplexer (MDM) (typical of all 10 DPS MDM's). The PL3 MDM power switch is not wired for SS 1 and 2.

3.11.5 DEU LOAD (2-position, momentary toggle switch)

Requests the Initial Program Load (IPL) software in a Mass Memory Unit (MMU) to be stored in a GPC for transfer to the designated DEU (typical of all four DEU's). When the switch is momentarily placed in LOAD during nominal DEU operations, the GPC will stop responding to keyboard inputs from that DEU and sending data for the CRT. The DEU/DU will be lost for nominal usage until initialization which can occur only via a GPC just after GPC IPL.

3.11.6 General Purpose Computer

3.11.6.1 POWER (2-position, guarded toggle switch). - Permits power inputs to the designated GPC (typical of all 5 GPC's).

3.11.6.2 OUTPUT (2-state talkback). - Indicates barberpole for a PASS GPC if it stops output over its assigned Flight Critical (FC) data bus(es) pre-BFS engage or when the BFS is engaged. Indicates barberpole for the BFS GPC pre-BFS engage or if it stops output over the FC data buses post-BFS engage. During nominal operation of a GPC, a loss of power, critical

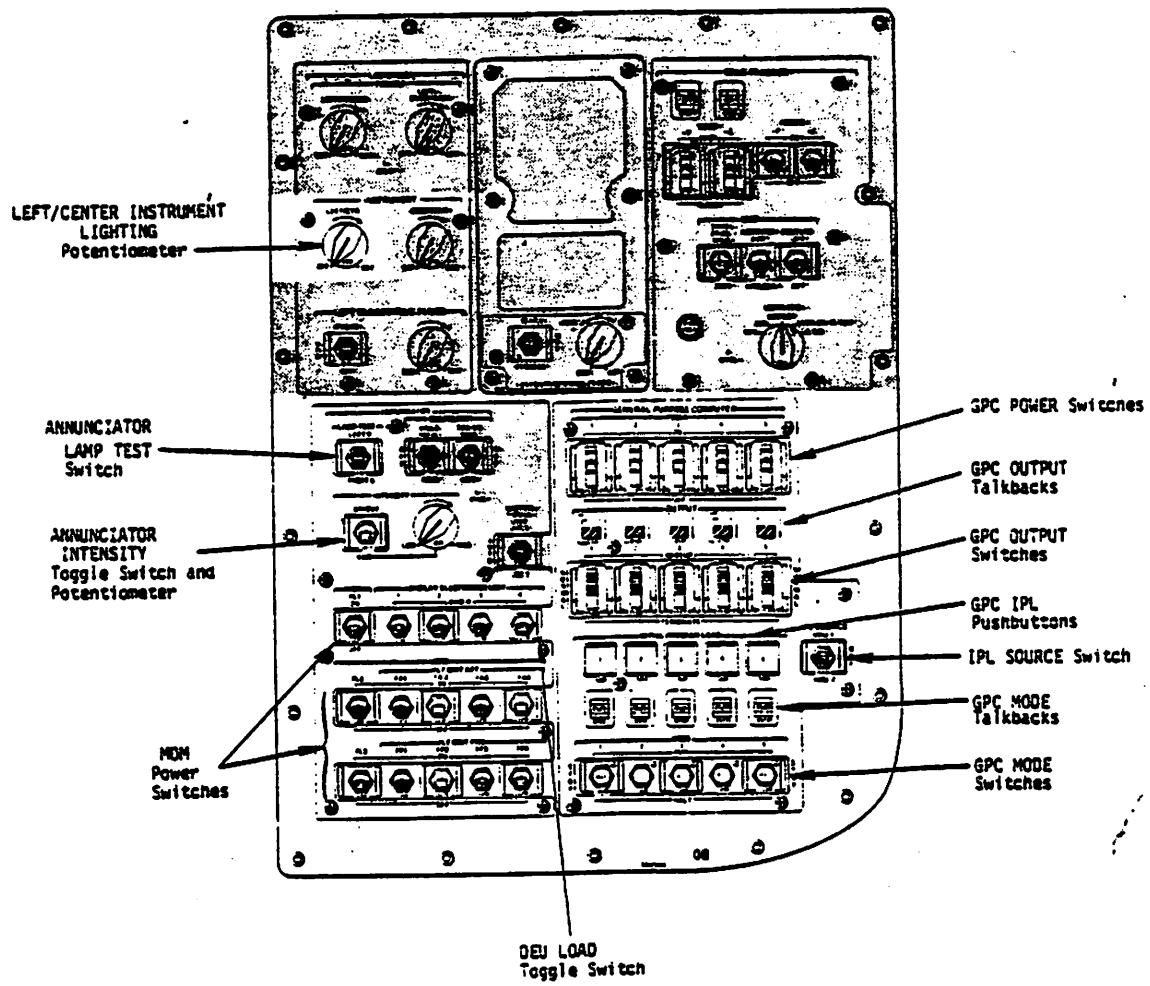


Figure 3-11.- PANEL 06.

internal failure halting Software, OUTPUT Switch = TERMINATE or MODE Switch = HALT will cause a GPC's OUTPUT talkback to go barberpole. Nominal state is gray.

3.11.6.3 OUTPUT (3-position, guarded toggle switch).- Terminates FC output for the indicated GPC and allows onboard acknowledgement of BFS GPC for coordination of PASS to BFS handover of vehicle control. Selection of BFS GPC occurs during GPC IPL/Activation and not with this switch. If all five GPC OUTPUT switches (often called the BACKUP/NORMAL/TERMINATE) are in either NORMAL or TERMINATE, the PASS GPC's will retain control of the vehicle if BFS ENGAGE is requested via an RHC pushbutton. If more than one GPC's OUTPUT switch is in BACKUP, the higher numbered GPC's OUTPUT switch will be acknowledged to be in BACKUP; all others will default to NORMAL.

3.11.6.4 IPL (pushbutton).- Initiates IPL for the indicated GPC if power is on, MODE = HALT, an MMU is selected and the selected, MMU is ready. Depression of the IPL pushbutton during nominal GPC operations will not be recognized. Only one GPC at a time is initialized since command of the MM 1 and 2 data buses is required.

3.11.6.5 MODE (3-state talkback).- Indicates status of software processing for designated GPC. During the IPL sequence, IPL will be driven on the talkback. During nominal operations RUN will be driven unless power is off, a critical internal failure has halted software, or MODE = HALT/STBY, in which case barberpole will be displayed.

3.11.6.6 MODE (3-position toggle switch: one position lever-locked).-

- RUN: The designated GPC is under software control.
- STBY: A PASS GPC is in a software "WAIT" state. A BFS GPC is under software control.
- HALT: The designated GPC is under hardware control, processing no software.

NOTE: During initialization, a GPC's MODE switch is in HALT. After initialization, transition from HALT to STBY enables loading of system software while subsequent transition from STBY to RUN initiates execution of the OPS 0 system software. Transition from RUN to STBY during nominal operations stops a PASS GPC from executing software while transition back to RUN only initiates the OPS 0 system software. Normal shutdown of a GPC involves transition from RUN to STBY to HALT. Transition from RUN directly to HALT prevents an orderly shutdown of the GPC to a "known" state.

3.11.7 IPL SOURCE (3-position toggle switch)

Indicates to GPC's which MMU is to be the source of the IPL software. When in OFF, IPL will not occur.

3.12 PANEL 08

3.12.1 RIGHT INSTRUMENT (potentiometer)

Permits variable input to control brightness of right forward station instrumentation lamps; e.g., right keyboard lamps.

3.12.2 ANNUNCIATOR LAMP TEST (3-position toggle)

Permits power to the forward station annunciator lamps (including the Panel 01 GPC STATUS matrix when in the "LEFT" position) for bulb test.

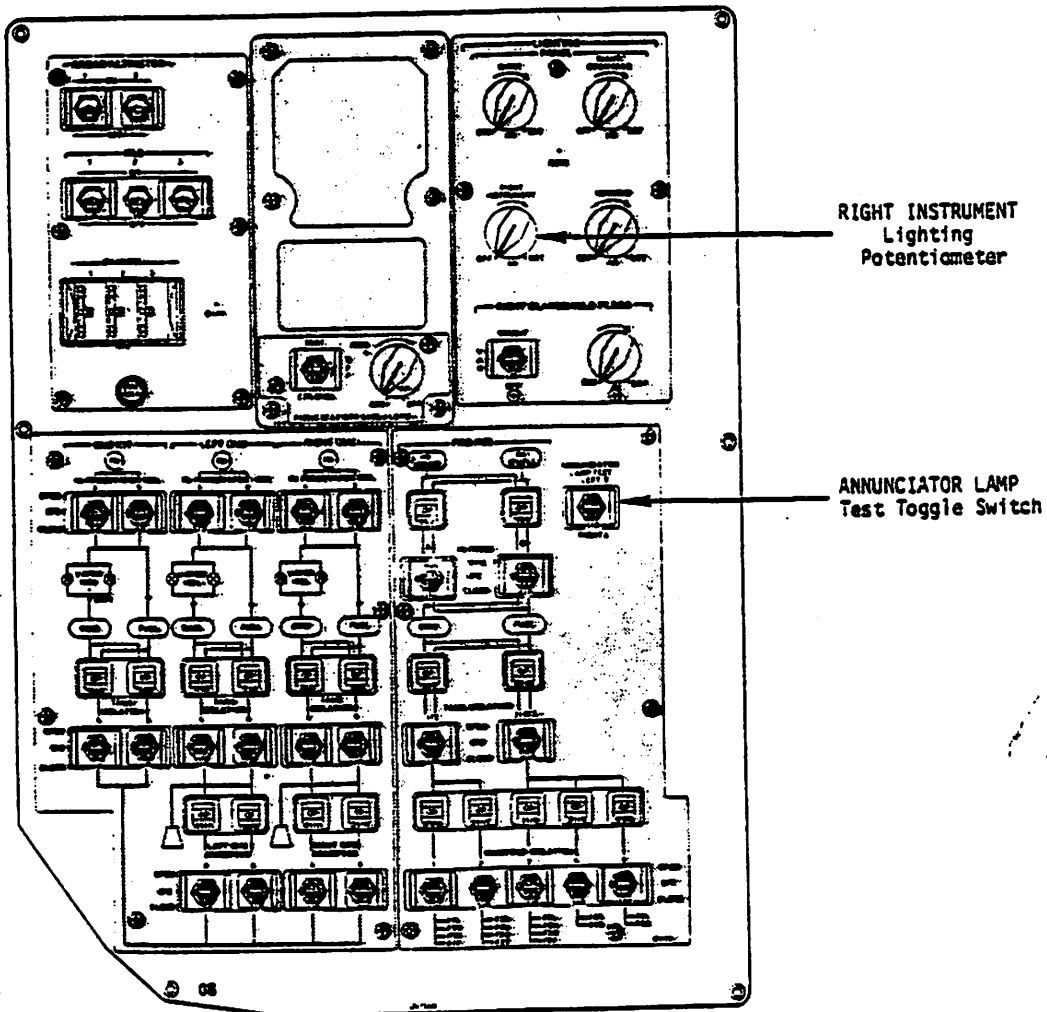


Figure 3-12.- Panel 08.

3.13 PANEL 013

3.13.1 GPC STATUS (cb)

Permits essential bus power to the logic and onboard controls which drive the GPC STATUS matrix annunciations.

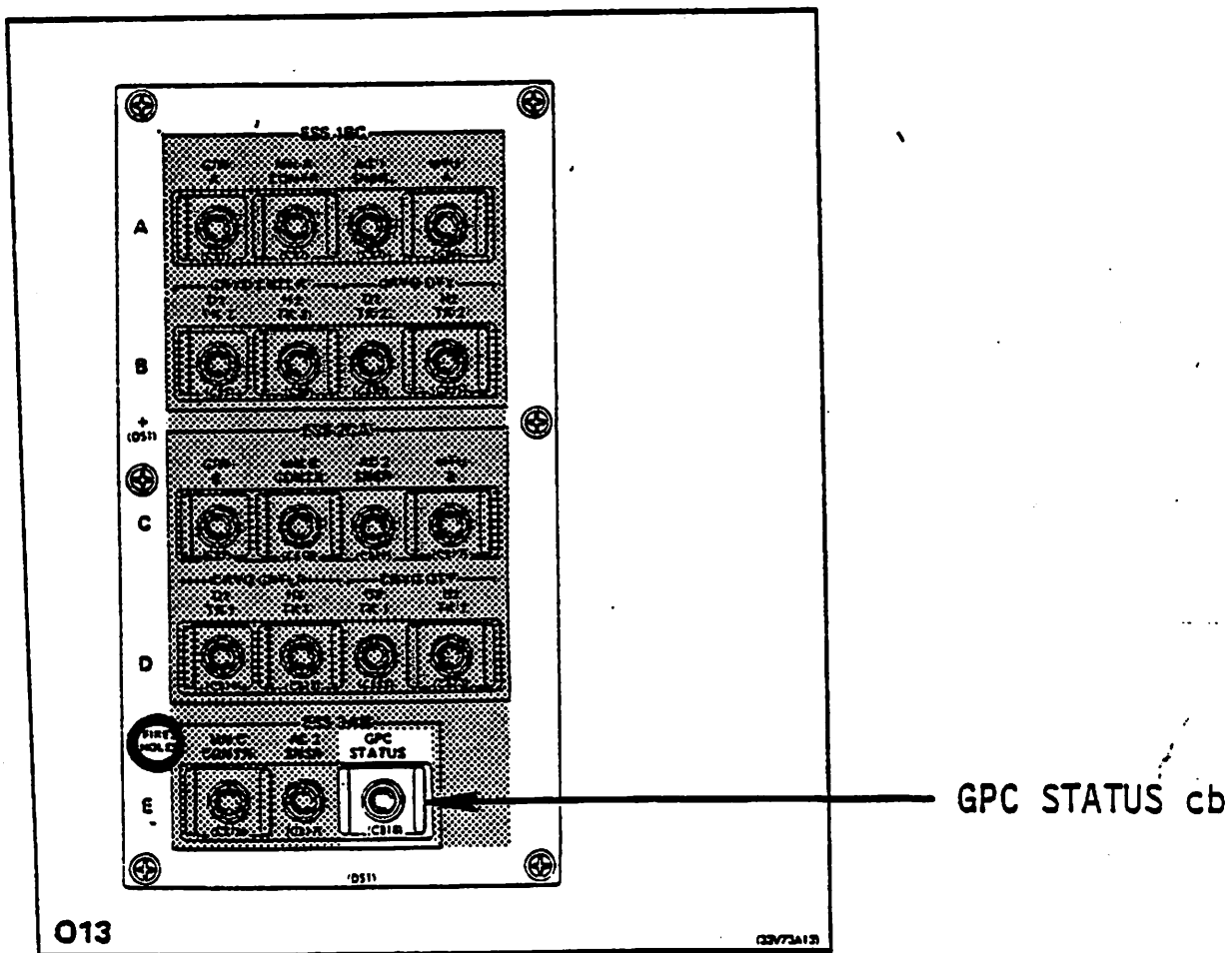


Figure 3.13.- Panel 013.

3.14 PANEL 014

3.14.1 MMU 1

Permits 28 Vdc to MMU 1 power supply (2-position toggle switch).

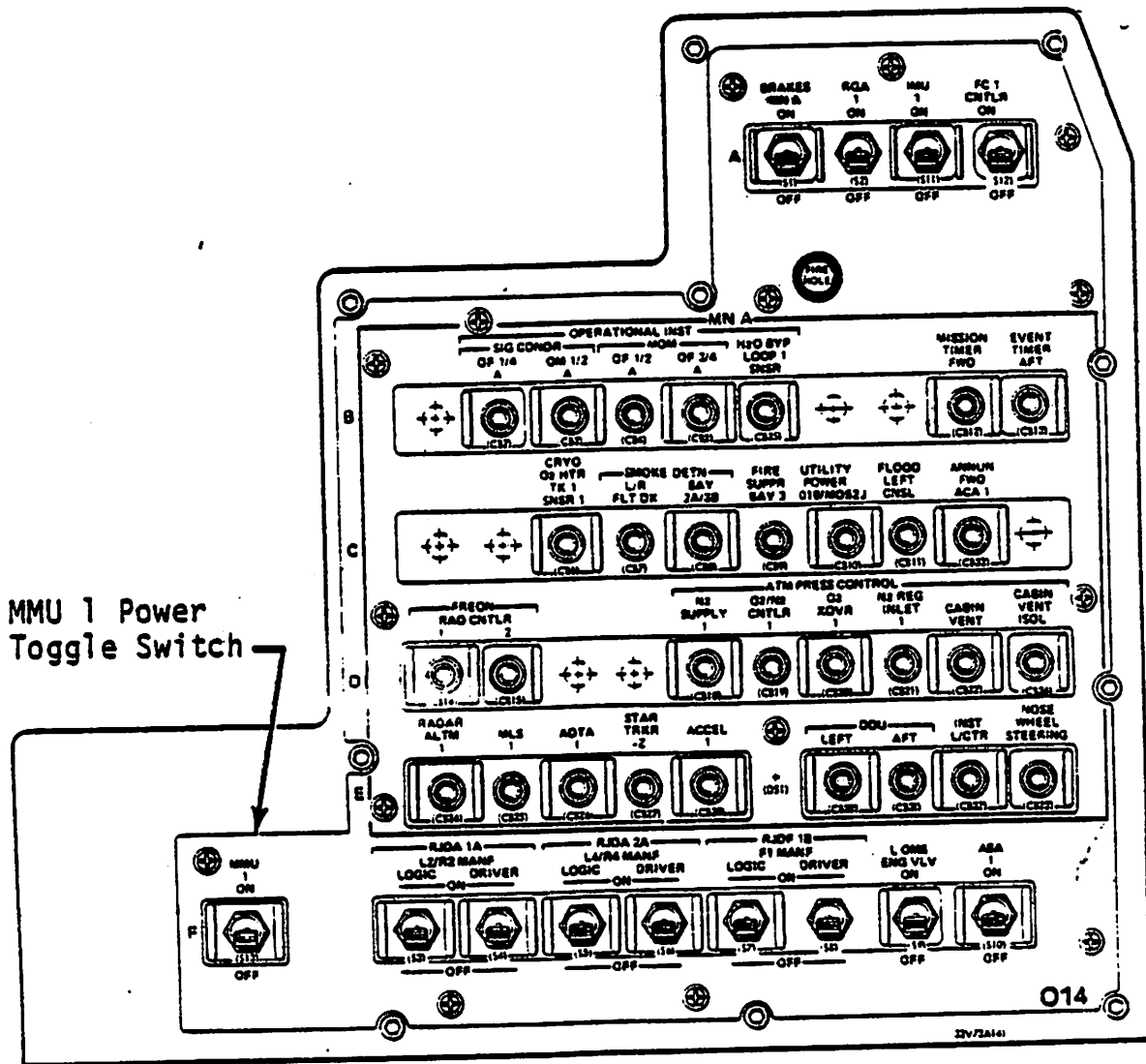


Figure 3-14.- Panel 014.

3.15 PANEL 015

3.15.1 MMU 2

Permits 28 Vdc to MMU 2 power supply (2-position toggle switch).

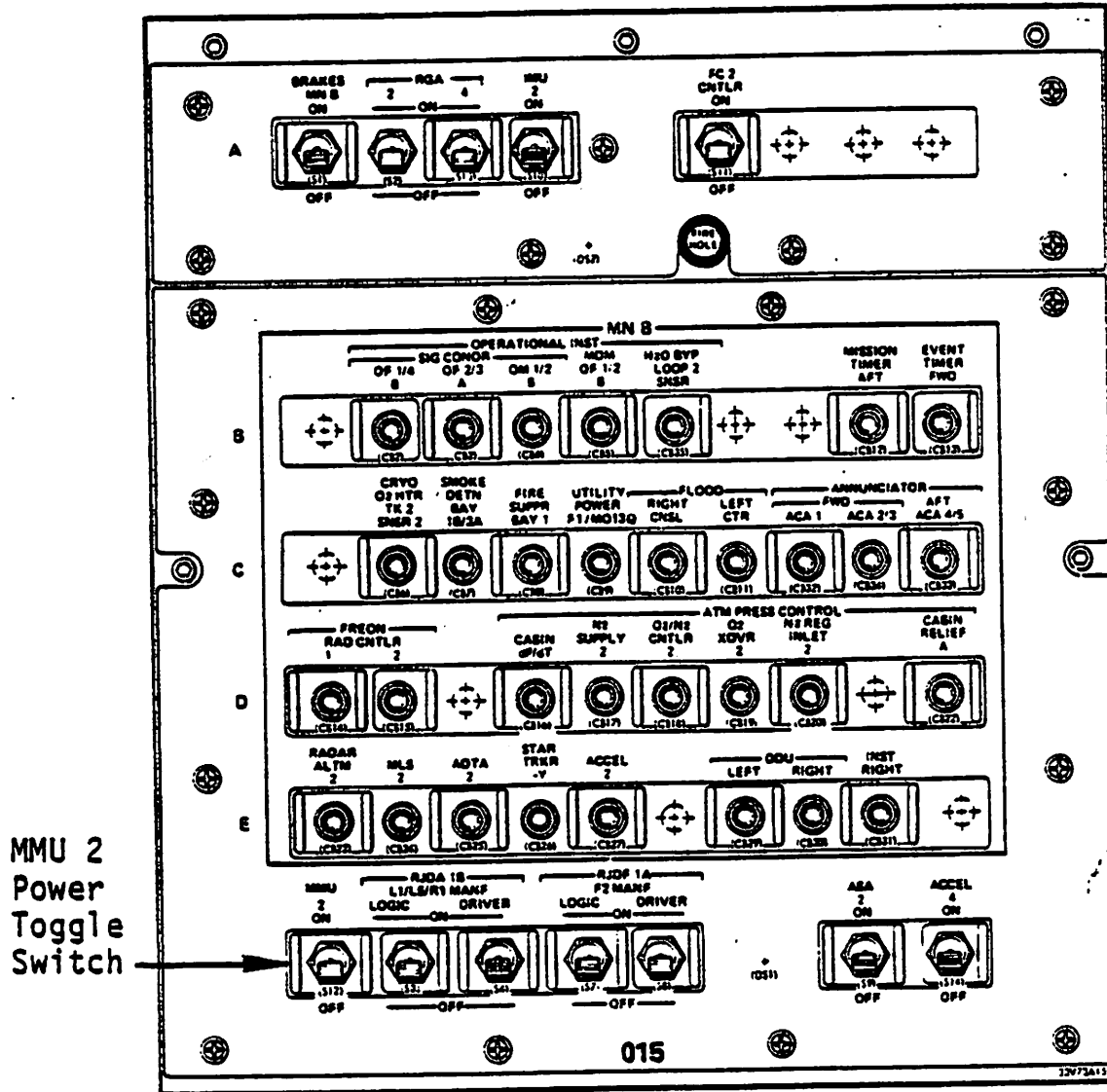


Figure 3-15.- Panel 015.

3.16 PANEL R10

3.16.1 MS LIGHTING PANEL (potentiometer)

Permits variable input to control brightness of MS panel lamps;
e.g., MS keyboard lamps.

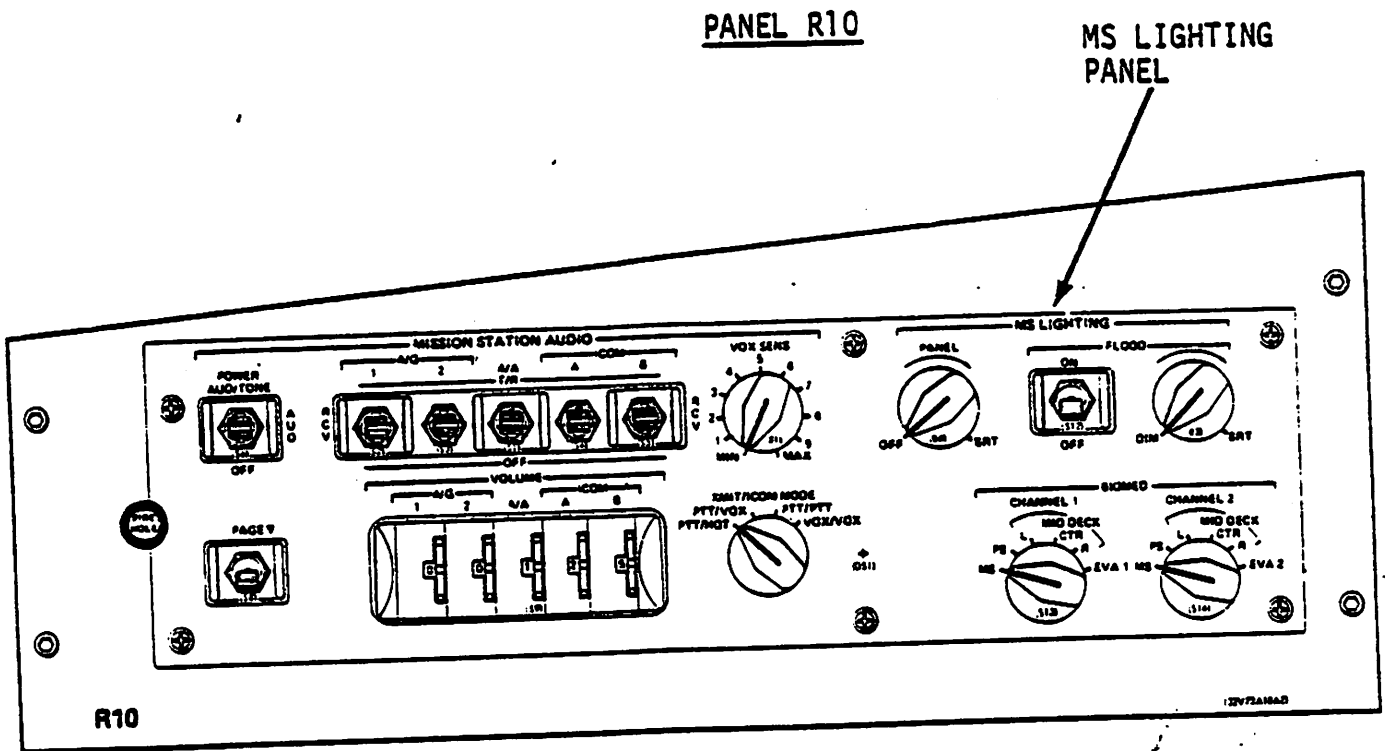


Figure 3-16.- Panel R10.

3.17 PANEL R12

The controls on Panel R12 provide the same function for DEU/DU/CRT 4 as similar controls on Panels C2 and F7 provide for DEU/DU/CRT's 1, 2, and 3. The MS keyboard functions are the same as those defined for the Panel C2 keyboards.

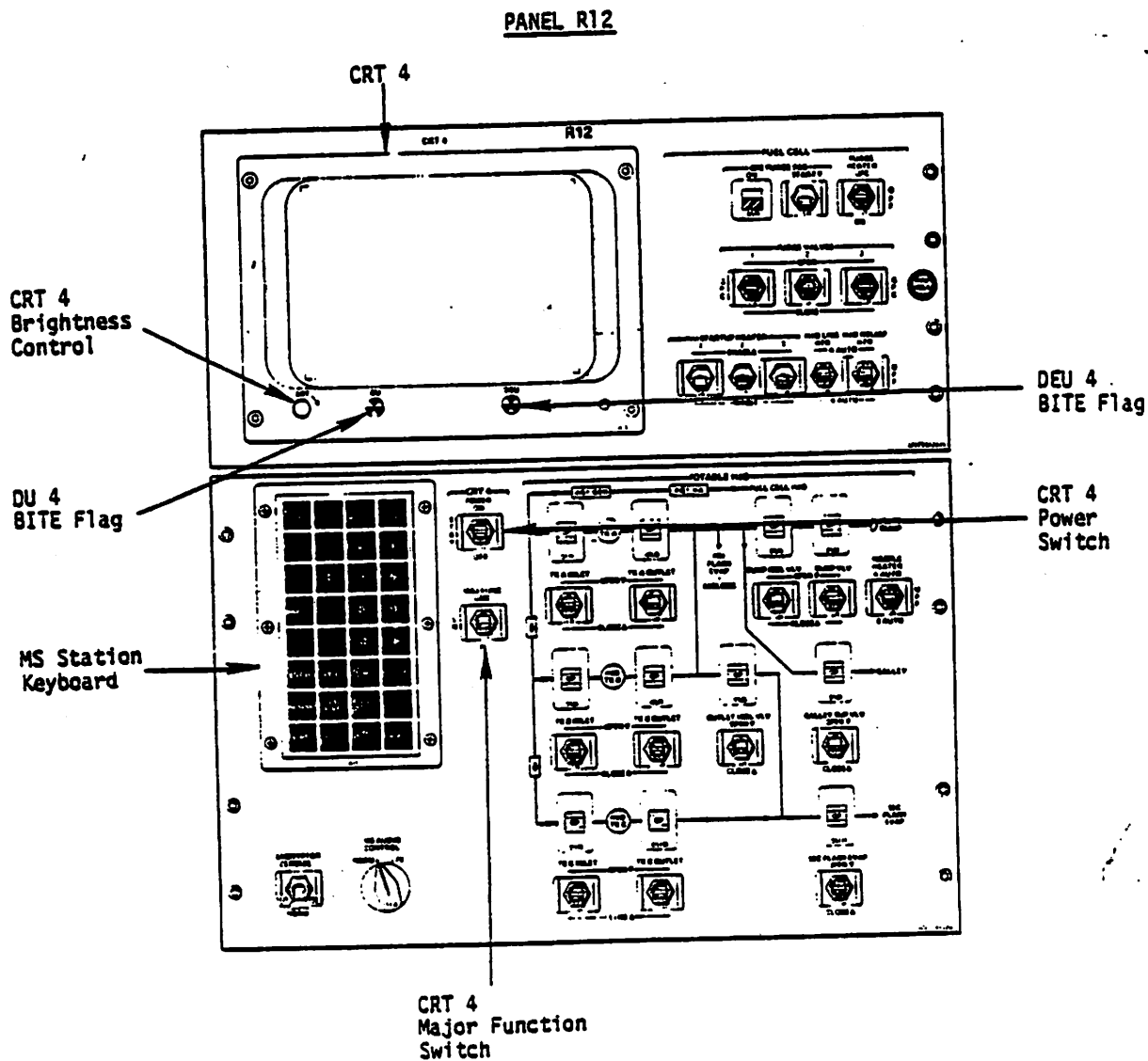


Figure 3-17.- Panel R12.

3.19 PANEL A1

3.19.1 DATA RATE XMIT (2-position toggle switch)

Directs the GCIL to command the NSP to transmit data at 128 kbps (HIGH) or 64 kbps if the S-BAND PM hardware is under crew station control (ref: Panel C3, S-BAND PM CONTROL toggle switch).

3.19.2 POWER (3-position toggle switch)

Directs the GCIL to permit power to NSP 1, NSP 2 or neither NSP if the S-BAND PM hardware is under crew station control (ref: Panel C3, S-BAND PM CONTROL toggle switch).

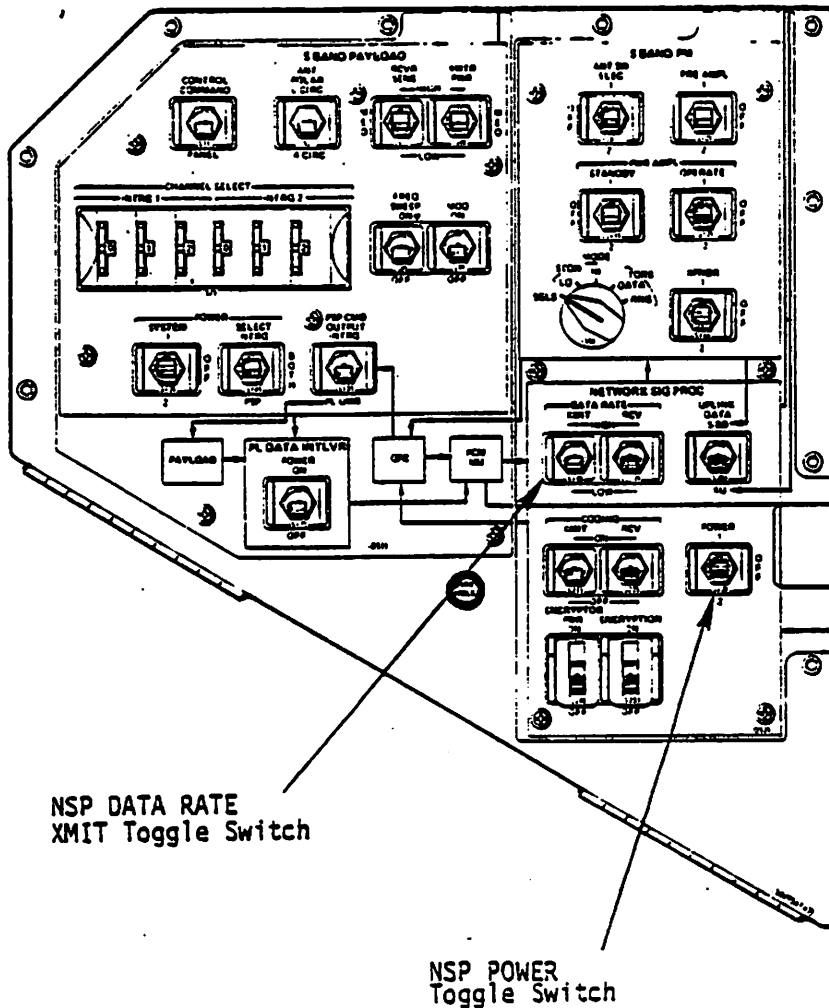


Figure 3-19.- Panel A1.

3.20 PANEL A7

3.20.1 MASTER ALARM (Black letters on red background)

Illuminated by C&W electronics upon detection of a Class 2 problem (DPS Class 2 involves GPC fail-to-sync and sumwork miscompare). Extinguished only by depression of any MASTER ALARM pushbutton indicator. Normally accompanied by a MASTER ALARM tone.

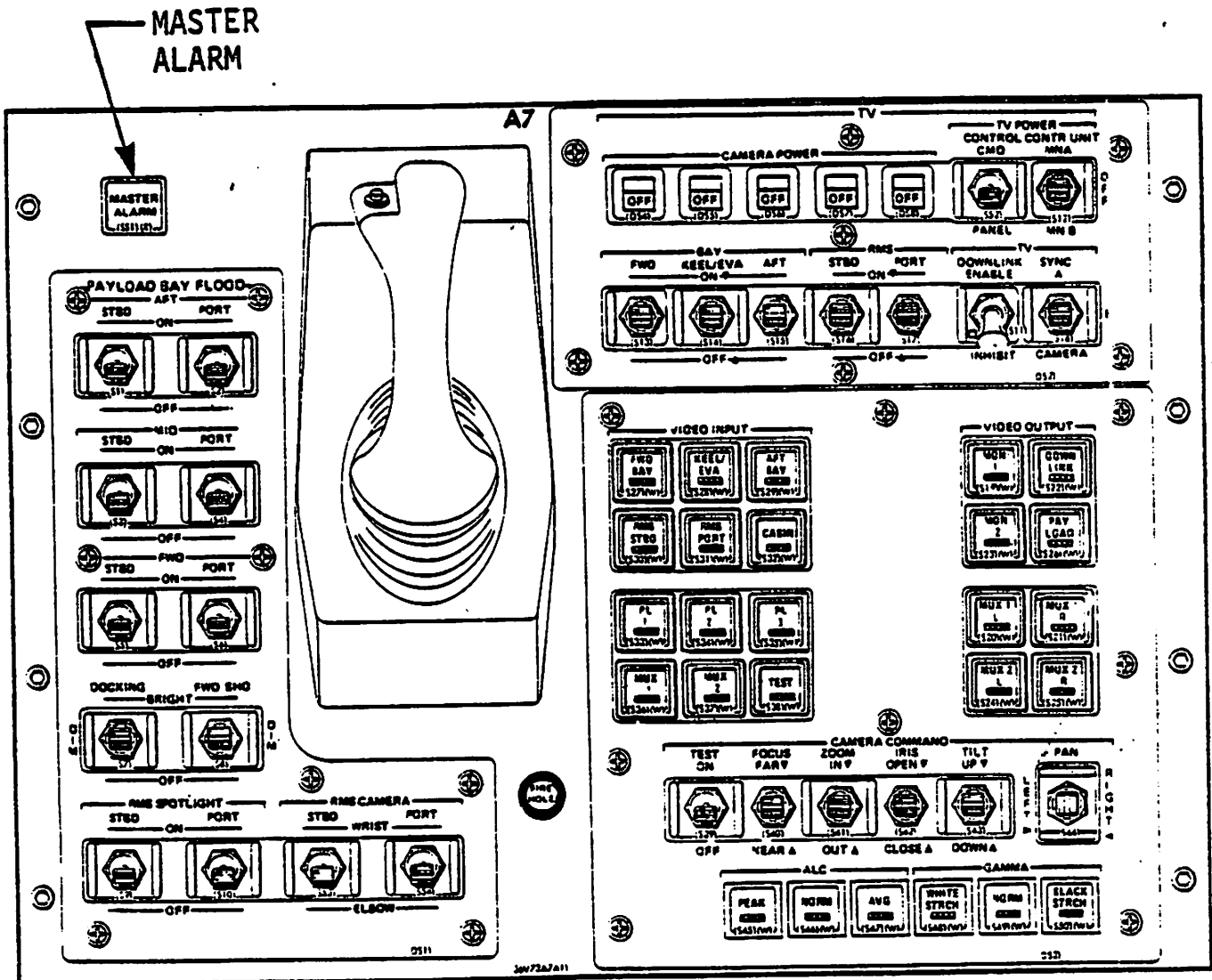


Figure 3-20.- Panel A7



SECTION 4
FLIGHT COMPUTER SOFTWARE

4.1 OVERVIEW

The OFT flight computer software consists of system software and applications software modules.

The system software modules consist of the software required to control the PASS GPC's and to provide the input, output and operational control services to the applications software, ground users, and flight crew. It is resident in all PASS GPC's following Initial Program Load (IPL) and is partitioned into the Flight Computer Operating System (FCOS), the User Interface module and the Systems Control module. As this last subdivision is transparent to the user, no distinction will be made in this document between the FCOS, User Interface and Systems Control modules. Instead, they will collectively be referred to as the system software. The system software provides the following services:

- Starts and coordinates the initialization process.
- Coordinates General Purpose Computer (GPC) and data bus configuration.
- Discrete input monitoring and distribution.
- Main memory modification.
- Main memory overlays.
- Synchronization.
- Redundancy Management.
- Timekeeping.
- Input/Output (I/O) management and I/O error processing.
- Multifunction CRT Display System (MCDS) interface software.
- Uplink processing.
- Downlist formatting.
- Ground Support Equipment (GSE) processing.
- System-level Specialist Function (SPEC) interface.
- Post-IPL (and before any Operational Sequences (OPS) overlays), contains Display Electronics Unit (DEU) loader software and DEU self-test package.

The Backup Flight System (BFS) software also includes system software modules which perform many of these same functions and will be discussed in section 5.

In order to conserve memory in each GPC, the software used to perform the mission (applications software) is divided into the Guidance, Navigation, and Control (GNC) major function, the Systems Management (SM) major function, and the Payload (PL) major function. The GNC, SM, and PL major function software blocks are further subdivided into mission-phase-oriented blocks called OPS. Each OPS is given a number to identify it. For example, the GNC launch OPS is called OPS 1 while the entry OPS is called OPS 3, as illustrated in figure 4-1.

Each of these OPS is subdivided further into software blocks called major modes, which relate to a specific portion of a mission phase. For example, Major Mode 01 in OPS 1 (often referred to as OPS 101 or Major Mode 101) contains the software pertaining to that part of the launch sequence known as the "terminal count" period, which extends from approximately 20 minutes prior to ignition until lift-off. Each major mode has an associated OPS display, which will be displayed by an MCDS if it is in the appropriate major function.

A transition from one mission phase (OPS) to another is referred to as an OPS transition. These transitions are always initiated by flight crew intervention.

Depending upon the individual case, a major mode may be initiated automatically (based on specific events) or through a keyboard entry to a DEU which is assigned to the appropriate GPC(s). Under certain conditions, the current major mode may be requested for purposes of reassigning data buses and changing the redundant set. Note that a complete keyboard entry must be made to initiate a major mode. If the transition from OPS 2 Major Mode 1 to OPS 2 Major Mode 2 is desired, a crew entry of "OPS 202 PRO" will be required. Also, only certain of these OPS/mode transitions are allowed by software. The current legal OPS/mode transition table is in appendix G. The Class 5 fault message "ILLEGAL ENTRY" will appear if an illegal OPS/mode transition is requested.

4.2 CONCEPTS AND DEFINITIONS

4.2.1 Displays

There are three levels of displays which can be used by the flight crew to observe systems data and status, and for SM and control via keyboard entries. First, there is a display called an OPS display associated with each OPS/major mode. The OPS displays are the highest priority of the three types. There are portions of each OPS display which can be manipulated by flight crew keyboard input (or ground uplink) via item entries, which are used to view and modify systems parameters and allow for data entry.

The next level of displays is that associated with blocks of software called SPEC's. These SPEC displays are invoked by a "SPEC ABC PRO"

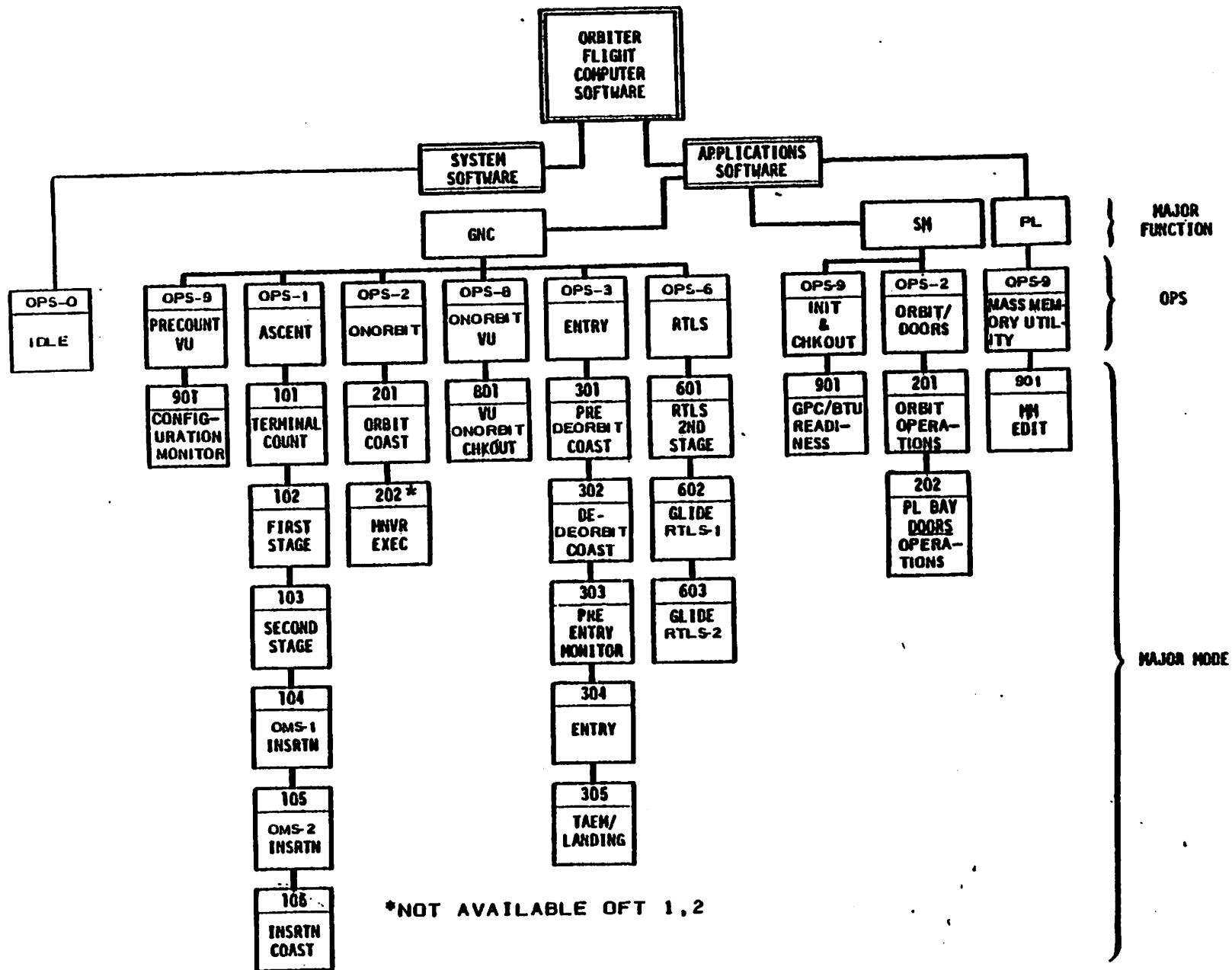


Figure 4-1.- Orbiter flight computer software.

keyboard entry (where $A \neq 9$, $0 \leq B \leq 9$ and $0 \leq C \leq 5$). A SPEC display "overlays" the current OPS display and is also used to view and modify parameters via keyboard item entries. Depression of the KBU RESUME key will terminate the SPEC display, and the overlaid OPS display will reappear. Whether or not the software associated with the SPEC is terminated depends upon the individual case.

The third level of displays are those associated with blocks of software called display functions (DISP's). These DISP displays are also invoked by a "SPEC ABC PRO" keyboard entry (where $A = 9$, $0 \leq B \leq 9$ or $6 \leq C \leq 9$). These displays can only be used to view systems parameters, and do not allow manipulation of the system via item entries. The DISP's will overlay the current OPS display and the current SPEC display if a SPEC had been invoked. Use of the RESUME key will terminate the DISP and recall the previous SPEC (if available) or OPS display (if no SPEC had been overlaid).

4.2.2 System Software Displays

There are five displays associated with the systems software. They are illustrated on the next three pages.

- FAULT - DISP 99; called with the FAULT SUMM key; available all OPS.
- GPC MEMORY - OPS display in GNC OPS 9 and OPS 0; SPEC 0 in all OPS.
- DPS UTILITY - SPEC 1; not available GNC OPS 1, 3, 6.
- TIME - SPEC 2; not available GNC OPS 1, 3, 6.
- GPC/BUS STATUS - DISP 6; not available GNC OPS 1, 3, 6.

Following IPL, a PASS GPC is loaded only with system software and certain other initialization software such as the DEU loader and self-test software. At this time, five system level CRT displays are supported - GPC MEMORY, DPS UTILITY, TIME, GPC/BUS STATUS and FAULT. However, following any OPS transition, the initialization software is overlaid with other software and is no longer available. Also, following an OPS transition to GNC OPS 6, OPS 1, or OPS 3, the DPS UTILITY, TIME, and GPC/BUS STATUS display software will be overlaid and will not be available. When an OPS other than OPS 1, 3, or 6 is loaded, these three displays (DPS UTILITY, TIME, GPC/BUS STATUS) are again included in the overlay and are available for use.

The statement that a PASS GPC is in GPC OPS 0 means that it is processing system software, but is not processing any applications (GNC, SM, PL) software. Thus, in OPS 0, a GPC can perform certain tasks including downlist, uplink, timekeeping, DEU polling, GSE polling as well as tasks initiated by crew interface with one of the available system level displays. The OPS display for OPS 0 is the GPC MEMORY display.

A GPC will be placed in OPS 0 by a crew entry of "OPS 000 PRO" to a DEU to which it is listening if it is in one of the following major modes: GNC OPS 201 or 901; SM OPS 201, 202, or 901; or PL OPS 901.

| CRT ID | FAULT | C/W | GPC | TIME |
|-----------|------------|-----|-----|--------------------------------|
| | | | | 2 137/22:10:18 000/01:30:00 |
| | | | | TIME TONE 4 137/22:10:10 |
| 388 | EVAP OUT T | 1 | 4 | 137/22:09:20 |
| 023 | RCS SYSTEM | F | 12 | 137/22:08:01 |

Figure 4-2.- FAULT display.

| 2011/000/ | | GPC MEMORY | | 2 137/22:10:18 000/08:10:18 | |
|----------------|---------|-------------------|------------|--------------------------------|--|
| MEM/BUS CONFIG | | READ/WRITE | GPC | | |
| 1 CONFIG | 3 (G3) | DATA 20* | BIT SET 22 | SEQ ID 24 | |
| 2 GPC 1 | 2 1 4 0 | CODE 21 | BIT RST 23 | WRITE 25 | |
| | | 26 ENG UNITS | | HEX 27* | |
| STRING 1 | 7 1 | ADD ID | DESIRED | ACTUAL | |
| | 2 8 2 | 28 | 29 | | |
| | 3 8 1 | 30 | 31 | | |
| | 4 10 0 | 32 | 33 | | |
| PL 1/2 | 11 0 | 34 | 35 | | |
| | | 36 | 37 | | |
| CRT 1 | 12 1 | 38 | 39 | | |
| | 2 13 2 | <hr/> | | | |
| | 3 14 0 | MEMORY DUMP | | | |
| | 4 15 0 | 40 START ID | ----- | | |
| LAUNCH 1 | 16 0 | 41 NUMBER MOS | ----- | | |
| | 2 17 0 | 42 MOS/FRAME | ---- | | |
| | | DUMP 43 | | | |
| NR 1 | 18 1 | 44 DOWNLIST GPC 1 | | | |
| | 2 19 1 | | | | |

Figure 4-3.- GPC MEMORY display.

```

2011/001/          OPS UTILITY          2 137/22:10:18
                                         000/08:10:18

MMU ASSIGN
  1 2
  GNC 1° 2
  SM 3 4°
  PL 5 6°
  OPS 0 7° 8

MMU STATUS
  1 ROY
  2 ROY

MMU SOURCE/BUS
  GPC/MMU 9°
  MMU/MMU 10
  GPC/LOB 11

CKPT RETRV ENA 12

RTC
  13 -----
  CMD 14

PORT ASSIGN
          PRI | SEC
-----|-----
STRING 1 15° | 16
        2 17° | 18
        3 19° | 20
        4 21° | 22
        PL 1/2 23° | 24

VARIABLE PARAM ID LIST
  25 112E0
  26 112E1
  27 112E2
  28 112E3
  29 112E4
  30 112E5
  31 112E6
  32 112E7
  33 112E8
  34 112E9

```

Figure 4-4.- DPS UTILITY display.

```

2011/002/          TIME                  2 237/14:35:02
                                         000/01:30:00

MISSION TIME          TONE
  GNT 1°             3 14:43:00 MSN T
  NET 2              6 : :

CRT TIMER
  9 SET [L_:_:__:__ 20 [L_:_:__:__ CRT T
  START 12 STOP 13

  14 START AT _:__:__ MSN T 23 DURATION 02
  17 COUNT TO 16:05:04 MSN T

-----
NTU
  24 GNT Δ [L_:_/_:__:__
  28 NET Δ [ ] / : :
  UPDATE 32

-----
GPC TIME
          GNT          STAT TRM          GPC
MMU ACCUM 1 210/12:02:11.315 BITE 33 1 A2
          2 237/14:35:02.453 34 2 A2
          3 237/14:35:02.453 35 3 A2
          GPC 237/14:35:02.453 36 4 A2
          5 A2

TIME SYNC 37

```

Figure 4-5.- TIME display.

2011 / / 006

GPC / BUS STATUS

137 / 22 : 10 : 18

000 / 08 : 10 : 18

| GPC | | 1 | 2 | 3 | 4 | 5 |
|--------|-----|------------|------------|-------------|------------|---|
| MODE | OPS | RUN G 2 | RUN G 2 | HALT G 3 | RUN S 2 | |
| STRING | 1 | FF | * | | | |
| | | FA | * | | | |
| | 2 | FF | | * | | |
| | | FA | | * | | |
| | 3 | FF | | * | | |
| | | FA | | * | | |
| | 4 | FF | * | | | |
| | | FA | * | | | |
| PL | 1 | | | | * | |
| | 2 | | | | * | |
| LAUNCH | 1 | | | | | |
| | 2 | | | | | |
| CRT | 1 | * | | | | |
| | 2 | | | | | |
| | 3 | | | | * | |
| | 4 | | | | * | |

4-7

Figure 4-6.- GPC/BUS STATUS display.

Note that if a GNC redundant set exists, in GNC OPS 2 or 9, an "OPS 000 PRO" input to a PASS GNC DEU will result in all members of the redundant set going to OPS 0 (i.e., ceasing to process GNC application software). A single PASS GPC may be placed in OPS 0 at any time by moving that GPC's MODE switch from RUN to STBY (STANDBY) and back to RUN, or from RUN to STBY to HALT and back to RUN. If a GPC were running in a specified major function (GNC, SM, PL) and it was not a target GPC for a new OPS in that major function, then it would be forced to OPS 0 at that transition. Thus, it will stop processing major function software.

To leave OPS 0, a PASS GPC must be moded to GNC OPS 201, 301, or 901; SM 201 or 202; or PL OPS 901. These are the only legal OPS transitions from PASS GPC OPS 0 as illustrated in figure 4-7.

4.2.3 GPC MODE - HALT, STBY, and RUN

Each GPC has its own three-position toggle-type MODE switch located on Panel 06. Each of these switches has a HALT, a STBY, and a RUN position; and the position of this switch determines the software processing available from that GPC's as illustrated in table 4-1.

In the HALT mode, the GPC is in a hardware-controlled state in which no software can be executed. The GPC MODE switch, the IPL SOURCE switch, the Mass Memory Units (MMU) Ready discretes, and the GPC IPL pushbutton discretes are all monitored in this state.

In the RUN mode, the GPC supports its normal OPS-assigned vehicle operations.

With the exception of the IPL case, a PASS GPC in STBY is in a state in which no software is executed. In this state, only the GPC MODE switch discretes are monitored. It is necessary, as a matter of procedure, that a GPC being moded from RUN to HALT be moded to STBY prior to going to HALT (long enough for the STBY discrete to be monitored for 1-2 seconds), since moding to STBY allows for an orderly software cleanup, which will then allow a GPC to be correctly reinitialized without the necessity of performing an IPL. Should a GPC be moded from RUN to HALT (without pausing in STBY), there would be no guarantee that it could correctly perform its functions upon being remoded to RUN.

The current GPC MODE of each of the PASS GPC's will appear on the GPC/BUS STATUS display (available during all mission phases except GNC OPS 1, 3, and 6). See figure 4-4. Note that only RUN or HALT will be displayed as STBY is not distinguished from HALT.

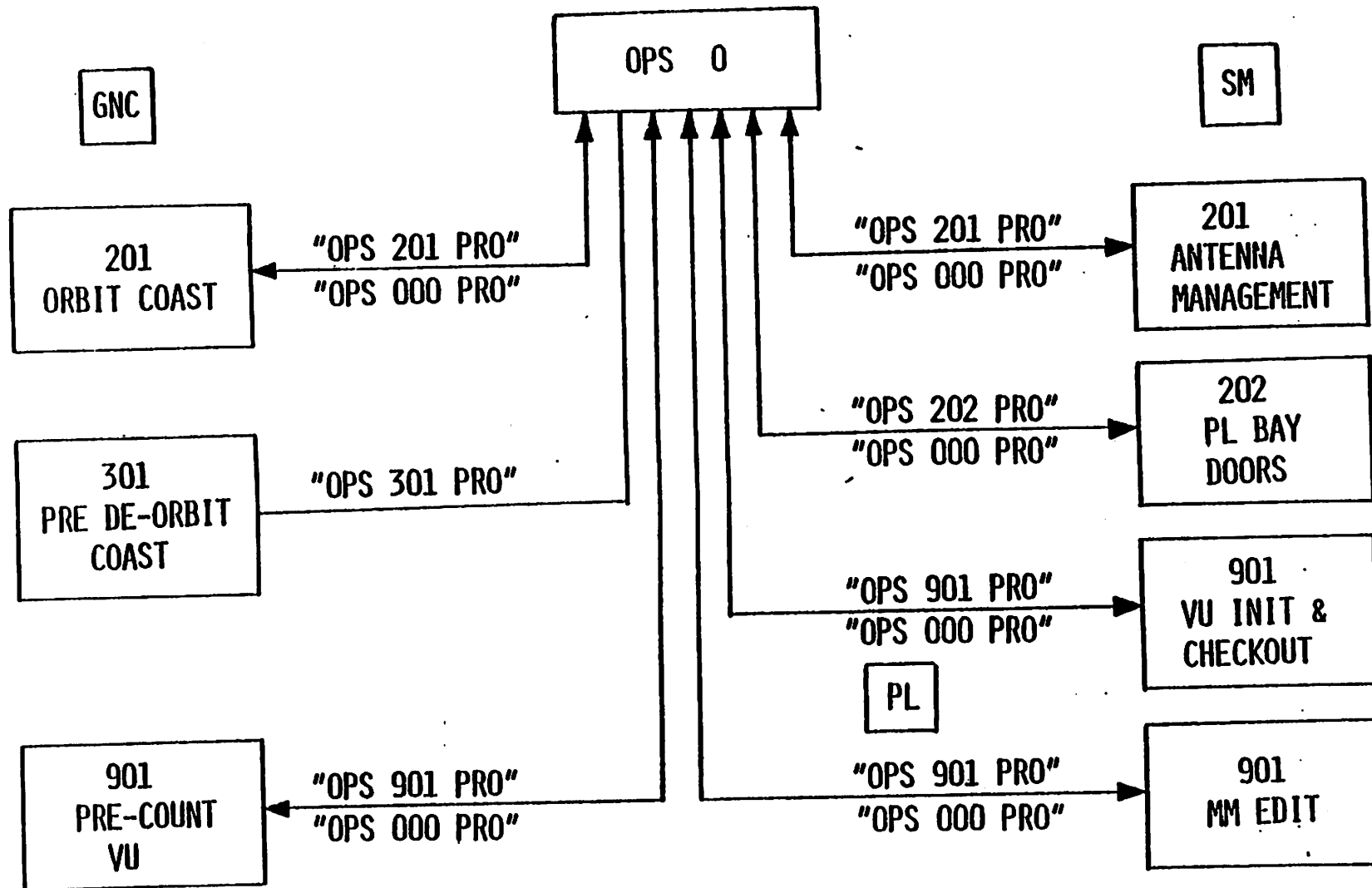


Figure 4-7.- Transitions involving OPS 0.

TABLE 4-1.- MODE SWITCH TRANSITIONS

| From \ To | HALT | STANDBY | RUN |
|-----------|---|--|---|
| HALT | | <p>Systems reset:</p> <ul style="list-style-type: none"> ● IPL cleanup (if necessary). ● Ready talkback (TB) to RUN. ● Initiate cyclic monitor for RUN mode transition. | <p>Systems reset:</p> <ul style="list-style-type: none"> ● IPL cleanup (if necessary). ● Ready talkback to RUN. ● Activate communications with other GPC's. ● Initiate time management. ● Initiate downlist. ● Initiate DEU and network signal processor command (if no other GPC in control). ● Force GPC to OPS-0. |
| STBY | <p>Hardware halt:</p> <ul style="list-style-type: none"> ● No active software. ● GPC IPL (if required). | | <p>Systems reset:</p> <ul style="list-style-type: none"> ● Ready talkback to RUN. ● Activate communications with other GPC's. ● Initiate time management. ● Initiate downlist. ● Initiate DEU and NSP command (if no other GPC in control). ● Force GPC to OPS-0. |
| RUN | <p>Same as STBY → HALT transition (not a preferred sequence; software downmode in STANDBY is proper).</p> | <p>Systems reset:</p> <ul style="list-style-type: none"> ● Terminate all CPU and IOP processes. ● Monitor for RUN mode switch position. ● Ready talkback to barberpole. | |

4.2.4 Downlist GPC

All GPC's which are operating in a redundant set are processing identical software, using identical inputs, and processing identical outputs. Therefore, only the downlist from one member of the redundant set needs to be incorporated into the telemetry and sent to the ground. The redundant set GPC whose downlist is incorporated into the telemetry and sent to the ground is called the downlist GPC (not prime GPC).

Selection of the downlist GPC can occur automatically according to a selection hierarchy based upon certain conditions, or as a result of a flight (or ground) crew entry to a CRT display. The first PASS GPC to complete IPL and be moded to RUN will be the downlist GPC. Under the following conditions, the selection of a new downlist GPC is automatically initiated:

- At OPS transitions and OPS mode recalls involving redundant set formation.
- In the event of a downlist GPC powerdown.
- In the event the downlist GPC MODE switch is moded from RUN to STBY or HALT.
- In the event the downlist GPC fails to sync with all other redundant set GPC's and there are at least two other GPC's operating in the redundant set.

In any of the above situations, the software automatically selects the lowest numbered GPC in the redundant set as the new downlist GPC. If there is no redundant set, the remaining GNC GPC becomes the downlist GPC.

Also, any GNC GPC in the redundant set may be manually selected as the downlist GPC by keyboard entry (ITEM 44 on the GPC MEMORY SPEC). See figure 4-3. If a GPC other than one in the redundant set is entered in this item, the "ILLEGAL ENTRY" fault message will be generated.

The current downlist GPC ID appears in ITEM 44 on the GPC MEMORY display.

4.2.5 Memory Configuration (MC)

An MC consists of the software resident in the GPC. All the software necessary for a flight is recorded on each of the MMU tapes. When a PASS GPC completes its IPL, it is loaded with the systems software, plus certain initialization software. This is referred to as Memory Configuration 0.

In order to perform other tasks which are related to a mission phase, other software is loaded into the GPC's memory. An additional block of software known as a Major Function Overlay (MFO) (which contains software related to either GNC, PL, or SM applications) and a block of software known as an OPS overlay (which contains the mission-phase-common software) are loaded into the appropriate GPC's following a specified OPS request as illustrated in table 4-2. It should be noted that the GNC MFO software

contains certain flight-critical (FC) software which will be retained from one mission phase to another. To the user, it appears that both of these software blocks (the MFO and the OPS overlay) are loaded into the GPC's at the same time.

Table 4-2.- GPC-1 MEMORY CONFIGURATION ON ASCENT

| SYSTEM SOFTWARE BASE | GNC MAJOR FUNCTION OVERLAY | OPS-1 (ASCENT) |
|----------------------------|----------------------------------|-------------------|
| | | OPS-6 (RTLS) |

The current resident major function and OPS for each PASS GPC will appear on the GPC/BUS STATUS display (not available in GNC OPS 1, 3, or 6) with an alphanumeric indicator in which the left-most character will be a G(GNC), S(SM), P(PL), or a blank (IPL) and the right digit will indicate the number of the current OPS.

4.2.5.1 Memory configuration table.- Each PASS GPC maintains a software memory configuration table, which contains the initiating OPS and the numbers of the GPC's that are scheduled to receive the software for each MC. Those GPC's are often referred to as the target GPC's or "selected" GPC's for that MC. This table also includes the nominal data bus assignments for each MC and is used at OPS transitions involving memory reconfiguration or upon a legal OPS/Mode Recall as is illustrated in table 4-3.

The new MC is called into the target GPC's when a crew entry is made to a keyboard unit, based on the position of the associated MAJ FUNC switch. For example, a crew entry of "OPS 301 PRO" with a MAJ FUNC switch setting of GNC would bring Memory Configuration 3 into GPC's 1, 2, 3, and 4.

| CONTENTS | SELECTION OF OPS | | | CAUSES | WHICH CONTAINS OPS #'S | | | TO BE LOADED INTO | | | | |
|----------------------------------|------------------|----|----|--------|------------------------|------|----|-------------------|---------|--|--|--|
| | GN&C | SM | PL | | MEMORY CONFIG # | GN&C | SM | PL | GPC#S: | | | |
| | | | | 0 | | | | | | | | |
| GNC-(1) ASCENT, (6) ABORTS | | | | 1 | 1,6 | | | | 1 2 3 4 | | | |
| GNC-(2) ON-ORBIT | | | | 2 | 2 | | | | 1 2 | | | |
| GNC-(3) ENTRY (NOMINAL) | | | | 3 | 3 | | | | 1 2 3 4 | | | |
| SM2 ORBIT/DOORS | | | 2 | 4 | | 2 | | | 4 | | | |
| PL9 VU MM UTILITY | | | | 6 | | | 9 | | 1 | | | |
| SM9 VU INIT & CHKOUT | | | 9 | 7 | | | 9 | | 2 | | | |
| GNC 8 - VU ON-ORBIT CHKOUT | | | | 8 | | | | | 1 2 | | | |
| GNC 9 - VU PRECOUNT | | | | 9 | | | | | 1 2 3 4 | | | |

TABLE 4-3.- NOMINAL OFT MEMORY CONFIGURATION TABLE

4.2.5.2 Bus assignment table.- Associated with each MC is a bus assignment table (for that MC) which pertains to the assignment of the FC, PL, Launch Boost (LB), Mass Memory (MM), and Display/Keyboard (DK) data buses as illustrated in table 4-4.

This internally stored table indicates which buses will be commanded (transmitters enabled) by which target GPC's for that MC.

The assignment of strings and data buses to GPC's is accomplished during OPS transitions and OPS/mode recalls. The current GPC/bus assignment may be observed, on the GPC/BUS STATUS display (not available GNC OPS 1, 3, 6) for the Strings, PL, Launch, and DK (also referred to as CRT) data buses.

The Multiplexer/Demultiplexer's (MDM's) on the Strings and PL data buses are dual port devices. The hardware is designed, however, to allow only one port to be accessed at a time. Still, if it was determined that one port of one of these MDM's had failed, it would be advantageous to switch and send commands to the other port. This capability is available in all OPS except GNC OPS 1, 3 and 6 via inputs to the OPS UTILITY display (figure 4-4). On this display, an asterisk by the appropriate item number (15-24) indicates which ports (Primary or Secondary) are being accessed on that String or PL data bus. When this display is available, it is possible to switch ports being accessed with the appropriate item entry.

The flight crew (and ground controllers via an uplink capability known as DEU EQUIVALENT) have the capability to observe and modify the memory configuration and bus assignment tables by making keyboard entries to the GPC MEMORY display. This display is a system level SPEC which is available in all OPS. In order to observe or modify the selected GPC's and data bus assignments for a particular MC, the number (x) of that MC must be entered with Item 1 (ITEM 1 + x EXEC). At this time the appropriate "*"s and numbers will appear to indicate the target GPC's and assigned command GPC's for each of the data buses. To modify this table, the appropriate item numbers and, for data bus assignments, GPC numbers must be entered. Note that the command GPC for a data bus must also be a target (selected) GPC for that MC for the assignment to take effect. Also, modification of the table is not effective until an OPS transition involving the MC or a legal OPS/Mode Recall. In addition, a GPC/CRT keyboard message will modify the bus assignment table for the current MC pertaining to which CRT (DK) data buses are assigned to which GPC's.

4.2.6 Freeze-dried GPC

A GPC which is loaded with the software for a particular MC and placed in OPS 0 or moded to STBY (and then HALT or powered off) is said to be freeze-dried with that MC. Prior to the OPS transition to that MC, the freeze-dried GPC could be moded back to RUN, if necessary (it will now be in OPS 0 not processing any application software), and then the appropriate OPS requested. Thus, the freeze-dried GPC would serve as a safeguard in case the MMU and/or MM buses failed.

TABLE 4-4.- NOMINAL BUS ASSIGNMENTS

| MEMORY CONFIGURATION | 1 (G1,G6) | 2 (G2) | 3 (G3) | 4 (S2) | 6 (P9) | 7 (S9) | 8 (G8) | 9 (G9) |
|----------------------|--------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| TARGET GPC's | 1,2,3,4 | 1,2 | 1,2,3,4 | 4 | 2 | 4 | 1,2 | 1,2,3,4 |
| STRING 1 | 1 | 1 | 1 | 0 | 0 | 4 | 1 | 1 |
| STRING 2 | 2 | 2 | 2 | 0 | 0 | 4 | 2 | 2 |
| STRING 3 | 3 | 2 | 3 | 0 | 0 | 4 | 2 | 3 |
| STRING 4 | 4 | 1 | 4 | 0 | 0 | 4 | 1 | 4 |
| PL1/2 | 1 | 0 | 1 | 4 | 0 | 4 | 0 | 1 |
| LDB-1 | 3 | 0 | 0 | 4 | 0 | 4 | 1 | 1 |
| LDB-2 | 3 | 2 | 3 | 0 | 0 | 4 | 2 | 3 |
| MMU-1 | 1 | 1 | 1 | 4 | 2 | 4 | 1 | 1 |
| MMU-2 | 4 | 2 | 4 | 4 | 2 | 4 | 2 | 3 |
| DK-1 | 1 | 1 | 1 | 4 | 2 | 4 | 1 | 1 |
| DK-2 | 2 | 0 | 2 | 0 | 0 | 0 | 2 | 2 |
| DK-3 | 3 | 2 | 3 | 4 | 2 | 4 | 2 | 3 |
| DK-4 | 0 | 1 | 0 | 4 | 2 | 4 | 0 | 0 |

4.2.7 Memory Reconfiguration

Systems software may perform GPC main memory reconfiguration with the use of an MMU or another GPC as the memory source. This reconfiguration is initiated by user selection or a MFO and OPS overlay software via a keyboard entry - OPS ABC PRO.

Although the system software is loaded into a GPC following IPL, a transition to Memory Configuration 1 or 3 overlays the part of the system software including the software associated with the DPS UTILITY, GPC/BUS STATUS and TIME displays. Thus, these displays are not available in GNC OPS 1, 3 or 6. However, when a transition is made from OPS 1, 3, or 6 to another OPS (such as GNC OPS 2 or 9, SM OPS 2, etc.), it will be necessary to reload these areas of system software as well as possibly reload a major function or OPS overlay. Still, current estimates indicate that an OPS MFO with no errors will take less than 15 seconds.

If a legal OPS transition is requested (the legal OPS transitions are included in appendix G), the necessary OPS overlay (and the necessary major function/system software overlay, if required) will be loaded into all target GPC's in the common set as specified in the memory configuration table. However, a user input requesting that a simplex MC (SM OPS 2, PL OPS 9, and SM OPS 9) be loaded into multiple GPC's (via modification of the memory configuration table) will be rejected and an "ILLEGAL ENTRY" fault message will be generated. Thus, neither PL nor SM software can be run redundantly. Also, if a target GPC is new to the major function configuration and is not in OPS 0 when the reconfiguration is requested, the request will be rejected and the Class 3 alarm and "GPC CONF" fault message will be generated. An attempt to reconfigure a GPC which is not a member of the common set (the BFS GPC, for example) will result in a Class 3 alarm and a "GPC CONF" fault message.

If an OPS transition is requested which is not legal, the fault message "ILLEGAL ENTRY" will appear. Also, it should be pointed out that if a GPC is running in a certain major function but is not a target GPC for a particular OPS (MC) in that major function, then that GPC will be forced to OPS 0 (i.e., stop application software processing) when that OPS is requested. Thus, within a major function, only one OPS may be active.

4.2.8 OPS/Mode Recall

An OPS/Mode Recall can be made (i.e., the current major mode may be re-requested) under the same limitations as a legal OPS transition in any major mode providing that no change in the selected GPC's for that MC will be involved. If such a change has been made, the request will be accepted only in the following major modes: GNC's 201, 301, 801 and 901, and SM's 201 and 202.

In any other major mode, the request will be denied with the Class 5 fault message "ILLEGAL ENTRY". This means that an OPS/Mode Recall may be used at any time in the mission to simply reassign data buses, but can only be used in a few specific cases to instigate main memory reconfiguration.

4.2.9 Memory Source Selection

4.2.9.1 IPL.- During an IPL, an MMU is selected for the memory load via the "IPL SOURCE" switch on Panel O6. This switch is a three-position toggle switch which will be either on the MMU 1 or MMU 2 position during the IPL sequence. At all other times, this switch will be in the OFF position.

4.2.9.2 Non-IPL source selection.- Each PASS GPC exchanges its currently resident MC as part of its common set sync status information. Then, when a request is made for MC, each GPC's software can determine if another GPC has the requested OPS or current major function base. Typically, the lowest numbered GPC which already has the requested software will be used as a source for the GPC's as illustrated in figure 4-8. If there is no available GPC source, the OPS request will be made to MMU. Thus, Item 9 is nominally selected on the DPS UTILITY display. It is possible to force the OPS overlay from an MMU. This is done by an ITEM 10 entry to the DPS UTILITY SPEC. If this item is selected, both the MFO and OPS overlay will be forced from MMU. This means that certain GNC OPS transition FC information, such as vehicle state vector, will be lost and/or inaccurate, with a previously stored one substituted from MMU. If there is no usable GPC source and/or the selected MMU is OFF or being used for another memory transaction, the Class 3 fault message "MM OFF/BSY" is initiated. The current status of each MMU is shown on the DPS UTILITY display as either RDY (ready to respond) or BSY (OFF or currently responding to a GPC command).

4.2.9.3 Input errors during OPS transition.- During an OPS transition, if an I/O error or checksum error is encountered during an MMU read operation, the software will automatically generate a Class 3 "I/O ERROR MMU" fault message and retry the transaction. This retry serves to filter MMU and MM data bus transients. If the error occurs again, the Class 3 and fault message "I/O ERROR MMU" will be generated, and the software will automatically retry the transaction on the other MMU. An automatic realignment of this new MMU to the appropriate major function will occur, and this reassignment will be reflected on the portion of the DPS UTILITY display which relates to MMU assignment (Items 1-8). This automatic switching protects against a single MMU or MM data bus failure.

Any GPC which again detects an error on the transaction (while other GPC(s) were successful) will force fail to sync with the successful GPC's and enter the OPS 0 state. An "I/O ERROR MMU" error message will be generated, and the successful GPC's will process the overlay. If all target GPC's detect an error, they will not process the overlay, be forced to OPS 0, and drive the GPC MEMORY display on their CRT's.

TYPICAL ON-ORBIT TO ENTRY TRANSITION

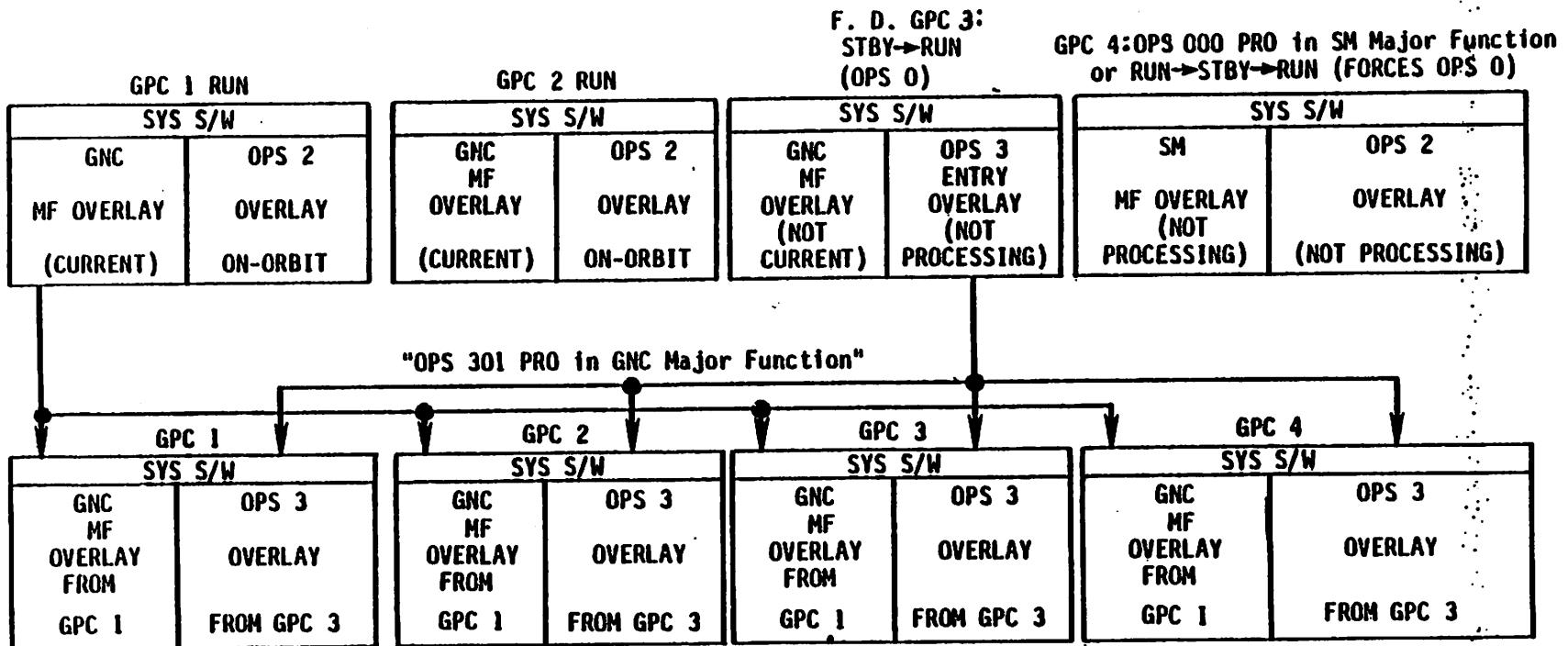


Figure 4-8.- Typical DPS reconfiguration.

The software which handles GPC-to-GPC-transaction I/O errors operates in a similar manner except that no checksum is computed. In case of an error, an "I/O ERROR MMU" fault message is generated and the transaction is retried. If another error is detected, the "I/O ERROR MMU" fault is generated; and then, the alternate bus is selected and the transaction retried.

After exhausting the retry options, the OPS will be initiated in the successful GPC's and the erring GPC(s) will fail to sync.

4.2.10 Checkpoint

Blocks of data, called checkpoint data, can be reserved for future use by storing these data on MMU. These data represent a "snapshot" look at the appropriate systems data taken at the time the checkpoint is made. Prior to launch, an initialized set of checkpoint data is loaded on the MMU's. At specified times during a flight, these data can be updated in order to provide a more accurate data source should retrieval of this information be required. A checkpoint can be made for each major function. However, the software required to support a GNC or PL checkpoint will not be available in the early Shuttle flights, so only an SM checkpoint capability will be discussed here. This SM checkpoint is initiated by user entry to the SM TABLE MAINTENANCE display. The data in this checkpoint include current Fault Detection and Annunciation (FDA) status, including limit values, noise filter constants, telemetry constants, parameter annunciation inhibits, and current time. The checkpoint is initiated by an "ITEM 18 EXEC" input to the SM TABLE MAINTENANCE display as shown in figure 4-9. If the checkpoint is successfully written, the time and status (GOOD) will appear.

Item 12 on the DPS UTILITY display (figure 4-4) is the control which enables the incorporation of checkpoint data upon an OPS transition or an OPS/mode recall. This capability will be inhibited when the display is first initiated. This particular item number (12) is a "SET/RESET" type of item. The first entry of "ITEM 12 EXEC" will enable the checkpoint retrieval capability and place an asterisk next to the item number on the display. The next entry of "ITEM 12 EXEC" will inhibit the capability and cause the "*" to disappear. After the checkpoint has been used during an OPS transition or recall, the capability will again be inhibited automatically.

2011/060/

SM TABLE MAINT

2 237/14:35:02
000/01:30:00

PARAM

1 ID 0470215
VALUE = +58000.00+

LIMITS

| ALERT | | LIMITS | | BACKUP C&W | |
|------------------------|------------------------|------------------------|-------------------------|---------------------|----|
| LOW | HI | | | LOW | HI |
| 2 * <u>[+]14000.00</u> | 3 * <u>[+]50000.00</u> | 11 * <u>[+]2000.00</u> | 12 * <u>[+]57500.00</u> | | |
| 4 [] | 5 * <u>[+]52500.00</u> | | | | |
| 6 [] | 7 [] | | | | |
| | 8 FILTER <u>03</u> | | | 13 FILTER <u>03</u> | |
| | ENA 9* | | | ENA 14* | |
| | INH 10 | | | INH 15 | |

CONSTANT

16 ID 0914123
17 VALUE = [+]75541.0000

CHECKPT 236/00:05:00
INITIATE 18
STATUS GOOD

FDA
ENA 19*
INH 20

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Figure 4-9.- SM TABLE MAINT display.

4.3 SYNCRONIZATION/GPC REDUNDANCY MANAGEMENT

The SYNC and GPC RM schemes employ both hardware and software methods to ensure that the GPC's operate together properly. The software controlled SYNC scheme is used to ensure simultaneous GPC operation, intercomputer communication (ICC) of specified GPC status information, and that all of the appropriate GPC's have received their required data. A software controlled sumword comparison is made to ensure that the redundant set GPC's are issuing identical critical output commands. Software detected discrepancies in the above schemes may result in a FAIL discrete being sent to the erring GPC from the detecting GPC(s) via a dedicated FAIL discrete line(s).

A hardware "voter" in each GPC is used to initiate GPC self-fail annunciation as a result of its receiving two of the above-mentioned FAIL discrettes or by the GPC's own software SYNC or sumword comparison schemes indicating a "self-failure."

4.3.1 SYNC/GPC RM Failure Indicators

A failure detected by the hardware or software SYNC/GPC/RM scheme will be annunciated in one or more of the following ways: A Class 2 alarm which includes "GPC x" (x = GPC Id) fault messages, illumination of the MASTER ALARM lights on Panels F2, F4, MO42J and A7, illumination of the BACKUP C/W ALARM light on Panel F7, the sounding of a C&W tone, the illumination of a light or lights on the GPC STATUS matrix on Panel O1, the GPC light on Panel F7, and illumination of a light or lights on the 120-light C&W matrix on Panel R13. Also, a "+" and "M's" may appear on the GNC SYSTEM SUMMARY displays and the GPC/BUS STATUS displays (if available).

4.3.1.1 GPC STATUS matrix.- The GPC STATUS matrix, located on Panel O1, is a 5x5 matrix of lights used to annunciate the GPC status when a GPC has failed a SYNC or GPC RM scheme with another GPC. Each lighted element represents one GPC's FAIL discrete (vote) for another GPC. For example, if GPC 1 sends a FAIL discrete to GPC 3, Element 1/3 will light (refer to figure 4-10). All of the lights that can illuminate as a result of one GPC voting against another are white in color. Those lights which would be illuminated due to GPC self-failure recognition are yellow in color and form the upper-left to lower-right diagonal. When a GPC lights its own diagonal, it will also automatically reset any FAIL discrettes it had sent to other GPC's. Thus, its non-diagonal row will be extinguished. The cross-hatched column of lights in figure 4-10 illustrates a GPC STATUS matrix indication if GPC 1 failed in a nominal ascent or entry configuration.

The GPC STATUS matrix discrettes are reset by the involved GPC's at any OPS transition or OPS/Mode Recall involving MC. Also, when a GPC is powered off, its corresponding row and column are extinguished, and if it is placed in HALT, it will extinguish its non-diagonal row. Furthermore, as will be discussed later, if the lights were set as a result of a sumword miscompare they will be reset following a correct comparison.

The GPC STATUS matrix is used primarily to annunciate redundant set GPC failures. Any GPC which goes to software halt (as a result of crew station panel configuration, hardware detected problems or BFS engage) should light its diagonal light.

Note here that whenever a diagonal element on the GPC STATUS matrix is lit, the GPC light on the 40 light F7 C&W matrix will light.

4.3.1.2 120-light caution and warning matrix.- There is a 120-light C&W matrix located on Panel R13. Five of the elements on this matrix parallel the main diagonal elements (SELF-FAIL discretes) of the GPC STATUS matrix. For example, Element 05 (the first digit indicates the row, the last digit indicates the column) corresponds to the GPC 1 SELF-FAIL light (1/1) on the GPC STATUS matrix. Likewise, Element 015 corresponds to the 2/2 diagonal, 025 corresponds to the 3/3 diagonal, and so forth.

Indications on Panel R13 become useful only when there would be a crew member available to access this panel, since a manual change to the parameter-status toggle switch (to the "tripped" position) must be made in order to read these status lights.

4.3.2 Mechanization of Synchronization

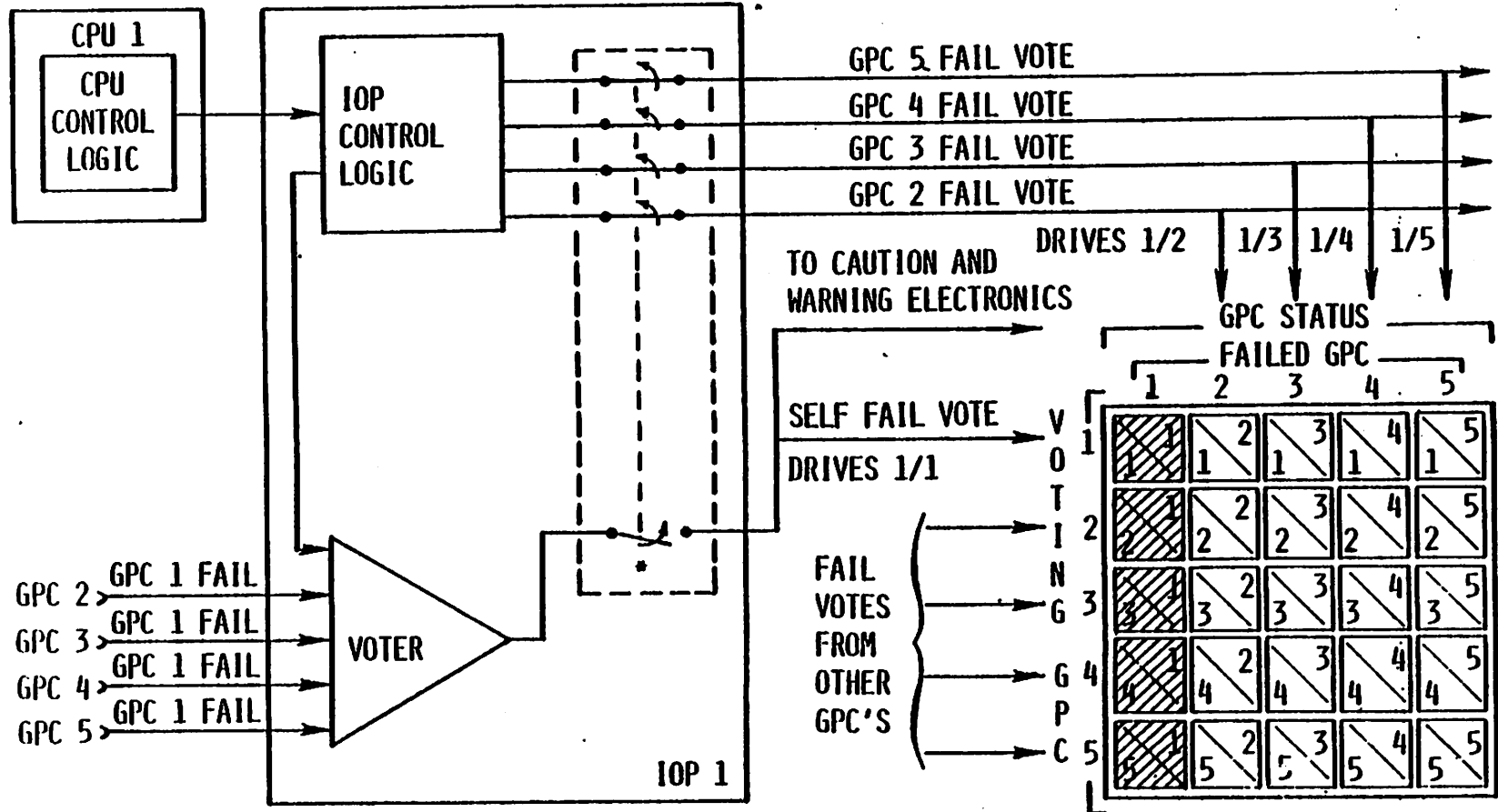
SYNC is the software scheme used to ensure adequate ICC of GPC status, data and error information between PASS GPC's. Two types of GPC operations in which SYNC plays a part are common set and redundant set operations.

4.3.2.1 Common set operations.- A common set is a set of PASS GPC's which cyclically exchange certain status information at a rate of 6.25 times per second over the ICC data buses at specified "sync points". This exchanged status information includes the following:

- I/O errors
- Fault messages
- GPC STATUS matrix data
- DEU MAJOR FUNCTION switch settings
- GPC/CRT keyboard entries
- Current Central Processing Unit (CPU) duty cycle
- Resident MC
- Memory configuration table
- OPS overlay request
- Master Timing Unit (MTU) Time
- Internal GPC time
- System-level display information
- Network Signal Processor (NSP) read data (uplink)

The GPC's in the common set may be executing different applications software, as the on-orbit case in which GPC's executing GNC software and the GPC executing SM software will both be operating as members of the common set.

GPC VOTER HARDWARE



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*SELF FAIL VOTE DISABLES CAPABILITY TO SEND VOTES TO OTHER GPC'S

Figure 4-10.- GPC fail votes output.

Each PASS GPC attempts to join the common set when it is moded from HALT to RUN, or from STBY to RUN after an IPL. Each GPC maintains an internal table of the other GPC's with which it has achieved common set sync (its common set sync set or common set mask). Except under GPC failure conditions, all active PASS GPC's will be members of the common set.

4.3.2.2 Redundant set operations.- A redundant set is a set of two or more GPC's which are performing identical tasks using identical inputs and producing identical outputs. Therefore, except for the Instrumentation/PCMMU (IP) data bus, (each GPC is assigned a dedicated IP data bus) any bus assigned to a member of the redundant set will be listened to by all members of the redundant set. Thus, if GPC 1 commands String 1 and DK 1, all of the redundant set GPC's will receive the data transmitted over String 1 and DK 1, since they are listening on those buses.

The redundant set SYNC schemes ensure that the redundant set software processing is done simultaneously in all redundant set GPC's and also that all redundant set GPC's are receiving the requested data. This requirement ensures identical inputs to the redundant set GPC's and, if any redundant set GPC detects an error, no redundant set GPC will process the input data. Such an I/O transaction is called a "protected" transaction.

The above requirements result in status being exchanged between the redundant set GPC's at a rate of 400 to 600 times per second (at redundant set sync points). Each GPC maintains a table of the other GPC's with which it will attempt to maintain redundant set sync (its redundant set sync set or redundant set mask).

Only GNC programs can be executed by a redundant set. An attempt to load an SM or PL MC into multiple GPC's will result in the generation of an "ILLEGAL ENTRY" fault message. The redundant set is formed automatically by systems software at specified OPS transitions and legal OPS/mode recalls.

4.3.2.3 Synchronization operation.- Each GPC is connected to the other four GPC's with a dedicated set of three discrete sync lines. Over such a set of discrete lines, each GPC periodically (as specified "sync points") will broadcast a three-bit binary signal called a "sync code". A GPC which is powered off, is in STBY or HALT (according to the GPC MODE switch position), software HALT (internal failure or BFS-engage command), or is the BFS GPC, will broadcast a sync code of "000." This "000" sync code will tell the other GPC's that the transmitting GPC is in STBY or HALT.

A PASS GPC, which is actively processing software, will broadcast a "111" sync code except at certain "sync points." At the common set sync point (6.25 times per second), all common set GPC's will issue a sync code of "100." If all of the common set GPC's correctly broadcast "100," they will exchange their status information over the ICC buses.

At redundant set sync points (400 to 600 times per second), the redundant set GPC's compare their sync codes. At certain points in software processing, whenever a branch in software is indicated, the redundant set GPC's issue a "110" sync code and enter a specific type of synchronization logic called a Supervisor Call (SVC) sync. This ensures that they leave the

branch together. After each I/O transaction involving the redundant set ("protected" transactions), each redundant set GPC issues one of two sync codes: "010" for I/O complete without error or "011" for I/O complete when an error has occurred. Thus, it can be immediately determined whether or not all the GPC's have successfully completed the transaction. This particular sync routine is also used by the common set GPC's following ICC data transfer at each common set sync point.

Periodically, another interrupt is generated by the redundant set GPC's and the sync code "101" is broadcast. All Flight Critical (FC) I/O is initiated at such interrupts. These interrupts are also used to resynchronize the redundant set following OPS overlays to redundant set members.

4.3.2.4 Joining the common set.- Following IPL, anytime a PASS GPC is transitioned from HALT or STBY to RUN, that GPC will attempt to join the current common set. The new GPC will monitor the other GPC's sync lines to determine if and when they are broadcasting the common set sync code. If it does detect that the other GPC's are broadcasting the common set sync code, it will wait a prescribed amount of time and then begin also broadcasting the common set sync code and entering the SYNC scheme described earlier. The old common set GPC's note the change in another GPC's sync discrettes from "000" (HALT or STBY) to "111" (RUN) and then add such a GPC to their common set sync set and expect that GPC at the next sync point. If the new GPC successfully joins the common set, it will begin ICC data transfer with the old common set GPC's.

4.3.3 Fail to Sync Annunciation

The annunciation following a GPC failing to sync is dependent upon a number of factors, such as, whether the GPC was a simplex GPC or a redundant set GPC, whether the failure was at a common set or redundant set sync point, and which GPC's detected the problem.

The software logic ensures that if a redundant set GPC fails to sync with all other redundant set GPC's, and if its software is still processing, it will determine that it has self-failed and will initiate a command to its voter to annunciate self-failure (resulting in the illumination of a diagonal light on the GPC STATUS matrix, etc). If a GPC has not failed to sync with all other redundant set GPC's, it will send a FAIL discrete (vote) to any redundant set GPC with which it has not synced (resulting in GPC STATUS matrix off-diagonal annunciation, etc). Furthermore, a GPC's hardware voter will trigger self-fail annunciation if it receives FAIL discrettes (votes) from two or more of the other GPC's. This results in diagonal GPC STATUS matrix annunciation, etc.

If a GPC is in the redundant set and it fails to sync with all other redundant set GPC's, but is still in the common set, ICC will continue and the subsequently produced fault messages will continue to be exchanged. Thus, the contents of the FAULT page will remain the same no matter which GPC is driving it. If that GPC fails common set sync also (as is typically the case), ICC will cease and thus differences will appear between the FAULT pages driven by the GPC's. In either case, that GPC will stop

listening on any bus (with the possible exception of the ICC buses as described above) commanded by a GPC remaining in the common set. Conversely, each GPC remaining in the redundant set will set masks on buses commanded by that GPC (with the exception of the ICC data bus if common set sync is maintained). The following annunciation will appear for the crew:

- The diagonal light for the failing GPC on the GPC STATUS matrix will illuminate. Also any element in that GPC's row corresponding to a GPC remaining in the redundant set will illuminate if more than two GPC's remain in the redundant set, and this GPC did not fail to sync with all of them.
- On a CRT driven by the failing GPC:
 - "+"s and "M's" on the GNC SYS SUMM 1 and GPC/BUS STATUS displays to indicate masking of buses commanded by GPC's remaining in the redundant.
 - A "+" under the failed GPC on the GNC SYS SUMM 1 and GPC/BUS STATUS display.
 - Class 2 alarm (BACKUP C/W ALARM light, MASTER ALARM light/tone) and fault message:
 - If the failing GPC disagreed with another GPC the message "GPC X+ N" would appear, where X is the other GPC and N is this (the failing) GPC. Note that if the failing GPC remained in the common set, this message would appear on any CRT driven by a common set GPC and this message would appear on a FAULT page driven by the failing GPC.
- On a CRT driven by a healthy GPC (GPC X) remaining in the redundant set:
 - "+"s and "M's" on the GNC SYS SUMM 1 and GPC/BUS STATUS displays to indicate masking of buses commanded by the failing GPC.
 - A "+" under the failed GPC on the GNC SYS SUMM 1 and GPC/BUS STATUS displays.
 - Class 2 alarm and fault message: "GPC N + X--".

Note that if there are only two GPC's in the redundant set, each will respond as the failed GPC, as described above.

If the failing GPC is in the redundant set and fails to sync with some member of the redundant set but not all members of the common set, the software response is similar to what was described above with a few exceptions. An example would be the "2 on 2" cases. In this case, the bus masking and CRT annunciation follows the same principles as described above. However, the annunciation on the GPC STATUS matrix would be dependent upon timing factors. If a GPC receives two FAIL votes from the other redundant

set GPC's, its voter will reset any FAIL discretess (votes) set against other GPC's and will send a SELF-FAIL discrete to light its diagonal light on the GPC STATUS matrix.

If a simplex GPC fails common set sync, the ICC exchange between that GPC and the other GPC's cease. This means that if the simplex GPC is not in control of FC 1, 2, or 3, it will not receive MTU or NSP (uplink) data as this data was passed from the GPC's in control of those buses to the simplex GPC over ICC. Thus, information such as fault messages, on a CRT driven by the simplex GPC will differ from that driven on a GPC remaining in the common set. The simplex GPC will drive the BACKUP C/W ALARM light and a Class 2 GPC message(s) on its CRT indicating it has disagreed with the other common set GPC's. Similarly, each of the remaining common set GPC's will drive the BACKUP C/W ALARM light and a Class 2 combined message indicating that they disagreed with the simplex GPC. A "+" will appear on the GPC/BUS STATUS and the GNC SYS SUMM 1 display under the simplex GPC regardless of which GPC was commanding the display. Thus, on-orbit, if GPC 4 is the SM GPC and GPC's 1 and 2 form a GNC redundant set, failure of GPC 4 to sync with GPC's 1 and 2 will result in the following annunciation:

- CLASS 2 ALARM (BACKUP C/W ALARM light, MASTER ALARM light/tone)
- On a CRT driven by GPC 4 - "GPC 1 + 4" fault message
"GPC 2 + 4" fault message
"+" under GPC 4 on the GPC/BUS STATUS display (if available)
- On a CRT driven by GPC 1 or GPC 2 - "GPC 4 + 12" fault message
"+" under GPC 4 on the GNC SYS SUMM 1 and GPC/BUS STATUS displays

Note that there will be no annunciation on the GPC STATUS matrix.

4.3.3.1 Force fail to sync. - A GPC will force itself to fail to sync (both from the common set and the redundant set) under each of the following conditions:

- A redundant set GPC which has an I/O error when all the other redundant set GPC's have successfully completed the transaction will fail to sync the set upon the detection of a second consecutive error.
- After certain ICC data bus I/O errors (to be discussed in Section 4.3.8.).
- After that GPC's OUTPUT switch is set to TERMINATE.
- If that GPC (but not all target GPC's) fails to correctly receive an OPS overlay after the retry options are exhausted, that GPC will fail to sync and go to OPS 0.

4.3.3.2 Downlist GPC impact.- If the downlist GPC fails either the redundant set or common set sync by disagreeing with all other redundant set GPC's or by forcing fail to sync, and is in a redundant set with at least two other GPC's, a new downlist GPC will be selected. The new downlist GPC will be the lowest numbered GPC in the redundant set.

4.3.4 Sumword Comparison

The redundant set GPC's are required to execute identical software simultaneously, using identical inputs and producing identical outputs. Although the redundant set GPC outputs are not directly compared, the GNC applications software in each of these GPC's will take the sum of a specified set of critical output commands and store the "least significant" bits of this sum in a 64-bit "double-precision" word called a sumword. This sumword is passed to the systems software from which it is transferred over the ICC data buses to the other GPC's, 6.25 times per second. Each GPC then performs a bit-by-bit comparison of each of the redundant set GPC's sumwords. This operation is referred to as a sumword comparison. The software sumword voting logic and the hardware voter, as a part of GPC fault detection and identification, are incorporated to determine and annunciate the specific problem should a GPC repeatedly fail the sumword comparison test ("sumword miscompare"). Note that a sumword miscomparison only results in an annunciation of the problem. It does not necessarily impact the redundant set or any software operation of the GPC's.

The sumword computed by the GNC applications program has an OPS-dependent composition (refer to table 4-4). For example, the following items are included in the entry (Memory Configuration 3) sumword: OMS commands, inboard/outboard elevon commands, rudder, bodyflap and speed brake commands, and accelerometer assembly data. Also included in this sumword are the forward and aft vent commands, the Orbital Maneuvering System (OMS), Main Propulsion System (MPS), and Reaction Control System (RCS) commands, the Reaction Jet Driver Forward (RJDF) commands and the Doppler Extractor data.

The software sumword voting logic in each GPC keeps track of the number of sumword miscompares it has detected, and this number is exchanged among the common set GPC's for downlist purposes.

If a GPC logs three consecutive miscompares with all of the other redundant set GPC's, its software will determine that it has self-failed and will issue a self-fail "test command" to its hardware voter. This will result in the illumination of that GPC's diagonal element (SELF-FAIL light) on the GPC STATUS matrix and the GPC light on the 40-light C&W matrix on Panel F7. A Class 2 alarm (Master Alarm light, C&W tone, Backup C/W ALARM light on Panel F7) will then be generated, along with the fault message "GPC N + N" (assuming GPC N is the GPC under consideration). A "+" will appear under GPC N on the display (if available) GPC/BUS STATUS and GNC SYS SUMM display.

If a GPC detects that it has miscompared with another redundant set GPC three consecutive times, and that it has not miscompared with all the

other redundant set GPC's, then it will generate a Class 2 alarm and a fault message of the "GPC X + N" type which indicates that GPC N thinks that the problem lies with the miscomparing GPC X. GPC N will also send a FAIL discrete to the GPC X's hardware voter. This FAIL vote is also sent to the GPC STATUS matrix, which results in the illumination of the appropriate element (row N, column X).

Each redundant set GPC's hardware voter determines if two FAIL discrettes from other redundant set GPC's have been received. If two FAIL votes have been received, the erring GPC will issue a SELF-FAIL vote with all of the accompanying annunciations. This self-failed GPC will reset all of its votes against the other GPC's and its voting row on the GPC STATUS matrix will be extinguished (with the exception of its main diagonal).

Following a sumword miscompare, assuming that the redundant set is still intact, sumwords are still exchanged and compared, and a single correct comparison results in the reset of all "miscompare counters" and annunciation. These FAIL discrettes and counters are also reset by the involved GPC's at an OPS transition which involves the formation of a new redundant set.

4.4 INPUT/OUTPUT MANAGEMENT

One of the responsibilities of systems software is the management of input and output operations. This function includes assigning GPC's as "commanders" and "listeners" on the data buses, and the logic involved in sending commands to these data buses at specified rates upon requests from the applications software. Furthermore, the systems software I/O Management function includes the I/O error processing techniques and some special tests for certain failure conditions. This software will also provide failure annunciation to the ground and to the flight crew, should an I/O error be detected.

The I/O Management logic related to bus assignment and I/O error processing varies between the data bus groups. Therefore, these data bus groups and their associated I/O Management logic, will be examined separately. Prior to doing this, however, some of the major concepts which are basic to the entire subject of I/O Management will be discussed.

4.4.1 I/O Transaction

An I/O transaction is an operation which is initiated by a software request for the initiation and the execution of a data transfer into, or out of, a GPC. This request can be based upon a request from the applications software or can come directly from the systems software. An I/O transaction may involve multiple data buses connected to multiple Bus Terminal Units (BTU's), each of which is connected to multiple sensors or effectors.

In order to maintain consistently identical inputs for the redundant set GPC's, input transactions involving these redundant set GPC's are "protected". This means that either all of the redundant set GPC's correctly receive and process the input data, or they ignore the data. Following

TABLE 4-5.- SUMWORD COMPOSITION

| COMPONENT | MEMORY CONFIGURATION: | | | |
|-----------|---------------------------|-----|---|---|
| | | 1/6 | 2 | 3 |
| MPS (1-3) | ENG ACTR CMD | ✓ | | |
| | ENG ACTR BYPASS | ✓ | ✓ | ✓ |
| | ENG ACTR RESET | ✓ | ✓ | ✓ |
| | ENG MAINSTAGE CMD | ✓ | ✓ | ✓ |
| | ENG LO2 PREVALVE CMD | ✓ | ✓ | ✓ |
| | ENG LH2 PREVALVE CMD | ✓ | ✓ | ✓ |
| | ENG EMERG SHTDN INH CMD | ✓ | ✓ | ✓ |
| | SIG COND PWR CMD | ✓ | | |
| | LO2 ACC RECIRC VLV CMD | ✓ | | |
| | LO2 FDLN RLF VLV CMD | ✓ | ✓ | ✓ |
| | LO2 FEED DISC VLV CMD | ✓ | ✓ | ✓ |
| | LO2 INBD FILL VLV CMD | ✓ | | |
| | LH2 INBD FILL VLV CMD | ✓ | ✓ | ✓ |
| | LH2 FEED DISC VLV CMD | ✓ | ✓ | ✓ |
| | LH2 RTLS MANF REPRESS CMD | ✓ | | |
| | LH2 RTLS OUTBD CMD | ✓ | | |
| | LH2 RTLS INBD CMD | ✓ | | |
| | REPLACE LO2 ULLAGE PRESS | ✓ | | |
| | REPLACE LH2 ULLAGE PRESS | ✓ | ✓ | ✓ |
| OMS (L,R) | ENG ACTR CMD | ✓ | ✓ | ✓ |
| | ENG CTRL VLV CMD | ✓ | ✓ | ✓ |
| | POD VAPOR ISLN VLV CMD | ✓ | ✓ | ✓ |
| | POD FUEL ISLN VLV CMD | ✓ | ✓ | ✓ |
| | POD OXDZR ISLN VLV CMD | ✓ | ✓ | ✓ |
| | POD FUEL XFD | ✓ | ✓ | ✓ |
| | POD FUEL XFD VLV CMD | ✓ | ✓ | ✓ |
| | POD OXDZR XFD VLV CMD | ✓ | ✓ | ✓ |
| RCS | OX XFD VLV CMD | ✓ | ✓ | ✓ |
| | FU TK ISLN CMD | ✓ | ✓ | ✓ |
| | OX TX ISLN CMD | ✓ | ✓ | ✓ |
| | MANF ISLN VLV CMD | ✓ | ✓ | ✓ |
| SRB | ACTR BYPASS | ✓ | ✓ | ✓ |
| | ACTR RESET | ✓ | | ✓ |
| ATVC | ACTR CMD | ✓ | | |
| RJDA | JET CMD | ✓ | ✓ | ✓ |

TABLE 4-5.- Concluded

| COMPONENT | MEMORY CONFIGURATION: | MEMORY CONFIGURATION: | | |
|--------------------|----------------------------------|-----------------------|--------|-------------|
| | | 1/6 | 2 | 3 |
| RJDF | JET CMD | ✓ | ✓ | ✓ |
| ET UMB | DR CMD | ✓ | ✓ | ✓ |
| VENT CMDS | | ✓ | ✓ | ✓ |
| ACCEL ASSEMBLY BIT | | ✓ | ✓ | ✓ |
| DOPPLER EXTRACTOR | START TIME TEST MODE DISCRETE | ✓ ✓ | ✓ ✓ | ✓ ✓ |
| GROUND SPEED | ENBL CMD | ✓ | ✓ | ✓ |
| ELEVON | CMD ACTR BYPASS ACTR RESET | ✓ ✓ | | ✓ ✓ ✓ |
| SPEEDBRAKE | CMD BYPASS RESET | ✓ ✓ | | ✓ ✓ ✓ |
| RUDDER | CMD BYPASS RESET | | ✓ ✓ | ✓ ✓ ✓ |
| BODY FLAP | CMD | ✓ | | ✓ |

the detection of an input error, the transaction typically will be tried again in the next data cycle.

Special Logic is incorporated to ensure that a faulty GPC can not prevent the other redundant set GPC's from receiving necessary data. If a GPC in the redundant set is the only redundant set GPC to detect the same I/O error two consecutive times, that GPC will force fail to sync, and therefore, drop out of the redundant set.

The protected transaction capability is maintained through the use of sync codes and certain I/O error processing techniques. Following an input transaction over the FC data buses, which involves the redundant set GPC's, a special sync code is issued by each of the involved GPC's: "010" if the transaction was completed without any errors, and "011" if an error was detected on the transaction. This sync pattern is known as the "I/O Problem Report (IPR)" sync. If one of the involved GPC's broadcasts the IPR sync code which indicates an I/O error, an ICC transaction is initiated in order to transfer information among the participating GPC's as to the specific source of the problem. This ICC transaction is also called an IPR. Thus, if any member of the redundant set detects an error during an I/O transaction, that information is exchanged among all of the redundant set GPC's. How this information is utilized is a subject which will be discussed in greater detail later on in this section.

While protected transactions are used primarily for redundant set transactions, there is also one case where the same philosophy is invoked: ICC transactions involving the common set. Here again, if one GPC in the common set detects an I/O error on an ICC transaction, this information will be revealed to the other common set GPC's using the appropriate IPR sync code, and no common set GPC will use the data that was received over the involved ICC bus.

4.4.2 Minor Cycle/Major Cycle

Within the software system there are certain high-rate cyclic processes which are critical to both the safety and the performance of the vehicle. The principle example of such applications software processing is that which relates to the GNC flight control and flight control-related operations. The period over which one cycle of these processes can be performed is called a minor cycle. It will be 40 msec in duration since the highest rate of cyclic processing used is 25 Hz.

A major cycle is a time period consisting of 24 minor cycles, during which a majority of the cyclic software processing is scheduled. Thus, a major cycle is of 960 msec in duration and is initiated at 1.04 Hz.

4.4.3 I/O Transaction Rates

Many commands and requests for data are sent to hardware devices at specified rates. These rates vary from once per minor cycle (25 Hz) to once every major cycle (1.04 Hz). Some examples are as follows:

- There is a transaction consisting of a set of flight control commands and requests for data which is sent over the FC data buses. This transaction, which is known as the GNC High Frequency Executive (HFE) transaction and which involves all eight of the FC data buses, includes requests for data from the Engine Interface Units (EIU's), Air Data Transducer Assemblys (ADTA's), the RCS, the MPS, and the OMS once every minor cycle (25 Hz).
- Since many navigation computations run at 6.25 Hz (every fourth minor cycle), data from many of the avionics sensors, such as the Inertial Measurement Units (IMU's), Tactical Air Command and Navigation System (TACAN) and the Radar Altimeters (RA's), is requested at this 6.25 Hz rate. These data requests are a part of the Mid Frequency Executive (MFE) transaction, which consists of the set of commands and data requests that are sent out over the eight FC data buses at 6.25 Hz.
- Once every minor cycle (25 Hz), each GPC, which is actively processing software, sends its downlist to the Pulse-Code Modulation Master Unit (PCMMU).
- Commands are sent to the MTU, for the current Greenwich Mean Time (GMT), Mission Elapsed Time (MET) and Built-In Test Equipment (BITE) status data, once every major cycle (1.04 Hz).

However, not all I/O transactions are cyclic in nature. Certain of these transactions are initiated only on a specific request from an applications or a systems software program.

4.4.4 MDM PROM Segment

An MDM Programmable Read-Only Memory (PROM) segment is a hardware sequence which is contained in an MDM to support the capability to access multiple hardware devices with a single command from a GPC. The PROM's, which cannot be changed in flight, contain all of the pre-set programming required to support their individual functions. An input PROM stored in an FF MDM is illustrated in table 4-6. A complete listing of the input and output PROM's for the FF and FA MDM's is included in appendix D.

TABLE 4-6.- FF INPUT PROM

| PROM segment | Description of input | Freq. | Word count |
|--------------|---|-------------------|------------------|
| 1 | RCS tank temp/press RCS manf. press | 6.25 Hz | 6 2 |
| 2 | Discretes | 6.25 Hz/ 25 Hz | 13 |
| 3 | RSC thrust inj. temp. | 25 Hz | 8 |
| 4 | LH RHC CMDS LH RPTA CMD LH SBTC CMD AFT RCH CMDS | 25 Hz | 3 1 1 3 |
| 5 | RH RHC CMDS RH RPTA CMD RH SBTC CMD | 25 Hz | 3 1 1 |
| 6 | Lateral acc'm Normal acc'm | 25 Hz | 1 1 |
| 7 | FF discrete output channels | Non-cyclic | 10 |
| 8 | FF discrete output channels | Non-cyclic | 8 |

4.4.5 Bus Control Element (BCE) Chain

An I/O transaction is comprised of "groups" of subsystem data from one or more BTU's.

A BCE chain is a sequential set of software instructions, each of which accesses a group of subsystem data from one or more BTU's, which is initiated through a single BCE and, thus, through a single data bus.

Each of the software instructions and the associated subsystem data in a BCE chain is called a BCE chain element or, more simply, a BCE element. The associated subsystem data may include an MDM return word, a segment of an MDM PROM, MDM stored data associated with an external device or data from an individual BTU (such as an EIU). For example, at 6.25 Hz, the following BCE chain may be initiated over FC1 (BCE 20) by each GNC GPC.

TABLE 4-7.- I/O TRANSACTION for BCE 20 - FC1

| BCE element number | Request for data from: |
|--------------------|------------------------|
| 1 | FF1 PROM segment 1, 2 |
| 2 | IMU 1 |
| 3 | TAC/RA 1 |
| 4 | MSBLS 1 |
| 5 | STU 1 |
| 6 | OWDE 1 |

An I/O transaction may involve several BCE chains. For example, the MFE transaction (6.25 Hz) discussed earlier in this section, is composed of eight BCE chains (one for each of the FC data buses 1 through 8).

Through the use of certain validity checks (performed by the Multiplexer Interface Adapter (MIA), BCE, and the I/O error processing logic in the systems software), a problem with a BCE chain may be identified as an error from a specific BCE or from the involved MDM. Currently, BCE chains have been identified for the FC and PI data buses only as presented in Appendix C.

4.4.5.1 MDM Return Word.- The first element of certain BCE chains is called an MDM Return Word. This word is used to determine whether or not the MDM is capable of communicating, and is used by the I/O error processing logic to determine whether or not an I/O error is the result of an MDM failure or a particular BCE chain element failure.

If there are multiple BCE chains associated with a BCE and an MDM, the BCE chain which has the highest frequency will have the MDM Return Word as its first element. The philosophy here is that if the MDM Return Word is correct (which indicates that the MDM is still communicating with the GPC) on the highest frequency transaction, it would also be correct for the lower frequency transactions.

4.4.5.2 BCE element bypass.- A BCE chain is composed of multiple BCE elements which relate to multiple hardware line replaceable units (LRU's) and which usually involve at least one BTU/MDM. Special I/O error processing logic is invoked to determine if a detected problem is a result of a GPC, a BTU/MDM or an individual hardware item (LRU) problem. If, as a result of this I/O error processing logic, the GPC is determined to be at fault, that GPC may be forced to fail to sync. This topic will be discussed in greater detail later in this section.

If the problem is at the BTU/MDM level (as detected by an incorrect or absent MDM return word), the problem will be downlisted and annunciated and no further I/O transactions would be attempted involving that BTU/MDM "port." This action is called a BTU segment bypass. If the problem existed with FF MDM 1, for example, a Class 3 alarm would be generated along with the fault message "I/O ERROR FF 1." Also, additional information concerning this failure will be displayed on the current GNC SYS SUMM 1 display and the GPC/BUS STATUS display, if available.

If the problem is determined to be at the individual LRU level (BCE element level), the problem will be annunciated by a Class 3 alarm and fault message. The fault message will indicate whether the bypass was on a PL or FC chain. If the problem is on a FC chain, the string and element will be identified in the message. See appendix C for the list of BCE element bypass fault messages. The problem will also be downlisted and that BCE element will be bypassed on subsequent transactions. An appropriate time delay will be inserted in the chain to replace that particular request for data.

For example, in the HFE transaction, the BCE chain being executed for BCE 20 attached to FC 1 is illustrated in table 4-8.

TABLE 4-8.- FC1 HFE TRANSACTION

| BCE element # | Request for data from | BCE element # | Request for data from |
|---------------|-----------------------|---------------|-----------------------|
| 1 | FF1 RTN WD | 1 | FF1 RTN WORD |
| 2 | PL/SNSR | 2 | PL/SENSR |
| 3 | ADTA 1 | 3 | DELAY |
| 4 | FF1 PROM SEG 2-6 | 4 | FF1 PROM SEG 2-6 |
| BEFORE BYPASS | | AFTER BYPASS | |

If ADTA 1 fails and does not respond to the BCE 3 request for data (two consecutive times to insure that it is not just a transient problem), then that element will be bypassed and a time delay substituted for that request for data as illustrated in table 4-8. The Class 3 fault message "BCE STRING 1 ADTA" will be generated.

4.4.6 Bus Masking

Bus masking is a software controlled technique which results in a GPC terminating its command and listen mode on a given data bus. It is used when a bus is no longer controlled by a GPC within the GPC set (i.e., common set or redundant set) performing the transaction. For example, if on Ascent, GPC 3 fails to sync with GPC's 1, 2, and 4 (assuming the nominal string assignment on Ascent), then GPC's 1, 2 and 4 will mask FC buses 3 and 7 (String 3) which are commanded by GPC 3. Similarly, if GPC 3 is still processing software, it will mask FC 1, 2, 4, 5, 6, and 8 buses (Strings 1, 2, and 4) which are commanded by GPC's 1, 2, and 4, respectively.

Bus masks of this type will be reset following a GPC being moded from HALT or STANDBY to RUN, following an OPS transition (which involves memory reconfiguration or redundant set formation), or following a legal OPS/mode recall in which memory reconfiguration or string reassignment is performed. Thus, in the previous example, if String 3 was reassigned to GPC 2 with an OPS/mode recall, GPC's 1, 2 and 4 would remove their bus masks on FC 3 and 7 (String 3).

When the BFS GPC is "engaged", the PASS GPC's go to a state of SOFTWARE HALT. If an attempt is made to reinitialize a PASS GPC (via a new IPL

sequence), that PASS GPC will set bus masks on all of the data buses being used by the BFS GPC (FC, PL and DK buses). These bus masks will be removed following recognition by the PASS GPC of the BFS DISENGAGE condition. This ensures that the newly IPL'd PASS GPC does not interfere with the data buses until the BFS is disengaged.

Also, bus masks are normally set by systems software when a GPC is required neither to transmit or receive data on a particular data bus. For example, the GNC GPC's will set bus masks on the PL data buses during the orbital flight phase, when the PL buses are assigned to the SM GPC.

There is no special fault annunciation associated with the bus masking except, in some cases, the use of "+"s on the GPC/BUS STATUS and GNC SYS - SUMM 1 displays and "M's" on other displays to indicate missing data.

4.4.7 I/O Error Handling

4.4.7.1 General description.- The I/O error handling logic is designed to detect data transmission errors. It is not designed to determine any other data validity. Data validity determination is the responsibility of the application software.

The specific way that I/O errors are handled is dependent on the type of data bus involved. Some similar concepts exist, and they will be discussed here. In general, only input errors are detected and annunciated directly by the systems software. The exception is with the output of the GPC downlist to the PCMMU over the IP data buses.

For protected-input transactions, the general logic is as follows: The IPR report from all of the redundant set GPC's are compared per bus. If a single GPC detects the same I/O error two consecutive times, it will "force fail to sync" (both the common set sync and the redundant set sync) with the other GPC's. If more than one GPC detects a particular I/O error two consecutive times, each GPC will perform the BTU segment or BCE element bypass as required.

For non-protected transactions (transactions for a simplex GPC), no special logic is necessary to determine which GPC is responsible for detecting the error. Following two consecutive errors of a particular type, the GPC will do either a BTU segment or a BCE element bypass, depending on the nature of the problem.

Special I/O error handling checks exist to protect against certain hardware states and failures. For example, a specific test is made, following any I/O error, to insure that only the assigned command GPC has its transmitters enabled. If another GPC's transmitter is detected to be "on" that GPC will go to software halt. A special test is also made following any I/O error to determine if the BFS had been engaged (the switches which determine the BFS engage condition are monitored at a once-per-second rate). If the BFS has been engaged, the PASS GPC's will go to software halt.

4.3.7.2 General annunciation.- I/O errors on any of the seven groups of data bus will initiate Class 3 alarms. This means that, along with a

fault message, the blue SM ALERT Light on Panel F7 will be illuminated and the SM ALERT tone will be generated. The fault message will be one of two forms: "I/O ERROR ABC" if the error is attributable to a BTU (ABC refers to which BTU is at fault, such as FF 1, PL 1, MMU, etc.), or "BCE -----" if the problem results in a BCE element bypass on a string or the PL data buses. Furthermore, the fault message will indicate which GPC's detected the problem and at what time (MET) the problem was detected. For example, the fault message:

"I/O ERROR FF1 1 2 3 4 05:01:00"

indicates that GPC's 1, 2, 3 and 4 each detected a problem with MDM FF1 at 05:01:00 MET.

4.4.7.3 Error logging for downlist purposes.- The systems software in each PASS GPC will log any I/O error in a memory "stack" which will contain the latest five I/O errors. The total number of I/O errors detected by a GPC will be maintained by a counter. At common set sync, the latest I/O error, its timetag and the cumulative number of all I/O errors will be exchanged between the GPC's over the ICC data buses. Each GPC then, will make available for downlist, its own 5-deep log of I/O errors, each common set GPC's latest I/O error, and each GPC's I/O error cumulative counter.

4.4.7.4 Commfault.- The systems software provides status information on I/O errors called communications fault (commfault) indicators to the appropriate applications (GNC, SM, PL) software. It is then the responsibility of the application software to determine whether or not to use this data. Typically, such data will be flagged as "missing", and an "M" will appear on the appropriate display.

Commfault indicators are set as the result of bus masking, BCE element bypasses and BTU segment bypasses. The logic involved is as follows: When an I/O error is detected on a BCE chain by any GPC, the data on the entire chain is flagged as invalid (commfaulted) for the applications software. On subsequent transactions, if the problem is isolated, only the faulty element(s) is flagged as invalid. In a similar way, if a bus mask is set, all BCE elements and data associated with that bus is indicated via commfault as being in error.

4.4.7.5 Resetting I/O error indications.- The BCE chains and error counters associated with the I/O error processing logic are reset by the appropriate GPC's under the following conditions:

- OPS transitions and OPS/mode recalls involving memory reconfiguration or new redundant set formation, and OPS/mode recalls involving bus reassignments, will reset all counters to zero and reset the BCE chains to their nominal configurations.
- A keyboard entry of "I/O RESET EXEC" will reset the counters and BCE chains in all of the GPC's listening to that particular keyboard.
- If a string or PL bus is moded from one port to another, all counters will be zeroed, but only the BCE chains associated with the moded strings or buses will be reset.

- Reassigning a CRT to a new GPC via a GPC/CRT key input will reset the appropriate counter (and I/O error) for that DK Bus.
- On the IP data buses, a single good data cycle resets the counters.
- Moding a GPC from HALT to RUN or STANDBY to RUN will reset the counters and BCE chains in that GPC.

4.4.8 Flight Critical (FC) Data Buses

The first GPC to complete an IPL will assume command of all eight FC data buses. This setup remains in effect until the first OPS transition to an MC where the strings would normally be reassigned. Following an OPS transition to an MC which supports string to GPC assignments, a nominal bus assignment table is used to determine the commanding GPC for each string. This table originally contains I-loaded values for each MC which can be observed at any time by the crew via the GPC MEMORY display. The observation and modification of these tables was discussed in section 4.2.5.

With one exception, there is no automatic way to reassign the strings other than at certain OPS transitions or OPS/mode recalls. Only in the case of a redundant set of GPC's, which is moded to OPS 0 via an "OPS 000 PRO" keyboard entry, will the strings be automatically reassigned to the lowest numbered GPC in that set. Therefore, with that case excluded, if a GPC fails, the string(s) that GPC commanded can not be reassigned to another GPC until an OPS transition or an OPS/mode recall in that major function.

Note that it is possible to assign multiple strings to a single GPC. Optimally, each string would be assigned to a different GPC. Thus, if a GPC failed, at most one string would be lost; the attached sensors and effectors would receive, at most, one set of erroneous data from the failed GPC. However, there are certain cases, such as on-orbit, where there are only two GPC's, and where each string will be assigned to a GPC. Typically GPC 1 will command Strings 1 and 4, and GPC 2 will command Strings 2 and 3. The current string assignments for the common set GPC's will be indicated on the GPC/BUS STATUS display (available all OPS except GNC OPS 1, 3, 6).

4.4.8.1 String moding.- As mentioned earlier, each of the FA and FF MDM's has dual ports. Only one port of an MDM may be active at any one time. When only the primary (number 1) ports are accessed, the string which interfaces with those MDM's is said to be in the primary mode. When only the secondary (number 2) ports are being accessed, the string is said to be in the secondary mode. This concept of primary and secondary modes is a software restriction (not a hardware limitation), which pertains to the FF and FA MDM's and also to the PL MDM's. Thus, regardless of whether a string is in the primary or secondary mode, the commands to the other BTU's on the string Display Driver Units (DDU's), EIU's, Master Events Controllers (MEC's) are not affected.

Initially, all of the strings will be in the primary mode. However, following certain types of failures, it is possible in any OPS (except GNC OPS

1, 3, 6) to mode an individual string to the secondary mode (or back to the primary mode) through the use of Items 15-20 on the DPS UTILITY display. These changes take effect immediately.

4.4.8.2 I/O error handling.- All of the I/O transactions involving the FC data buses are implemented using the BCE chain concept described earlier. Thus, the I/O error handling functions involved with FC bus transactions include BCE element bypasses and BTU segment bypasses. Also, status indicators in the form of down-arrows (↓) will appear in the appropriate locations on the GPC/BUS STATUS display beside the involved FF or FA MDM if a BTU segment bypass has occurred. No "+" will appear for a BCE element bypass. In the same way, on the GNC SYS SUMM 1 display, a "↓" will appear under the appropriate FF or FA MDM in order to indicate which MDM was at fault. In addition, for either BCE element bypasses or BTU segment bypasses, "M's" may appear in other portions of this display and others to indicate missing data.

4.3.9 Intercomputer Communication (ICC or IC) Data Buses

There are five unidirectional ICC data buses - one for each GPC to transmit messages to the other GPC's. Any transmissions over these data buses are processed only by the common set GPC's. Therefore, the BFS GPC will not process data received over the ICC data buses, and will also not transmit information over its own ICC bus.

The ICC bus traffic includes the assorted GPC status information necessary to keep the common set GPC's running together. Such information as OPS overlay requests, GPC/CRT assignment, the MAJ FUNC switch setting on each DEU, and the current fault messages are exchanged. Also, the MTU time, uplink data and the current vehicle state vector are sent to the SM GPC on-orbit. In order to maintain the redundant set, SUMWORDS are exchanged over ICC as well as I/O errors as they are detected (IPR).

As mentioned earlier, all transactions involving the ICC buses are protected. If an I/O error is detected by any involved GPC, that error will be indicated to the other GPC's via the appropriate IPR sync code. The transaction is automatically retried, and the exchanged data over the ICC buses will include the error status from the previous transaction. The general logic which is then invoked is as follows:

- If a single GPC detects an error over an ICC bus, that GPC will be presumed in error and will force fail to sync.
- If multiple GPC's report an error over a particular ICC bus, the commanding GPC for that bus will be assumed at fault, and will force fail to sync.
- If multiple GPC's report ICC errors with no agreement on the buses, all such GPC's will force fail to sync.

In any of the above cases, there will be the previously described Class 2 alarm (section 4.3.3) and annunciation associated with a GPC's failure to sync. This problem will also be logged in the GPC error log.

4.4.10 Mass Memory (MM) Data Buses

There are two identical MMU's connected to the GPC's via two MM data buses. The assignment of these MM buses is dependent upon a number of factors. In most cases, only one MMU and its MM data bus will be assigned to respond to commands from a GPC in a specific major function. These assignments can be controlled by the flight crew or the ground via Items 1-6 on the DPS UTILITY display.

The MASS MEMORY READ/WRITE display which is the OPS display in the Payload major function (PL OPS 9) and a SPEC display in SM OPS 2 allows access to either of the MMU's by either the PL OPS 9 GPC or by the SM OPS 2 GPC. Recall that Items 7 and 8 on the DPS UTILITY display refer to the assignment of an MMU to an OPS 0 GPC for such functions as retrieving the DEU initialization logic from the MMU following a GPC IPL. Note that Items 1 and 2, 3 and 4, 5 and 6, 7 and 8 on the DPS UTILITY display are mutually exclusive.

Thus, which MMU is to be used by a given major function and which GPC in the major function will command a specific MM bus is determined by one of two factors. During a GPC-to-GPC overlay, the source GPC for that overlay will automatically assume command of that MM data bus. In the other kinds of transactions involving the MM buses, the command GPC is determined by a nominal bus assignment table which specifies, per MC, which GPC will command an MM bus. This table may be observed and modified via Items 1, 18, and 19 on the GPC MEMORY display. Also, there is an automatic MM bus switching capability should I/O or checksum errors be encountered during MMU access for a memory reconfiguration.

4.4.10.1 I/O error handling.- All MMU transactions are protected. A single occurrence of a checksum or I/O error during an MMU transaction which does not involve GPC memory reconfiguration causes a Class 3 alarm and annunciation and an "I/O ERROR MMU" fault message. As in all protected transactions, the software in each of the members of the GPC set will reject the transaction.

I/O error handling during memory reconfiguration involves the following: Upon the detection of an I/O error (by any participating GPC) on one data bus, the transaction will be automatically retried on the same data bus. If the error is detected again, a Class 3 alarm and fault message "I/O ERROR MMU" will be generated. The transaction will be automatically retried on the other MM bus. If the error occurs again, the transaction will once again be retried. If any GPC still detects the error, the "I/O ERROR MMU" fault message will again be generated and the GPC detecting the error will force fail to sync and go to OPS 0.

4.4.11 Payload (PL) Data Buses

There are two PL data buses, PL 1 and PL 2, each of which is attached to all five GPC's and to a port in each of the two PL MDM's (PL 1 and PL 2). Following STS 2, a third PL MDM may be added to the PL 1 and PL 2 data buses, and a PAYLOAD DATA INTERLEAVER (PDI) may be added to the PL 1 data bus. The type of data transferred through the PL MDM's include commands concerning the PL Bay Doors, fuel cell purges, the antenna management

system and the PL and SM C&W. On later flights, data from PL test articles and experiments may also be accessed through the PL data buses. Note here that the PL MDM's are also referred to as PF1 and PF2 in some documentation.

4.4.11.1 PL MDM port moding.- As was the case for the FC MDM's, each of the PL MDM's is a dual port device. Note that PL data bus 1 is attached to the number 1 port in both of the PL MDM's and PL2 is attached to the number 2 port in both the PL1 and PL2 MDM's (figure 2-5). As before, only one port of an MDM may be accessed at a time, and the systems software in the GPC's is designed such that this restriction is not violated. Thus, the PL MDM's may be accessed in one of two modes - primary or secondary. In the primary mode, Port 1 of MDM PL1 is accessed via the PL1 data bus, and port 2 of MDM PL2 is accessed by the PL2 bus. In the secondary mode, Port 2 of MDM PL1 is accessed by the PL2 data bus and port 1 of MDM PL2 is accessed by the PL1 bus. As with the strings, the PL MDM's will initially be operating in the primary mode. There is a capability, using Items 23 and 24 on the DPS UTILITY display to select which mode is used. However, the capability to mode the PL MDM's is not available during GNC OPS 1, 3, and 6.

4.3.11.2 I/O error handling.- As with the FC MDM's, BCE chains will be used for I/O transactions on the PL data buses. Upon two consecutive I/O errors with a PL BCE element, a Class 3 alarm and fault message "BCE PL" will be generated. There also is a PL MDM Return Word. If two consecutive I/O errors are detected with a Payload MDM Return Word, a Class 3 alarm and a fault message will be generated. The fault message will be of the "I/O ERROR ABC" type, where "ABC" will read either PL1 or PL2, depending upon which MDM caused the problem. Also, a "+" will appear on the GPC/BUS STATUS display under the detecting GPC in the "PL" row.

4.4.12 Display Electronics Unit/Keyboard (DK) Data Bus I/O Management

There are four DK data buses - one for each DEU - connected to each of the five GPC's.

A GPC in command of a particular DK data bus polls the DEU attached to that DK bus twice every second. In this way, the GPC can keep track of the current MAJ FUNC switch setting of that DEU. Changes in that switch setting may result in the change of commanders on that DK bus.

The DK data buses are assigned to GPC's according to a hierarchy based upon several factors: the MAJ FUNC switch position, the nominal bus assignment table, GPC/CRT keyboard input, the BFC DISPLAY/SELECT switches and the moding of the BFS.

The assignment of CRT's (DK buses) to the BFS GPC will be discussed in section 5. However, in summary, if the BFS GPC is moded from HALT to STBY or RUN, it will begin commanding an CRT/DK 4 whether or not the PASS is commanding on that bus. If the BFC DISPLAY switch is ON, the BFS GPC will command on the first indicated CRT if it is not engaged, and on both indicated CRT's if it is engaged. If the BFC DISPLAY switch is OFF, the BFS GPC takes no forward CRT if it is not engaged, and CRT's 1 and 2 if

the BFS is engaged. The GPC/CRT key can also be used to assign a CRT to the BFS GPC via either a PASS or BFS controlled keyboard. User care must be taken to insure that no multiple commanders on a DK bus occur. Pre-engaged, the BFS GPC listens to PASS-controlled DK buses to acquire major mode transitions and certain display data.

For the PASS, the MAJ FUNC switch is used in connection with the Nominal Bus Assignment Table (NBAT), which is MC dependent, to specify which PASS GPC will command a given CRT. If the switch-selected major function is supported by only one PASS GPC, that GPC will receive command of the CRT regardless of the NBAT assignment, with the exceptions which are described below. If the switch-selected major function is supported by a redundant set, then the NBAT should specify which GPC in the redundant set will command the CRT. However, if the NBAT-specified GPC is not in the redundant set, or if the NBAT GPC ID IS 0 (with the exceptions described below), the involved DEU will be assigned to the lowest numbered GPC in the redundant set and these new assignments will be reflected in the NBAT. If the switch-selected major function is not supported by any member of the common set, no change in CRT commanders will occur; however, the OPS 0 display will appear. The exceptions to the above are as follows:

- Only three DK buses may be assigned at any time to the common set. An attempt to assign a fourth DEU to the common set will result in a Class 3 alarm and fault message: ">3 DEU". During an OPS transition, DEU's 1, 3, and 4 are first considered. If the NBAT for the requested MC assigns DEU's 1, 3, and 4 to a common set GPC, and the software then attempts to assign DEU 2 to a member of the common set, the attempt will be denied and the above mentioned fault message generated.
- If a DEU currently has no commander in the common set and an OPS transition is requested to an MC when the NBAT specified GPC ID is zero for that DEU, then no GPC in the common set will attempt to command that DEU following the OPS transition.

The above Maj Func switch logic is initiated at OPS transitions and following GPC/CRT key input, as well as when a DEU poll response indicates a change in MAJ FUNC switch setting.

The GPC/CRT key is also used to reassign CRT's (DK buses) among the PASS GPC's. Following a GPC/CRT key input, the software automatically will transfer control of the CRT to the requested GPC. No check is made by the old commander's software to see if the newly assigned GPC is in the common set or in a matching major function. Also, no check is made to ensure against multiple command GPC's on the same DK bus if control handover of a CRT is requested which has a current commander not in the common set. The GPC/CRT key is also used to make BFS DK bus assignment changes as described in section 5.2.5.

Multiple commanders on a CRT will be readily apparent to the user as two CRT background formats will be loaded and the DEU will flash. THE GPC/CRT key also is used to assign a CRT to the BFS GPC as described in section 2.

4.4.12.1 I/O error handling.- If a DEU is assigned to an redundant set GPC, all of the members of the redundant set will listen on that DK data bus, and

all the transactions on that bus will be "protected." When an I/O error is detected by any GPC on that data bus, all the participating GPC's will ignore the input. After two consecutive I/O errors are detected on a DK bus, the Class 3 alarm and the fault message "I/O ERROR CRT X" will be generated (where "X" indicates on which DK bus the problem was detected). Also a "0" will appear on the GPC/BUS STATUS display by the appropriate DK (CRT) bus and under the detecting GPC(s).

Since transactions involving the redundant set are protected, if only one redundant set GPC detects an I/O error two consecutive times on a DK bus transaction, that GPC will force fail to sync with the corresponding annunciation.

4.4.13 Instrumentation/PCMMU (IP) Data Bus I/O Management

Each GPC is assigned a dedicated IP data bus which connects that GPC with each of the two PCMMU's. Over these IP data buses, each active GPC sends its downlist to the active PCMMU. Also, the SM GPC accesses certain instrumentation and systems data through the active PCMMU over its IP data bus. Note that each IP data bus is hardwired to both PCMMU's, but only one PCMMU may be powered-up (active) at any one time. I/O error annunciation exists for the IP data buses if a GPC detects an error in the downlist transaction. If two consecutive errors are detected, a Class 3 alarm will be annunciated and the fault message "I/O ERROR PCM" will be generated. The detecting GPC will continue sending its downlist data to the PCMMU after this problem has been annunciated. Also, the SM applications software will drive the Class 3 "I/O ERROR PCM" message following three consecutive input errors detected on its IP data bus. The SM GPC performs some logic to determine which parameters are missing and flags these with "M's." It continues to retry IP transactions. The "M's" are removed upon a good parameter sample. The I/O error count is not removed until a single error-free data cycle is received.

4.4.14 Launch Data Bus (LDB) I/O Management

There are two LDB's, each of which is connected to all five GPC's. They are primarily used for ground checkout and launch phase activities. In particular, there is an interface with the GSE launch processing subsystem through both LDB data buses. The Launch Forward (LF) and Launch Aft (LA) MDM's, also known as the command decoder MDM's, are connected to these LDB buses, and are used only during the preflight (and possibly during the postflight) phases for checkout of various Orbiter systems. There is also an interface with the left and right Solid Rocket Boosters (SRB's) for obtaining certain data which are incorporated into the downlist. The LL and LR MDM's (in the left and right SRB's, respectively) are used for this function prior to SRB separation. In addition, LDB 1 is attached to the Manipulator Controller Interface Unit (MCIU) which is associated with the remote manipulator system. The MCIU may be accessed preflight for checkout and eventually, for on-orbit operations. The LDB's may also be used for a GPC to GPC memory overlay if so commanded via an entry to the DPS UTILITY display.

Initially, the command GPC for the LDB's is the first GPC to complete IPL and be placed in RUN. After the first OPS transition, the command GPC for the LDB's will be as specified in the nominal bus assignment table for that MC (unless altered by a GSE command or following certain types of I/O errors). The current command GPC for the LDB's is shown with an "*" under the command GPC on the GPC/BUS STATUS display. The only exception to the above is when the LDB's are specified for use in a GPC-to-GPC memory overlay. In this case, the LDB used (LDB 1 or 2) has the same number as the MMU/MM bus specified in Items 1-6 on the DPS UTILITY display. The command GPC for such a transaction would be the source GPC for the memory overlay.

4.4.14.1 I/O error handling.- The I/O error handling for the LDB's is dependent upon whether the transaction failures occurred during a GPC-to-GPC transaction, or during a transaction with the LA or LF MDM's. In the first case, I/O errors on GPC-to-GPC transactions are handled similarly with GPC-to-GPC transactions using the MM data buses. There is an automatic retry on the same bus, and there can be up to two retries on the other LDB. In the second case, for I/O errors on a LF or LA MDM transactions, a Class 3 alarm and a fault message is generated following two consecutive I/O errors. The message would be either "I/O ERROR LF1" or "I/O ERROR LA1." The software response is to switch data buses and retry the transaction. This automatic switching does not come into play for the SRB (LL and LR) MDM's.

4.5 TIME MANAGEMENT

The GPC complex requires a stable, accurate time source, since the software within the PASS GPC's uses GMT for scheduling software processing. Each of the five GPC's uses the MTU to update its internal clock, since the MTU provides the most accurate timing source. The MTU, which provides precise frequency outputs for various timing and synchronization purposes to the GPC complex and many Orbiter subsystems, includes three time accumulators. Each of these MTU accumulators provide both GMT and MET, which can be updated by external control.

The software Time Management Processor (TMP), which is a part of each GPC's systems software, provides external control over the MTU through synchronizing and/or updating the MTU accumulators, as well as requesting the current time and BITE status from the MTU. The TMP is also responsible for comparing the internal GPC time with the MTU time sources, selecting the best source and updating its internal clock as necessary.

A systems level SPEC, called TIME (figure 4-5), provides the capability to the user to observe the current MTU and GPC clock status, synchronize or update the MTU and GPC clocks, select MET or GMT as the CRT mission time and set CRT timers and alert tone duration/timers. This SPEC is available in all OPS except GNC OPS 1, 3, and 6.

4.5.1 Master Timing Unit (MTU)

The MTU is a device which provides GMT and MET for all Orbiter applications, and provides precise frequency outputs for various timing purposes.

The MTU outputs serial digital time data (GMT/MET) on demand to the GPC's which use this time for a computer reference time and indirectly for time tagging of GNC and SM processing. The MTU also provides continuous digital timing outputs for driving the four digital timers in the crew compartment (there are two mission timers, one on Panel O3 and one on Panel A4, which have an associated switch to display GMT or MET, and an events timer on Panel A4 and on Panel F7).

There are three timing terms that are used when discussing time management.

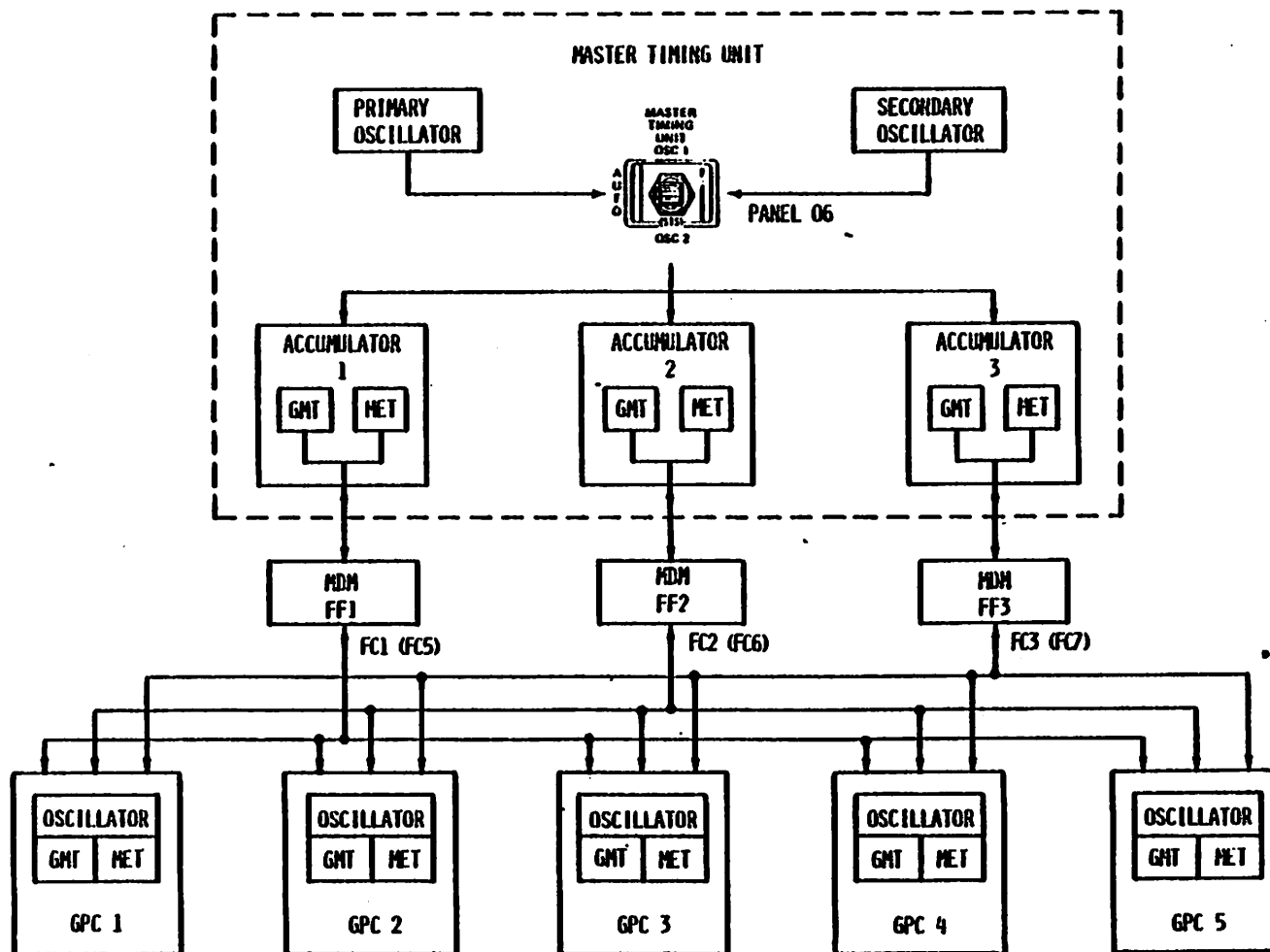
- **Runtime** - Runtime is the time derived from a GPC's internal clock (in GMT). All software processing in a GPC is scheduled according to that GPC's runtime. Therefore adjustments to a GPC's runtime affects its software processing. A GPC's runtime is also referred to as internal time.
- **Clocktime** - Clocktime is a commonly derived value of time which is used during redundant set operations for applications software computations which require time (such as state vector propagation, IMU reads, etc.). This time is computed 25 times a second, and thus is accurate to 40 msec. It is then stored in a location which can be accessed by the application software.
- **Mission Time** - Mission Time is the time value which is displayed in the upper right hand corner of each CRT display. This time can be displayed in either GMT or MET. Items 1 and 2 on the TIME SPEC control whether GMT or MET is displayed for all common set GPC's. Note that in the on-orbit case, for example, when there is both GNC major function software and SM major function software processing simultaneously, a change in the mission time selection to a GNC GPC controlled keyboard will be seen on both GNC and SM driven displays. An "*" will be displayed next to the type of time used as the mission time.

4.5.1.1 MTU hardware.- The MTU is a stable, crystal-controlled frequency source with an accuracy of one part in 10^9 per day, after a 16-hour warm-up (as illustrated in figure 4-13). The MTU uses two 4.608 MHz oscillators as redundant frequency sources. The signals from one of these sources (selectable via the MASTER TIMING UNIT OSC select switch on Panel O6) are passed to the three GMT/MET accumulators. These accumulators keep track of time in days, hrs, min, sec, and msec. The GMT can be accumulated for up to a total of 366 days, 23 hrs, 59 mins, 59 secs, and 999.875 msec. The MET can be accumulated for up to 365 days, 23 hrs, 59 mins, 59 secs, and 999.875 msec.

The MTU sends its BITE status to the GPC's and PCMMU's. The MTU BITE word is incorporated into the operational instrumentation downlink and some of the MTU status derived from the BITE word is displayed in the TIME SPEC. More detail about the MTU operational aspects are presented in SFOM Volume 4B.

4.5.1.2 GPC/MTU operational interface.- Each of the MTU accumulators is tied to a Flight Critical Forward (FF) MDM. (Accumulator 1 to MDM FF1, etc).

GPC/MTU OPERATIONAL INTERFACE



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Figure 4-11.- MTU hardware.

Because of this arrangement, any one of the GPC's which is "listening" on Strings 1, 2, or 3, will receive MTU time and BITE status directly. The redundant set GPC's will receive the MTU timing inputs simultaneously, thereby allowing them to keep their timing and processing within the limits required for redundant set operations. Note that each GPC will receive timing inputs from each of the three MTU accumulators.

A software module in each GPC, called the TMP attempts to obtain GMT, MET and BITE from all three accumulators 1.04 times per second. The GPC which is in command of the appropriate FC bus (and FF MDM) actually sends the command for data to the corresponding MTU accumulator, and all GPC's listening on that data bus will hear the MTU response. If an I/O error causes data loss from that accumulator, an "M" will be displayed next to the MTU accumulator time word on the TIME SPEC. The current MTU accumulator times will also be exchanged among the common set GPC's at the next common set sync point over the ICC data buses. This ICC exchange will also include the current time value for each common set GPC. Thus, each common set GPC may have as many as seven sources of time available: the three MTU accumulators and four common set GPC runtimes (itself included).

It should be noted that although the GPC's receive GMT, MET and BITE from the MTU, they do not utilize the MTU's MET. Instead, that value is ignored and the GPC's compute MET based upon GMT.

4.5.1.3 MTU accumulator status.- If an accumulator fails to incorporate an update signal from the MTU oscillator, as detected by the MTU BITE, an appropriate bit will be set in the MTU BITE word sent to the GPC's and the PCMMU's. Should this happen, the word "BITE" will appear next to the erring accumulator time word in the status column on the TIME display. In addition, a "+" will appear next to the accumulator time word should this accumulator failure cause the GPC to fault down to another time source when it goes through its time selection process. (This would be accompanied by a "TIME MTU" Class 3 fault message on the CRT's fault message line.)

4.5.2 Time Management Processor (TMP)

The systems software module known as the TMP is initiated once every major cycle (1.04 Hz). Its purpose is to gather and adjust time source information from the three MTU accumulators and from the other common set GPC's. It then selects a time source (either automatically or through a crew entry to the TIME SPEC) with which to correct its internal clock. Whether the selected time source is an MTU accumulator or another GPC's runtime is based upon several factors.

If a GPC has selected an MTU source on the previous cycle, it will compare its internal runtime with that of the MTU source on this cycle and see if the difference is less than a tolerance factor, K1. K1 typically is 450 msec. This K1 or "credibility" test is used to insure that an MTU accumulator failure K1, the GPC will use that MTU accumulator time to correct its own runtime for drift.

If the difference is greater than K1, that GPC will initiate a Class 3 alarm alarm and TIME "MTU" fault message. Also, a "+" will appear next

to the former MTU time source's time word on the TIME SPEC. Next, the GPC will sequentially compare its runtime with the other two MTU accumulators. The first one to pass the K1 test will be the new selected time source for that GPC and will be used to update its runtime. If no MTU accumulator passes the K1 test, that GPC will then select a GPC source with which to correct its runtime. Once this happens, the GPC will not check an MTU source on future time management cycles until user intervention.

In order to select a GPC source, the following logic is incorporated: The two lowest numbered common set GPC's times are compared. If the difference is less than K1, after faulting from an MTU source, K1 is set to 5 msec for that cycle. Then the lowest numbered common set GPC's time is compared with this GPC's time; otherwise, the third lowest numbered common set GPC's time is compared with this GPC's time. In either case, if this difference is less than K1, this GPC will correct its runtime based upon that GPC's internal time; otherwise, it will fault down to internal time, i.e., not update its time.

If the GPC selected a GPC time source on the previous cycle, then it will again go through the logic described above to select a GPC source again. The only exception here is that K1 will be once again 450 μ sec.

If there was a crew entry of one of Items 33, 34, 35 or 36 to the TIME SPEC, all common set GPC's will begin their time source selection process using the source selected on the TIME SPEC. However, such a user entry changes the value of K1 to 5 msec for that cycle and thus increases the probability that the user selected time source passes the K1 test and will be used to update the common set GPC's internal clocks. On future TMP cycles, K1 is again reduced to 450 μ sec.

If any case, the time source (MTU A1, A2 or A3, GPC 1, 2, 3, 4, 5) selected by the GPC will appear in the lower right hand corner of the TIME SPEC.

4.5.2.1 Time sync.- It is possible, via a single user entry (Item 37 EXEC) to the TIME SPEC, to synchronize the three MTU accumulators to the time source used by the lowest numbered GPC which has control of at least one of FC Data Buses 1, 2, and 3. The runtime of all common set GPC's will be set equal to this time source, as will the time values in the three accumulators. All the GPC's would then, at least temporarily, attempt to use MTU A1 as their time source.

4.5.2.2 Initialization.- The first PASS GPC to complete IPL and be moded to RUN will request the current MTU accumulator times. This GPC will set its runtime equal to this PCMMU GMT. If none is available (the MTU is off), it will continue to process, using its own runtime.

If the GPC's OUTPUT switch is in TERMINATE, or the BFS is engaged, the PASS GPC will not be transmitting or receiving on the FC data buses, and so will not be listening to the MTU. In this case (initialization only), the PCMMU will be substituted for the MTU as a time source. This is done to synchronize the GPC's downlist with the PCMMU downlink.

If one PASS GPC is already in RUN and is in control of at least one of FC Data Buses 1, 2, and 3, then when another GPC is moded from HALT or

STANDBY to RUN, it will set its runtime equal to that of the lowest numbered GPC in control of one of FC 1-3. This "new" GPC will also initiate its TMP software, using the same time source as the lowest numbered GPC in control of one of the FC 1-3 Data Buses.

4.5.3 MTU/GPC Clock Update

It is possible to update the GMT and/or the MET clocks in the MTU and in the GPC's by entering a "delta time update" via a user entry to the TIME SPEC. The MET may also be updated via the applications software. An example of this is at liftoff when the MET clocks are automatically set to zero.

Items 24-27 (25-27 are "implied item numbers") on the TIME SPEC allow for user entry of a desired GMT delta update in days, hours, minutes, seconds, and milliseconds. Similarly, Items 28-31 allow for a user entry of a desired MET delta update. MET is actually derived from the GMT, so a GMT update would result in a corresponding MET update.

The sign of the update (+ or -) will correspond to the sign of the lowest entered item number for the GMT or MET set. Therefore, if an MET delta update is entered using a "+" key for the Item 24 entry and the "-" key as a delimiter for the rest of the entries, the sign of the delta update would be positive.

Entry of "Item 32 EXEC" initiates the time update, using the values entered in the previous locations, with the actual update occurring from 1-2 minutes later at the MTU coincidence time. The coincidence time is computed by rounding the current time to the next minute and adding 1 minute. After "Item 32 EXEC" is entered, Items 24-31 will be blanked. Another point to note is that following a GMT update, the TMP in each GPC will select MTU Accumulator 1 for its time source.

A GMT update request of more than 15 msec will be rejected, and an "ILLEGAL ENTRY" fault message generated. Since each PASS GPC bases its processing on its internal GMT runtime, this limitation insures that no GPC will go inactive for more than 15 msec. An exception to this limitation is an update to a single running GPC in OPS 0. In such a case, the GMT may be updated by days, hrs, mins, secs, and msec, and the MET will be reset to zero. Furthermore, both GMT and MET updates can not be entered at once.

4.5.4 CRT Timer

Each major function is provided a separate CRT timer. This timer's current value is displayed on the second line in the upper right-hand corner of all displays within the applicable major function. This timer can be controlled by a specific OPS sequence or SPEC software.

Figure 4-12 illustrates a typical "XXXXX MNVR XXXXX" display (in this case, the ORBIT MNVR EXEC display), which is an OPS display. On this display, The Time of Ignition (TIG) of a burn can be entered using Items

```

2021/ / ORBIT MNVR EXEC I 209/16:52:33
GMBL CK I 000/00:37:31

L R TRIM L R
P +1.5 +2.3 P 12 [-] 2
Y +0.6 +1.1 Y 13 [+] 0.7 14 [-] 1.2

SEL
PRI 2* 5* ENG SEL OMS
SEC 3 6 OMS BOTH 15* PURGE INH 19*
OFF 4 7 L 16
BURN ATT R336 R 17
P134 RCS -2 ACC 18
Y 15 20 ROLL 180
MNVR 11 21 WT 209265

HA HP TARGET
TGT 147 +132 27 TIG 17:30:04.8
CUR 147 +129 35 AVX [+] 56.7
TTA 15:25 36 AVY [+] 0.0
EXEC 37 AVZ [+] 0.0

AVTOT 56.7
TGO 3:02
VGO X + 43.20
Y - 7.60
Z + 15.40 LOAD 38 ST CRT TMR 39

```

Figure 4-12.- ORBIT MNVR EXEC display.

27-29, and loaded into the appropriate GPC's for execution using Item 38. When the timer is started (ITEM 39 EXEC), the difference between the TIG and the current mission time will appear in the CRT timer, and the CRT timer will begin counting down, reaching zero at the burn TIG.

A specified time can be placed in the CRT timer by using item entry controls on TIME SPEC. This entry can be positive or negative, and can include hours, minutes, and seconds. Items 9-11 are used to enter this data, and the sign of the lowest entered item number defines the sign of the entire time string. A minus entry here, when started, will cause the CRT timer to count down to zero and then begin counting up. A positive entry will simply count up from the entered value.

This CRT timer value is loaded into the timer, and the timer started in one of two ways. An entry of "ITEM 12 EXEC" will start the timer, at which time the data entered in Items 9-11 will blank. Item 13 can be used to stop and zero the CRT timer.

Another method for loading the CRT timer is to enter a mission time value, in hours, minutes, and seconds, into Items 14-16. This time is then compared with the value of the current mission time. When these two times are equal, the previously loaded time in Items 9-11 will be loaded into the CRT timer, Items 9-11 and Items 14-16 will blank, and the timer will begin counting.

4.5.5 Alert Tones

The TIME SPEC also contains controls to set times at which alert tones will be sounded (two for selected mission times and one for CRT timer), and also to set the duration of the SM alert tone (used in Class 3 alarms).

Item 23 is used to set the duration of the SM alert tone, using an "ITEM 23 + XY EXEC" type entry, where "XY" represents the tone duration in seconds. This value can be set in a range from zero (which would inhibit the tone) to 99 sec. Note that this tone duration control alters the tone duration for all applications of the SM alert tone, and not just those related to those on the TIME SPEC. Also the tone duration will be in effect for any GPC in the common set.

The initial time duration is 3 seconds. This duration is "I-loaded" into all of the GPC's.

There is another method of setting the CRT timer, which, like the controls on the "XXXXX MNVR XXXXX" display, sets the timer to count down to a specific event or mission time.

This is done by entering the "target" mission time into Items 17, 18, and 19. Upon completion of this command sequence, the difference between the target mission time and the current mission time is loaded into the CRT timer, and the timer begins counting down. The CRT timer will reach zero when the current mission time and the target mission time are equal. When this happens, the data fields for Items 17-19 will blank.

Whenever the CRT timer is required to count down to zero, it will start counting up again, as soon as the zero point is reached.

Note that a separate CRT timer is available within each major function. Thus, using some of the controls previously mentioned, the user may set up one timer in the GNC major function, one in the SM major function, and a third timer in the PL major function.

There are three sets of item controls on the TIME SPEC, which allow the user to enter time values at which the alert tone will be sounded. Two of these sets (Items 3-5 and 6-8) allow the user to enter mission times for sounding the alert tone. When the current mission time equals the time input to one of these data sets, the alert tone will be activated for the time period specified by the 'duration' item. At the same time, a fault message ('TIME TONE') will be generated on the appropriate CRT's, and the SM alert light will be illuminated. The involved data field will also blank at this time.

The third data set (Items 20-22) allows the user to activate the alert tone at a specified CRT timer value. A negative value will result in a tone when the CRT timer counts down to that value, and a positive input "event" time will result in a tone when the CRT timer counts up to that value. The same responses and actions that pertain to the mission time event timers also pertain to the CRT time event timer.

These "event timers" are based on a 24-hour clock; so if an event time input is made which is less than the current time, the alert tone will not be activated until the following day, when the current time and the event time are again equal.

4.6 DATA PROCESSING SYSTEM GPC MAIN MEMORY MODIFICATION

The contents of memory within the GPC's (main memory) can be modified by by both the ground support personnel as well as by the crew. During pre-launch operation main memory can be modified via the LDB interface with the GSE computers, inflight via uplink commands from mission control and at any time by the crew or ground support personnel via the GPC MEMORY SPEC (see figure 4-3).

The following discussion will not cover the LDB interface but will cover uplink and the GPC MEMORY SPEC.

4.6.1 Uplink Commands

The ground can uplink three distinct and separate types of uplink data to modify main memory. The first type is for modifying either contiguous or scattered locations in memory containing code as well as data. Note that this method directly modifies memory without interfacing with the MCDS system. As a result, it is not as visible to the crew, nor is it constrained as much as using the GPC MEMORY SPEC for memory modification; i.e., 64 16-bit words at a time versus 6 32-bit words KEYED IN ONE WORD AT A TIME. The second type of uplink data comes via the "DEU equivalent"

command capability of the ground. The ground can call SPEC's, execute item numbers and/or modify main memory via the GPC MEMORY SPEC, etc., the same way that the crew would with the GPC MEMORY CRT display. The third type of uplink commands from the ground that modify memory are those that change certain groups of variables in core such as state vectors, refsmmats, guidance polynomials, launch targets, IMU gyro biases, IMU accelerometer biases, quaternions, deorbit landing site parameters, etc. These commands do not change code, but alter data that is regularly used by the flight software.

4.6.2 GPC MEMORY CRT Display

The read/write portion of the GPC MEMORY display provides the user interface to review and change the value contained in any specified GPC MEMORY location. The general use of this portion of the display is to first read the present value of a given location. The value then may be changed using a two-step load sequence. Additional control items allow the user to read sequential memory locations with minimal keystroke inputs, and to select the mode in which the reading and writing is performed. This part of the display is initialized with all fields blank except the mode, which will indicate DATA, and the major function indicator which will show which major function software is being addressed. Changes made to main memory via the read/write portion of this SPEC affect only those GPC's which are listening to the involved DEU/CRT. Thus, if the DEU's MAJ FUNC switch is in the GNC position, only the GNC GPC's will be affected. Similarly, if the MAJ FUNC switch is in the SM position, only the SM GPC will be affected. If the DEU has been assigned to an OPS 0 GPC, only that GPC will hear the transactions from this part of the SPEC. The major function of the GPC driving this display will be indicated on the display.

4.6.2.1 Operational modes.- The spec has two modes of operation; the DATA mode and the CODE mode. In the DATA mode, the crew or the ground can review or modify any data location in main memory. In the CODE mode, the crew or the ground can review or modify any instruction location in main memory. Instructions or code can only be changed by having the software clear the "storage-protect bit" that is normally set for all code locations. The protect bit is cleared upon execution of Item 2 and input of an address on the GPC MEMORY Spec. That action causes the word "CODE" to flash and also allow complete freedom in altering main memory. The protect bit is not cleared when in DATA mode and thus prevents accidental alteration of flight software instructions.

The read/write part of the GPC MEMORY display is primarily intended to address the data sections of main memory which are unprotected. For this reason, the display is initialized with Item 20 (DATA) enabled. A special operating mode is provided which allows the user to address the protected areas (CODE) of the main memory. As a protection feature, when the CODE mode is selected by the user, (ITEM 21 EXEC), the word CODE will flash.

In addition, after the user writes in a code location(s), the mode will automatically revert back to the DATA mode. Items 22 and 23 are designed to allow the user to set and reset individual bits in memory.

Upon executing any of Items 20, 21, 22, or 23, the active mode will be indicated by an asterisk to the right of the corresponding item number, and all the data fields will blank. This * will remain next to the selected mode until changed by another mode item entry, or until the display is dropped, or in the CODE mode case, until a WRITE command is executed. The four mode item numbers are mutually exclusive.

•4.6.2.2 Memory read operations.- The contents of any memory location may be observed after the selection of the appropriate operational mode is made (DATA, CODE, BIT SET, or RESET). This display is initialized with DATA (Item 20) and half-word hex (Item 27) selected. This read is accomplished by entering the appropriate memory location address (ADD ID) and an appropriate scaling factor of engineering units or half-word hex. The ADD ID is a five-digit hexadecimal number which identifies the memory location being addressed.

A scaling factor of engineering units or half-word hex may be selected via Items 26 or 27 for the display of the contents of addresses specified in Items 28-38. However, the desired contents for such an address must be input in half-word hex. A three-digit number may be input to Item 26 to indicate that the contents of the addresses in Items 28-38 are to be viewed in the specified Engineering Units. The first digit identifies fixed or floating point. The second and third digits select the desired unit conversion.

Digit 1

1 - 16 bit/fixed

2 - 32 bit/floating

Digits 2 and 3

00 - Units in Memory (no conversion)

01 - NM from feet

02 - NM from K feet

03 - Feet from MN

04 - K feet from NM

05 - Feet/Sec² from G

06 - Deg/Sec from M Rad/Sec

07 - Deg from Arc Sec

08 - Feet/Sec² from Micro G

09 - Deg from Rad

10 - KFT from feet

Upon the entry of a correct ADD ID the current value of that memory location will be displayed in the CURRENT column.

It is also possible, via the sequential ID Item 24, to read sequential memory locations, starting with the most recently entered ADD ID. The scale of these sequential locations is the same as that of the most recently entered ADD ID. These scales can be changed later as required. Also, the sequential locations are sequential by quantity, not necessarily by number. Thus, if the data being observed requires two sequential memory locations for each value displayed in the CURRENT column, the ADD ID values displayed after a SEQ ID command will reflect this by skipping every other ADD ID.

If no ADD ID or SCALE is initially given, and Item 7 is executed, a Class 5 fault message (ILLEGAL ENTRY) will be generated. Note that the SEQ ID command will fill the GPC READ/WRITE table starting in the row that follows the most recently entered ADD ID.

4.6.2.3 Bit set/reset operations.- The capability also exists to set individual bits to a logical "1" (bit set) or to a logical "zero" (bit reset), as opposed to writing over a memory location with new data. This capability is only available when half-word hex (ITEM 27) is selected.

In order to perform the bit set function, ITEM 22 EXEC must be entered to initiate the BIT SET mode. ITEM 27 (half-word hex) must be entered if it is not already selected and the appropriate ADD ID must then be entered, bringing the value in that memory location into the CURRENT column on the display. A 16-bit "mask word," represented by four hexadecimal characters, is then placed in the DESIRED column. This "mask word" identifies the individual bits which are to be set with a logical "1", and the bits which are to remain unchanged with a logical "zero".

ITEM 8 EXEC initiates the bit set function and the specified memory word is altered accordingly, with the new representation displayed in the CURRENT field.

The reset function works the same way except that ITEM 23 must be selected and a logical "1" in the "mask word" resets the appropriate bit in memory to a "zero", and a logical "zero" in the "mask word" leaves its corresponding memory word bit unaltered.

These two functions are especially useful when a specific data word is partially dynamic, and the user wishes to alter only part of the data word, while allowing the rest of the data word to update freely.

4.6.2.4 Memory write operations.- All changes to GPC main memory are done in an ARM/FIRE method. In order to perform a write operation, the appropriate mode (DATA or CODE) must be selected, and then the appropriate ADD ID and scaling factor entered, resulting in the display of the present data value in the current column. The user then must enter the value to be written into memory in the DESIRED column in half-word hex. The user can verify the new value prior to writing this new value into memory. An entry of ITEM 25 EXEC will send this desired value to the specified memory location for storage. The CURRENT field will then reflect the new stored

value, which can be compared to the desired field. The desired field will not blank until the mode is changed, reselected, or the display dropped.

Selected values in the current list can be changed by supplying desired data only for those values, and then executing a WRITE command. Blank rows in the desired column are skipped, and their current values remain unchanged. If no desired value has been entered prior to a WRITE command, the ILLEGAL ENTRY fault message will be generated.

The operational mode will automatically revert to the DATA mode following a WRITE command in the CODE mode. If the DATA mode is selected, and the user attempts to write into a CODE location (these locations are protected), the ILLEGAL ENTRY fault message will be generated. However, there is no software protection to stop the user from writing into a DATA location while in the CODE mode. This would result in the DATA location being transformed into a CODE (protected) location. This could result in the loss of the involved GPC's, or the loss of that data word with unknown results (e.g., state vector).

4.7 DATA PROCESSING SUBSYSTEM MASS MEMORY MODIFICATION

The data contained on either Mass Memory magnetic tape can be modified by the ground support personnel as well as by the crew, via the LDB's (during prelaunch operations) or inflight via uplink commands or crew controls on the MASS MEMORY R/W SPEC display (figure 4-13). The inflight techniques involving uplink commands and crew controls will be discussed here.

When required to update Mass Memory, a GPC must be executing SM OPS 2 or PL OPS 9 software to provide enough GPC main memory storage to perform the function. This is necessary because modification of Mass Memory occurs by reading a software load block into a special storage area of the GPC (available in special SM and PL OPS), modifying the load block and writing the modified load block back onto Mass Memory. The special storage area of main memory is 2,048 16-bit words in SM OPS 2, 16,384 16-bit words in PL OPS 9 and non-existent in any other major function OPS.

4.7.1 Uplink Commands

Mass Memory is modified via direct write commands or DEU equivalent commands using the MASS MEMORY R/W display. The direct write capability is mechanized like the MASS MEMORY R/W display without interfering with any MCDS operations. The DEU equivalent method requires activating the MASS MEMORY R/W display and interfacing with the MCDS input processor as would a crewmember as described below.

4.7.2 MASS MEMORY R/W CRT Display

The MASS MEMORY R/W display allows reading and changing of data stored on an MMU, comparing a load block between MMU 1 and MMU 2 and dumping MMU data to the ground via downlist. The area on the right third of the display selects which MMU data to change or dump and maintains the status of

the operation. The area on the left two-thirds of the display shows the current data in the specified location, allows entry of the data desired to be in the specified location and indicates the hexadecimal checksum of the operation in progress. The display is initialized with blanks in all data slots when the Spec is activated as SPEC 85 in SM OPS 2 or as the OPS display in PL OPS 9.

4.7.2.1 Memory write operation.- A MMU write operation initially requires specification of which MMU (ITEM 40 or 41) and which software system

| <u>Software System ID</u> | <u>Software System</u> |
|---------------------------|-----------------------------|
| 0 | Text and Graphics (OFT,KSC) |
| 1 | PASS Version 1 |
| 2 | PASS Version 2 |
| 3 | PASS Version 3 |
| 4 | BFS (KSC) |
| 5 | DEU |
| 6 | SSME |
| 7 | TCS Sequences (OFT,KSC) |

contain the data to be changed. Only one MMU can be modified at a time. The particular software phase (ITEM 43) and load block (ITEM 44) within the specified system must be identified since MMU-to-GPC data transfers occur in load blocks consisting of up to 16,384 16-bit words. The display only has the capability to present 39 16-bit words at a time for modification. Hence, the words of the load block to be changed must be identified relative to the first word of the load block by specifying the offset (ITEM 45) into the load block and the number of contiguous words (ITEM 46) to be changed.

Each time a MMU load block is read into GPC main memory, the version of the MMU contents is displayed (MM VERSION). Whenever a particular load block is modified, a log of MMU changes is updated by assigning a hexadecimal ID (ITEM 47) to the particular load block modification or patch.

A read operation is initiated by transferring the identified load block from the MMU to the GPC (ITEM 48). The STATUS (IP, CPLT, ERR) is presented to indicate a successful or unsuccessful data transfer operation (and a numerical CODE to identify error if unsuccessful). The MMU 8-BITE status REGISTER A and B data (which are transferred to the GPC with the load block transfer) and the checksum word are displayed in hexadecimal notation. When loaded into the special main memory storage area, the hexadecimal data values to be changed (as specified via ITEMS 40-46) appear in the slots on the display beside the appropriate item numbers under the ACTUAL column. A DESIRED hexadecimal value must be entered for each ACTUAL data value before the DESIRED values overlay or merge with (ITEM 49) the ACTUAL data value, making the ACTUAL column = the DESIRED column.

The STATUS of the merge operation is presented as during the data transfer operation. If more than 39 16-bit words or a different set of 16-bit words are to be modified, ITEMS 45 and 46 are reentered for the next set of 16-bit words to be changed, blanking ITEMS 1-39. When all DESIRED values have been merged with the ACTUAL values of the load block, the load

```

0801          MASS MEMORY R/W          1 273/15:35:02
                                000/01:30:00

DESIRED  ACTUAL  DESIRED  ACTUAL
  1  43AC  53AC   21
  2
  3
  4
  5
  6
  7
  8
  9
 10
 11
 12
 13
 14
 15
 16
 17
 18
 19
 20

                                SELECT
MMU 1          40*
MMU 2          41
42 S/W SYSTEM   4
43 PHASE        11
44 LOAD BLK     12
45 OFFSET      ---45
46 NUMBER       -1
47 PATCH ID    1111
                VIOLATE  NO
READ LOAD BLK  48*
MERGE          49
WRITE LOAD BLK 50
COMPARE        51
STATUS          CPLT
                ERROR CODE
REGISTER A
                B
MM VERSION     12.11
DUMP VIA DL    52
CHECKSUM

```

Figure 4-13.- MASS MEMORY R/W SPEC display.

block is written back into the selected MMU (ITEM 50). A problem with the write operation attempting to VIOLATE restrictions of patch ID or simultaneous MMU read will be indicated as would the STATUS of the write operation itself. As part of the write operation, the load block will be read back into the GPC to perform a word-by-word comparison check to verify proper coordination and allow user retry if necessary.

4.7.2.2 Memory compare operations.- The particular load block of one MMU identified via ITEMS 40-44 can be compared to the same load block on the other MMU using a word-by-word comparison (ITEM 51) and any error conditions displayed as STATUS and CODE. The capability to dump Mass Memory via downlist is described in Section 4.8.3.2.

4.8 DOWNLIST

A downlist is a set of data transferred from a GPC to the PCMMU. The downlist system software executive in each GPC organizes data obtained directly, or via one of the DPS MDM's, and data from the various systems software modules, into sets of data called downlist formats (also referred to as the GPC's downlist). Each GPC transmits its downlist format to the PCMMU's as illustrated in figure 4-14. The PCMMU's interleave Operational Instrumentation (OI) data from OI MDM's and PL data (from the payload data interleaver and Spacelab) with the downlist telemetry data into telemetry data formats for transmission to the Network Signal Processors (NSP's). The NSP's combine the PCMMU telemetry data with onboard voice into operational downlink telemetry formats. The S-band subsystem converts the NSP operational downlink telemetry format into the proper waveform for transmission to the ground by a transponder transmitter (XPNDR XMTR).

One of several Spacecraft Tracking and Data Network (STDN) remote site stations receives the operational downlink telemetry and separates voice from data. In addition, the STDN remote site documents and reformats the operational downlink telemetry before transmitting the voice and data to Goddard Space Flight Center (GSFC) in Greenbelt, Maryland. Goddard manages the STDN remote sites and transfers the voice and data to JSC's Mission Control Center (MCC).

The communication interface system in MCC validates and preprocesses downlink data prior to shipping it to the Shuttle Data Processing Complex (SDPC). The SDPC performs data manipulation and processing of downlink data before transmission of the realtime data to the display control system for routing to the appropriate MCC console.

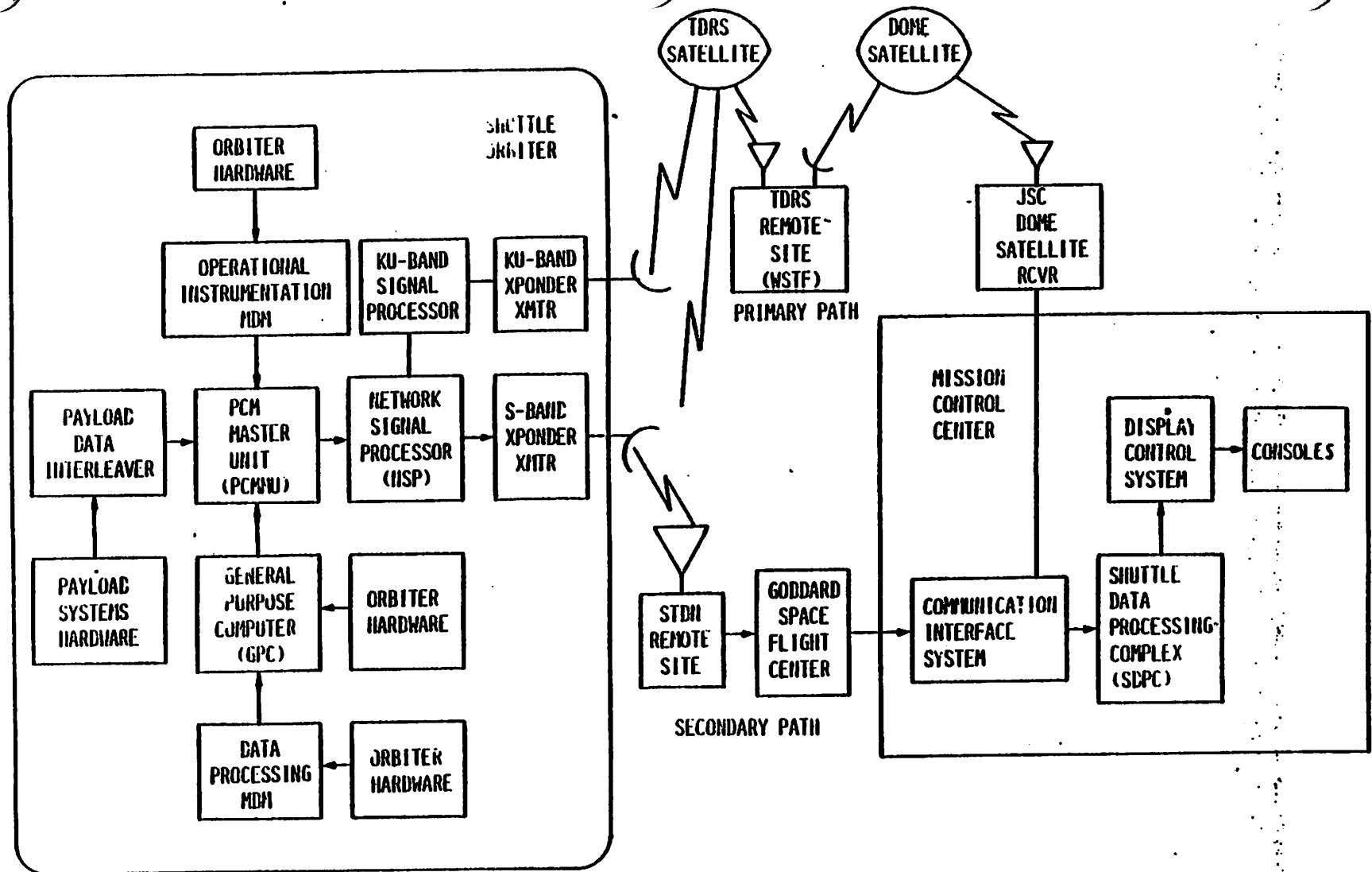
During later OFT flights and the OPS flights, the STDN downlink system will become the secondary downlink method. The primary downlink system will be a Tracking Data Relay Satellite (TDRS) system. The formation of downlink telemetry will follow the same data flow as that in the early OFT phase as far as the Orbiter NSP's. The NSP's will transfer the operational downlink to the S-band system or to the Ku-band system for processing. The S-band system or the Ku-band system transmits operational downlink telemetry to a TDRS as the primary telemetry path, while the STDN remote sites will remain functional as secondary telemetry paths.

The TDRS system will transfer the operational downlink telemetry to a TDRS remote site for relay to the Domestic Satellite (DOME SAT). The DOME SAT will transfer the telemetry to the DOME SAT receiver which will relay the combined voice and data to the MCC communication interface system for separation and validation processing by the SDPC.

4.8.1 Composition of the Downlist

The groups of data included in a typical GPC downlist format are shown below. The composition of a typical downlist varies as a function of the GPC's MC. The DPS hardware and systems software data are available in every downlist format. Furthermore, anytime a GPC is executing software, it is sending downlist data to the PCMU's for inclusion into the operational downlink telemetry to the ground.

- Crew station controls & displays
- MTU
- MPS, OMS, RCS
- SM sequence software
- Ku-band, S-band
- Landing gear
- Aerosurface amplifiers/actuators
- Flight control sensors (e.g., RGA)
- Vents, payload bay doors
- NAV SENSORS (e.g., IMU)
- NAV AIDS (e.g., TACAN)
- CONTROLLERS (e.g., RHC)
- DEDICATED DISPLAYS (e.g., AMI)
- Guidance software
- Navigation software
- Flight Control software



FUNCTIONAL REAL TIME DOWNLINK DATA FLOW FOR LATER O/T AND OPS FLIGHTS

Figure 4-14.- Functional real time downlink data flow:

- DPS hardware data
 - BITE status (DEU 1-4, Mass Memories 1-2)
 - DEU 1-4 scratch pad lines
 - Current major function & display for all DEU's
- SYSTEM SOFTWARE data
 - GPC mode, voting status, duty cycle
 - GMT, time source for timekeeping software
 - Redundant and common set status
 - Latest five GPC & I/O Errors of Self
 - Accumulated # and last I/O Error for common set GPC's
 - Accumulated # and last GPC Error for common set GPC's
 - BCE chain element status and BUS masks
 - Latest five fault messages
 - Discrete outputs and inputs
 - NSP Status word, NSP power status
 - GPC Command validity word
 - 2-stage buffer contents

4.8.2 Downlist Format Composition

Data parameters (in GPC main memory) to be downlisted are selected pre-flight and organized into "frames." One frame of data is transmitted to the PCMMU's every 40 msec. Fifty of these frames comprise one complete data cycle, which is 2 secs in length.

Sample rates for the downlist parameters can be 1, 5, 12.5, or 25 samples per sec. A one sample per sec (S/S) parameter will appear once in the first 25 data frames and once again in the same relative frame of the second group of 25 frames. For example, DEU BITE, which is sampled once per sec, may appear in Frame 3 and again in Frame 28. A parameter which is sampled 25 times per sec will appear in every frame of the downlist.

Each frame is composed of 16, 32, 64 or 128 16-bit words depending on the MC software. The first frame in each group of 25 frames has a header identifying the downlist format, GMT and other associated data. Each frame then has a counter to allow time tagging of downlist data on the ground within 40 msec.

4.8.2.1 OFT downlist formats.- The GPC's MC determines which downlist format will be transmitted to the PCMMU's. The MC software downlist format specifies which parameters (as a function of GPC main memory location), and how many 16-bit words per frame (the frame length) will be sent to the PCMMU's.

Each format is allowed only in one MC except for the memory dump formats. Memory dumps from the Orbiter replace the nominal downlist data during the dump for at least one data cycle. Mass Memory and main memory dumps are discussed in section 4.8.3.

A table which presents the downlist formats for STS 1 and 2 as a function of format identification number (FMT ID), frame length, and memory configuration, is presented in table 4-9 for your information.

4.8.2.2 STS 1 and 2 downlink/downlist combinations.- Table 4-10 presents the downlink/downlist combinations for STS 1 and 2 as extracted from the Computer Program Development Specification (CPDS) SS-P-0002-140E, Volume I, Book 4, Downlist/Uplink Software Requirements, November 18, 1977, and the Telemetry Data Format Control Book, JSC-11384, Section 2, Volume I, April 1977, and conversations with reliable FOD personnel.

Selection of the 128 kbps high data rate (HDR) or 64 kbps low data rate (LDR) depends on station acquisition and transmitting signal strength and is performed by the NSP's as directed by Ground Control Interface Logic (GCIL) via the NETWORK SIG PROC XMIT DATA RATE control on Panel A1 or via uplink command.

Selection of a 128 kbps PROM (HDR-H) format or 128 kbps RAM (HDR) format within a flight phase requires onboard manipulation of the OI PCMMU FORMAT control on Panel C3, SM SPEC keyboard entries or uplink commands.

Loading operational instrumentation formats into the PCMMU programmable Random Access Memories (RAM's) requires placing the OI PCMMU FORMAT control to "GPC" and entering item entries on the "PCMMU/PL COMM" SPEC in SM OPS 2 or on BFS MEMORY in ascent or entry to request a format to be loaded in the RAM's.

Changing downlist formats sent from a GPC to PCMMU's requires requesting a new MC to be loaded into the GPC.

Changing into which toggle buffer a GPC loads data requires item entries on the "GPC MEMORY" SPEC (e.g. reassigning Downlist GPC).

Combination 5 in the table is the 128 kbps PROM (HDR-H) format 129 of which 50 percent (64/128) is OI data, 40 percent (51.2/128) is data from toggle buffer 1 and 10 percent (12.8/64) is data from toggle buffer 5. Combination 6 is the 64-KBPS RAM (LDR) format 002 which maintains the relative percentages but reduces the amount of data output (and therefore, reduces the amount of data downlisted).

4.8.2.3 Loss of downlist.- If a PASS GPC detects a problem with its downlist (called the downlist command message) prior to transmission to the PCMMU's, an I/O ERROR PCM fault message will be generated and will

TABLE 4-9 - DOWNLIST FORMATS, STS FLIGHTS 1 AND 2

| FMT ID | Downlist frame length | POST IPL OPS 0-00 | MC1 GNC 1,6 | MC2 GNC 2 | MC3 GNC 3 | MC4 SM2 | MC6 PL9 | MC7 SM9 | MC8 GNC 8 | MC9 GNC 9 | Name |
|--------|-----------------------|-------------------|-------------|-----------|-----------|---------|---------|---------|-----------|-----------|---|
| 20 | 32 | X | | | | | | | | | POST IPL/OPS 0-00 GN&C ASCENT/ABORT GN&C ON-ORBIT GN&C ENTRY SM ORBIT DOORS INIT AND CHECKOUT SM 9 |
| 21 | 128 | | X | | | | | | | | |
| 22 | 128 | | | X | | | | | | | |
| 23 | 128 | | | | X | | | | | | |
| 24 | 32 | | | | | X | | | | | GN&C 9 PRECOUNT GN&C 8 ORBIT CHECKOUT FRT - GENERAL MM UTILITY PL 9 |
| 42 | 128 | | | | | | | X | | | |
| 44 | 128 | | | | | | | | X | | |
| 32 | 128 | | | | | | | X | | | |
| 46 | 128 | | | | | | | X | | | MAIN MEMORY DUMP MASS MEMORY DUMP PCMMU CHECKOUT-ADDRESS PCMMU CHECKOUT-052525 (OCTAL) PCMMU CHECKOUT-12525 (OCTAL) |
| 48 | 32 | | | | | | X | | | | |
| 44 | | | | | | | X | X | X | X | |
| 90 | | X | X | X | X | X | X | X | X | X | |
| 91 | | | | | | X | X | | | | PCMMU CHECKOUT-ADDRESS PCMMU CHECKOUT-052525 (OCTAL) PCMMU CHECKOUT-12525 (OCTAL) |
| 97 | 128 | | | | | | | X | | | |
| 98 | 128 | | | | | | | X | | | |
| 99 | 128 | | | | | | | X | | | |

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appear on all CRT's driven by the PASS. A loss of downlist could also be caused by the loss of an IP data bus or a PCMMU MIA. These last two problems would cause a downlist loss which would only be detectable by the ground.

If the downlist GNC GPC fails "hard" (loss of sync, software halt, etc.), the PASS software will automatically reassign a "healthy" GPC to take over the role of supplying downlist data to toggle buffer 1. The PCMMU would then have a good set of PASS GNC downlist data to incorporate into the PCMMU output.

If the loss of downlist is caused by an IP or PCMMU failure, this failure may be corrected by switching over to the other PCMMU via the OI PCMMU power switch on Panel C3. This switchover may be done during the dynamic flight phases, but requires using only the PROM format for the 128 kbps formatter since the RAM's are volatile in the new PCMMU. Loading Telemetry Format Loads (TFL's) into the new PCMMU during ascent or entry requires BFS to reestablish the RAM.

During coasting flight, downlist may be recovered in similar ways. The PCMMU toggle buffer designations may also be reassigned via uplink or GPC MEMORY SPEC keyboard entries.

4.8.2.4 Downlist variable parameter list.- Item entries 25-34, located in the lower right-hand corner of the DPS UTILITY SPEC, are used to control which parameters are placed in 10 variable parameter slots of each downlist format. Items 25-34 identify which parameters, according to their hexadecimal main memory addresses, are to be placed into the variable parameter list (one 16-bit word per slot). An entry of an improper address will result in an "ILLEGAL ENTRY" fault message. For example, "ITEM 1 + 1FA EXEC" would be a correct entry, while "ITEM 1 + 341FA EXEC" would be illegal since the GPC only has 34000 addresses in hexadecimal rotation.

An entry for one of Items 25-34 would immediately tell the downlist formatter to incorporate the parameter identified into the variable parameter slot for inclusion in the downlist. Any changes to the VARIABLE PARAMETER ID LIST becomes effective immediately. Nominally, fault messages 6, 7 and 8 will occupy the variable parameter slots.

4.8.3 Memory Dumps

The capability exists to "DUMP" selected portions of GPC main memory and portions of the Mass Memory to the ground, by replacing the nominal downlist data with the specific "DUMP" data. GPC main memory may be dumped using controls on the GPC MEMORY SPEC, or via uplink commands. Mass Memory may be dumped via inputs to the "MASS MEMORY R/W" SPEC, or via uplink commands. In both cases, if the dumps are performed by the flight crew, all of the keyboard entries will be coordinated with the MCC flight control team. For any dump operation, the dump format will replace the nominal data for at least one data cycle but only as long as it takes to get the data dumped once.

TABLE 4-10.- STS 1 AND 2 DOWNLINK/DOWNLIST COMBINATIONS

| Combinations phase | no. | Operational instrumentation | | | GPC toggle buffer 1 | | | GPC toggle buffer 2 | | | GPC toggle buffer 3 | | | GPC toggle buffer 4 | | | GPC toggle buffer 5 | | | MEM. CONF. | |
|--------------------------------|----------|-----------------------------|----|--------|------------------------|-----|----|------------------------|-----|----|------------------------|-----|----|------------------------|-------|------|------------------------|-----|----|---------------|-------|
| | | FMT | ID | Type | BW | OPS | DL | BW | OPS | DL | BW | OPS | DL | BW | OPS | DL | BW | OPS | DL | | BW |
| Prelaunch | 1 | 129 | | IHR-H | 64 | S9 | 42 | 51.2 | | | | | | | | | | B-S | 12 | 12.8 | 7.8 |
| | 2 | 160 | | IHR | 64 | S9 | 42 | 51.2 | | | | | | P9 | 48 | 12.8 | | B-S | 12 | 12.8 | 7.6 |
| | 3 | 129 | | IHR-II | 64 | G9 | 44 | 51.2 | | | | | | | | | | B-S | 12 | 12.8 | 9.8 |
| | 4 | 160 | | IHR | 64 | G9 | 44 | 51.2 | | | | | | P9 | 48 | 12.8 | | | | | 9.6 |
| Ascent | 5 | 129 | | IHR-H | 64 | G1 | 21 | 51.2 | | | | | | | | | | B-A | 15 | 12.8 | 1.8 |
| | 6 | 002 | | LDR | 32 | G1 | 21 | 25.6 | | | | | | | | | | B-A | 15 | 6.4 | 1.8 |
| Orbit | 7 | 129 | | IHR-H | 64 | G2 | 22 | 51.2 | | | | | | | | | | B-A | 15 | 12.8 | 2.8 |
| | 8 | 002 | | LDR | 32 | G2 | 22 | 25.6 | | | | | | | | | | B-A | 15 | 6.4 | 2.8 |
| | 9 | 161 | | IHR | 64 | G2 | 22 | 51.2 | S2 | 24 | 12.8 | | | | | | | | | | 2.4 |
| | 10 | 003 | | LDR | 32 | G2 | 22 | 25.6 | S2 | 24 | 6.4 | | | | | | | | | | 2.4 |
| | 11 | 129 | | IHR-H | 64 | G2 | 22 | 51.2 | | | | | | | | | | S-2 | 24 | 12.8 | 2.4 |
| | 12 | 002 | | LDR | 32 | G2 | 22 | 25.6 | | | | | | | | | | S-2 | 24 | 6.4 | 2.4 |
| Entry C/O | 13 | 162 | | IHR | 64 | G8 | 32 | 51.2 | S2 | 24 | 12.8 | | | | | | | | | | 2.4 |
| | 14 | 004 | | LDR | 32 | G8 | 32 | 25.6 | S2 | 24 | 6.4 | | | | | | | | | | 2.4 |
| Entry | 15 | 129 | | IHR-H | 64 | G3 | 23 | 51.2 | | | | | | | | | | B-E | 13 | 12.8 | 8.8 |
| | 16 | 164 | | IHR | 32 | G3 | 23 | 51.2 | | | | | | | | | | B-E | 13 | 12.8 | 3.8 |
| | 17 | 005 | | LDR | 32 | G3 | 23 | 25.6 | | | | | | | | | | B-E | 14 | 12.8 | 3.8 |
| | 18 | 162 | | IHR | 64 | G3 | 23 | 51.2 | S2 | 24 | 12.8 | | | | | | | | | | 3.4 |
| | 19 | 004 | | LDR | 32 | G3 | 23 | 25.6 | S2 | 24 | 6.4 | | | | | | | | | | 3.4 |
| GPC Utility | 20 | 163 | | IHR | 51.2 | G2 | 22 | 51.2 | S2 | 24 | 12.8 | | | | OPS 0 | 20 | 12.8 | | | | 2.4,0 |
| | 21 | 006 | | LDR | 25.6 | G2 | 22 | 25.6 | S2 | 24 | 6.4 | | | | OPS 0 | 20 | 6.4 | | | | 2.4,0 |
| GPC/MM C/O | 22 | 163 | | IHR | 51.2 | G2 | 22 | 51.2 | S2 | 24 | 12.8 | | | | P9 | 48 | 12.8 | | | | 2.4,6 |
| | 23 | 006 | | LDR | 25.6 | G2 | 22 | 25.6 | S2 | 24 | 6.4 | | | | P9 | 48 | 6.4 | | | | 2.4,6 |
| "SICK GPC" or HISAM DUMP | (note 6) | 163 | | IHR | 51.2 | G2 | 22 | 51.2 | S2 | 24 | 12.8 | | | | NA | 90 | 12.8 | | | | 2.4 |
| | | 006 | | LDR | 25.6 | G2 | 22 | 25.6 | S2 | 24 | 12.8 | | | | NA | 90 | 6.4 | | | | 2.4 |

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- NOTES:
1. The main and mass memory dump downlist ID's are considered special cases and do not require additional combinations.
 2. IHR-II equals high data rate in the IHRD 128 KBPS PROM format. All other ID formats are Telemetry Format Load (TFL) RAM formats.
 3. B-S equals Backup in standby, B-A equals backup in ascent mode, and B-E equals backup in entry mode.
 4. Combinations 11 and 12 require a manual toggle buffer assignment change for S2.
 5. Band Width (BW) refers to the share of the telemetry allotted to the data.
 6. Downlist dump may be skewed with respect to PCM telemetry output frame.

In the case where the dump request would require more than one data cycle to complete, the dump downlist format would remain in effect until the dump was completed. As soon as the dump is completed, the nominal downlist format would be restored. These memory dumps would result in the loss of at least one downlist format data cycle, which would be replaced by the dump frames and fill data.

4.8.3.1 GPC main memory dump.- A GPC main memory dump would normally be used for MCC verification of selected portions of a GPC's main memory after an OPS transition caused a change in the software content of that GPC. Presently, the capability to dump a GPC's main memory exists in all MC except MC1 (Ascent) GPC MEMORY SPEC keyboard entries (via onboard or uplink). The dump will occur in those GPC's which are listening to the DEU which is supporting this SPEC at the time of the dump. A dump of a GPC requires about 70 seconds to complete in High Bit Rate (HBR).

The capability also exists to dump a GPC using the panel MO42F GPC MEMORY DUMP rotary switch when a GPC has been moded from HALT to STBY with its OUTPUT switch in TERMINATE (Panel O6). The PCMMU telemetry format may have to be changed since the GPC dump initiated in such a manner will send its data to toggle buffer 5 which may be read by the telemetry formatter in the current configuration. This specialized configuration will be primarily used to dump memory of GPC's which have failed and takes about 4 minutes in HBR to complete.

4.8.3.2 Mass memory dump.- The Mass Memory dump capability, which can be accomplished either via uplink commands or via crew keyboard entries to the "MASS MEMORY R/W" SPEC, will not normally be used inflight. This capability exists only in MC 4 (SM OPS 2) and in MC 6 (PL OPS 9), in the on-orbit mission phase.

The MASS MEMORY R/W SPEC, illustrated in figure 4-13, is available as SPEC 85 in SM OPS 2 and as the PL OPS 901 major mode ("OPS") display. It can allow the crew or ground control the capability to observe selected Mass Memory data on the CRT, modify this data, and to dump selected Mass Memory data to the ground via the downlist. Once the MMU software system, phase and load block (ITEMS 40-44) are specified, the dump is initiated (ITEM 52). STATUS indicators and the checksum value are displayed when the data is read from the MMU and the dump operation occurs.

Dumps of Mass Memory data are limited to 2048 16-bit words in SM OPS 2, and limited to 16,384 16-bit words during PL OPS 9. As you will recall, the downlist frame length for both GPC main memory dumps and for Mass Memory dumps is controlled via the control in the GPC MEMORY SPEC. The Mass Memory to be dumped, the data to be dumped, and the request for the dump are controlled via the MASS MEMORY R/W display.

4.9 UPLINK

Uplink is the method by which ground commands, originating in the Mission Control Center, are formatted, generated, and transmitted to the Orbiter for validation, processing, and eventual execution by onboard software. This capability allows the ground to control software processing, affect

mode changes in Orbiter hardware, and to store or change software in GPC main memory and Mass Memory.

Figure 4-15 illustrates the functional operational uplink data flow. Commands are issued at MCC consoles which request uplink communications. The SDPC formats the command requests into what is called a command load and transmits this command load to the Network Output Multiplexer (NOM). The NOM mixes the command loads with voice, and ships this operational uplink to the GSFC, which distributes it to the appropriate STDN remote site for transmission to the Orbiter.

The Orbiter's S-band transponder receiver (XPNDR RCVR) demodulates this received operational uplink and transmits it to the NSP which validates and separates the commands from the voice. The DPS MDM's format the commands and transmit them to the GPC's when requested by systems software. The uplink processor software within the GPC(s) executes commands to control software operations, store or change software in GPC or Mass Memory, and affect mode changes in Orbiter hardware.

For later OFT and OPS flights, the function operational uplink data flow will change to reflect the use of satellite communications, as is shown in figure 4-15. The method of uplink which utilizes the STDN will then become the secondary method of providing uplink.

The primary method will involve the output of the NOM being transmitted to the JSC DOME SAT Transmitter (XMTR), which will transmit the operational uplink to a TDRS remote site through a DOME SAT. The TDRS remote site XMTR will then relay the operational uplink to the Orbiter through a TDRS, to either a KU-band receiver or an S-band receiver onboard the Orbiter.

The KU-band XPONDER RCVR will demodulate the received data and voice, and ship it to the KU-band signal processor, where the signal will be validated and the commands separated from the voice. The uplink commands will then be transferred to the NSP. If received by the S-band XPONDER RCVR, the operational uplink will be sent to the NSP's, which will separate commands from voice. An NSP will buffer the uplink commands until requested by GPC system software.

4.9.1 Uplink Command Description

Uplink commands can be issued to a GPC by number (GPC 1, GPC 2, etc), by major function (ALL GNC, ALL SM, ALL PL), all active GPC's in the common set, or to the BFS GPC. An OP CODE identifies which operation is to be performed. A table of current approved command OP codes are presented in the appendix.

MCC builds commands loads to perform certain functions as identified by the OP code of the command.

There are three types of uplink command loads. These are the single stage commands, the critical (or two-stage) commands, and the stored program commands (which are really a special case of the critical commands).

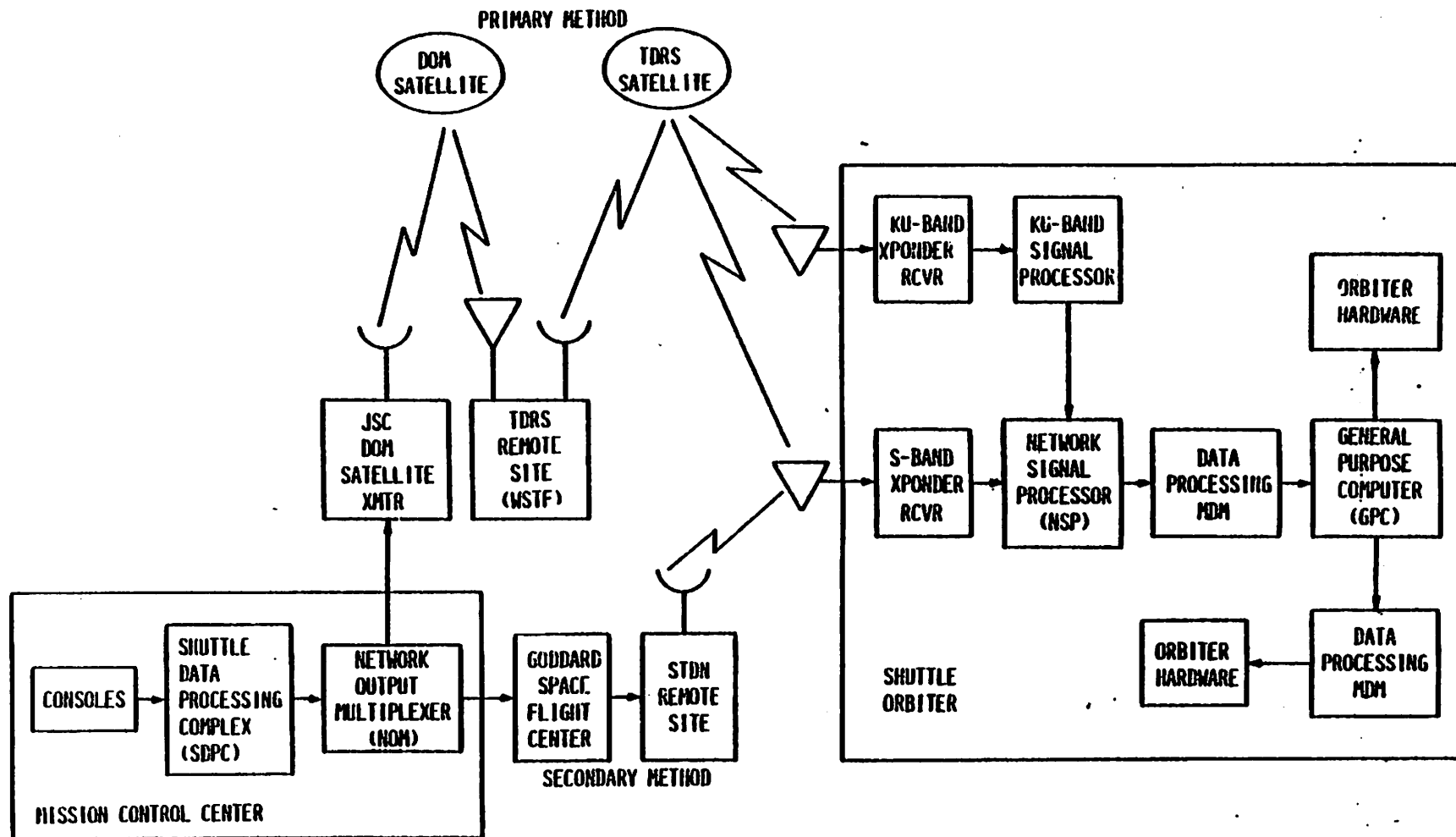


Figure 4-15.- Functional uplink data flow.

Single stage commands, upon reception, will be buffered and executed by the uplink processor software.

All critical commands, when received, will be buffered by the uplink processor software. The content of this buffer is then downlisted for command verification (onboard verification is available via the "GPC MEMORY" SPEC). While a command is stored in the 2-stage buffer, the "UL" indicator appears on all CRT displays associated with the GPC. When the uplink processor software receives a "BUFFER EXECUTE" single stage command, it will send a flag to the appropriate software modules to execute the buffered command and blank the UL indicator.

The stored program commands are buffered in the same fashion as the two-stage commands, except that they are time-tagged, and will be executed when the GMT in the command load equals the GPC's GMT. These stored program commands are used to set or reset MDM discrete outputs.

4.9.1.1 DPS uplink commands.- The uplink commands which relate directly to the DPS include commands used to set or reset discrete outputs for a particular DPS MDM discrete output module channel. Up to 16 discrete outputs can be set or reset in a single command load. This process is also known as a Real Time Command (RTC). Two DPS MDM discrete output module channels can have their outputs set or reset each time the two-stage command is executed (either via a buffer-execute command or a GMT time of execution). The MDM's in consideration for these last two items are the four FF MDM's, the four FA MDM's, the PL MDMS, and the LF and LA MDM's. An RTC load includes an RTC to reset the MDM discrete output channels to zero and a second RTC to set the appropriate MDM discrete output channels to one.

The DPS uplink commands can also be used to write over GPC main memory, either in contiguous or in scattered locations except in Memory Configuration 1. The capability also exists to read, write or dump Mass Memory words in SM OPS 2 or PL OPS 9.

One form of DPS uplink commands, known as the "DEU equivalent" commands, allows the ground to perform most of the functions the flight crew could perform, as if the ground had its own "keyboard". The "DEU equivalent" commands from the ground go through the NSP to the GPC two-stage buffer, and when executed are transferred to the "equivalent DEU input table." An event is set to signal the MCDS input processor that a message is waiting, and the input processor transfers the data into the DEU input table and the standard keyboard message processing takes over. At this point, the ground interacts with the GPC in exactly the same manner as the crew. In other words, the ground has the capability, via uplink, to activate or deactivate SPEC software, mode the current OPS, make item entries, etc., as if keyboard entries were made onboard. A CRT format activated via uplink is charged to the major function addressed (e.g., one of the SPEC's is used). In addition, if the DEU/DU combination is powered up, the SPEC or DISP activated via uplink will appear on the CRT.

DPS uplink commands can also clear or execute the two stage command buffer, clear the stored program command buffer, correct the two stage command

buffer, and turn the "UL" (uplink) indicators (on the title line of the CRT display formats) on or off.

For STS 1 and 2, single stage and stored program commands are allowed in every MC, whereas two-stage commands are processed only in specified MC's. A table of the OP codes, uplink loads, and the MC's in which they are available, is given in appendix G.

4.9.2 NSP/MDM/GPC Interface

The Orbiter NSP's 1 and 2 are hardwired to the DPS FF MDM's FF1 and FF 3, as shown in figure 4-16. The NSP's store the uplinked command loads until they are requested by the GPC's via these two MDM's. The GPC's also read the NSP BCE bypass status and power status, in order to determine which NSP is powered up, and therefore is to be polled.

The GPC that is in charge of the string containing the active NSP initiates the request for the NSP to send its data over the FC data buses (referred to as "polling the NSP"). The NSP responds by sending the data to all of the GPC's which are "listening" to the critical data buses, including the BFS GPC. Those GPC's which are not listening to the FC data buses will receive the NSP status and command over the ICC data buses as it is sent to them by the other GPC's. At the next processing cycle, all GPC's will initiate their processing of the uplink command.

After receiving the uplink command load, the GPC checks the NSP status word to determine if all commands have been blocked from processing by the UPLINK BLOCK switch (Pancel C3). If they have, the uplink processing software will stop its command processing and wait to process the next uplink command.

If all commands are not blocked by the UPLINK BLOCK switch, the uplink processing software checks to see if the NSP is ready to transmit the uplink commands. If the NSP is not ready, the uplink processing software will stop its processing and wait for the next uplink command.

If the NSP is ready to transmit the uplink commands, the GPC receives these commands and validates them. The resulting command validity word is stored for inclusion in the GPC's downlist. Assuming that the command is valid, the GPC proceeds to perform the valid operation.

4.9.2.1 NSP status word.- The NSP status word is a 16-bit data word that conveys the NSP condition to the GPC's. The first bit of this word, if set to a logical "1", tells the GPC's that the NSP is not ready to transmit its command data. The second bit of this word is controlled by the "ALL" position of the UPLINK BLOCK switch, and if it is set to a logical "1", tells the GPC's that all commands are blocked from processing. The remaining bits (3-16) contain the NSP BITE status.

2/2/78

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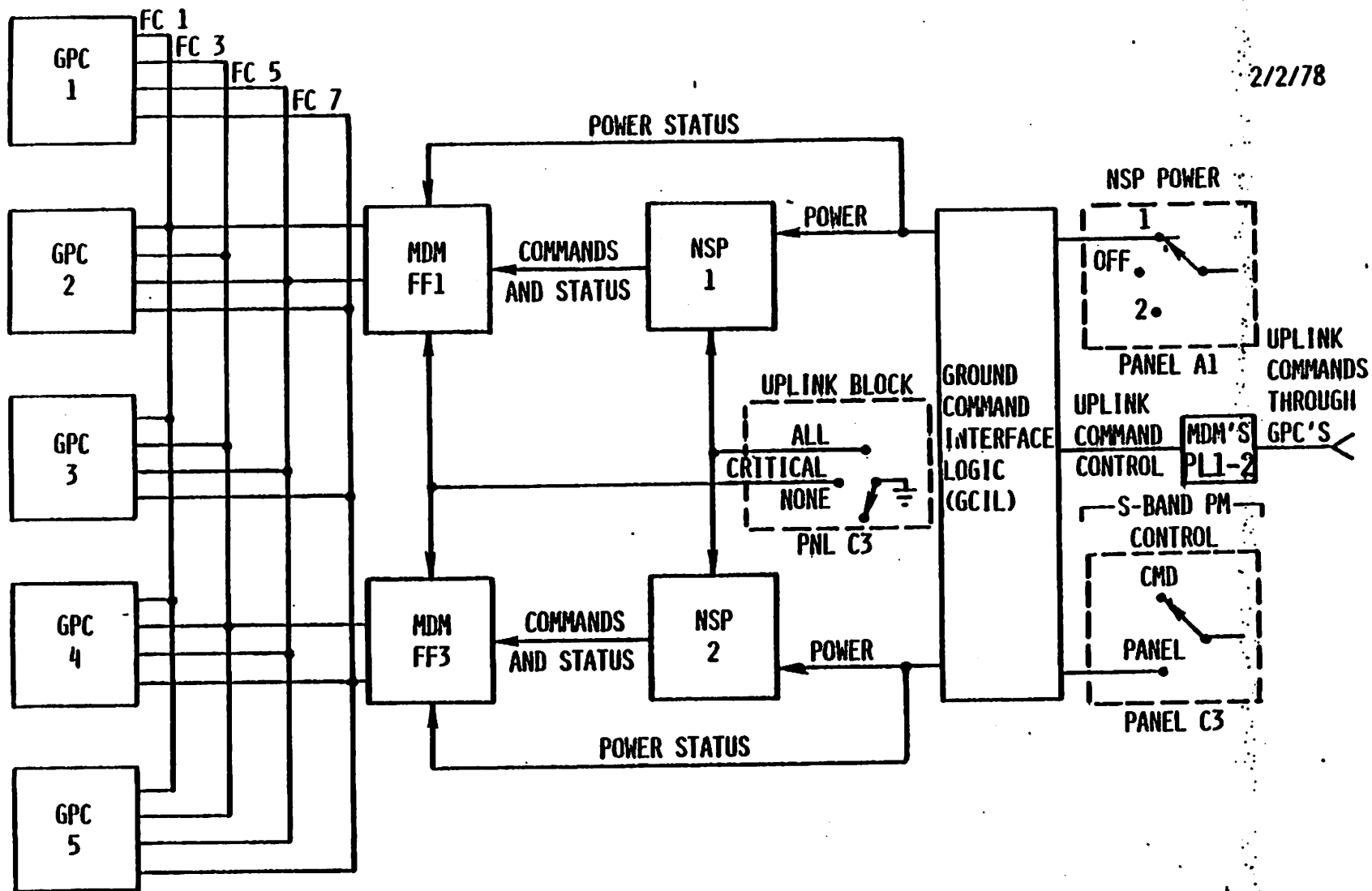


Figure 4-16.- NSP/MDM/GPC interface diagram.

4.9.2.2 GPC command validity word.- Each GPC creates a 16-bit "command validity word", in response to uplink commands from the NSP, which defines the possible errors that may have occurred in the uplink transaction. Normally, all 16 bits of this word are zero. Any bit set to a logical "1" will indicate a problem in the command processing. The GPC "command validity word" is part of each downlist at a 1 Hz rate.

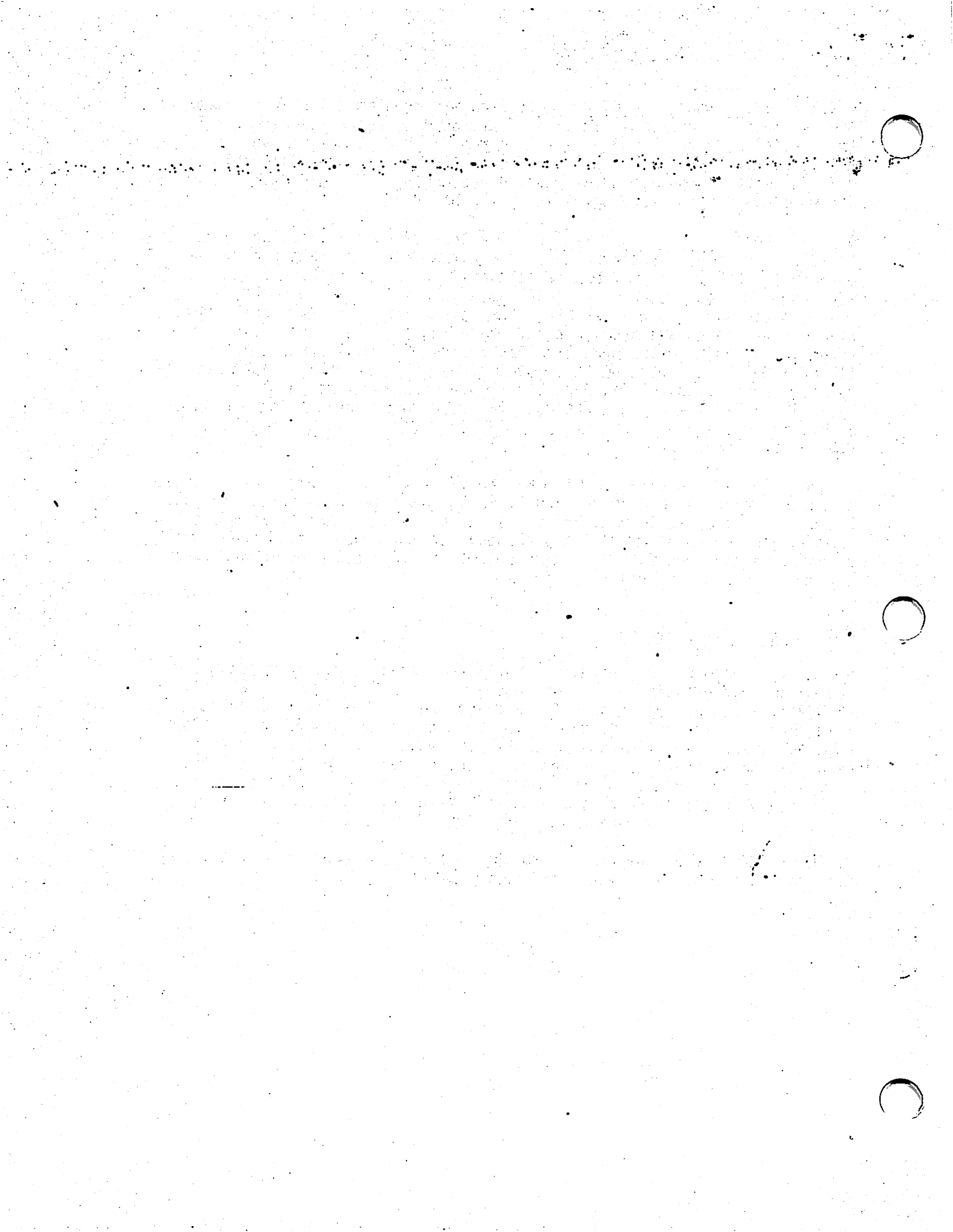
4.9.2.3 Loss of uplink to the GPC's.- A loss of uplink from the NSP's to the GPC's may occur if a problem exists either with the NSP, the data path between the NSP and the FF MDM it is hardwired to, with the MDM itself, with the data path between the GPC's and the MDM, or with the GPC(s) itself. Obviously, the cure for this loss of uplink is a function of what kind of failure causes this loss and where the failure occurs. An I/O error, detected when the NSP is polled by the GPC, will cause a "BCE STRING X NSP" fault message (X = 1,3 implies NSP 1 or NSP2, respectively) to be generated, which will indicate that a problem exists with the specified NSP. If only one GPC of a four GPC redundant set (on ascent or entry) detects a problem, that GPC will force fail to sync and will be removed from the set.

If the NSP itself has failed, the NSP POWER switch on Panel A1 may be used to select the other NSP if the S-band PM hardware is under panel control. Since this switch is in the aft crew station, this onboard "fix" would be unavailable during dynamic flight phases, but the ground could send uplink commands to the GCIL to select the correct NSP if the S-band PM hardware was under command control.

4.9.3 Real-Time Commands

A real-time command is the capability to set or reset discrete outputs for one channel of one discrete output module in one of the FF, FA, PL, LA, or LF MDM's. The onboard capability involves the DPS UTILITY SPEC and an item entry corresponding to the second word of an MDM single stage uplink command, which identifies the MDM, the I/O module, the discrete output channel, and whether the bits are to be set or reset and the third word of the MDM single-stage uplink command, which identifies which bits are to be set or reset as directed by the first four digits. All eight of the digits entered are hexadecimal notation via ITEM 13.

"ITEM 14 EXEC" sends the command to the systems software which sets-up and transmits the required output word to the specified MDM.



SECTION 5 BACKUP FLIGHT SYSTEM SOFTWARE

5.1 BACKUP OPERATING SYSTEM (BOS)

The BOS is the software in the Backup Flight System (BFS) which plays the same role in the BFS as the system software does in the Primary Avionics Software System (PASS). The BOS software forms the interface between the applications program (Guidance, Navigation and Control (GNC), Systems Management (SM), and Sequencing) and the outside world through Uplink, Downlist, the Multifunction CRT Display System (MCDS), and the Ground Support Equipment (GSE). The BOS provides for the output of commands and/or the retrieval of data from the PASS and the hardware external to the General Purpose Computers (GPC's) such as the avionics devices, Caution and Warning (C&W) electronics, the Master Timing Unit (MTU), etc. The BOS is also responsible for updating the BFS GPC's internal clock and making Greenwich Mean Time (GMT) and Mission Elapsed Time (MET) available to the BFS applications programs.

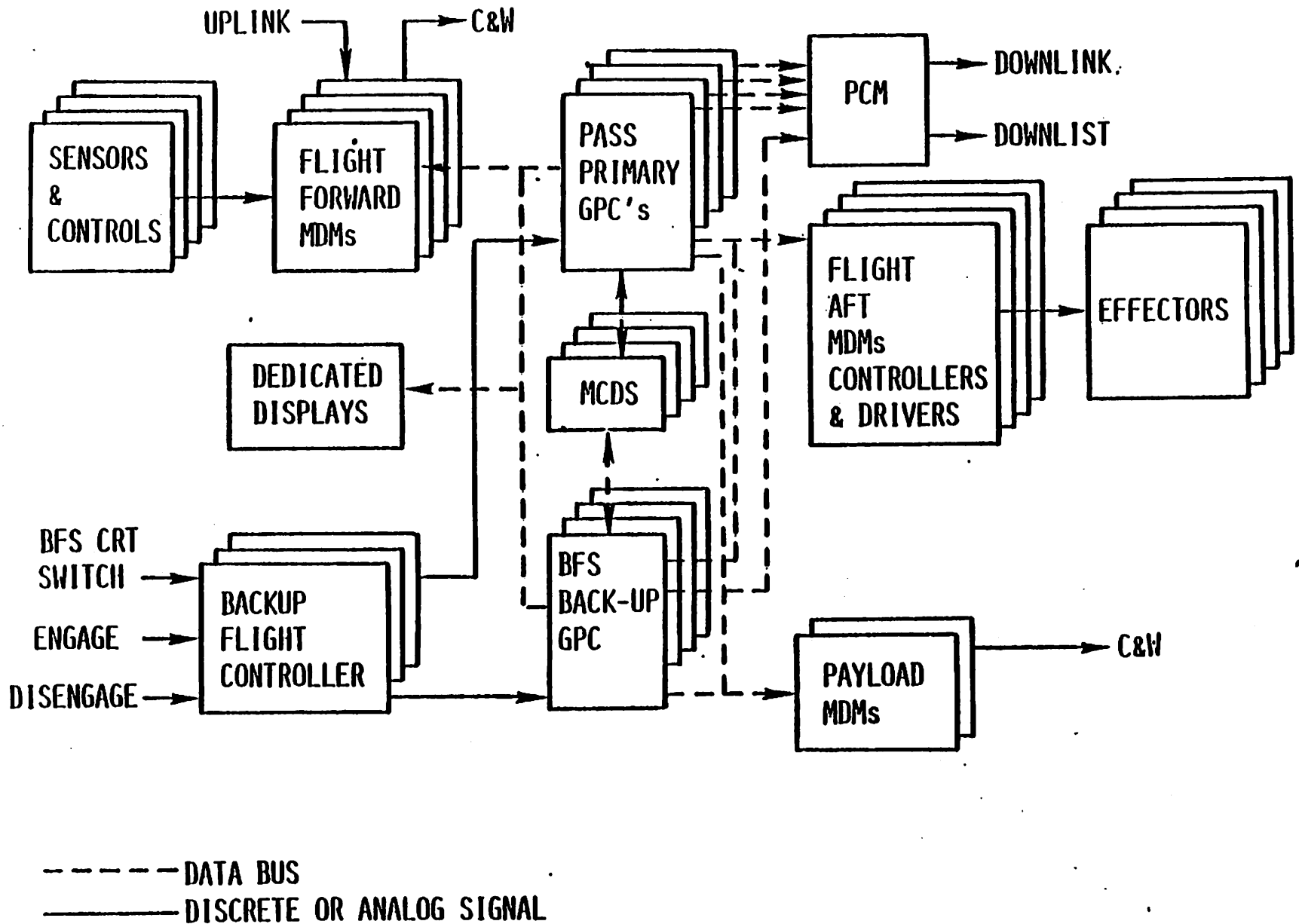
5.2 ACTIVE PASS/BFS INTERFACE

The BFS is designed to take over vehicle control in case of a major failure in the PASS, and perform limited SM during the critical mission phases. When the BFS is not engaged (preengaged), the PASS GPC's control the flight critical (FC) data buses. Therefore, during GNC Operational Sequence (OPS) 1 and OPS 3, the BFS GPC must track the PASS GPC's for receipt of data over the FC data buses and certain PASS-loaded or computed parameters such as the current vehicle state, vector mission phase sequencing, the Bus Control Element (BCE) chain element bypass status, the inertial measurement unit Reference Stable Member Matrix (REFSMMAT), etc. In order to accomplish this, the BFS GPC "listens" on the FC data buses. This ensures that the BFS GPC can receive uplink and the MTU updates. In addition, the PASS GPC's send data known as "PASS transfer data" to the BFS GPC over the FC data buses up to 25 times-per-second.

To perform its SM functions, the BFS GPC assumes command of the payload (PL) data buses when the PASS GPC's receive the BFS GPC's BFS RUN discrete.

The BFS GPC may also be assigned Display Keyboard (DK) DATA bus 4 and another DK DATA bus as a function of the BFC CRT DISPLAY and SELECT switches, the BFS GPC MODE switch, or a GPC/CRT keyboard message. The BFS listens to all PASS-controlled buses in the preengaged state.

Once the BFS is engaged, no further interface is made between the BFS and the PASS GPC's. Figure 5-1 illustrates the PASS/BFS functional configuration.



5-2

Figure 5-1.- PASS/BFS functional configuration.

5.2.1 PASS/BFS Discrete Interface

In addition to the interfaces previously mentioned, the PASS and BFS GPC's have specialized discrete interfaces. The BFS must not interfere with the PASS GPC's synchronization schemes. Therefore the BFS GPC holds its three SYNC discrettes to a "000" pattern. When in the RUN mode, the BFS GPC issues its BFS RUN discrete to the PASS GPC's which tells the PASS to surrender control of the PL data buses and results in the BFS taking command of the PL data buses (except in BFS OPS 0).

The BFS GPC will also not drive any GPC FAIL discrettes or any GPC STATUS matrix lights other than its own diagonal. It should drive its own diagonal if it goes into a software HALT state. Conversely, the PASS GPC's will not issue GPC FAIL discrettes or light GPC STATUS matrix lights for the BFS GPC.

5.2.2 BFS ENGAGE Condition

The BFS GPC is engaged following the BFS GPC's OUTPUT switch being placed in the BACKUP position and depression of the ENGAGE pushbutton on either the left or right RHC. The outputs of these switches (the OUTPUT switch and ENGAGE pushbutton) are sent to the Backup Flight Control (BFC) modules. The BFC outputs the BFS ENGAGE discrettes (1, 2, 3) and "I/O Terminate B" discrete (see section 2.6). PASS notification of the BFS GPC ENGAGE condition is discrete output "I/O Terminate B" = 1 and discrete inputs 1, 2, 3 = 1. The PASS responds by relinquishing command capability on all data buses within 200 msec and by entering software HALT. The BOS changes BFS operations from disengaged to engaged when at least two BFS ENGAGE 1, 2 and 3 discrettes change to "1's" from "zeroes" and the "I/O Terminate B" discrete = 0. At this time, the BFS GPC will takeover command of the FC data buses, two forward Cathode Ray Tubes (CRT's) and the PL data buses, (if it was not already in command of the PL data buses), and assumes vehicle control.

The Orbiter flight crew has available to them a series of indications which show that the BFS has been engaged. The BFS software illuminates a BFC light on Panel F2 and on Panel F4 (the "Eyebrow Panels") via the PL Forward MDM PF2. The BFS GPC OUTPUT talkback on Panel O6 will go gray, while the OUTPUT talkbacks of the PASS GPC's go to barberpole. Any PASS GPC's in RUN will light their diagonal lights on the GPC STATUS matrix, and illuminate the GPC light on the 40-light C&W matrix (Panel F7). The two CRT's indicated on the BFC CRT SELECT switch will be driven by the BFS GPC if the BFS CRT DISPLAY switch is in the ON position. If this switch is in the OFF position, the BFS GPC will drive CRT's 1 and 2. Those CRT's which are not controlled by the BFS GPC will show a big "X" across the CRT screen, and the message "POLL FAILURE" will appear on the left side of the scratch pad line. (These are the same indications that occur under other circumstances when a DEU does not receive GPC update commands for a 3-second period.)

5.2.3 BFS DISENGAGE Condition

The BFC DISENGAGE switch, located on Panel F6, is used to disengage the BFS. Response to this switch inverts the BFS ENGAGE 1, 2, and 3, and "I/O TERMINATE B" discrete inputs. When the BFS GPC detects that at least two of the BFS ENGAGE 1, 2, and 3 discrettes have changed from "1's" to "zeroes", the BFS enters the DISENGAGED-STAND ALONE state (stops FC output, continues software processing independent of the PASS and releases control of the second Display Electronics Unit (DEU)).

If the PASS has undergone Initial Program Load (IPL), has been moded to RUN and to the appropriate GNC OPS/Major Mode, and "sees" the BFS ENGAGE 1, 2, 3 and "I/O TERMINATE B" discrettes = 0, the PASS will assume control of the FC data buses and the vehicle. If the PASS has not undergone a new IPL, it may remain in software HALT resulting in no vehicle control.

A BFS GPC power transient could cause an inadvertent BFS GPC disengage due to the BFC power reset. The BFS GPC can again be engaged via a repeat of the BFC ENGAGE command via a BFC ENGAGE pushbutton.

When the BFS is disengaged, the BFC light on Panels F2 and F4 will be extinguished, and the BFS GPC's OUTPUT talkback will go to barberpole. If the PASS had undergone a new IPL; the PASS GPC's will extinguish their GPC STATUS Matrix lights, and thus the GPC light on the C&W Panel. The PASS GPC's will also take control of their assigned DK buses, except for the first CRT allocated to the BFS via the BFC CRT switches. In addition, the PASS GPC's OUTPUT talkbacks will go gray.

5.2.4 Effects Of The GPC MODE Switch

Assuming the BFS GPC's power is ON, the BFS GPC's MODE switch HALT discrete is transferred to the BFS GPC via its associated BFC module (as in the case with all of the GPC's). When the BFS GPC receives this HALT discrete, it terminates its active software, which puts it in a hardware-controlled state and its OUTPUT talkback and MODE talkback will go barberpole. This state is the one in which any GPC must be in order to begin the IPL sequence, and is illustrated in figure 5-2.

When the BFS GPC's MODE switch is in STANDBY, (and it is not engaged), the software processing is identical to that done in the RUN position except that the BFS GPC will not take control of the PL data buses. A BFS GPC in STANDBY and engaged is operationally the same as if it were in the RUN mode. It will gain control of the PL data buses as well as the FC data buses and the two selected DK buses.

When the BFS GPC is in the RUN mode, it sets the BFS RUN discrete output and assumes command of the PL data buses within 2 seconds. The PASS GPC's, accordingly, set bus masks on the PL data buses upon receipt of the BFS RUN discrete. In the RUN mode, the BFS GPC continues the software processing associated with its current major mode and state (tracking PASS or not).

| TO FROM | HALT | | STANDBY | | RUN | |
|------------|---|-------------|---|----------------------------|---|----------------------------|
| | PRE-ENGAGE | POST-ENGAGE | PRE-ENGAGE | POST-ENGAGE | PRE-ENGAGE | POST-ENGAGE |
| HALT | | | <ul style="list-style-type: none"> ● PERFORM SYSTEMS RESET ● ATTEMPT TO "TRACK" THE PASS GPC'S ● ENTER BFS OPS 0 STATE (DISCUSSED LATER) ● OUTPUT TALKBACK TO GRAY IF ENGAGED ● OUTPUT TALKBACK REMAINS BARBERPOLE PRE-ENGAGE ● BEGIN COMMANDING ON CRT/DK4 ● GENERATE "BFS RUN" DISCRETE AND GAIN CONTROL OF THE PL DATA BUSES IF IN RUN OR STANDBY ENGAGED | | | |
| STANDBY | <ul style="list-style-type: none"> ● RETURN TO A HARDWARE CONTROLLED STATE | | | | <ul style="list-style-type: none"> ● GENERATE "BFS RUN" DISCRETE AND GAIN CONTROL OF THE PL DATA BUSES | RUN IS THE SAME AS STANDBY |
| RUN | <ul style="list-style-type: none"> ● OUTPUT TALKBACK TO BARBERPOLE ● RESET "BFS RUN" DISCRETE AND RELINQUISH CONTROL OF THE PL DATA BUSES | | <ul style="list-style-type: none"> ● RESET THE "BFS RUN" DISCRETE AND RELINQUISH CONTROL OF THE PL DATA BUSES | STANDBY IS THE SAME AS RUN | | |

Figure 1.2. BFS GPC mode transitions post-IPL.

5.2.5 BFS CRT Selection

BFS GPC control of the selected forward station CRT's is controlled by the BFC CRT DISPLAY and SELECT switches, which are illustrated in figure 3-4, and by a backup method using the GPC/CRT key. The BFC CRT DISPLAY switch permits power to the SELECT switch which allows BFS GPC control of the designated DK data bus, and therefore the designated CRT. When the BFS is engaged, the BFS GPC also takes command of the second CRT indicated by the BFC CRT SELECT switch position. Should the display switch be OFF when the BFS is engaged, the BFS GPC will take control of CRT's 1 and 2. Note here that if the BFS is engaged and the IPL source SELECT switch on Panel O6 is moved to either the MMU 1 or MMU 2 position, the BFS GPC will give up control of the first indicated CRT/DK bus. The reason for this bus surrender is the IPL procedure. If another GPC undergoes IPL at this time, (with the BFC CRT DISPLAY switch ON), it will take control of this DK bus in order to generate the GPC IPL MENU display. If the BFS GPC has not given up this DK bus, both GPC's would be commanding over the same data bus with unpredictable results (most likely a flashing CRT).

Input of the "GPC/CRT" key, followed by two digits corresponding to the desired GPC commander (first digit) and the desired CRT (second digit) is another method for assigning/deassigning BFS control of any DEU. This method would be used following BFC CRT select switch failure or in case the user desires to assign two forward CRT's to the BFS preengage (or three forward CRT's postengage). GPC/CRT key inputs to the BFS can override the BFC CRT select switch if used to deassign the selected BFS CRT. Also, the BFS GPC will respond to GPC/CRT key inputs from either a PASS or BFS keyboard as long as the desired GPC commander is BFS GPC. The BFS GPC uses DK listen to receive inputs from a PASS keyboard. User care will be necessary to ensure that multiple commanders on a CRT do not result.

Following a transition from HALT to STANDBY or RUN, the BFS GPC will begin commanding CRT 4 via DK 4. This is to allow the BFS GPC to control certain functions from the aft station such as the closing of the payload bay doors. Thus, it must be ensured that no PASS GPC is commanding DK 4 or multiple commanders may result. This may be accomplished via the nominal bus (CRT) assignment table or through entry of "GPC/CRT 04 EXEC" to a PASS assigned keyboard. The BFS GPC can also be made to release DK 4 by an entry of "GPC/CRT 04 EXEC" to a BFS assigned keyboard, and can regain command on DK 4 following an entry of "GPC/CRT 54 EXEC" to any assigned keyboard.

5.3 BFS OPS/MAJOR MODES/DISPLAYS

Essentially, the BFS will support identical GNC OPS/Major Modes as the PASS does during ascent and entry (Memory Configurations 1 and 3). In the SM major function, the BFS only supports one OPS/Major Mode. The BFS also supports a transition state called BFS OPS 0, which, it should be noted, is not the same as the PASS GPC OPS 0 state.

5.3.1 BFS OPS 0

BFS OPS 0 is the state which is used to begin scheduled software processing following IPL or a HALT to STANDBY or RUN transition (System Reset). It can also be entered during OPS 1 or 3 by crew entry of "OPS 000 PRO" to a BFS-controlled keyboard. The transition from BFS OPS 0 to OPS/Major Mode 101 or 301 is, in turn, initiated by an "OPS 101 PRO" or "OPS 301 PRO" BFS keyboard entry.

In BFS OPS 0, all outputs over the FC data buses are inhibited. If the BFS is tracking the PASS, it will receive FC data inputs through the active PASS/BFS interface, but the BFS GPC will not process any GNC software in OPS 0. It will support, however, monitoring of the GPC MODE and GPC OUTPUT switches, and display of the FAULT Summary display, the BFS MEMORY Spec and the SM displays. This software state will also support downlist, SM processing (except as limited by lack of command of the PL data buses) and, if the active PASS/BFS interface exists (and therefore BFS communication with the network signal processors), uplink. It also supports data bus configuration control, GNC mode transition monitoring, ENGAGE/DISENGAGE monitoring, DK data bus input/output (I/O), and instrumentation data I/O via the IP data bus.

Regardless of the ENGAGE condition, no GNC software processing takes place in BFS OPS 0. It requires a keyboard entry of "OPS 101 PRO" or "OPS 301 PRO" to a BFS keyboard to leave OPS 0. Actually, transitions to other BFS modes are legal, but the proper initialization of the GNC or SM software processing is not supported. Thus, such a transition may not be successful.

5.3.2 BFS OPS/Major Mode Transitions

The BFS GPC can be moded from one OPS to another only by a crew input of "OPS XYZ PRO" to a BFS controlled keyboard. This includes transitions to OPS 0, OPS 1 and OPS 3. Within an OPS, transitions between major modes may be made several ways. The BFS does listen on PASS controlled DK buses as well as BFS controlled DK buses for keyboard entries to sequence major modes. Also, the BFS monitors other systems such as the Solid Rocket Boosters (SRB's) to determine if moding is appropriate. Based on these factors, the BFS will sequence from one major mode to another. Table 5-1 indicates the criteria for OPS/Major Mode transitions.

TABLE 5-1.- OPS TRANSITION/SELECTION.

| | | |
|-----------------|--------------------------------------|-----------------|
| IF GPC-IPL | =====> | OPS 000; |
| IF SYSTEM-RESET | =====> | OPS 000; |
| OPS 000: | If BFS not engaged | |
| | then if "OPS 101 PRO" entered | =====> OPS 101; |
| | OR if "OPS 301 PRO" entered | =====> OPS 301; |
| OPS 101: | If SRB chamber pressure GT 50 PSIA | =====> OPS 102; |
| | If "OPS 000 PRO" entered | =====> OPS 000; |
| OPS 102: | If SRB-SEP completed | =====> OPS 103; |
| OPS 103: | If DELTA-V-Z-AUTO-TRANS completed | =====> OPS 104; |
| | If "OPS 104 PRO" entered | =====> OPS 104; |
| | If "OPS 104 PRO" entered in PASS | =====> OPS 104; |
| OPS 104: | If "OPS 105 PRO" entered | =====> OPS 105; |
| | If "OPS 105 PRO" entered in PASS | =====> OPS 105; |
| OPS 105: | If "OPS 106 PRO" entered | =====> OPS 106; |
| | If "OPS 106 PRO" entered in PASS | =====> OPS 106; |
| OPS 106: | If "OPS 301 PRO" entered | =====> OPS 301; |
| | If "OPS 000 PRO" entered | =====> OPS 000; |
| OPS 301: | If "OPS 302 PRO" entered | =====> OPS 302; |
| | If "OPS 302 PRO" entered in PASS | =====> OPS 302; |
| | If "OPS 000 PRO" entered | =====> OPS 000; |
| OPS 302: | If "OPS 303 PRO" entered | =====> OPS 303; |
| | If "OPS 303 PRO" entered in PASS | =====> OPS 303; |
| | If "OPS 301 PRO" entered, | |
| | OR If "OPS 301 PRO" entered in PASS, | |
| | Then if TIG-GMT GT 5 sec | =====> OPS 301; |
| OPS 303: | If "OPS 304 PRO" entered | =====> OPS 304; |
| | If "OPS 304 PRO" entered in PASS | =====> OPS 304; |
| | If "OPS 301 PRO" entered | =====> OPS 301; |
| | If "OPS 301 PRO" entered in PASS | =====> OPS 301; |
| OPS 304: | If TAEM-Interface achieved | =====> OPS 305; |
| | If "OPS 305 PRO" entered | =====> OPS 305; |
| | If "OPS 305 PRO" entered in PASS | =====> OPS 305; |
| OPS 305: | If "OPS 000 PRO" entered | =====> OPS 000. |

5.3.3 BFS CRT Displays

The BFS GPC supports a limited number of Specialist Functions (SPEC's) and Display Functions (DISP's).- As is the case with the PASS, each BFS SPEC and DISP is given a three-digit number by which the SPEC or DISP is called up using a SPEC ABC PRO keyboard entry to the BFS-controlled keyboard. The distinction between SPEC's and DISP's is the same as that of the PASS SPEC's and DISP's, and the BFS Systems Summary (SYS SUMM) displays (GNC and SM) are called using the SYS SUMM key on the BFS keyboard. Also, as in the PASS, the FAULT page may be called via the FAULT key on the keyboard or via SPEC 99 PRO to clear the FAULT page. Any BFS display will contain the notation "BFS" in the upper-right portion of the display next to the CRT Timer (Line 2).

5.3.3.1 System displays.- The following displays are available at all times in any supported major function, where the keyboard invocation is also listed:

| <u>Display</u> | <u>Keystrokes</u> |
|-----------------------------------|----------------------------------|
| BFS MEMORY (figure 5-3) FAULT' | SPEC 0 PRO SPEC 99 PRO, FAULT |

Payload Displays. No displays are supported for this major function. If payload is selected as the new major function from the requesting MCDS, and if the previous major function was not payload, the previous major function is maintained. Otherwise, no display is presented at the CRT.

5.3.3.2 GN&C displays.- The BFS Memory display is supported for OPS 0, Major Mode 00.

The following major mode displays are supported for OPS 1: where MM denotes Major Mode:

| <u>Display</u> | <u>Major Mode</u> |
|----------------------|-------------------|
| LAUNCH TRAJ 1 | 101 |
| ASCENT/ATO TRAJ 1 | 102 |
| ASCENT/ATO TRAJ 2 | 103 |
| OMS/ATO 1 MNVR EXEC | 104 |
| OMS/ATO 2 MNVR EXEC | 105 |
| OMS/ATO 2 MNVR COAST | 106 |

The following SPEC displays are available at any time during OPS 1. The keyboard selection required to invoke the displays is also listed.

| <u>Display</u> | <u>Keystrokes</u> |
|----------------|-----------------------|
| GNC SYS SUMM 1 | SPEC 18 PRO, SYS SUMM |
| GNC SYS SUMM 2 | SPEC 19 PRO, SYS SUMM |
| HORIZ SIT | SPEC 50 PRO |

```

0001/ / BFS MEMORY 5 000/01:20:00
BFS 000/00:00:00

READ/WRITE
DATA 1* BIT SET 3 SEQ ID 5
CODE 2 BIT RST 4 WRITE 6
7 ENG UNITS --- HEX -8*
ADD ID DESIRED ACTUAL
9 ----- 10 -----
11 ----- 12 -----
13 ----- 14 -----
15 ----- 16 -----
17 ----- 18 -----
19 ----- 20 -----

```

```

MEMORY DUMP LAUNCH BUS 1 25
21 START ID ----- 2 26
22 NUMBER WDS ----- OFF 27*
DUMP 23
TFL EXEC 28
PASS/BFS XFER ENA 24

```

Figure 5-3.- BFS MEMORY display.

The following major mode displays are available in OPS 3:

| <u>Display</u> | <u>Major Modes</u> |
|--------------------------|--------------------|
| DEORB MNVR COAST | 301, 303 |
| DEORB MNVR EXEC | 302 |
| ENTRY TRAJ 1, 2, 3, 4, 5 | 304 |
| VERT SIT 1, 2 | 305 |

The following displays are available at any time in OPS 3. The keyboard invocation is also listed:

| <u>Display</u> | <u>Keystrokes</u> |
|----------------|-----------------------|
| HORIZ SIT | SPEC 50 PRO |
| GNC SYS SUMM 1 | SPEC 18 PRO, SYS SUMM |
| GNC SYS SUMM 2 | SPEC 19 PRO, SYS SUMM |

5.3.3.4 SM displays.- The following displays are available at all times in the SM major function. The keyboard input necessary to invoke the display is also listed.

| <u>Display</u> | <u>Keystrokes</u> |
|----------------|-----------------------|
| THERMAL/PL | Major mode display |
| SM SYS SUMM 1 | SPEC 78 PRO, SYS SUMM |
| SM SYS SUMM 2 | SPEC 79 PRO, SYS SUMM |
| PL BAY DOORS | SPEC 63 PRO |

Since there is only one OPS in the SM major function, the THERMAL/PL display is active at all times as the underlying OPS/major mode display.

5.4 BFS GPC - NOT ENGAGED/ENGAGED

Following the BFS IPL or transition from HALT to STANDBY or RUN, the BFS GPC will enter BFS OPS 0. If the BFS is not engaged, it will monitor the FC data buses to determine whether or not the PASS is in a state which supports the active PASS/BFS interface; i.e., in OPS 1 or OPS 3. If the PASS is in one of these states, the BFS will begin "tracking" (or maintaining a kind of sync with) the PASS based upon receipt of the 25 Hz High Frequency Executive (HFE) transaction and the PASS transfer data. If the PASS was not in OPS 1 or 3, the BFS will ignore the PASS and enter the DISENGAGED-STAND ALONE Mode in which no FC data bus inputs are considered valid.

5.4.1 Transitions Between the STAND-ALONE and PASS TRACKING States - Not Engaged

If the BFS GPC is in the DISENGAGED-STAND ALONE state, it will require either a BFS "I/O RESET EXEC" input, a transition to OPS 101 or 301, or a movement of the BFS GPC MODE switch to HALT and back to STANDBY or RUN to

force it to attempt to "track" the PASS. It should be noted that a transition from HALT to STBY or RUN significantly impacts software processing as it forces BFS OPS 0 (stops GNC processing in particular) whereas an "I/O RESET EXEC" input does not force OPS 0. An I/O reset of this type is done automatically by the BFS system software following a BFS keyboard-entry for an OPS transition to OPS 1 or 3 (OPS 101 PRO or OPS 301 PRO). The BFS GPC will enter the STAND ALONE state when the PASS transitions to an OPS which the BFS cannot support (such as the OPS 1 to OPS 2 PASS GPC transition). If the BFS GPC is engaged and then disengaged (using the BFC DISENGAGE switch, for example,) it will enter this STAND ALONE state. Also, if the BFS GPC is tracking the PASS and a GMT update of over 5 msec is made to the PASS, the BFS will enter the DISENGAGED-STAND ALONE state. For whatever the reason, whenever the BFS GPC stops tracking the PASS, it will generate four fault messages indicating that the BFS is not listening to any PASS BCE chain inputs (e.g., BCE/STRING 1 (2,3,4) PASS).

5.4.2 BFS Listening to the PASS DK Buses - Not Engaged

The BFS GPC will listen on all DK buses including those controlled by the PASS. On the PASS DK buses, the BFS will process only certain specified item entries on the HORIZ SIT, ENTRY TRAJ X (MM304), and XXXXX MNVR XXXXX displays, and manual major mode transition requests within an OPS. Also, GPC/CRT XY EXEC entries, where "X" is the BFS GPC ID, are recognized by the BFS. This capability eliminates the necessity to enter these items through both the PASS and BFS keyboards to the appropriate displays. Table 5-2 lists the items on the three displays which the BFS will receive by DK listen.

TABLE 5-2.- PASS DISPLAYS MONITORED BY BFS.

| Display | Keyboard inputs | Remarks |
|----------------------|---|---|
| HORIZONTAL SITUATION | Item 1 Items 2-4 Items 5,6 Item 7 | Altimeter data Runway select Glide slope select MEP/NEP select |
| XXXX MNVR YYYY | Items 2-7 Items 8-10 Items 12-14 Items 15-18 Item 21 Items 27-38 Item 39 Item 40 | OMS gimbal drive select Entry interface attitude Gimbal trim select Engine burn select Vehicle weight PEG 4/7 targeting data Load targeting data Start CRT timer |
| ENTRY TRAJ X | Item 1 | Bias |

5.4.3 BFS GPC Selective Listen Mode - FC Data Buses - Not Engaged

As previously mentioned, the BFS GPC receives data from the PASS controlled FC data buses by operating in a "Selective Transaction Listen Mode." In OPS 1 and 3, the PASS commander of a FC data bus begins its I/O sequence by sending a "listen" command (used only by the BFS GPC) which identifies the particular I/O sequence and Bus Terminal Unit (BTU) address (Flight Forward (FF), Multiplexer/Demultiplexer (MDM), Master Events Controller (MEC), Engine Interface Unit (EIU), Data Display Unit (DDU)). The BFS recognizes this "listen" command and prepares itself to receive the subsequent data response. The selective transaction listen mode allows the BFS GPC to receive uplink commands and MTU updates as well as avionics sensor and status information. The BFS GPC does not, however, monitor the PASS GPC outputs to those BTU's mentioned above.

5.4.4 PASS/BFS Transfer Data - Not Engaged

During the OPS 1 and OPS 3 mission phases, the PASS GPC's will send certain status and computational information to the BFS GPC over FC data buses 5, 6, 7, and 8, including MDM/BCE element bypass data, string and PL port mode indicators, PASS major mode information, and an indicator which tells where the PASS is in its processing sequence (minor cycle sequencing). The minor cycle sequencing and string mode data are used to establish PASS tracking by the BFS. The above mentioned data is transferred at 25 Hz. Also transmitted in this transfer data are the state vector with a time tag, the IMU REFSMMAT and the PASS "time-to-Launch" reference. This data is transferred at 1.04 Hz. The BFS GPC uses the PASS state vector to update its own state vector only after it has been moded from OPS 0 to OPS 301 and begins tracking the PASS. It uses the PASS state vector one time only. After that the BFS computes its own state vector and ignores the PASS state vector. This PASS/BFS transfer data should be identical over all four FC data buses (FC5 - FC8). The BFS GPC checks to ensure that this information is identical. If a discrepancy is found, a Class 3 fault message is generated (BCE STRG X PASS) and the lowest-numbered two identical FC inputs will be used. This BFS GPC will ignore, until reinitialized, those strings over which the differing data was transmitted. This means that if the BFS GPC detects that identical data is transferred over FC 5, 6, and 7 but (twice in a row) the transfer data over FC 8 is different, the BFS GPC will ignore String 4; i.e. both FC 4 and 8. If no two inputs are the same, the BFS GPC enters the DISENGAGED-STAND ALONE state. In either case, an appropriate TBD fault message will be generated.

5.4.5 One-Shot Transfers - Not Engaged

In order to transfer certain data (launch polynomial, Inertial Measurement Unit (IMU) calibration data, accelerometer data, etc.) into the BFS GPC during the launch countdown (prior to PASS moding to OPS 1), a "one-shot transfer" capability will be included in the PASS GPC OPS 9 software in the General Test Support (GTS) SPEC display. The BFS GPC must be in OPS 0 and in the DISENGAGED-STAND ALONE state for this to be possible. An item number (24) exists on the BFS MEMORY display which, when initiated, will cause the BFS to set up to receive the data. An asterisk will appear

next to Item 24. An item number (29) exists on the PASS GTS display (SPEC 100) to initiate the transfer. If the transaction is successful, the asterisk on the BFS MEMORY display will disappear. If it was not successful, the one-shot transfer can be repeated if necessary. Both displays must appear on different CRT's simultaneously for the transfer to occur.

5.4.6 BFS/I/O Management

5.4.6.1 Data bus control - summary.- The BFS GPC will not access the Intercomputer Communication (ICC) or, after IPL, the Mass Memory (MM) data buses. The BFS GPC will begin commanding on the PL data buses when it is in RUN or Engaged. Preengage, the BFS will not command any FC data bus and will listen on the FC data buses only if it is tracking PASS (OPS 1,3). When engaged, the BFS will command on the FC data buses and gain control of the vehicle. Whenever the BFS is moded from HALT to STBY or RUN, it will begin transmitting on DK 4. The BFS GPC may be assigned one forward CRT preengage, and two forward CRT's postengage via the BFC/CRT DISPLAY and SELECT switches. Also, the GPC/CRT key may be used to assign or deassign the BFS from any DK bus. This capability provides a backup method for assigning the forward CRT's to the BFS if the BFC CRT SELECT switch develops a problem. Each GPC has a dedicated IP bus through which it receives OI data and transmits its downlist. When the BFS GPC is initialized, it does not have command of the LDB's. Control may be assigned to the BFS GPC via a keyboard entry to the BFS MEMORY display (Items 25 or 26). It is the user's responsibility to insure that the PASS is no longer commanding on those data buses.

5.4.6.2 BFS I/O error processing.- As is the case in the PASS, errors detected on outputs will be recorded in an I/O error log but cause no special "downmoding" or annunciation. The BFS tracks PASS detected BCE element bypasses on the FC data buses through the PASS transfer data (25 times-per-second) and also performs its own I/O error processing based solely on its own inputs.

For data access on the FC data buses and PL data buses, two consecutive errors on a particular transaction involving a BCE element (other than on an MDM return word) will result in a BCE element bypass. In this case, the element will no longer be accessed for data and a Class 3 alarm and fault message will be generated. The fault message will be of the same format as those generated by the PASS ("BCE STRG X ABCD" where X = 1,2,3,4 and ABCD indicates the failed element). Also, two consecutive errors with the MDM return word on a transaction will result in the BFS ignoring that MDM and generating an appropriate Class 3 fault message of the "I/O ERROR ABC" variety. Also, a "+" will appear on the BFS GNC SYS SUMM 1 display beside the fault MDM (FF, FA, PL) just like in the PASS. It should be noted that this means that an MDM or certain Line Replaceable Unit (LRU) failures will result in double annunciation by the PASS and BFS in the preengage state. After the first error detected on a DK bus, or the second consecutive error detected on the Instrumentation/Pulse-Code Modulation Master Unit (IP) data bus, the fault is annunciated, (Class 3 alarm and "I/O ERROR ABC" fault message where ABC indicates the faulty bus), but the BFS GPC continues to use the bus. In these cases, the data bus is not downmoded.

Preengage, if the BFS GPC fails to correctly receive the PASS transfer data or the HFE transaction listen commands two consecutive times over a string, then the BFS GPC will downmode the involved string (HALT I/O on that string). This downmoding remains in effect until the BFS is reinitialized using its MODE switch, or until an I/O RESET is made (automatically upon OPS transition, or BFS engagement, or manually upon BFS keyboard entry). Also, the Class 3 fault message "BCE STRG X PASS" will be generated where "X" indicates on which string the problem was detected.

When the BFS is engaged, its I/O error processing is the same as that which is done in the PREENGAGE state, except that it ignores any PASS-detected I/O errors. When the BFS is engaged, it also performs an automatic reset of all I/O errors.

5.4.7 I/O RESET Response

Following an "I/O RESET EXEC" command to a BFS keyboard, the BFS restores data buses and BCE elements to their nominal configuration for the current mission, phase and state (engaged or not). Because no downmoding occurs on the IP or DK buses, only the FC and PL buses are affected by an I/O RESET.

If the BFS is engaged when the I/O RESET is commanded, both the FC and PL buses are configured in the command mode and BCE elements are restored as appropriate for the current mission phase.

If the BFS is not engaged, and an I/O RESET is commanded, the FC buses are placed in the listen mode and the BFS attempts to synchronize with the PASS. If the BFS succeeds in establishing sync with the PASS, the FC BCE elements are configured to the state indicated in the PASS transfer data. If the BFS is not successful, the BFS enters the DISENGAGED-STAND ALONE state and disables the FC data buses. In either case, the BFS configures the PL buses in the command mode if the BFS is in RUN and BCE elements are restored.

5.4.8 Timekeeping

The BOS software maintains the current value of GMT and MET for use by applications programs as well as for its own use. These values are internally updated 25 times-per-second (once per "minor cycle"). Once per "major cycle" (1.04 times per second), a comparison is made between the internally computed time and an MTU source, if available (through the BFS listen mode on the FC Data Buses, when the BFS is not engaged but tracking the PASS, or through its normal I/O on the FC data buses when it is engaged). The BFS checks the MTU responses for commfault and BITE. If at least two of the MTU sources pass the commfault and BITE test, the BFS simply uses a mid-value selection to pick its time source. If only one time source passes the BITE/commfault test, it is used as a time source. In either case, the BFS uses this good source to update its internal clock. If no good source is found, the MTU is ignored until user intervention.

When the BFS GPC is initialized (moded from HALT to STANDBY or RUN), it checks for an MTU source. If one is available, it sets its GMT/MET to the lowest numbered available MTU accumulator GMT/MET (if valid). If no valid MTU source is available, the BFS GPC defaults its time values to "day one" for GMT and its MET to "zero". It is proposed that when the BFS is forced to OPS 0 prior to OPS 3, the BFS will again update its internal clock to the MTU time upon the OPS transaction to OPS 3.

There is no time management display for the BFS, and so the BFS GPC MEMORY display must be used to change the time. This process must be done carefully, however, as it may affect BFS applications software processing (GNC, sequencing).

The current BFS mission time in MET will be in the top line in the upper right-hand corner of all BFS driven CRT's. The CRT timer may be initiated to countdown of the loaded Time of Ignition (TIG) time through a crew input to the current XXXXX MNVR XXXXX display through a BFS keyboard, or through the BFS listening to PASS controlled DK buses. The current CRT Timer time appears in the second line in the upper right-hand corner of all BFS CRT displays.

5.4.9 Uplink

Uplink to the BFS GPC is similar to uplink to the PASS GPC's. Only a subset of the PASS uplink commands will be used for the BFS as illustrated in appendix E. For example, no DEU Equivalent commands can be sent from the ground to the BFS. The ground can only uplink to the BFS GPC when the BFS GPC is "listening" on Strings 1 or 3, since the Network Signal Processor (NSP) 1 is on FF1 and NSP 2 is on FF3. The BFS, if not engaged, must be in the selective listen mode on the FC data buses in order to receive uplink and thus the PASS must be in OPS 1 or OPS 3. If the BFS entered the DISENGAGED-STAND ALONE state, it would stop listening on the FC data buses and thus would not be capable of uplink. If the BFS is engaged, it will be capable of responding to uplink commands since it controls the FC Data Buses.

5.4.10 Downlist

The BFS GPC collects and sends its downlist to the Pulse-Code Modulation Master Unit (PCMMU) 24 times-per-major cycle. This downlist data is stored in the PCMMU's toggle buffer 5 for incorporation into the Downlink during the OPS 1 and OPS 3 mission phases. There are controls on the GPC MEMORY display to dump BFS main memory and to enter Real Time Commands (RTC's).

APPENDIX A
MDM TABLES

APPENDIX A
MDM TABLES

MDM FF1

- MDM BITE STATUS REGISTER
- CARD 0 - TACAN #1 PWR, BRNG, RANGE, CHAN SEL, MODE, ANTENNA (TAC) SEL RADAR ALTIMETER #1 ALTITUDE DATA, STATUS, LOCK-ON, TEST
- CARD 1 - LH RHC ROLL, PITCH, YAW - CMD A (AID) LEFT RUDDER PEDAL - CMD A LH SBTC - CMD A AFT RHC ROLL, PITCH, YAW - CMD A
- CARD 2 - RT FWD VENTS (1/2) - OP/CL/PURGE - CMD 1B (DOH) RCS FWD MANF ISOL VLV #1 - OP RCS FWD MANF ISOL VLV #4 - CL A RCS FWD OX TNK ISOL VLV 3/4/5 - OP A/CL B RCS FWD TNK ISOL VLV 3/4/5 - CL A N/W STEERING - GROUND SPEED ENA CMD MPS STATUS AMBER LITE - ON (E1) LH EVENT SEQUENCE A/B/C/D/E DPLR XTRTR - UNIT 1 RCS CMD R/P/Y - LAMP A - LEFT/RT FWD DAP AUTO-SELECT A, MANUAL-SELECT B LITES FWD RCS JETS NORM LITE/VERNIER LITE OMS - LEFT ENG ACTR SEL ACTIVE 1/2 RT/LEFT PLB VENT 3 OP/CL - CMD 1B LEFT PLB VENT 6 OP/CL/PURGE 1/PURGE 2 - CMD 1B RT PLB VENT 5 OP/CL - CMD 1B
- CARD 3 - IMU #1 STATUS, DATA (SIO) MTU - CHAN 1 GMT, MET, BITE STATUS, GMT/MET UPDATE -Z STAR TRKR STATUS, DATA, POSITION, CMD WORD
- CARD 4 - FCS MON CHAN 3 - RESET/OVERRIDE B, CHAN 4 - RESET/OVERRIDE C (DIH) FCS LH PITCH AUTO MODE A/CSS MODE A FCS LH R-Y AUTO MODE A/CSS MODE A GPC UPLINK 2-STAGE BLOCK CMD A LH BODY FLAP UP/DOWN CMD A, AUTO/MAN CMD A MPS ME 1 SHUTDOWN CMD A RJDF 1 TRICKLE CURRENT CONTINUITY 1 RCS FWD FU MANF ISOL VLV 1 OP/CL RCS FWD FU TANK ISOL VLV 3/4/5 - OP/CL RCS HE FU PRESS VLV-A OP/CL LH AIR DATA SOURCE SEL - LEFT/NAV/RT LH ADI ATT SEL - INERTIAL/LVLH/REFERENCE LH ADI RATE SCALE - HIGH/MED/LOW LH ADI ERROR SCALE - HIGH/MED/LOW LH SPEED BRAKE/THROTTLE AUTO/MAN A START TRKR -Z DOOR - OP/CL-2 ENTRY ROLL MODE AILERON A

MDM FF1 (Continued)

- CARD 4 - RT/LEFT PLB VENT 3 OP/CL-1
(DIH) RT FWD VENTS 1/2 OP/CL/PURGE IND 1
LEFT PLB VENT 6 OP/CL/PURGE IND 1
RT PLB VENT 5 OP/CL 1

- CARD 5 - RJDF 1 JET F1F/F1L/F1U/F1D CMD A
(DOL) ACCEL ASSY 1 STATUS
DPLR XTRTR #1 STATUS
FWD EVENT TIMER - ABORT RESET
LEFT RCS LEAK DET

- CARD 6 - RJDF 1 JET F1F/F1L/F1U/F1D CHMBR PRESS IND
(DIL) LH DDU PWR SUPPLY A/B/C STATUS
FWD THC +/- X,Y,Z OUTPUT-A
LH SBTC TAKEOVER-A
LH RHC +/- PITCH, ROLL TRIM-A
SRB SEP AUTO A CMD
SRB SEP MAN/AUTO ENA A CMD
SRB SEP INIT A CMD

- CARD 7 - RCS FWD OX/FU THRUST INJ TEMP F1F/F1L/F1U/F1D
(AIS) RCS FWD HE FU TANK TEMP 1/PRESS 1
RCS FWD OX TANK TEMP A
RCS FWD HE OX TANK PRESS 2
RCS FWD FU TANK OUT PRESS
RCS FWD OX TANK ULLAGE PRESS
RCS FWD OX/FU MANF PRESS-1/2

- CARD 8 - MPS E1 MAIN CHMBR PRESS/CMPT
(AOD) RCS FWD OX/AFT OX (LEFT/RT) QTY
RCS FWD/L AFT LOWEST PROPELLANT QTY
OMS PBR OX TNK TOTAL QTY
SPEED BRAKE POSN - SPI
LH INBD/OUTBD - ELEVON POSN - SPI
RH INBD/OUTBD ELEVON POSN - SPI
ACCEL ASSY 1 NORM/LAT TEST STIM

- CARD 9 - RJDF 1 JET F1F/F1L/F1U/F1D DRIVER
(DIH) FWD DAP SEL A-A/SEL B-A/AUTO A/MAN A
AFT DAP SEL A-C/SEL B-C/AUTO C/MAN C
FCS FWD LOOP GAIN PITCH/ROLL-YAW HIGH-A/LOW-A
SENSE SW -Z CON A/-X CON A
ENTRY ROLL MODE AUTO-A
FWD ROTATION R/P/Y DISC RATE A/ACCEL A/PULSE A
FWD RCS JETS NORM A/VERNIER A
FWD TRANSLATION X/Y/Z NORM A/PULSE A/HIGH A
MPS LO2 FEEDLINE DUMP START A/STOP A
LH AIR DATA PROBE DEPLOY 1/STOW 1
ADTA 1 PWR ON CMD
IMU 1 PWR ON CMD-B
MSBLS #1 PWR STATUS
TACAN #1 AUTO DISCRETE

MDM FF1 (Continued)

- CARD 10 - RT FWD VENTS 1/2 OP/CL/PURGE CMD 1A
(DOH) LH BODY FLAP AUTO
LH SPEED BRAKE AUTO
FCS MODE - LH P/R/Y AUTO
RCS FWD FU TK ISOL VLV 3/4/5 OP A/CL B
RCS FWD MANF ISOL VLV 5 CL A
RCS FWD HE PRESS VLV A OP A/CL A
RCS FWD MANF ISOL VLV 4 CL B
MPS STATUS/RED LIGHT-
FWD ROTATION R/P/Y DSCR/ACCEL/PULSE LITES
FWD TRANSLATION X/Y/Z NORMAL/PULSE/HIGH LITES
SM B/U C/W A CMD 1/TONE A CMD 1/ALERT A CMD 1
RT/LEFT PLB VENT 3 OP/CL CMD 1A
LEFT PLB VENT 6 OP/CL/PURGE 1/PURGE 2 CMD 1A
RT PLB VENT 5 OP/CL CMD 1A

- CARD 11 - ADTA #1 STATUS, PRESS, TOTAL TEMP
(SIO) MSBLS #1 AZIMUTH DATA, STATUS, ELEVATION DATA, RANGE
DPLR XTRTR 1 STATUS, STATION ID, XPNDR MODE A/B/C, XPNDR SEL
MTU STATUS
DPLR XTRTR 1 NSP 1/2 SEL
DPLR COUNT/INTERVAL COUNT
NSP 1 STATUS, CMD 1, NSP 1 CMD 2, NSP 1 CMD 3, NSP 1 CMD 4,
NSP 1 CMD 5, NSP 1 CMD 6, NSP 1 CMD 7, NSP 1 CMD 8,
NSP 1 CMD 9, NSP 1 CMD 10, NSP CMD VALIDITY

- CARD 12 - FCS MON CHAN 1 RESET/OVERRIDE B
(DIH) LH +/- P/R/Y TRIM A
RCS FWD OX MANF ISOL VLV 1 OP/CL
RCS FWD OX PRESS VLV-A OP/CL
RCS FWD OX TANK ISOL VLV 3/4/5 OP/CL
RADAR ALTM LH DISPLAY SEL NO 1/NO 2
LH HSI MLS, NAV TACAN APPROACH /TAEM /ENTRY MODE SEL
LH HSI SOURCE SEL 1/2/3
LH RHC TRIM INH 4
-Z ST PWR ON CMD
FCS RATE GAIN PITCH MED A
RCS MASTER XFEED FROM LEFT 1/RT 1
ATO/AOA/RTLS ABORT REQUEST SIGNAL A
LH ADI ATT REF PB-A/PB-B
LEFT PLB VENT 5 PURGE 2 IND 1
FCS RATE GAIN PITCH OFF A/ROLL-YAW MED A/ROLL-YAW OFF A
STAR TRKR -Y DR OP 1/CL 1
AFT RCS OPTIONS NORMAL-C/VERNIER-C

- CARD 13 - RJDF 1 JET FIF/FIL/FIU/FID CMD B
(DOL) ADTA 1 HIGH/LOW TEST MODE CMD
IMU-1 OPERATE MODE CMD
SPI DATA STATUS

- CARD 14 - ACCEL ASSY 1 LAT/NORM ACCEL
(AID)

MDM FF1 (Continued)

- CARD 15 - IMU 1 STATUS
(DIL) AFT THC +/- X,Y,Z OUTPUT A
ET SEP MNL ENA A/INIT A/AUTO A
LH DOU STATUS

MDM FF2

- MDM BITE STATUS REGISTER
- CARD 0 - TACAN #2 PWR, BRNG, RANGE, CHAN SEL, MODE, ANTENNA
(TAC) SEL RADAR ALTIMETER #2 ALTITUDE DATA, STATUS, LOCK-ON, TEST
- CARD 1 - LH RHC R, P, Y - CMD B
(AID) LEFT RUDDER PEDAL - CMD B
LH SBTC - CMD B
AFT RHC R, P, Y - CMD B
- CARD 2 - LEFT FWD VENTS (1/2) - OP/CL/PURGE - CMD 2B
(DOH) RCS FWD MANF ISOL VLV 2 - OP
RCS FWD MANF ISOL VLV 3 - CL A
MPS E2 STATUS/AMBER LITE ON
OMS - LEFT ENG ACTR SEL STBY 1/2
LEFT PLB VENT 3 OP/CL CMD 2B
LEFT PLB/W VENTS 4&7 OP/CL CMD 2B
RT PLB VENT 6 OP/CL/PURGE 1/PURGE 2 CMD 2B
RT PLB VENT 5 OP/CL - CMD 2B
- CARD 3 - IMU #2 STATUS, DATA
(SIO) MTU - CHAN 2 GMT, MET, BITE STATUS, GMT/MET UPDATE
- CARD 4 - FCS MON CHAN 2 - RESET/OVERRIDE A, CHAN 3 - RESET/OVERRIDE C
(DIH) ENTRY ROLL MODE AILERON B
LH BODY FLAP UP/DN B, AUTO/MAN B
MPS ME-1 SHUTDOWN CMD B
RJDF 1 TRICKLE CURRENT CONTINUITY 2
RCS FWD FU MANF ISOL VLV 2 OP/CL
RCS HE FU PRESS VLV-B OP/CL
NOSE WHEEL STEERING MAN - ON/COMPUTER-ON
RH AIR DATA SOURCE SEL - LEFT/NAV/RT
RH ADI ATT SEL - INERTIAL/LVLH/REFERENCE
RH ADI RATE SCALE - HIGH/MED/LOW
RH ADI ERROR SCALE - HIGH/MED/LOW
FCS LH PITCH AUTO MODE B/CSS Mode B
FCS LH R-Y AUTO MODE B/CSS MODE B
LH SPEED BRAKE/THROT AUTO/MAN B
MPS ENG LIMIT CNTL #1 ENA/INH/AUTO
LEFT PLB VENT 3 OP/CL-2
LEFT FWD VENTS (1/2) OP/CL/PURGE IND 2
RT PLB VENT 6 OP 2/CL 2/PURGE 1 IND 2
LEFT PLB/W VENTS 4&7 OP/CL 2

MDM FF2 (Continued)

- CARD 4 - RT PLB VENTS OP/CL 2
(DIH)
- CARD 5 - RJDF 1 JET F2F/F2R/F2U/F2D CMD A
(DOL) ACCEL ASSY 2 BITE
- CARD 6 - RJDF 1 JET F2F/F2R/F2U/F2D CHMBR PRESS IND
(DIL) RH DDU PWR SPLY A/B/C GOOD
FWD THC POS/NEG X/Y/Z OUTPUT B
LH SBTC TAKEOVER-B
LH RHC +/- PITCH/ROLL TRIM B
- CARD 7 - RCS FWD OX/FU THRUST INJ TEMP - F2F/F2R/F2D/F2U
(AIS) RCS FWD HE OX/FU PRESS-2
RCS FWD HE FU TANK TEMP-1
- CARD 8 - MPS E2 MAIN CHMBR PRESS/CMPT
(AOD) NOSE WHEEL STEERING COMPUTER CMD
BODY FLAP POS SPI
AILERON POS - SPI
- CARD 9 - RJDF 1 JET F2F/F2R/F2U/F2D DRIVER
(DIH) FWD DAP SEL A-B/B-B
FWD DAP MAN B/AUTO B
FCS FWD LOOP GAIN PITCH/ROLL-YAW HIGH-B/LOW-B
MPS ME-2 SHUTDOWN CMD A
SENSE SW -Z/-X CON B
ENTRY ROLL MODE AUTO-B
FWD ROTATION R/P/Y DISC RATE B/ACCEL B/PULSE B
FWD RCS JETS NORM B/VERNIER B
FWD TRANSLATION X/Y/Z NORM B/PULSE B/HIGH B
MPS LO2 FEEDLINE DUMP START B/STOP B
LH AIR DATA PROBE DEPLOY 2/STOW 2
ADTA 2 PWR ON CMD
IMU-2 PWR ON CMD-B
MSBLS 2 PWR STATUS
TACAN 2 AUTO DISCRETE
- CARD 10 - LEFT FWD VENTS 1/2 OP/CL/PURGE CMD 2A
(DOH) LH BODY FLAP MAN
LH SPEED BRAKE MAN
FCS MODE - LH PITCH/ROLL-YAW CSS
RCS FWD MANF ISOL VLV-3 GPC CL B
MPS E2 STATUS/RED LITE ON
SM BU C&W A CMD 2/TONE A CMD 2/ALERT A CMD 2
LEFT PLB VENT 3 OP/CL CMD 2A
LEFT PLB/W VENTS 4&7 OP/CL CMD 2A
RT PLB VENT 6 OP/CL/PURGE 1/PURGE 2 CMD 2A
RT PLB VENT 5 OP/CL CMD 2A
- CARD 11 - ADTA 2 STATUS DATA
(SIO) MSBLS 2 STATUS DATA

MDM FF2 (Continued)

- CARD 12 - FCS MON CHAN 1 RESET/OVERRIDE A
(DIH) LH +/- P/R/Y TRIM B
RCS FWD OX MANF ISOL VLV 2 OP/CL
RCS FWD HE OX PRESS VLV B OP/CL
NLG NO WEIGHT-ON-WHEELS #2
NLG UNLOCKED
RADAR ALTIM RH DISPLAY SEL 1/2
RH HSI MLS/NAV/TACAN/SEL
RH HSI APPROACH/TAEM/ENTRY MODE SEL
RH HSI SOURCE SEL 1/2/3
LH RHC TRIM INH B
FCS RH PITCH/ROLL-YAW AUTO/CSS MODE A
RH BODY FLAP AUTO/MAN A
RH SPEED BRAKE/THROTTLE AUTO/MAN A
RCS MASTER XFEED FROM LEFT-2/RT-2
ATO/AOA/RTLS ABORT REQUEST SIGNAL B
RH ADI ATT REF PLB A/B
RT PLB VENT 6 PURGE 2 IND 2
LMG NO WEIGHT ON WHEELS/UNLOCKED
RMG DR UNLOCKED
FCS RATE GAIN PITCH/ROLL-YAW MED B/OFF B
- CARD 13 - RJDF 1 JET F2F/F2R/F2U/F2D CMD B
(DOL) ADTA 2 HIGH/LOW TEST MODE CMD
IMU 2 OPERATE MODE CMD
- CARD 14 - RH RHC R/P/Y CMD-A
(AID) RIGHT RUDDER PEDAL CMD-A
RH SBTC CMD-A
ACCEL ASSY 2 LAT/NORM ACCEL
- CARD 15 - IMU 2 STATUS
(DIL) RH DDU STATUS
AFT THC +/- X/Y/Z OUTPUT B
RH SBTC TAKEOVER A

MDM FF3

- MDM BITE STATUS REGISTER
- CARD 0 - TACAN #3 PWR, BRNG, RANGE, CHAN SEL, MODE, ANTENNA
(TAC) SELECT
- CARD 1 - LH RHC R, P, Y-CMD C
(AID) LEFT RUDDER PEDAL CMD-C
LH SBTC-CMD C
AFT RHC R, P, Y-CMD C
- CARD 2 - LEFT FWD VENTS 1&2 OP/CL/PURGE CMD 1B
(DOH) RCS FWD MANF ISOL VLV 4 OP

CARD 2 (DOH)

RCS FWD MANF ISOL VLV 1 CL-A
RCS FWD OX TNK ISOL VLV 1/2 OP A/CL B
RCS FWD TNK ISOL VLV 1/2 CL A
MPS E3 STATUS/AMBER LITE ON
RH EVENT SEQUENCE A/B/C/D/E COMPUTER CONT
DPLR XTRTR - UNIT 2
RCS CMD R/P/Y LEFT/RT LAMP B
RCS CMD PITCH UP/DOWN B
AFT DAP AUTO (LITE)/SEL A (LITE)
OMS R ENG ACTR SEL STBY 1/STBY 2
AFT DAP MAN (LITE)/SEL B (LITE)
AFT RCS JETS VERNIER (LITE)/NORMAL (LITE)
RT PLB/W VENTS 4&7 OP/CL CMD 2B
LEFT PLB/W VENTS 4&7 OP/CL CMD 1B
RT PLB VENT 6 OP/CL/PURGE 1/PURGE 2 CMD 1B
LEFT PLB VENT 5 OP/CL CMD 1B

CARD 3 (SIO)

IMU 3 STATUS, DATA
MTU CHAN 3 GMT/MET, BITE STATUS, GMT/MET UPDATE
KU-A CH 2 ANT STRG AUTO 2: A/B SEL
-Y STAR TRKR STATUS, DATA
KU-A CH 2 STATUS, DATA

CARD 4 (DIH)

FCS MON CHAN 2 RESET/OVERRIDE B
FCS CHAN 1 RESET/OVERRIDE C
GPC UPLINK 2-STAGE BLOCK CMD B
RH BODY FLAP UP/DOWN A
MPS ME-3 SHUTDOWN CMD A
RJDJF 2 TRICKLE CURRENT CONTINUITY 4,5
RCS FWD FU MANF ISOL VLV 4 OP/CL
RCS FWD FU TANK ISOL VLV 1/2 OP/CL
RCS FWD FU MANF ISOL VLV 5 OP/CL
STAR TRKR - Z DOOR OP/CL 1
AFT ADI ATT SEL INERTIAL/LVLH/REFERENCE
AFT ADI RATE SCALE HIGH/MEDIUM/LOW
AFT ADI ERROR SCALE HIGH/MEDIUM/LOW
FCS LH PITCH/ROLL-YAW AUTO/CSS MODE C
LH SPEED BRAKE/THROT AUTO/MAN C
MPS ENG LIMIT CNTL #2 ENA/INH/AUTO
RT PLB/W VENTS 4&7 OP/CL 2
LEFT FWD VENTS 1&2 OP/CL/PURGE IND 1
RT PLB VENT 6 OP/CL/PURGE IND 4
LEFT PLB/W VENTS 4&7 OP/CL 1
LEFT PLB VENT 5 OP/CL 1

CARD 5 (DOL)

RJDJF 2 JET F4R/F4D/F5L/F5R CMD A
ACCEL ASSY 3 BITE
DPLR XTRTR 2 START D TIME/TEST MODE DISCRETES
RCS FAIL/OMS-TVC FAIL
OMS LEFT-ENG/RT-ENG ABNORMAL
FCS CHANNEL FAIL
FCS SATURATION

MDM FF3 (Continued)

- CARD 5 - IMU/RH RHC/LH RHC/NAV SENSOR/GYRO ACCEL FAIL
(DOL) RT RCS/FWD RCS LEAK DET
- CARD 6 - RJDF 2 JET F4R/F4D/F5L/F5R CHMBR PRESS IND
(DIL) AFT DDU PWR SPLY A/B/C GOOD
FWD THC +/- X/Y/Z OUTPUT-C
LH SBTC TAKEOVER-C
- CARD 7 - RCS FWD OX THRUST INJ TEMP - F4R/F4D/F5L/F5R
(AIS) RCS FWD FU THRUST INJ TEMP - F4R/F4D/F5L/F5R
RCS FWD FU TANK TEMP 1
RCS FWD HE FU TANK PRESS 2
RCS FWD HE OX TANK TEMP 1/PRESS 1
RCS FWD OX TANK OUT PRESS
RCS FWD FU TANK ULLAGE PRESS
RCS FWD FU/OX MANF PRESS 3/4/5
- CARD 8 - MPS E3 MAIN CHMBR - PRESS/CMPT
(AOD) RCS FWD/LEFT-AFT/RT-AFT FU QTY
RCS - RT AFT LOWEST PROPELLANT QTY
ACCEL ASSY 3 NORM/LAT TEST STIM
- CARD 9 - RJDF 2 JET F4R/F4D/F5R/F5L DRIVER
(DIH) AFT DAP SEL A-A/B-A
FWD DAP SEL A-C/B-C
AFT DAP AUTO A/MAN A
FWD DAP AUTO C/MAN C
FCS FWD LOOP GAIN PITCH/ROLL-YAW HIGH-C/LOW-C
MPS ME-2 SHUTDOWN CMD B
SENSE SW -Z/-X CON C
ENTRY ROLL MODE AUTO-C
AFT ROTATION R/P/Y DISC RATE/ACCEL RATE/PULSE A
AFT RCS JETS NORM A/VERNIER A
AFT TRANSLATION X/Y/Z PULSE A/HIGH A/NORM A
MPS LH2 FEEDLINE DUMP START A/STOP A
RH AIR DATA PROBE DEPLOY 1/STOW 1
ADTA 3 PWR ON CMD
IMU 3 PWR ON CMD B
MSBLS 3 PWR STATUS
TACAN 3 AUTO DISCRETE
- CARD 10 - LEFT FWD VENTS 1&2 OP/CL/PURGE CMD 1A
(DOH) RH BODY FLAP AUTO
RH SPEEDBRAKE AUTO
FCS MODE - RH PITCH/RH ROLL-YAW AUTO
RCS FWD FU TNK ISOL VLV 1/2 OP A/CL B
RCS FWD MANF ISOL VLV 5 OP A
RCS FWD HE PRESS VLV B OP/CL A
RCS FWD MANF ISOL VLV 1 CL B
MPS E3 STATUS/RED LITE ON
AFT ROTATION R/P/Y DSCR/ACCEL/PULSE (LITES)
AFT TRANSLATION X/Y/Z NORM/PULSE/HIGH (LITES)

MDM FF3 (Continued)

- CARD 10 - SM BU C&W A CMD 3/TONE A CMD 3/ALERT A CMD 3
(DOH) RT PLB/W VENTS 4&7 OP/CL CMD 2A
LEFT PLB/W VENTS 4&7 OP/CL CMD 1A
RT PLB VENT 6 OP/CL/PURGE 1/PURGE 2 CMD 1A
LEFT PLB VENT 5 OP/CL CMD 1A

- CARD 11 - ADTA 3 STATUS, DATA
(SIO) MSBLS 3 STATUS, DATA
DPLR XTRTR 2 STATUS, DATA
NSP 2 STATUS, DATA

- CARD 12 - FCS MON CHAN 4 RESET/OVERRIDE B
(DIH) RH +/- P/R/Y TRIM A
RCS FWD OX MANF ISOL VLV 4 OP/CL
RCS FWD OX TANK ISOL VLV 1/2 OP/CL
RCS FWD OX MANF ISOL VLV 5 OP/CL
NLG NO WEIGHT ON WHEELS #1
NLG DOOR UNLOCKED
ENTRY ROLL MODE AILERON C
FCS RATE GAIN PITCH/ROLL-YAW MED/OFF C
-Y STAR TRKR PWR ON CMD
RH RHC TRIM INH A
FCS RH PITCH/ROLL-YAW AUTO/CSS MODE B
RH BODY FLAP AUTO/MAN B
RH SPEED BRAKE/THROT AUTO/MAN B
RCS MASTER XFEED FROM LEFT-3/RT-3
AOA/ATO/RTLS ABORT REQUEST SIGNAL C
APT ADI ATT REF PLB-A/PLB-B
RT PLB VENT 6 PURGE 2 IND 1
RMG NO WEIGHT ON WHEELS
RMG UNLOCKED
LMG DOOR UNLOCKED
STAR TRKR -Y DR OP 2/CL 2
FWD RCS OPTIONS NORM C/VERNIER C

- CARD 13 - RJDF 2 JET F4R/F4D/F5L/F5R CMD B
(DOL) ADTA 3 HIGH/LOW TEST MODE CMD
IMU 3 OPERATE MODE CMD

- CARD 14 - RH RHC ROLL/PITCH/YAW CMD B
(AID) RT RUDDER PEDAL CMD B
RH SBTC CMD B
ACCEL ASSY 3 NORM/LAT ACCEL

- CARD 15 - IMU 3 STATUS, DATA
(DIL) AFT DDU GOOD
AFT THC +/- X/Y/Z OUTPUT C
RH SBTC TAKEOVER-B
RH RHC +/- PITCH/ROLL TRIM A

MDM FF4

- MDM BITE STATUS REGISTER
- CARD 0 - EMPTY
(TAC)
- CARD 1 - EMPTY
(AID)
- CARD 2 - RT FWD VENTS 1&2 OP/CL/PURGE CMD 2B
(DOH) RCS FWD MANF ISOL VLV 3 OP
RCS FWD MANF ISOL VLV 2 CL-A
OMS - R ENG ACTR SEL ACTIVE-1/ACTIVE-2
RT PLB VENT 3 OP/CL CMD 2B
RT PLB/W VENTS 4&7 OP/CL CMD 1B
LEFT PLB VENT 6 OP/CL/PURGE 1/PURGE 2 CMD 2B
LEFT PLB VENT 5 OP/CL CMD 2B
- CARD 3 - EMPTY
(SIO)
- CARD 4 - FCS MON CHAN 3 RESET/OVERRIDE A
(DIH) FCS CHAN 2 RESET/OVERRIDE C
RH BODY FLAP UP/DOWN B
MPS ME-3 SHUTDOWN CMD 8
RJDF 2 TRICKLE CURRENT CONTINUITY 3
RCS FWD FU MANF ISOL VLV 3 OP/CL
MPS ENG LIMIT CONTROL #3 ENA/INH/AUTO
RT PLB VENT 3 OP/CL-2
RT FWD VENTS 1&2 OP/CL/PURGE IND-2
LEFT PLB VENT 6 OP 2/CL 2/PURGE IND 2
RT PLB/W VENTS 4&7 OP/CL-1
LEFT PLB VENT 5 OP/CL-2
- CARD 5 - RJDF 2 JET F3F/F3L/F3U/F3D CHAMBER PRESS IND
(DOL) ACCEL ASSY 4 LAT/NORM BITE
FWD EVENT TIMER - LIFT-OFF START
- CARD 6 - RJDF 2 JET F3F/F3L/F3U/F3D CMD A
(DIL) SRB SEP AUTO B CMD
SRB SEP MAN/AUTO ENA B CMD
SRB SEP INIT B CMD
- CARD 7 - RCS FWD OX/FU THRUST INJ TEMP - F3F/F3L/F3U/F3D
(AIS) RCS FWD OX/FU TANK OUT PRESS
RCS FWD FU TANK TEMP 1
- CARD 8 - ACCEL ASSY 4 NORM/LAT TEST STIM
(AOD)

MDM FF4 (Continued)

- CARD 9 - RJDF 2 JET F3F/F3L/F3U/F3D DRIVER
(DIH) AFT DAP SEL A-B/B-B
AFT DAP AUTO/MAN B
ENTRY ROLL MODE AUTO D
AFT ROTATION R/P/Y DISC RATE B/ACCEL B/PULSE B
AFT RCS JETS NORM B/VERNIER B
AFT TRANSLATION X/Y/Z NORM B/PULSE B/HIGH B

- CARD 10 - RT FWD VENTS 1&2 OP/CL/PURGE CMD 2A
(DOH) RH BODY FLAP MAN/SPEEDBRAKE MANUAL
FCS MODE RH PITCH/ROLL-YAW CSS
RCS FWD MANF ISOL VLV-2 CLOSE B
SM BU C&W A CMD 4/TONE A CMD 4/ALERT A CMD 4
RT PLB VENT 3 OP/CL CMD 2A
RT PLB/W VENTS 4&7 OP/CL CMD 1A
LEFT PLB VENT 6 OP/CL/PURGE 1/PURGE 2 CMD 2A
LEFT PLB VENT 5 OP/CL CMD 2A

- CARD 11 - , ADTA STATUS/DATA
(SIO)

- CARD 12 - FCS MON CHAN 4 RESET/OVERRIDE A
(DIH) RH +/- P/R/Y - TRIM B
RCS FWD OX MANF ISOL VLV 3 OP/CL
RH RHC TRIM INH B
FCS RH PITCH/ROLL-YAW AUTO/CSS MODE C
RH BODY FLAP AUTO/MAN C
RH SPEED BRAKE/THROT AUTO/MAN C
LEFT PLB VENT 6 PURGE 2 IND 2
ENTRY ROLL MODE AILERON D

- CARD 13 - RJDF 2 JET F3F/F3L/F3U/F3D CMD B
(DOL) ADTA 4 HIGH/LOW TEST MODE CMD

- CARD 14 - RH RHC R, P, Y CMD-C
(AID) RT RUDDER PEDAL CMD C
RH SBTC CMD-C
ACCEL ASSY 4 LAT/NORM ACCEL

- CARD 15 - RH SBTC TAKEOVER-C
(DIL) RH RHC +/- PITCH/ROLL TRIM-B
ET SEP MAN ENA B/INIT B/AUTO B

MDM FA1

● MDM BITE STATUS REGISTER

- CARD 0 - LH TVC TILT ACTR CNTRL A CMD
(AOD) RH TVC ROCK ACTR CNTRL A CMD
MPS ENG 2 Y (P) ACTR A CMD
MPS ENG 1 P ACTR A CMD
LEFT INBD (OUTBD) ELEVON (SPEED BRAKE CMD 1, RUDDER CMD 1) CMD 1

- CARD 1 - LEFT INBD (OUTBD) ELEVON POSN FDBK-1
(AID) RT INBD (OUTBD) ELEVON POSN FDBK-1
SPEED BRAKE POSN FDBK-1
RUDDER POSN FDBK-1
BODY FLAP POSN FDBK-1

- CARD 2 - RJDA 1 JET LIA (L1L,L1U,R1A,R1R,R1U,L5D,L5L) CMD A
(DOL) MPS ENG 1 P ACTR A BYPASS (RESET)
MPS ENG 2 P (Y) ACTR A BYPASS (RESET)
LH SRB TILT ACTR A BYPASS (RESET)
RH SRB ROCK ACTR A BYPASS (RESET)
LEFT INBD (OUTBD) ELEVON ACTR 1 BYPASS (RESET)
RT INBD (OUTBD) ELEVON ACTR 1 BYPASS (RESET)
SPEED BRAKE BYPASS (RESET) 1
RUDDER BYPASS (RESET) 1
BODY FLAP UP (DOWN) CMD 1

- CARD 3 - RT INBD (OUTBD) ELEVON ACTR 1 FAIL
(DIH) RUDDER ACTR 1 FAIL
MPS ENG 1 (2,3) P.ACTR A FAIL
LH SRB TILT ACTR A FAIL
RH SRB ROCK ACTR A FAIL
RJDA 1 TRICKLE CURRENT CONTINUITY 1,5L
ET - LH2 LOW LEVEL LIQ SENSOR NO. 4
MPS LH2 INBD FILL VLV (REPLENISH VLV) CLOSED
MPS E-1 LH2 PREVLV OPEN A
ET SEP A
LH SRB SEP IND B
OMS PBK (LEFT-POD) FU ISOL VALVE A POSN OP (CL)
OMS - LEFT POD VAPOR ISOL VLV 1 POSN OP
OMS - LEFT ENG PURGE VLV 1 POSN OP
OMS - LEFT ENG ARM PRESS (ARM) CMD 2 OP
OMS - RT POD OX XFEED (FU XFEED) VLV A POSN OP (CL)
ET UMB DR LCH 1 LKD (STWD) IND 1
RCS RT AFT FU (OX) MANF ISOL VLV-1 (HE OX/FU PRESS VLV-A)
OP (CL)
RCS RT AFT FU (OX) XFEED VLV-3/4/5 OP (CL)

- CARD 4 - LH TVC ROCK ACTR CNTRL A CMDS
(AOD) RH TVC TILT ACTR CNTRL A CMDS
MPS ENG 3 P (Y) ACTR A CMDS
MPS ENG 1 (Y) ACTR A CMDS
RT INBD (OUTBD) ELEVON CMD 1

CARD 4 - OMS - LEFT ENG ACTV P (Y) ACTR CMDS
RGA I R (P,Y) BITE TORQUE CMDS

CARD 5 - RJDA I JETS (LIA,LLI,LIU,RIA,RIR,RIU,LSO,LSL) CHMBR P IND
RGA I R (P,Y) SMRD IND

CARD 6 - RCS RT AFT FU THRUST IND TEMP-(RIA,RIR,RIU,LSL)
RCS RT AFT OX THRUST IND TEMP-(RIA,RIR,RIU,LSL)
RCS LEFT AFT HE FU TANK TEMP (PRESS)-1
RCS LEFT AFT OX TANK TEMP-1 (ULLAGE PRESS)
RCS LEFT AFT HE OX TANK PRESS-2 (FU TANK OUT PRESS)
RCS LEFT AFT HE OX TANK PRESS (HE TANK PRESS, TEMP-UPPER)
OMS LEFT POD FU TANK ULLAGE PRESS (HE TANK PRESS, REG OUT PRESS)
OMS LEFT ENG OX INLET PRESS (PNEU SUPPLY PRESS 2, REG OUT PRESS)
OMS RT POD OX TANK ULLAGE PRESS
OMS PBK HE TANK PRESS-2
OMS PBK OX (FU) AFT COMPARTMENT QTY
ET LH2 (LO2) ULLAGE PRESS NO. 1
HYD SYS I SUPPLY PRESS A
LH SRM CHMBR PRESS-A (VOLTAGE IGN PIC CAP A)

CARD 7 - ET UMB DR CL LCH I STOM (LOCK) CMD 1A
ET LAUNCH-UMB CL/OUT-DR CL (LCH) CMD 1A
LEFT AFT VENTS 8&9 CL (OP, PURGE) CMD 1A
MPS E-1 LO2 (LH2) PREVLY OP (CL) CMD 8
REPLACE LH2 ULLAGE PRESS NO 1 XDCR
MPS E-1 MAINSTAGE CMD A
MPS LH2 REPLENISH VLV OP CMD
MPS LH2 MANF REPRESS NO 1 OP CMD
OMS RT ENG CNTRL VLV 1 COIL 2 OP
OMS LEFT POD VAPOR ISOL VLV 1 OP
OMS LEFT POD FU (OX) ISOL VLV A CMD 2 OP (CL)
OMS LEFT RT POD FU (OX) XFEED VLV A CMD 2 OP (CL)
RCS LEFT AFT XFEED VLV-3/4/5 GPC CL (OP) A
RCS LEFT AFT XFEED VLV-3/4/5 GPC CL (OP) A
RCS LEFT AFT TANK A ISOL VLV 1/2 GPC CL (OP) B
RCS LEFT AFT HE (OX) TANK A ISOL VLV 1/2 GPC CL (OP) B
RCS LEFT AFT MANF ISOL VLV-1 (5) GPC OP A
RCS LEFT AFT MANF ISOL VLV-3 GPC CL A (B)
RCS LEFT AFT HE PRESS VLV-A GPC OP (CL) A

CARD 8 - RJDA I JET DRIVER (LIA,LLI,LIU,RIA,RIR,RIU,LSO,LSL)
ET LAUNCH UMB CL/OUT DR OP (CL,LTCHD,LTCH REL IND)-1
ET LAUNCH UMB CL/OUT DR RDY-TO-LTCH IND 1 (2,3)

CARD 9 - LEFT INBD (OUTBD) PRI DELTA PRESS 1
RT INBD (OUTBD) PRI DELTA PRESS 1
RGA I R (P,Y) RATE
LH RGA P (Y) RATE A
RH RGA P (Y) RATE A

MDM FAI (Continued)

- CARD 10 - RJDA 1 JET LIA (L1L,L1V,R1A,R1R,R1U,L5D,L5L) CMD B
(DOL)
MPS ENG 1 Y ACTR A BYPASS (RESET)
MPS ENG 3 Y (P) ACTR A BYPASS (RESET)
RH TILT SRB ACTR A BYPASS (RESET)
RH ROCK SRB ACTR A BYPASS (RESET)
BODY FLAP ENA CMD 1

- CARD 11 - LEFT INBD (OUTBD) ELEVON ACTR 1 FAIL
(DIH)
SPEED BRAKE ACTR 1 FAIL
MPS 1 (2,3) Y ACTR A FAIL
LH ROCK SRB ACTR A FAIL
RH TILT SRB ACTR A FAIL
MPS LOX LOW LVL LIQUID SNSR #4
MPS ENG 1 LOX PRE VLV OP
LEFT AFT VENTS 8&9 CL (OP, PURGE) 1
OMS PBK OX ISOL VLV A1 POSN OP (CL)
OMS LEFT POD HE ISOL VLV A POSN OP
OMS PBK OX TNK (L POD OX TNK, L POD FU TNK) LVL LOW
OMS LEFT POD OX (FU) XFEED VLV A POSN OP (CL)
OMS PBK OX (FU) DUMP VLV A1 POSN OP (CL)
RCS LEFT AFT OX (FU) ISOL VLV-1 OP (CL)
RCS LEFT AFT OX (FU) TANK ISOL VLV-1 (2) OP/CL
RCS LEFT AFT HE OX (FU) PRESS VLV-A OP (CL)
RCS LEFT AFT OX (FU) MANF ISOL VLV-5 OP (CL)

- CARD 12 - MPS LO2 RECIRC VLV 1 CL CMD A
(DOH)
MPS SIG COND PWR NO 1 ON CMD
MPS LH2 RTLS INBD (OUTBD) D/V OPEN CMD C
MPS LO2 INBD ALL VLV OP CMD A
MPS RTLS MANF REPRESS 1 OP CMD B
MPS E-3 LO2 PREV LV OP (CL) CMD C
MPS E-3 LH2 PREV LV OP (CL) CMD C
REPLACE LO2 ULLAGE PRESS NO 1 XDCR
MPS LH2 FDLN RLF S/O VLV CL CMD C
MPS E-3 MAINSTAGE CMD B
MPS E-3 EMERG SHT DN INH CMD A
OMS PBK OX ISOL VLV A1 OP (CL)
OMS PBK FU ISOL VLV A1 OP (CL)
OMS LEFT ENG PURGE VLV 1 OP
OMS PBK OX DUMP VLV A1 OP (CL)
OMS PBK FU DUMP VLV A1 OP (CL)
HYD SYS 1 LDG GR ISOL VLV OP

- CARD 14 - RCS LEFT AFT FU (OX) THRUST INJ TEMP-L1A (L1L,L1U,L5D)
(AIS)
RCS LEFT AFT HE OX TANK TEMP (PRESS)-1
RCS LEFT AFT FU TANK TEMP-1 (ULLAGE PRESS)
RCS LEFT AFT HE FU TANK PRESS-2
RCS LEFT AFT OX TNK OUT PRESS
OMS LEFT ENG ACTV P (Y) ACTR POSN IN
MPS ENG 1 LH2 INLET PRESS (TEMP)
MPS ENG 1 LO2 INLET PRESS (TEMP)
MPS ENG 1 HE SPLY (REG OUTLET) PRESS

MDM FA1 (Continued)

- CARD 14 - MPS LH2 ENG MANF PRESS
(AIS) HYD SYS 1 SPLY PRESS B
RCS LEFT AFT OX MANF PRESS-1
RH SRM CHMBR PRESS A
RH IGN PIC CAP A VOLTAGE

- CARD 15 - ET UMB DR CL LCH 1 STOW (LK) CMD 1B
(DOH) ET LAUNCH UMB CL/OUT DR LCH CMD 1B
LEFT AFT VENTS 8&9 CL (OP, PURGE) CMD 1B
MPS LO2 FDLN RLF S/O VLV CL CMD B
MPS E-2 LO2 PREVLV OP (CL) CMD A
MPS E-2 LH2 PREVLV OP (CL) CMD A
MPS LH2 INBD FILL VLV OP (CL) CMD B
LH2 RTLS MANF REPRESS 2 OP CMD B
MPS E-2 EMER SHT DN INH CMD B
OMS LEFT ENG CNTRL VLV 1 COIL 2 OP
OMS LEFT POD HE ISOL VLV A OP
OMS LEFT POD TK VLVS B CMD 1 OP (CL)
ET/ORB SEP CAMERAS - HTR ON CMD
OMS LEFT POD XFEED VLVS B CMD OP (CL)
OMS RT POD XFEED VLVS B CMD OP (CL)
RCS RT AFT OX XFEED V-3/4/5 GPC OP (CL) B
RCS RT AFT FU XFEED V-3/4/5 GPC OP (CL) B
RCS RT AFT TK ISOL V-1/2 GPC OP (CL) A
RCS RT AFT MANF ISOL VLV-1 GPC OP
RCS RT AFT MANF ISOL V-3 (-5) GPC CL A
RCS LEFT AFT MANF ISOL V-3 GPC CL B
RCS RT AFT HE PRESS VLV-A GPC CL (OP) A

MDM FA2

- MDM BITE STATUS REGISTER

- CARD 0 - LH TVC TILT ACTR CNTRL B CMD
(AOD) RH TVC ROCK ACTR CNTRL A CMD
MPS ENG 2 Y (P) ACTR B CMD
MPS ENG 1 P ACTR B CMD
LEFT INBD (OUTBD) ELEVON CMD 2
SPEED BRAKE CMD 2
RUDDER CMD 2

- CARD 1 - LEFT INBD (OUTBD) ELEVON POSN FDBK-2
(AID) RT INBD (OUTBD) ELEVON POSN FDBK-2
SPEED BRAKE POSN FDBK-2
RUDDER POSN FDBK-2
BODY FLAP POSN FDBK-2

- CARD 2 - RJDA 2 JET L3A (L3L, L3D, R3A, R3R, R3D, R5R, R5D) CMD A
(DOL) MPS ENG 1 P ACTR B BYPASS (RESET)
MPS ENG 2 P (Y) ACTR B BYPASS (RESET)

MDM FA2 (Continued)

- CARD 2 - RH SRB ROCK ACTR B BYPASS (RESET)
(DOL) LH SRB TILT ACTR B BYPASS (RESET)
LEFT INBD (OUTBD) ACTR 2 BYPASS (RESET)
RT INBD (OUTBD) ACTR 2 BYPASS (RESET)
SPEED BRAKE BYPASS (RESET) 2
RUDDER BYPASS (RESET) 2
BODY FLAP UP (DOWN) CMD 2

- CARD 3 - RT INBD (OUTBD) ELEVON ACTR 2 FAIL
(DIH) RUDDER ACTR 2 FAIL
MPS ENG 1 (2,3) P ACTR B FAIL
SRB LH TILT ACTR B FAIL
SRB RH ROCK ACTR B FAIL
RJDA 2 TRICKLE CURRENT CONTINUITY 3,5R
ET - LH2 LOW LEV LIQ SENSOR NO. 2
MPS - LH2 OUTBD FILL VLV CLSD
MPS E-2 LH2 PREVLV OP-A
MPS LH2 FEED DISC VLV CLSD-A
ET SEP B
RH SRB SEP IND B
OMS PBK (LEFT-POD) FU ISOL VLV B POSN OP (CL)
OMS LEFT POD VAPOR ISOL VLV 2 POSN OP
OMS LEFT ENG PURGE VLV 2 POSN OP
OMS RT ENG ARM PRESS (ARM) CMD 2 OP
OMS RT POD OX XFEED VLV B POSN OP (CL)
OMS RT POD FU XFEED VLV B POSN OP (CL)
OMS PBK HE ISOL VLV A POSN OP
OMS PBK VAPOR ISOL VLV 1 POSN OP
ET UMB DR LCH 1 LKD (STWD) IND 2
RCS RT AFT FU MANF ISOL VLV-3(5) OP (CL)
RCS RT AFT OX MANF ISOL VLV-3(5) OP (CL)
RCS RT AFT FU TNK ISOL VLV-1/2 OP (CL)
RCS RT AFT OX TNK ISOL VLV-1/2 OP (CL)
RCS RT AFT HE FU PRESS VLV-B OP (CL)
RCS RT AFT HE OX PRESS VLV-B OP (CL)

- CARD 4 - SRB TVC LH ROCK ACTR CNTRL B CMD
(AOD) SRB TVC RH TILT ACTR CNTRL B CMD
MPS ENG 3 Y (P) ACTR B CMD
MPS ENG 1 Y ACTR B CMD
RT INBD (OUTBD) ELEVON CMD 2
OMS - LEFT ENG STBY P (Y) ACTR CMD
RGA 2 R (P,Y) BITE TORQUE CMD

- CARD 5 - RJDA 2 JET CHMBR PRESS IND L3L (L3D,L3A,R3A,R3R,R3D,R5R,R5D)
(DIL) RGA 2 R (P,Y) SMRD IND

- CARD 6 - RCS RT AFT FU THRUST INJ TEMP-R3A (R3R,R3D,R5R)
(AIS) RCS RT AFT OX THRUST INJ TEMP-R3A (R3R,R3D,R5R)
RCS RT AFT OX (HE FU) TANK TEMP-1
RCS RT AFT HE FU TANK PRESS-1
RCS RT AFT OX TANK ULLAGE PRESS

MDM FA2 (Continued)

- CARD 6 - (AIS)
 - RCS RT AFT FU TANK OUT PRESS
 - OMS RT POD FU TANK ULLAGE PRESS
 - OMS RT ENG OX INLET PRESS
 - OMS RT POD HE TANK PRESS 1 (TEMP UPPER)
 - OMS LEFT POD OX TANK ULLAGE PRESS
 - OMS RT ENG PNEU SPLY PRESS 2
 - OMS PBK HE TNK PRESS 1
 - OMS RT ENG REG OUT PRESS
 - OMS RT POD OX AFT COMPRTMNT QTY
 - OMS RT POD FU AFT COMPRTMNT QTY
 - OMS PBK HE TANK TEMP
 - ET LH2 ULLAGE PRESS NO 2
 - ET LO2 ULLAGE PRESS NO 2
 - HYD SYS 2 SPLY PRESS A
 - LH SRM CHMBR PRESS B
 - LH VOLTAGE IGN PIC CAP B

- CARD 7 - (DOH)
 - ET UMB DR CL LCH1 STOW (LOCK) CMD 2A
 - ET RT UMB-CL/OUT DR CL (LCH) CMD 2B
 - RT AFT VENTS 8&9 CL (OP,PURGE) CMD 2A
 - MPS E-1 LO2 (LH2) PREVLV CL (OP) CMD C
 - REPLACE LH2 ULLAGE PRESS NO 2 XDCR
 - MPS LH2 FEED DISC VLV CL (OP) CMD C
 - MPS E-1 MAINSTAGE CMD B
 - MPS LH2 MANF REPRESS NO 2 OP CMD
 - OMS RT ENG CNTRL VLV 2 COIL 2 OP
 - OMS LEFT POD VAPOR ISOL VLV 2 OP
 - OMS LEFT POD TANK VLVS A CMD 1 OP (CL)
 - OMS LEFT POD XFEED VLVS A CMD 1 OP (CL)
 - OMS RT POD XFEED VLVS A CMD 1 OP (CL)
 - OMS PBK VAPOR ISOL VLV 1 OP
 - RCS LEFT AFT OX (FU) XFEED V-3/4/5 GPC CL (OP) B
 - RCS LEFT AFT TNK ISOL V-1/2 GPC CL (OP) A
 - RCS LEFT AFT MANF ISOL VLV-3 GPC OP (-5 GPC CL A)
 - RCS LEFT AFT MANF ISOL V-1 GPC CL A (B)
 - RCS LEFT AFT HE PRESS VLV-B GPC OP (CL) A

- CARD 8 - (DIH)
 - RJDA 2 JET DRIVER L3A (L3L,L3D,R3A,R3R,R3D,R5R,R5D)
 - ET RT UMB CL/OUT DR CLSD (OP,LTCHD) IND 2
 - ET RT UMB CL/OUT DR LTCH REL IND 2

- CARD 9 - (AID)
 - LEFT INBD (OUTBD) PRI DELTA PRESS 2
 - RT INBD (OUTBD) PRI DELTA PRESS 2
 - RGA 2 R (P,Y) RATE
 - LH RATE Y (P) GYRO B
 - RH RATE Y (P) GYRO B

- CARD 10 - (DOL)
 - RJDA 2 JET L3A (L3L,L3D,R3A,R3R,R3D,R5R,R5D) CMD B
 - MPS ENG 1 Y ACTR B BYPASS/RESET
 - MPS ENG 3 P (Y) ACTR B BYPASS/RESET
 - SRB ACTR B LH ROCK BYPASS (RESET)

MDM FA2 (Continued)

- CARD 10 - SRB ACTR B RH TILT BYPASS (RESET)
(DOL) BODY FLAP ENA CMD 2

- CARD 11 - LEFT INBD (OUTBD) ELEVON ACTR 2 FAIL
(DIH) SPEED BRAKE ACTR 2 FAIL
MPS ENG 1 (2,3) Y ACTR B FAIL
SRB LH ROCK ACTR B FAIL
SRB RH TILT ACTR B FAIL
MPS LOX LOW LVL LIQ SNSR 2
MPS ENG 2 LOX PREVLV OP
MPS LO2 FD DISC VLV CL A
MPS LOX INBD FILL VLV CL
MPS LO2 OVERBD B/V CL B
RT AFT VENTS 8&9 CL (OP,PURGE) 2
OMS PBK OX ISOL VLV B1 POSN OP (CL)
OMS LEFT POD OX ISOL VLV B POSN OP (CL)
OMS LEFT POD HE ISOL VLV B POSN OP
OMS PBK FU TNK LVL LOW
OMS LEFT POD OX (FU) XFEED VLV B POSN OP (CL)
OMS RT POD OX (FU) TNK LVL LOW
OMS PBK OX (FU) DUMP VLV B1 POSN OP (CL)
RCS LEFT AFT FU (OX) MANF ISOL VALVE-3 OP (CL)
RCS LEFT AFT OX (FU) XFEED VLV-3/4/5 OP (CL)

- CARD 12 - MPS LO2 ACC RECIRC VLV 2 CL CMD A
(DOH) MPS LO2 OVERBD B/V CL CMD C
MPS SIG COND PWR NO 2 ON CMD
MPS LH2 OUTBD FILL VLV OP (CL) CMD
MPS LO2 INBD FILL VLV OP (CL) CMD B
MPS E-3 LO2 (LH2) PREVLV CL (OP) CMD A
REPLACE LO2 ULLAGE PRESS #2 XDCR
LH2 RTLS MANF REPRESS 2 OP CMD C
MPS E-3 EMER SHT DN INH CMD B
OMS PBK OX (FU) ISOL VLV B1 OP (CL)
OMS PBK OX (FU) DUMP VLV B1 OP (CL)
OMS LEFT ENG PURGE VLV 2 OP
HYD SYS 2 LDG GR ISOL VLV OP

- CARD 14 - RCS LEFT AFT FU (OX) THRUST INJ TEMP-L3A (L3L,L3D)
(AIS) RCS RT AFT FU (OX) THRUST INJ TEMP-R5D
RCS RT AFT HE OX TNK TEMP-1 (PRESS-1)
RCS RT AFT FU TNK TEMP-1 (ULLAGE PRESS)
RCS RT AFT HE FU TNK PRESS-2
RCS RT AFT OX TNK OUT PRESS
OMS LEFT ENG STBY P (Y) ACTR POSN IN
MPS ENG 2 LH2 (LOX) INLET PRESS (TEMP)
MPS ENG 2 HE SPLY (REG OUTLET) PRESS
MPS LOX ENG MANF PRESS
HYD SYS 2 SPLY PRESS B
RCS LEFT AFT OX MANF PRESS-3
RH SRB CHMBR PRESS B
RH SRB IGN PIC CAP B VOLTAGE

MDM FA2 (Continued)

- CARD 15 - (DOH)
 - ET UMB DR CL LCH 1 STW CMD 2B
 - ET RT UMB CL/OUT DR LCH CMD 2A
 - RT AFT VENTS 8&9 CL (OP,PUR) CMD 2B
 - MPS LO2 FDLN RLF S/O VLV CL CMD A
 - MPS E-2 LO2 (LH2) PREVLV CLS (OP) CMD B
 - MPS LH2 INBD FILL VLV OP CMD A
 - MPS LO2 FEED DISC VLV CL (OP) CMD C
 - MPS E-2 MAINSTAGE CMD A
 - MPS E-2 EMERG SHT DN INH CMD A
 - OMS LEFT ENG CNTRL VLV 2 COIL 2 OP
 - OMS LEFT POD HE ISOL VLV B OP
 - OMS LEFT POD FU (OX) ISOL VLV B CMD 2 OP (CL)
 - OMS LEFT POD (R POD) FU (OX) XFEED VLV B CMD 2 OP (CL)
 - RCS RT AFT XFEED VLV-3/4/5 GPC CL (OP) A
 - RCS RT AFT FU (OX) TNK ISOL VLV-1/2 GPC OP (CL) B
 - RCS RT AFT MANF ISOL VLV-3 (-5) GPC OP A
 - RCS RT AFT MANF ISOL VLV-1 GPC CL A
 - RCS LEFT AFT MANF ISOL VLV-1 GPC CL B
 - RCS RT AFT HE PRESS VLV-8 GPC OP (CL) A

MDM FA3

- MDM BITE STATUS REGISTER
- CARD 0 - (AOD)
 - SRB TVC ACTR - LH TILT CONTROL C CMD
 - SRB TVC ACTR - RH ROCK CONTROL C CMD
 - MPS ENG 2 Y (P) ACTR C CMD
 - MPS ENG 1 P ACTR C CMD
 - LEFT INBD (OUTBD) ELEVON CMD 3
 - SPEED BRAKE CMD 3
 - RUDDER CMD 3
- CARD 1 - (AID)
 - LEFT INBD (OUTBD) ELEVON POSN FDBK-3
 - RT INBD (OUTBD) ELEVON POSN FDBK-3
 - SPEED BRAKE POSN FDBK-3
 - RUDDER POSN FDBK-3
 - BODY FLAP POSN FDBK-3
- CARD 2 - (DOL)
 - RJDA 1 JET L2L (L2U,L2D,R2R,R2U,R2D) CMD A
 - MPS ENG 1 P ACTR C BYPASS (RESET)
 - MPS ENG 2 P (Y) ACTR C BYPASS (RESET)
 - SRB ACTR C LH TILT BYPASS (RESET)
 - SRB ACTR C RH ROCK BYPASS (RESET)
 - LEFT INBD (OUTBD) ELEVON ACTR 3 BYPASS (RESET)
 - RT INBD (OUTBD) ELEVON ACTR 3 BYPASS (RESET)
 - SPEED BRAKE BYPASS (RESET) 3
 - RUDDER BYPASS (RESET)
 - BODY FLAP UP (DOWN) CMD 3

● CARD 3 - RT INBD (OUTBD) ELEVEN ACTR 3 FAIL
(DIH) RUDDER ACTR 3 FAIL OUTPUT
MPS 1 (2,3) P ACTR C FAIL
SRB LH TILT ACTR C FAIL
SRB RH ROCK ACTR C FAIL
RJDA TRICKLE CURRENT CONTINUITY 2
ET LHZ LOW LVL LIQ SENSOR NO 1
MPS LHZ RLS OUTBD D/V CL
MPS E-1 LHZ PREVLV OP B
LH SRB SEP IND A

OMS PBK FU ISOL VLV A2 POSN OP (CL)
OMS RT POD FU ISOL VLV B POSN OP (CL)
OMS RT ENG PURGE VLV 1 POSN OP
OMS LEFT ENG ARM/PRESS CMD 1 OP
OMS LEFT ENG ARM/CMD 1 OP
OMS PBK HE ISOL VLV B POSN OP
OMS PBK VAPOR ISOL VLV 2 POSN OP
ET UMB DR CL LCH 2 LOCKED (STOWED) IND 2
RCS RT AFT FU (OX) MANF ISOL VLV-2 OP (CL)
RCS RT AFT OX (FU) TNK ISOL VLV-3/4/5 OP (CL)
RCS LEFT AFT OX (FU) XFEED VLV-1/2 OP (CL)

● CARD 4 - SRB TVC LH ROCK ACTR CNTRL C CMD
(AOD) SRB TVC RH TILT ACTR CNTRL C CMD
MPS ENG 3 Y (P) ACTR C CMD
MPS ENG 1 Y ACTR C CMD
RT INBD (OUTBD) ELEVEN CMD 3
OMS RT ENG STBY P (Y) ACTR CMD
RGA 3 R (P,Y) BITE TORQUE CMD

● CARD 5 - RJDA 1 JET L2L (L2U,L2D,R2R,R2U,R2D) CHMBR PRESS IND
(DIL) RGA 3 R (P,Y) SMRD IND

● CARD 6 - RT AFT FU (OX) THRUST IND TEMP-R2R,R2U,R2D
(AIS) RCS LEFT AFT HE FU TANK TEMP-1 (PRESS-2)
RCS LEFT AFT FU TANK TEMP-1 (OUT PRESS)
RCS LEFT AFT HE OX TANK PRESS-2
OMS LEFT POD OX (FU) TANK TOTAL QTY
OMS LEFT ENG FU INLET PRESS (CHMBR PRESS)
OMS LEFT POD HE TANK PRESS 2
OMS LEFT ENG BI-PROP VLV 1 (2) POSN OP
OMS LEFT ENG PNEU SPLY PRESS 1
OMS PBK OX TANK TEMP (ULLAGE PRESS)
LH SRM CHMBR PRESS C
OMS LEFT POD OX (FU) AFT COMPRTMNT QTY
ET LHZ (LO2) ULLAGE PRESS 3
HYD SYS 3 SPLY PRESS A

● CARD 7 - ET UMB DR CL LCH 2 STOW (LOCK) CMD 2A
(DOH) ET RT UMB CL/OUT DR LCH CMD 1A
ET LEFT UMB CL/OUT DR CL CMD 2

CARD 7 - RT AFT VENTS 8&9 CL (OP, PURGE) CMD 1A
MPS E-1 L02 PREVLV OP (CL) CMD A
MPS E-1 LH2 PREVLV OP (CL) CMD A
REPLACE LH2 ULLAGE PRESS NO 3 XDCR
MPS LH2 FEED DISC VLV CL (OP) CMD A
MPS EI EMERG SHT DN INH CMD A
MPS RT ENG CNTRL VLV 1 COIL 1 OP
MPS RT POD VAPOR ISOL VLV 1 OP
MPS RT POD TNK VLVS A CMD 1 OP (CL)
MPS PBK VAPOR ISOL VLV 2 OP
RCS LEFT AFT OX XFEED VLV 1/2 GPC CL (OP) B
RCS LEFT AFT FU (OX) TK ISOL V 3/4/5 A GPC OP (CL)
RCS LEFT AFT MANF ISOL VLV-2 GPC OP
RCS LEFT AFT MANF ISOL VLV-4 GPC CL A
RCS RT AFT MANF ISOL VLV-4 GPC CL B

CARD 8 - RUDA 1 JET L2L (L2U, L2D, R2R, R2U, R2D) DRIVER
MPS L02 ACCUM RECIRC VLV 1 OP
MPS E-3 LH2 PREVLV OP B
ET LEFT UMB CL/OUT DR OP (CL) IND 2
ET RT UMB CL/OUT DR LTCHD (LCH REL) IND 1
ET RT UMB DR RDY-TO-LCH IND 1 (2,3)

CARD 9 - LEFT INBD (OUTBD) ELEVN PRI DELTA PRESS 3
RT INBD (OUTBD) ELEVN PRI DELTA PRESS 3
RGA 3 R (P, Y) RATE
LH RATE Y (P) GYRO C
RH RATE Y (P) GYRO C

CARD 10 - RUDA JET L2L (L2U, L2D, R2R, R2U, R2D) CMD B
MPS ENG 1 Y ACTR C BYPASS (RESET)
MPS ENG 3 Y (P) ACTR C BYPASS (RESET)
SRB RH TILT ACTR C BYPASS (RESET)
SRB LH ROCK ACTR C BYPASS (RESET)
BODY FLAP ENA CMD 3

CARD 11 - LEFT INBD (OUTBD) ELEVN ACTR 3 FAIL
SPEED BRAKE ACTR 3 FAIL
MPS ENG 1 (2,3) Y ACTR C FAIL
SRB RH TILT ACTR C FAIL
SRB LH ROCK ACTR C FAIL
MPS LOX LOW LVL LIQ SNSR NO 1
MPS LOX FEED DISC VLV OP (CL)
MPS LOX OUTBD FILL VLV CLS
MPS L02 OVERBD B/V CLSD A
AFT VENTS 8&9 CLSD (OP, PUR) 1
MPS PBK OX ISOL VLV AZ POSN OP (CL)
MPS RT POD OX ISOL VLV B POSN CL (OP)
MPS RT POD HE ISOL VLV A POSN OP
MPS LEFT ENG PRESS VLV POSN OP
MPS PBK OX DUMP VLV AZ POSN OP (CL)
MPS PBK FU DUMP VLV AZ POSN OP (CL)

MDM FA3 (Continued)

- CARD 11 - RCS LEFT AFT OX (FU) MANF ISOL VLV-2 OP (CL)
(DIH) RCS LEFT AFT OX (FU) TNK ISOL VLV-3/4/5 A OP (CL)
RCS LEFT AFT HE OX (FU) PRESS VLV-B OP (CL)

- CARD 12 - MPS LO2 ACC RECIRC VLV 1 CL CMD B
(DOH) MPS LO2 OVERBD B/V CL CMD A
MPS LH2 RTLS INBD (OUTBD) D/V OP CMD A
LH2 RTLS MANF REPRESS 1 OP CMD A
MPS LO2 FDLN RLF S/O VLV CL CMD C
LEFT SRB BUS C RPC C ON CMD
RT SRB BUS C RPC C ON CMD
OMS PBK OX (FU) ISOL VLV A2 OP (CL)
OMS RT ENG PURGE VLV 1 OP
OMS PBK OX (FU) DUMP VLV A2 OP (CL)
HYD SYS 3 LDG GR ISOL VLV OP

- CARD 14 - RCS LEFT AFT FU (OX) THRUST INJ TEMP-L2L (L2U,L2D)
(AIS) OMS RT ENG STBY P (Y) ACTR POSN IN
MPS ENG NO 3 LH2 (LOX) INLET PRESS (TEMP)
MPS ENG NO 3 HE SPLY (REG OUTLET) PRESS
HYD SYS 3 SPLY PRESS B
RCS LEFT AFT OX (FU) MANF PRESS 2
RCS RT AFT OX (FU) MANF PRESS 2
RH PRESS C SRM CHMBR

- CARD 15 - ET UMB DR CL LCH 2 STOW (LOCK) CMD 2B
(DOH) ET RT UMB CL/OUT DR LCH CMD 1B
RT AFT VENTS 8&9 CL (OP, PURGE) CMD 1B
MPS LH2 FDLN RLF S/O VLV CL CMD A
MPS E-2 LO2 PREVLV OP (CL) CMD C
MPS LO2 FEED DISC VLV CL (OP) CMD A
MPS E-2 MAINSTAGE CMD B
MPS LO2 MANF REPRESS NO 1 OP CMD
OMS LEFT ENG CNTRL VLV 2 COIL 1 OP
OMS RT POD HE ISOL VLV A OP
OMS RT POD FU ISOL VLV B CMD 2 OP (CL)
OMS RT POD OX ISOL VLV B CMD 2 OP (CL)
ET/ORB SEP CAMERAS ON CMD
OMS PBK HE ISOL VLV B OP
RCS RT AFT XFEED VLV-1/2 GPC CL (OP) A
RCS RT AFT FU TNK ISOL VLV 3/4/5 A GPC OP (CL)
RCS RT AFT OX TNK ISOL VLV 3/4/5 A GPC OP (CL)
RCS RT AFT MANF ISOL VLV-2 GPC OP
RCS RT AFT MANF ISOL VLV-4 GPC CL A
RCS LEFT AFT MANF ISOL VLV-4 GPC CL B
RCS LEFT AFT FU XFEED VLV-1/2 GPC CL (OP) B

MDM FA4

● MDM BITE STATUS REGISTER

- CARD 0 - TVC LH TILT ACTR CNTRL D CMD
(AOD) TVC RH ROCK ACTR CNTRL D CMD
MPS ENG 2 P (Y) ACTR D CMD
MPS ENG 1 P ACTR D CMD
LEFT INBD (OUTBD) ELEVON CMD 4
SPEED BRAKE CMD 4
RUDDER CMD 4

- CARD 1 - LEFT INBD (OUTBD) ELEVON POSN FDBK-4
(AID) RT INBD (OUTBD) ELEVON POSN FDBK-4
SPEED BRAKE POSN FDBK-4
RUDDER POSN FDBK-4
BODY FLAP POSN FDBK-4

- CARD 2 - RJDA 2 JET L4L (L4U,L4D,R4R,R4U,R4D) CMD A
(DOL) MPS ENG 1 P (Y) ACTR D BYPASS (RESET)
MPS ENG 2 P (Y) ACTR D BYPASS (RESET)
SRB RH ROCK ACTR D BYPASS (RESET)
SRB LH TILT ACTR D BYPASS (RESET)
LEFT INBD (OUTBD) ELEVON ACTR 4 BYPASS (RESET)
RT INBD (OUTBD) ELEVON ACTR 4 BYPASS (RESET)
SPEED BRAKE BYPASS (RESET) 4
RUDDER BYPASS (RESET) 4

- CARD 3 - RT INBD (OUTBD) ELEVON ACTR 4 FAIL
(DIH) RUDDER ACTR 4 FAIL OUTPUT
MPS ENG 1 (2,3) P ACTR D FAIL
SRB LH TILT ACTR D FAIL
SRB RH ROCK ACTR D FAIL
RJDA 2 TRICKLE CURRENT CONTINUITY 4
ET LH2 LOW LVL LIQ SENSOR NO 3
MPS LH2 RTLS INBD D/V CLSD
MPS E-2 LH2 PREVLV OP B
MPS LH2 FEED DISC VLV CL (OP) B
RH SRB SEP IND A
OMS PBK FU ISOL VLV B2 POSN OP (CL)
OMS RT POD FU ISOL VLV A POSN OP (CL)
OMS RT POD VAPOR ISOL VLV 2 POSN OP
OMS RT ENG PURGE VLV 2 POSN OP
OMS RT ENG ARM/PRESS (ARM) CMD 1 OP
ET UMB DR CL LCH 2 LOCKED (STOWED) IND 1
RCS RT AFT FU (OX) MANF ISOL VLV OP (CL)
RCS RT AFT FU (OX) TK ISOL VLV-3/4/5 B OP (CL)

- CARD 4 - TVC LH ROCK ACTR CONTROL D CMD
(AOD) TVC RH TILT ACTR CONTROL D CMD
MPS ENG 3 Y (P) ACTR D CMD
MPS ENG 1 Y ACTR D CMD
RT INBD (OUTBD) ELEVON CMD 4

MDM FA4 (Continued)

- CARD 4 - OMS RT ENG P (Y) ACTR CMD
(AOD) RGA 4 R (P,Y) BITE TORQUE CMD

- CARD 5 - RGA 4 YAW SMRD IND
(DIL)

- CARD 6 - RCS RT AFT FU (OX) THRUST INJ TEMP-R4R (R4U,R4D)
(AIS) RCS RT AFT HE FU TANK TEMP-1 (PRESS-2)
RCS RT AFT OX (FU) TANK OUT PRESS
RCS RT AFT HE OX TANK PRESS-2
RCS RT POD OX (FU) TANK TOTAL QTY
OMS RT ENG FU INLET PRESS
OMS RT POD HE TANK PRESS 2
OMS RT ENG CHMBR PRESS
OMS RT ENG BI-PROP VLV 1 (2) POSN OP
OMS RT ENG PNEU SPLY PRESS 1
OMS PBK FU TNK TEMP (ULLAGE PRESS)

- CARD 7 - ET UMB DR CL LCH 2 STOW (LOCK) CMD 1A
(DOH) ET LEFT UMB CL/OUT DR LCH CMD 2A
ET RT UMB CL/OUT DR CL CMD 1
LEFT AFT VENTS 8&9 OP (CL,PURGE) CMD 2A
MPS LH2 RECIRC DISC VLV OP (CL) CMD
MPS LH2 FEED DISG VLV CL (OP) CMD B
MPS E1 EMERG SHT DN INH CMD B
OMS RT ENG CONTROL VLV 2 COIL 1 OP
OMS RT POD VAPOR ISOL VLV 2 OP
OMS RT POD FU (OX) ISOL VLV A CMD 2 OP (CL)
RCS LEFT AFT XFEED VLV-1/2 GPC CL (OP) A
RCS LEFT AFT FU (OX) TNK ISOL V 3/4/5 B GPC OP (CL)
RCS LEFT AFT MANF ISOL VLV-4 GPC OP
RCS LEFT AFT MANF ISOL VLV-2 GPC CL A
RCS RT AFT MANF ISOL V-2 GPC CL B

- CARD 8 - RJDA 2 JET L4L (L4U,L4D,R4R,R4U,R4D) DRIVER
(DIH) MPS LO2 ACC RECIRC VLV 2 OP
MPS E-3 LH2 PREVLV OP A
ET RT UMB CL/OUT DR OP (CL) IND 1
ET LEFT UMB CL/OUT DR LCHD (LTCH REL) IND 2

- CARD 9 - LEFT INBD (OUTBD) ELEVON PRI DELTA PRESS 4
(AID) RT INBD (OUTBD) ELEVON PRI DELTA PRESS 4
RGA 4 R (P,Y) RATE

- CARD 10 - RJDA 2 JET L4L (L4U,L4D,R4R,R4U,R4D) CMD B
(DOL) MPS ENG 1 Y ACTR D BYPASS (RESET)
MPS ENG 3 Y (P) ACTR D BYPASS (RESET)
SRB RH TILT ACTR D BYPASS (RESET)
SRB LH ROCK ACTR D BYPASS (RESET)

- CARD 11 - LEFT INBD (OUTBD) ELEVON ACTR 4 FAIL
(DIH) SPEED BRAKE ACTR 4 FAIL

MDM FA4 (Continued)

- CARD 11 - MPS ENG 1 (2,3) Y ACTR D FAIL
(DIH) SRB LH ROCK ACTR D FAIL
SRB RH TILT ACTR D FAIL
MPS LOW LVL LIQ SNSR NO 3
MPS ENG NO 3 LOX PREVLV OP
LEFT AFT VENTS 8&9 OP (CL, PURGE) IND 2
OMS PBK OX ISOL VLV B2 POSN OP (CL)
OMS RT POD OX ISOL VLV A POSN OP (CL)
OMS RT POD HE ISOL VLV B POSN OP
OMS RT ENG PRESS VLV POSN OP
OMS PBX OX (FU) DUMP VLV B2 POSN OP (CL)
RCS LEFT AFT FU (OX) MANF ISOL VLV-4 OP (CL)
RCS LEFT AFT OX (FU) TNK ISOL VLV-3/4/5 B OP (CL)
RCS RT AFT OX (FU) XFEED VLV-1/2 OP (CL)

- CARD 12 - MPS LO2 ACC RECIR VLV 2 CL CMD B
(DOH) MPS LO2 OVERBD B/V CL CMD B
MPS SIG COND PWR #3 ON CMD
MPS LH2 RTLS INBD (OUTBD) D/V OP CMD B
MPS E-3 LO2 (LH2) PREVLV OP (CL) CMD B
REPLACE LO2 ULLAGE PRESS #3 XDCR
LH2 RTLS MANF REPRESS 1 OP CMD C
MPS E-3 MAINSTAGE CMD A
OMS PBK OX (FU) ISOL VLV B2 OP (CL)
OMS RT ENG PURGE VLV 2 OP
OMS PBK OX (FU) DUMP VLV B2 OP (CL)

- CARD 14 - RCS LEFT AFT FU (OX) THRUST INJ TEMP-L4L (L4U,L4D)
(AIS) OMS RT ENG ACTV P (Y) POSN IN
RCS LEFT AFT FU (OX) MANF PRESS 4
RCS RT AFT FU (OX) MANF PRESS 4

- CARD 15 - ET UMB DR CL LCH 2 STOW (LOCK) CMD 1B
(DOH) ET LEFT UMB CL/OUT DR LCH CMD 2B
LEFT AFT VENTS 8&9 CL (OP, PURGE) CMD 2B
MPS LH2 FDLN RLF S/O VLV CL CMD B
MPS LO2 OUTBD FILL VLV OP (CL) CMD
MPS E-2 LH2 PREVLV OP (CL) CMD C
MPS LO2 FEED DISC VLV CL (OP) CMD B
LH2 RTLS MANF REPRESS 2 OP CMD A
MPS LO2 MANF REPRESS NO 2 OP CMD
OMS LEFT ENG CNTRL VLV 1 COIL 1 OP
OMS RT POD HE ISOL VLV B OP
OMS RT POD TK VLVS B CMD 1 OP (CL)
RCS RT AFT OX XFEED V-1/2 GPC CL (OP) B
RCS RT AFT FU (OX) TNK ISOL V-3/4/5 B GPC CL (OP)
RCS RT AFT MANF ISOL VLV-4 GPC OP
RCS RT AFT MANF ISOL VLV-2 GPC CL A
RCS LEFT AFT MANF ISOL VLV-2 GPC CL B
RCS RT AFT FU XFEED VLV-1/2 GPC CL (OP) B

MDM PL1 (PF1)

- MDM BITE STATUS REGISTER
- CARD 0 - RCDR PL PRI BITS 1-16
(DOL) PL SYSTEM ACTIVATION 33-56
- CARD 1 - PL CAUTION/WARNING 13-25
(AID)
- CARD 2 - PLBD RT OP/CL CMD A
(DOH) PLBD RT FWD BHD LCH REL/LCH CMD 1
PLBD RT AFT BHD LCH REL/LCH CMD 2
PLBD OPERATION ENABLE CMD 1A/CMD 3A/CMD 4A
FLASH EVAP CNTLR PRI B ON (GPC)
NH3 BLR CNTLR PRI A/B ON - GPC CMD B
SM BU C&W B/TONE B/ALERT B - CMD 1
ABORT ADVISORY A
S-BAND FM ANT SEL 1 - LOWER/UPPER
S-BAND QUAD ANT SEL 1 - UPPER LEFT/UPPER RT/LOWER LEFT/
LOWER RT
PL SAFING CMD 19-30
- CARD 3 - PLBD RT FWD/AFT BHD RDY FOR LCH 1
(DIH) PLBD RT FWD BHD LCH REL 1/LCH 1
PLBD RT AFT BHD LCH REL 2/LCH 2
PLBD RT OP 1/CL 1
PLBD OP/CL CMD C
- CARD 4 - EMPTY
(AID)
- CARD 5 - PL CAUTION AND WARNING 36-50
(DIL) PL SYSTEM MONITOR 25-32
- CARD 6 - PLBD LEFT FWD/AFT BHD RDY FOR LCH-4
(DIH) PLBD LEFT FWD/AFT BHD LCH REL-1/LCH-1
PLBD LEFT OP 2/CL 2
PLBD OP/CL CMD B
PLBD LEFT 88 DEG OP 2
PLBD RT 88 DEG OP 1
KU BAND A RADAR - ON
- CARD 7 - PLBD OP/CL IND 1
(DOH) PLBD CENTERLINE LCH 1-4/5-8/9-12 LCH/REL CMD 1
PLBD CENTERLINE LCH 13-16 LCH/REL CMD 2
H2O LOOP 1 PUMP A/B CONT ON - GPC CMD
SILTS ON/OFF
FCP 1 PURGE VLVS GPC A/B OP
GCIL DECODER A SEL BIT A9
GCIL UPLINK PARALLEL CMD BIT A0-A8
- CARD 8 - KU-A CHAN 1 STATUS/DATA
(SIO)

MDM PL1 (PF1) (Continued)

- CARD 9 - PLBD LEFT FWD/AFT BHD RDY FOR LCH 2
(DIH) PLBD CENTERLINE LCH 1-4/5-8/9-12 LCH 1/REL 1
PLBD CENTERLINE LCH 13-16 LCH 2/REL 2
- CARD 10 - RCDR OPS 1 PRI BITS 1-16
(DOL) PL SYSTEM ACTIVATION 57-64
- CARD 11 - PL SYSTEM MONITOR 56-64
(AID)
- CARD 13 - PL SYSTEM MONITOR 33-48
(DIL)
- CARD 14 - PLBD LEFT OP/CL CMD 8
(DOH) PLBD LEFT FWD/AFT BHD LCH REL/LCH CMD 1
PLBD OPERATION ENA CMD 18/38/48
HYDR SYS 1/SYS 2/SYS 3 PUMP ON A
FCL 2 PUMP B ON
FCP 2 PURGE VLVS GPC-A/GPC-B OP
PL SAFING CMD 31-36
- CARD 15 - PL GN&C UPDATE - SERIAL I/O
(SIO) PL SENSOR SERIAL I/O

MDM PL2 (PF2)

- MDM BITE STATUS REGISTER
- CARD 0 - PL SYSTEM ACTIVATION 1-24
(DOL)
- CARD 1 - PL CAUTION/WARNING 1-12
(AID)
- CARD 2 - PLBD RT OP/CL CMD 8
(DOH) PLBD RT FWD BHD LCH REL/LCH CMD 2
PLBD RT AFT BHD LCH REL/LCH CMD 1
PLBD OPERATION ENA CMD 2A/5A/6A
FLASH EVAP CNTLR PRI A ON - GPC CMD
NH3 BLR CNTLR PRI A/B ON - GPC CMD
SYSTEM MGMT BU C/W B/TONE B/ALERT B CMD 2
ABORT ADVISORY B
S-BAND FM ANT SEL 2 - UPPER/LOWER
S-BAND QUAD ANT SEL 2 - UPPER LEFT/UPPER RT/LOWER LEFT/
LOWER RT
PL SAFING CMD 1-12
- CARD 3 - PLBD RT FWD/AFT BHD RDY FOR LCH 2
(DIH) PLBD RT FWD BHD LCH REL/LCH 2
PLBD RT AFT BHD LCH REL/LCH 1

MDM PL2 (PF2) (Continued)

- CARD 3 - PLBD RT OP 2/CL 2
(DIH) PLBD OP/CL CMD A
- CARD 4 - EMPTY
(AID)
- CARD 5 - PL CAUTION/WARNING 26-37
(DIL) PL SYSTEM MONITOR 1-8
- CARD 6 - PLBD LEFT FWD/AFT BHD RDY FOR LCH 3
(DIH) PLBD FWD/AFT BHD LCH - LCH/REL 2
PLBD LEFT OP 1/CL 1
PLBD OP/CL CMD D
PLBD LEFT 88 DEG OP 1
PLBD RT 88 DEG OP 2
FC GPC PURGE SEQUENCE START
- CARD 7 - PLBD OP IND 2/CL IND 2
(DOH) PLBD CENTERLINE LCH 1-4/5-8/9-12 LCH/REL CMD 2
PLBD CENTERLINE LCH 13-16 LCH/REL CMD 1
FLASH EVAP CNTLR SEC ON - GPC CMD
NH3 BLR CNTLR PRI A/B ON - GPC CMD C
H2O LOOP 2 PUMP CONT ON - GPC CMD
LH/RH BFS ENGAGE LITE
FCP 3 PURGE VLVS GPC-A/GPC-B OP
CCTV UPLINK PARALLEL CMD BITS A0-A13
GCIL DECODER B SEL BIT B9
GCIL UPLINK PARALLEL CMD BITS 80-88
- CARD 8 - KU BAND B CHAN 1 STATUS/DATA
(SIO)
- CARD 9 - PLBD RT FWD/AFT BHD RDY FOR LCH 3
(DIH) PLBD CENTERLINE LCH 1-4/5-8/9-12 LCH/REL 2
PLBD CENTERLINE LCH 13-16 LCH/REL 1
- CARD 10 - RCDR OPS 2 PRI BITS 1-16
(DOL) RCDR OPS 1/2 SEC BIT 13
RCDR OPS SEC BIT 14
GPC - PAYLOAD CAUTION
PL SYSTEM ACTIVATION 25-32
- CARD 11 - PL SYSTEM MONITOR 49-55
(AID)
- CARD 12 - APU 1/2/3 FU TNK QTY
(AOD) HYDR SYS 1/2/3 H2O BLR FLUID QTY CMPT
- CARD 13 - PL SYSTEM MONITOR 9-24
(DIL)

MDM PL2 (PF2) (Continued)

- CARD 14... PL80 LEFT OP/CL CMD A
(DOH) PL30 LEFT FWD/AFT BHD LCH REL/LCH CMD 2
PL80 OPERATION ENA CMD 2B/5B/6B
HYDR SYS 1/2/3 CIRC PUMP ON B
FCP O2/H2 PURGE HTRS GPC-A/GPC-B ON
PL SAFING CMD 13-18

- CARD 15 - PL GN&C UPDATE - SERIAL I/O
(SIO) PL SENSOR - SERIAL I/O

APPENDIX B
DPS BUILT-IN TEST EQUIPMENT SUMMARY

APPENDIX B
DPS BUILT-IN TEST EQUIPMENT SUMMARY

The following is a compilation of the Software and/or Hardware BITE status information for the DPS. Note that the CPU/IOP combination has no BITE status visible to the crew although software status is available to the ground via GPC Error Log and the I/O Error Log.

● MASS MEMORY BITE

● STATUS REGISTER A

BIT 9 - POWER INTERRUPT
BIT 10 - FILE ADDRESS NOT EQUAL TO LAST FILE SELECT COMMAND
BIT 11 - COMMANDED ADDRESS WITHIN OR BEHIND SUBFILE ADDRESS
BIT 12 - WRITE PROTECT VIOLATION
BIT 13 - INVALID OP CODE/MIA COMMAND ERRORS

● STATUS REGISTER B

BIT 9 - WRITE WORD COUNT ERROR
BIT 10 - READ TAPE DATA DROP OUT
BIT 11 - CLOCK ASSURANCE ON READ
BIT 12 - READ PARITY ERROR
BIT 13 - MIA INVALID MANCHESTER RECEIVED
BIT 14 - COMMAND RECEIVED WHEN NOT READY
BIT 15 - END-OF-FILE BLOCK COUNT NOT EQUAL TO ZERO
BIT 16 - END-OF-FILE NO SEARCH ADDRESS COMPARE
BIT 17 - MALFUNCTION (SPEED CONTROL; DIRECTION; HEAD SELECT;
TRACK PARITY)
BIT 18 - BEGINNING OF TAPE
BIT 19 - END OF TAPE
BIT 20 - ACTION ABORTED
BIT 21 - MIA BIT COUNT ERROR
BIT 22 - MIA PARITY ERROR
BIT 23 - INVALID SEV ON RECEIVED DATA
BIT 24 - RECEIVED DATA INTERRUPTED BY IOP OR MIA ERRORS

● MULTIPLEXER/DEMULTIPLEXER BITE

BIT 1 - POWER INTERRUPT
BIT 2 - INCOMING DATA ERROR
BIT 3 - OPERATION REQUESTED ON NON-EXISTENT CHANNEL
BIT 4 - UNABLE TO TRANSFER DATA TO/FROM IOM
BIT 5 - TOO MANY WORDS IN LAST MESSAGE
BIT 6 - LAST COMMAND NOT COMPLETED
BIT 7 - SIMULTANEOUS EXECUTION ON PRIMARY/BACKUP DATA BUS
BIT 8 - ILLEGAL MODE COMMAND
BIT 9 - INTERNAL ERROR DETECTED
BIT 10 - GAP TIME ERROR
BIT 11 - SUCCESSFUL BITE COMPLETION

● MULTIFUNCTION CATHODE RAY TUBE DISPLAY SYSTEM BITE

● STATUS REGISTER 1

- BIT 0 - ALWAYS SET 1
- BIT 1 - IPL HAS BEEN PERFORMED
- BIT 2 - IPL PARITY ERROR
- BIT 3 - IPL CIRCUIT TEST ERROR
- BIT 4 - INTENSITY ERROR
- BIT 5 - SINE-COSINE ERROR
- BIT 6 - SYMBOL GENERATOR ACTIVE
- BIT 7 - CHARACTER GENERATOR ERROR
- BIT 8 - OSCILLATOR ERROR
- BIT 9 - ANALOG DEFLECTION ERROR (ZERO TEST)
- BIT 10 - ANALOG DEFLECTION ERROR (NON-ZERO TEST)
- BIT 11 - ANALOG TEST FAIL (PULSE TEST)
- BIT 12 - CIRCLE OSCILLATOR ERROR
- BIT 13 - ANALOG FAILURE (OR OF BITS 9-12)
- BIT 14 - DIGITAL-TO-ANALOG CONVERTER FAILURE
- BIT 15 - REFRESH ERROR

● STATUS REGISTER 2

- BIT 0 - ALWAYS SET 1
- BIT 1-7 - SPARE
- BIT 8 - SMALL PROCESSOR SOFTWARE ERROR*
- BIT 9 - KEYBOARD CHANNEL A FAIL*
- BIT 10 - KEYBOARD CHANNEL B FAIL*
- BIT 11 - MIA ECHO CHECK ERROR
- BIT 12 - MIA PARITY ERROR
- BIT 13 - TRANSMIT ERROR
- BIT 14 - MIA BIT COUNT ERROR
- BIT 15 - MIA COMMAND ERROR

● STATUS REGISTER 3

- BIT 0 - ALWAYS SET 1
- BIT 1 - DU DEFLECTION STATUS
- BIT 2 - DU VIDEO STATUS
- BIT 3 - DU CRT PHOSPHOR PROTECT
- BIT 4 - SPARE
- BIT 5 - DU CRT FILAMENT CURRENT
- BIT 6 - DU TEMPERATURE STATUS
- BIT 7-14- SPARE
- BIT 15 - DU POWER SUPPLY STATUS

*CRITICAL BITE

● SOFTWARE STATUS REGISTER

BIT 0 - DISPLAY/FORMAT DATA FILL ERROR
BIT 1 - SPARE
BIT 2 - INITIALIZATION PERFORMED, IPL, OR POWER TRANSIENT*
BIT 3 - INVALID WORD COUNT IN GPC MESSAGE
BIT 4 - WRAP WORD ERROR
BIT 5 - COMMAND OVERLOAD
BIT 6 - SPARE
BIT 7 - DEU MEMORY PARITY ERROR*
BIT 8 - SPARE
BIT 9 - INVALID MESSAGE CODE
BIT 10 - RIPPLE TEST ERROR
BIT 11 - CHECKSUM ERROR
BIT 12 - INVALID DATA ADDRESS IN GPC MESSAGE
BIT 13 - RECEIVED MESSAGE ERROR
BIT 14 - CPU SELF-TEST ERROR
BIT 15 - TRANSMIT MESSAGE ERROR

*CRITICAL BITE

APPENDIX C
BCE CHAINS - HFE/MFE TRANSACTIONS

APPENDIX C
BCE CHAINS - HFE/MFE TRANSACTIONS

The following tables illustrate the BCE chains currently defined for each of the Flight Critical (FC) BCE's (as identified per Buses FC 1-8) during the High Frequency Executive (HFE) and Mid Frequency Executive (MFE) transactions and as partitioned per GNC OPS. Single element chains such as those for the MTU or NSP reads are not included here. Note that it is assumed that the FC MDM's are in the Prime mode in the following examples. Also note that in certain chains delays are included in the chains. In some cases this is to insure that FC port moding does not affect non FC MDM commands. In others, they are inserted when a particular hardware device (e.g. a star tracker) is accessible in certain similar BCE chains in a transaction for a phase but not in others. Additional delays may be added in-flight for an element in any of the BCE chains as a result of I/O errors resulting in a BCE element bypass.

TABLE C-1.- GNC 1/6 HFE INPUT TRANSACTION

| FC1 | FC2 | FC3 | FC4 | FC5 | FC6 | FC7 | FC8 |
|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| D E L A Y | D E L A Y | D E L A Y | D E L A Y | EIU1 | DELAY | DELAY | EIU1 |
| | | | | DELAY | EIU2 | DELAY | EIU2 |
| | | | | DELAY | DELAY | EIU3 | EIU3 |
| | | | | | | | |
| FF01 MDM RTN WD | FF02 MDM RTN WD | FF03 MDM RTN WD | FF04 MDM RTN WD | DELAY | DELAY | DELAY | DELAY |
| BYPASS DELAY | DELAY | DELAY | DELAY | FA01 MDM RTN WD | FA02 MDM RTN WD | FA03 MDM RTN WD | FA04 MDM RTN WD |
| ADTA1 | ADTA2 | ADTA3 | ADTA4 | FA PROM 3-10 | FA PROM 3-10 | FA PROM 3-10 | FA PROM 3-10 |
| FF PROM 2-6 | FF PROM 2-6 | FF PROM 2-6 | FF PROM 2-6 | | | | |

TABLE C-2.- GNC 1/6 MFE INPUT TRANSACTION

| FC1 | FC2 | FC3 | FC4 | FC5 | FC6 | FC7 | FC8 |
|---------------------|---------------------|---------------------|---------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| FF01 PROM 1-2 | FF02 PROM 1-2 | FF03 PROM 1-2 | FF04 PROM 1-2 | D E L A Y | D E L A Y | D E L A Y | D E L A Y |
| IMU1 | IMU2 | IMU3 | | | | | |
| TACAN/ RA1 | TACAN/ RA2 | TACAN/ RA3 | | | | | |
| MSBLS1 | MSBLS2 | MSBLS3 | | | | | |
| BYPASS DELAY | DELAY | BYPASS DELAY | | | | | |
| BYPASS DELAY | DELAY | BYPASS DELAY | | | | | |
| DELAY | DELAY | BYPASS DELAY | | | | | |
| | | | | FA01 PROM 1-2 | FA02 PROM 1-2 | FA03 PROM 1-2 | FA04 PROM 1-2 |
| | | | | EIU1 PRIM REG | EIU2 PRIM REG | EIU3 PRIM REG | |

TABLE C-3.- GNC 2 HFE INPUT TRANSACTION

| FC1 | FC2 | FC3 | FC4 | FC5 | FC6 | FC7 | FC8 |
|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| D E L A Y | D E L A Y | D E L A Y | D E L A Y | BYPASS DELAY | DELAY | DELAY | BYPASS DELAY |
| | | | | DELAY | BYPASS DELAY | DELAY | BYPASS DELAY |
| | | | | DELAY | DELAY | BYPASS DELAY | BYPASS DELAY |
| | | | | | | | |
| FF01 MDM RTN WD | FF02 MDM RTN WD | FF03 MDM RTN WD | FF04 MDM RTN WD | DELAY | DELAY | DELAY | DELAY |
| PL SENSOR | DELAY | DELAY | DELAY | FA01 MDM RTN WD | FA02 MDM RTN WD | FA03 MDM RTN WD | FA04 MDM RTN WD |
| BYPASS DELAY | BYPASS DELAY | BYPASS DELAY | BYPASS DELAY | FA PROM 3-10 | FA PROM 3-10 | FA PROM 3-10 | FA PROM 3-10 |
| FF PROM 2-6 | FF PROM 2-6 | FF PROM 2-6 | FF PROM 2-6 | | | | |

TABLE C-4.- GNC 2 MFE INPUT TRANSACTION

| FC1 | FC2 | FC3 | FC4 | FC5 | FC6 | FC7 | FC8 |
|---------------------|---------------------|---------------------|---------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| FF01 PROM 1-2 | FF02 PROM 1-2 | FF03 PROM 1-2 | FF04 PROM 1-2 | D E L A Y | D E L A Y | D E L A Y | D E L A Y |
| IMU1 | IMU2 | IMU3 | | | | | |
| BYPASS DELAY | BYPASS DELAY | BYPASS DELAY | | | | | |
| BYPASS DELAY | BYPASS DELAY | BYPASS DELAY | | | | | |
| STU1 | DELAY | STU2 | | | | | |
| OWDE1 | DELAY | OWDE2 | | | | | |
| DELAY | DELAY | RNDZ RADAR | | | | | |
| | | | | FA01 PROM 1-2 | FA02 PROM 1-2 | FA03 PROM 1-2 | FA04 PROM 1-2 |
| | | | | BYPASS DELAY | BYPASS DELAY | BYPASS DELAY | |

TABLE C-5.- GNC 3/8 HFE INPUT TRANSACTION

| FC1 | FC2 | FC3 | FC4 | FC5 | FC6 | FC7 | FC8 |
|-----------------------|------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| D E L A Y | D E L A Y | D E L A Y | D E L A Y | BYPASS DELAY | DELAY | DELAY | BYPASS DELAY |
| | | | | DELAY | BYPASS DELAY | DELAY | BYPASS DELAY |
| | | | | DELAY | DELAY | BYPASS DELAY | BYPASS DELAY |
| | | | | | | | |
| FF01 MDM RTN WD | FF02 MDM1 RTN WD | FF03 MDM RTN WD | FF04 MDM RTN WD | DELAY | DELAY | DELAY | DELAY |
| BYPASS DELAY | DELAY | DELAY | DELAY | FA01 MDM RTN WD | FA02 MDM RTN WD | FA03 MDM RTN WD | FA04 MDM RTN WD |
| ADTA1 | ADTA2 | ADTA3 | ADTA4 | FA PROM 3-10 | FA PROM 3-10 | FA PROM 3-10 | FA PROM 3-10 |
| FF PROM 2-6 | FF PROM 2-6 | FF PROM 2-6 | FF PROM 2-6 | | | | |

TABLE C-6.- GNC 3/8 MFE INPUT TRANSACTION

| FC1 | FC2 | FC3 | FC4 | FC5 | FC6 | FC7 | FC8 |
|---------------------|---------------------|---------------------|---------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| FF01 PROM 1-2 | FF02 PROM 1-2 | FF03 PROM 1-2 | FF04 PROM 1-2 | D E L A Y | D E L A Y | D E L A Y | D E L A Y |
| IMU1 | IMU2 | IMU3 | | | | | |
| TACAN/ RA1 | TACAN/ RA2 | TACAN/ RA3 | | | | | |
| MSBLS1 | MSBLS2 | MSBLS3 | | | | | |
| BYPASS DELAY | DELAY | BYPASS DELAY | | | | | |
| BYPASS DELAY | DELAY | BYPASS DELAY | | | | | |
| DELAY | DELAY | BYPASS DELAY | | | | | |
| | | | | FA01 PROM 2-2 | FA02 PROM 1-2 | FA03 PROM 1-2 | FA04 PROM 1-2 |
| | | | | BYPASS DELAY | BYPASS DELAY | BYPASS DELAY | |

TABLE C-7.- GNC 9 HOUSEKEEPING DATA ACQUISITION (HDA) INPUT

| FC1 | FC2 | FC3 | FC4 | FC5 | FC6 | FC7 | FC8 |
|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| | | | | | | | |
| | | | | | | | |
| FF01 MDM RTN WD | FF02 MDM RTN WD | FF03 MDM RTN WD | FF04 MDM RTN WD | DELAY | DELAY | DELAY | DELAY |
| PL SENSOR | DELAY | DELAY | DELAY | FA01 MDM RTN WD | FA02 MDM RTN WD | FA03 MDM RTN WD | FA04 MDM RTN WD |
| ADTA1 | ADTA2 | ADTA3 | ADTA4 | FA PROM 3-10 | FA PROM 3-10 | FA PROM 3-10 | FA PROM 3-10 |
| FF PROM 2-6 | FF PROM 2-6 | FF PROM 2-6 | FF PROM 2-6 | | | | |

TABLE C-8.- GNC 9 MFE TRANSACTION

| FC1 | FC2 | FC3 | FC4 | FC5 | FC6 | FC7 | FC8 |
|---------------------|---------------------|---------------------|---------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| FF01 PROM 1-2 | FF02 PROM 1-2 | FF03 PROM 1-2 | FF04 PROM 1-2 | D E L A Y | D E L A Y | D E L A Y | D E L A Y |
| BYPASS DELAY | BYPASS DELAY | BYPASS DELAY | | | | | |
| TACAN/ RA1 | TACAN/ RA2 | TACAN/ RA3 | | | | | |
| MSBLS1 | MSBLS2 | MSBLS3 | | | | | |
| STU1 | DELAY | STU2 | | | | | |
| OWDE1 | DELAY | OWDE3 | | | | | |
| DELAY | DELAY | RNDZ RADAR | | | | | |
| | | | | FA01 PROM 2-2 | FA02 PROM 1-2 | FA03 PROM 1-2 | FA04 PROM 1-2 |
| | | | | EIU1 PRIM REG | EIU2 PRIM REG | EIU3 PRIM REG | |

APPENDIX D
MDM INPUT PROM

APPENDIX D
MDM FF1 INPUT PROM

Prom
Segment

MDM FF1

1 RCS FWD HE FU TNK TEMP-1, PRESS 1
 RCS FWD OX TNK TEMP-1, ULLAGE PRESS
 RCS FWD HE OX TNK PRESS 2
 RCS FWD FU TNK OUT PRESS
 RCS FWD OX/FU MANF PRESS 1/2

2 MDM FF1 Card 4:

FCS MON CHAN 3 - RESET/OVERRIDE B, CHAN 4 -
 RESET/OVERRIDE C
FCS LH PITCH AUTO MODE A/CSS MODE A
FCS LH R-Y AUTO MODE A/CSS MODE A
GPC UPLINK 2-STAGE BLOCK CMD A
LH BODY FLAP UP/DOWN CMD A, AUTO/MANUAL CMD A
MPS ME 1 SHUTDOWN CMD A
RJDF 1 TRICKLE CURRENT CONTINUITY 1
RCS FWD FU MANF ISOL VLV 1 OPEN/CLOSE
RCS FWD FU TANK ISOL VLV 3/4/5 - OPEN/CLOSE
RCS HE FU PRESS VLV-A OPEN/CLOSE
LH AIR DATA SOURCE SELECT - LEFT/NAV/RIGHT
LH ADI ATTITUDE SEL - INERTIAL/LVLH/REFERENCE
LH ADI RATE SCALE - HIGH/MEDIUM/LOW
LH ADI ERROR SCALE - HIGH/MEDIUM/LOW
LH SPEED BRAKE/THROTTLE AUTO/MAN A
START TRKR -Z DOOR - OPEN/CLOSE-2
ENTRY ROLL MODE AILERON A
RT/LEFT PLB VENT 3 OPEN/CLOSE-1
RT FWD VENTS 1/2 OPEN/CLOSE/PURGE IND 1
LEFT PLB VENT 6 OPEN/CLOSE/PURGE IND 1
RT PLB VENT 5 OPEN/CLOSE 1

MDM FF1 Card 6:

RJDF 1 JET F1F/F1L/F1U/F1D CHAMBER PRESS IND
LH ODU POWER SUPPLY A/B/C STATUS
FWD THC +/- - X,Y,Z, OUTPUT-A
LH SBTC TAKEOVER-A
LH RHC +/- PITCH, ROLL TRIM-A
SRB SEP AUTO A CMD
SRB SEP MANUAL/AUTO ENABLE A CMD
SRB SEP INITIATE A CMD

MDM FF1 Card 9:

RJDF 1 JET F1F/F1L/F1U/F1D DRIVER
FWD DAP SELECT A-A/SELECT B-A/AUTO A/MAN A

Prom
Segment

2 AFT DAP SELECT A-C/SELECT B-C/AUTO C/MAN C

FCS FWD LOOP GAIN PITCH/ROLL-YAW HIGH-A/LOW-A
SENSE SW -Z CON A/-X CON A
ENTRY ROLL MODE AUTO-A
FWD ROTATION ROLL/PITCH/YAW DISC RATE A/ACCEL
A/PULSE A
FWD RCS JETS NORM A/VERNIER A
FWD TRANSLATION X/Y/Z NORM A/PULSE A/HIGH A
MPS LO2 FEEDLINE DUMP START A/STOP A
LH AIR DATA PROBE DEPLOY 1/STOW 1
ADTA 1 POWER ON CMD
IMU 1 POWER ON CMD-B
MSBLS #1 POWER STATUS
TACAN #1 AUTO DISCRETE

MDM FF1 Card 12:

FCS MON CHAN 1 RESET/OVERRIDE B
LH +/- PITCH/ROLL/YAW TRIM A
RCS FWD OX MANF ISOL VLV 1 OPEN/CLOSE
RCS FWD OX PRESS VLV-A OPEN/CLOSE
RCS FWD OX TANK ISOL VLV 3/4/5 OPEN/CLOSE
RADAR ALTM LH DISPLAY SEL NO 1/NO 2
LH HSI MLS/NAV/TACAN/APPROACH MODE/TAEM MODE/
ENTRY MODE SELECT
LH HSI SOURCE SELECT 1/2/3
LH RHC TRIM INHIBIT 4
-Z ST PWR ON CMD
RCS RATE GAIN PITCH MED A
RCS MASTER XFEED FROM LEFT 1/RIGHT 1
ATO/AQA/RTLS ABORT REQUEST SIGNAL A
LH ADI ATTITUDE REF PB-A/PB-B
LEFT PLB VENT 5 PURGE 2 IND 1
RCS RATE GAIN PITCH OFF A/ROLL-YAW MED A/ROLL-YAW
OFF A
STAR TRKR -Y DOOR OPEN 1/CLOSED 1
AFT RCS OPTIONS NORMAL-C/VERNIER-C

MDM FF1 Card is Channel 0:

IMU 1 STATUS
LH DDU STATUS
AFT THC +/- X,Y,Z OUTPUT A

3 RCS FWD OX/FU THRUST INS TEMP F1F, F1L, F1U, F1D

4 AFT/LH RHC R/P/Y-CMD A
LEFT RUDDER PEDAL-CMDA
LH SBTC-CMD A

From
Segment

5 DUMMY

6 ACCEL ASSY 1 LAT/NORM ACCEL

7 MDM FF1 Card 2 Ch 1,2:

MPS STATUS AMBER LIGHT - ON (E1)
LH EVENT SEQUENCE A/B/C/D/E
DOPPLER EXTRACTOR - UNIT 1
RCS CMD ROLL/PITCH/YAW - LAMP A - LEFT/RIGHT
FWD DAP AUTO/SELECT A/MANUAL/SELECT B LIGHTS
FWD RCS JETS NORM LIGHT/VERNIER LIGHT
OMS - LEFT ENG ACTR SELECT ACTIVE 1/2
RT/LEFT PLB VENT 3 OPEN/CLOSE - CMD 1B
LEFT PLB VENT 6 OPEN/CLOSE/PURGE 1/PURGE 2 - CMD 1B
RT PLB VENT 5 OPEN/CLOSE - CMD 1B

MDM FF1 Card 5 Ch 1:

FWD EVENT TIMER - ABORT RESET
LEFT RCS LEAK DET

MDM ff1 Card 10 Ch 1,2:

MPS STATUS/RED LIGHT
FWD ROTATION ROLL/PITCH/YAW DSCR/ACCEL/PULSE LIGHTS
FWD TRANSLATION X/Y/Z NORMAL/PULSE/HIGH LIGHTS
SM B/U C/W A CMD 1/TONE A CMD 1/ALERT A CMD 1
RT/LEFT PLB VENT 3 OPEN/CLOSE CMD 1A
LEFT PLB VENT 6 OPEN/CLOSE/PURGE 1/PURGE 2 CMD 1A
RT PLB VENT 5 OPEN/CLOSE CMD 1A

8 MDM FF1 Card 5 Ch 0:

RJDF 1 JET F1F/F1L/F1U/F1D CMD A
ACCEL ASSY 1 STATUS
DOPLR EXTR #1 STATUS

MDM FF1 Card 13 Ch 0:

RJDF 1 JET F1F/F1L/F1U/F1D CMD B
ADTA 1 HIGH/LOW TEST MODE COMMAND
IMU-1 OPERATE MODE CMD
SPI DATA STATUS

MDM FF1 Card 2 Ch 0:

RT FWD VENTS (1/2) - OPEN/CLOSE/PURGE - CMD 1B
RCS FWD MANF ISOL VLV #1 - OPEN
RCS FWD MANF ISOL VLV #4 - CLOSE A
RCS FWD OX TNK ISOL VLV 3/4/5 - OPEN A/CLOSE B

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8 RCS FWD TNK ISOL VLV 3/4/5 - CLOSE A
N/W STEERING - GROUND SPEED ENABLE CMD

MDM FF1 Card 10 Ch 0:

RT FWD VENTS 1/2 OPEN/CLOSE/PURGE CMD 1A
LH BODY FLAP AUTO
LH SPEED BRAKE AUTO
FCS MODE - LH PITCH/ROLL/YAW AUTO
RCS FWD FU TK ISOL VLV 3/4/5/ OP A/CL B
RCS FWD MANF ISOL VLV 5 CL A
RCS FWD HE PRESS VLV A OPEN A/CLOSE A
RCS FWD MANF ISOL VLV 4 CLOSE B

MDM FF2

1 RCS FWD HE FU TNK TEMP 1, PRESS 2
RCS FWD HE OX TNK PRESS 2

2 MDM FF2 Card 4:

FCS MON CHAN 2 - RESET/OVERRIDE A, CHAN 3 - RESET/
OVERRIDE C
ENTRY ROLL MODE AILERON B
LH BODY FLAP UP/DOWN B, AUTO/MANUAL B
MPS ME-1 SHUTDOWN CMD B
RJDF 1 TRICKLE CURRENT CONTINUITY 2
RCS FWD FU MANF ISOL VLV 2 OPEN/CLOSE
RCS HE FU PRESS VLV-B OPEN/CLOSE
NOSE WHEEL STEERING MANUAL - ON/COMPUTER-ON
RH AIR DATA SOURCE SELECT - LEFT/NAV/RIGHT
RH ADI ATTITUDE SEL - INERTIAL/LVLH/REFERENCE
RH ADI RATE SCALE - HIGH/MEDIUM/LOW
RH ADI ERROR SCALE - HIGH/MEDIUM/LOW
FCS LH PITCH AUTO MODE B/CSS MODE B
FCS LH R-Y AUTO MODE B/CSS MODE B
LH SPEED BRAKE/THROT AUTO/MAN B
MPS ENG LIMIT CONTROL #1 ENABLE/INHIBIT/AUTO
LEFT PLB VENT 3 OPEN/CLOSED-2
LEFT FWD VENTS (1/2) OPEN/CLOSED/PURGE IND 2
RT PLB VENT 6 OPEN 2/CLOSED 2/PURGE 1 IND 2
LEFT PLB/W VENTS 4&7 OPEN/CLOSED 2
RT PLB VENTS OPEN/CLOSED 2

MDM FF2 Card 6:

RJDF 1 JET F2F/F2R/F2U/F2D CHAMBER PRESS IND
RH DDU PWR SUPPLY A/B/C GOOD
FWD THC POS/NEG X/Y/Z OUTPUT B
LH SBTC TAKEOVER-B
LH RHC POS/NEG PITCH/ROLL TRIM B

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Segment

2 MDM FF2 Card 9:

RJDF 1 JET F2F/F2R/F2U/F2D DRIVER
FWD DAP SELECT A-B/B-B
FWD DAP MAN B/AUTO B
FCS FWD LOOP GAIN PITCH/ROLL-YAW HIGH-B/LOW-B
MPS ME-2 SHUTDOWN CMD A
SENSE SW -Z/-X CON B
ENTRY ROLL MODE AUTO-B
FWD ROTATION ROLL/PITCH/YAW DISC RATE B/ACCEL
B/PULSE B
FWD RCS JETS NORM B/VERNIER B
FWD TRANSLATION X/Y/Z NORM B/PULSE B/HIGH B
MPS LO2 FEEDLINE DUMP START B/STOP B
LH AIR DATA PROBE DEPLOY 2/STOW 2
ADTA 2 POWER ON CMD
IMU-2 POWER ON CMD-B
MSBLS 2 - POWER STATUS
TACAN 2 - AUTO DISCRETE

MDM FF2 Card 12:

FCS MON CHAN 1 RESET/OVERRIDE A
LH +/- PITCH/ROLL/YAW TRIM B
RCS FWD OX MANF ISOL VLV 2 OPEN/CLOSE
RCS FWD HE OX PRESS VLV B OPEN/CLOSE
NLG NO WEIGHT-ON-WHEELS #2
NLG UNLOCKED
RADAR ALTIM RH DISPLAY SELECT 1/2
RH HSI MLS/NAV/TACAN/SELECT
RH HSI APPROACH/TAEM/ENTRY MODE SELECT
RH HSI SOURCE SELECT 1/2/3
LH RHC TRIM INHIBIT B
RCS RH PITCH/ROLL-YAW AUTO/CSS MODE A
RH BODY FLAT AUTO/MANUAL A
RH SPEED BRAKE/THROTTLE AUTO/MANUAL A
RCS MASTER CROSSFEED FROM LEFT-2/RIGHT-2
ATO/AOA/RTLS ABORT REQUEST SIGNAL B
RH ADI ATTITUDE REF PLB A/B
RT PLB VENT 6 PURGE 2 IND 2

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Segment

2 LMG NO WEIGHT ON WHEELS/UNLOCKED
RMG DOOR UNLOCKED
FCS RATE GAIN PITCH/ROLL-YAW MED B/OFF B

MDM FF2 Card 15 Ch 0:

IMU 2 STATUS
RH DDU STATUS
AFT THC POS/NEG X/Y/Z OUTPUT B
RH SBTC TAKEOVER A

3 RCS FWD OX/FU THRUST INJ TEMP - F2F/F2R/F2U/F2D

4 AFT/LH RHC R/P/Y - CMD B
LEFT RUDDER PEDAL - CMD B
LH SBTC - CMD B

5 RH RHC R/P/Y - CMD A
RT RUDDER PEDAL - CMD A
RH SBTC CMD - A

6 ACCEL ASSY 2 LAT/NORM ACCEL

7 MDM FF2 Card 2 Ch 1,2:

MPS E2 STATUS/AMBER LITE ON
OMS - LEFT ENG ACTR SELECT STBY 1/2
LEFT PLB VENT 3 OPEN/CLOSE CMD 2B
LEFT PLB/W VENTS 4&7 OPEN/CLOSE CMD 2B
RT PLB VENT 6 OPEN/CLOSE/PURGE 1/PURGE 2 CMD 2B
RT PLB VENT 5 OPEN/CLOSE - CMD 2B

MDM FF2 Card 10 Ch 1,2:

MPS E2 STATUS/RED LIGHT ON
SM BU C&W A CMD 2/TONE A CMD 2/ALERT A CMD 2
LEFT PLB VENT 3 OPEN/CLOSE CMD 2A
LEFT PLB/W VENTS 4&7 OPEN/CLOSE CMD 2A
RT PLB VENT 6 OPEN/CLOSE/PURGE 1/PURGE 2 CMD 2A
RT PLB VENT 5 OPEN/CLOSE CMD 2A

8 MDM FF2 Card 5 Ch 0:

RJDF 1 JET F2F/F2R/F2U/F2D CMD A
ACCEL ASSY 2 BITE

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Segment

8

MDM FF2 Card 13 Ch 0:

RJDF 1 JET F2F/F2R/F2U/F2D CMD B
ADTA 2 HIGH/LOW TEST MODE CMD
IMU 2 OPERATE MODE CMD

MDM FF2 Card 2 Ch 0:

LEFT FWD VENTS (1/2) - OPEN/CLOSE/PURGE - CMD 2B
RCS FWD MANF ISOL VLV 2 - OPEN
RCS FWD MANF ISOL VLV 3 - CLOSE A

MDM FF2 Card 10 Ch 0:

LEFT FWD VENTS 1/2 OPEN/CLOSE/PURGE CMD 2A
LH BODY FLAP MANUAL
LH SPEED BRAKE MANUAL
FCS MODE - LH PITCH/ROLL-YAW CSS
RCS FWD MANF ISOL VLV-3 GPC CL B

MDM FF3

1

RCS FWD HE FU TNK TEMP-1, PRESS-2
RCS FWD HE OX TNK TEMP-1
RCS FWD OX TNK OUT PRESS
RCS FWD FU TNK ULLAGE PRESS
RCS FWD HE OX TNK PRESS-1
RCS-FWD OX/FU MANF PRESS-3/4/5

2

MDM FF3 Card 4:

FCS MON CHAN 2 RESET/OVERRIDE B
FCS CHAN 1 RESET/OVERRIDE C
GPC UPLINK 2 - STAGE BLOCK CMD B
RH BODY FLAT UP/DOWN A
MPS ME-3 SHUTDOWN CMD A
RJDF 2 TRICKLE CURRENT CONTINUITY 4,5
RCS FWD FU MANF ISOL VLV 4 OPEN/CLOSE
RCS FWD FU TANK ISOL VLV 1/2 OPEN/CLOSE
RCS FWD FU MANF ISOL VLV 5 OPEN/CLOSE
STAR TRKR -Z DOOR OPEN/CLOSED 1
AFT ADI ATTITUDE SELECT INERTIAL/LVLH/REFERENCE
AFT ADI RATE SCALE HIGH/MEDIUM/LOW
AFT ADI ERROR SCALE HIGH/MEDIUM/LOW
FCS LH PITCH/ROLL-YAW AUTO/CSS MODE C
LH SPEED BRAKE/THROT AUTO/MAN C
MPS ENG LIMIT CONTROL #2 ENABLE/INHIBIT/AUTO
RT PLB/W VENTS 4&7 OPEN/CLOSED 2
LEFT FWD VENTS 1&2 OPEN/CLOSED/PURGE IND 1

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Segment

2 RT PLB VENT 6 OPEN/CLOSED/PURGE IND 4
LEFT PLB/W VENTS 4&7 OPEN/CLOSED 1
LEFT PLB VENT 5 OPEN/CLOSED 1

MDM FF3 Card 6 Ch 0:

RJDF 2 JET F4R/F4D/F5L/F5R CHAMBER PRESS IND
AFT DDU PWR SPLY A/B/C GOOD
FWD THC +/- X/Y/Z OUTPUT-C
LH SBTC TAKEOVER-C

MDM FF3 Card 9:

RJDF 2 JET F4R/F4D/F5R/F5L DRIVER
AFT DAP SELECT A-A/B-A
FWD DAP SELECT A-C/B-C
AFT DAP AUTO A/MAN A
FWD DAP AUTO C/MAN C
FCS FWD LOOP GAIN PITCH/ROLL-YAW HIGH-C/LOW-C
MPS ME-2 SHUTDOWN CMD B
SENSE SW -Z/-X CON C
ENTRY ROLL MODE AUTO-C
AFT ROTATION ROLL/PITCH/YAW DISC RATE/ACCEL
RATE/PULSE A
AFT RCS JETS NORM A/VERNIER A
AFT TRANSLATION X/Y/Z PULSE A/HIGH A/NORM A
MPS LH2 FEEDLINE DUMP START A/STOP A
RH AIR DATA PROBE DEPLOY 1/STOW 1
ADTA 3 POWER ON CMD
IMU 3 POWER ON CMD B
MSBLS 3 POWER STATUS
TACAN 3 AUTO DISCRETE

MDM FF3 Card 12:

FCS MON CHAN 4 RESET/OVERRIDE B
RH +/- PITCH/ROLL/YAW TRIM A
RCS FWD OX MANF ISOL VLV 4 OPEN/CLOSE
RCS FWD OX TANK ISOL VLV 1/2 OPEN/CLOSE
RCS FWD OX MANF ISOL VLV 5 OPEN/CLOSE
NLG NO WEIGHT ON WHEELS #1
NLG DOOR UNLOCKED
ENTRY ROLLMODE AILERON C
FCS RATE GAIN PITCH/ROLL-YAW MED/OFF C
-Y STAR TRKR POWER ON CMD
RH RHC TRIM INHIBIT A
FCS RH PITCH/ROLL-YAW AUTO/CSS MODE B
RH BODY FLAT AUTO/MANUAL B

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Segment

2 RH SPEED BRAKE/THROT AUTO/MAN B
RCS MASTER CROSSFEED FROM LEFT-3/RIGHT-3
AOA/ATO/RTLS ABORT REQUEST SIGNAL C
APT ADI ATTITUDE REF PLB-A/PLB-B
RT PLB VENT 6 PURGE 2 IND 1
RMG NO WEIGHT ON WHEELS
RMG UNLOCKED
LMG DOOR UNLOCKED
STAR TRKR -Y DOOR OPEN 2/CLOSED 2
FWD RCS OPTIONS NORM C/VERNIER C

MDM FF3 Card 15:

IMU 3 STATUS, DATA
AFT DDU GOOD
AFT THC +/- X/Y/Z OUTPUT C
RH SBTC TAKEOVER-B
RH RHC +/- PITCH/ROLL TRIM A

3 RCS FWD OX/FU THRUST INJ TEMP F4R/F4D/F5L/F5R

4 AFT/LH RHC R/P/Y - CMD C
LEFT RUDDER PEDAL - CMD C
LH SBTC-CMD C

5 RH RHC R/P/Y - CMD B
RT RUDDER PEDAL - CMD B
RH SBTC - CMD B

6 ACCEL ASSY 3 LAT/NORM ACCEL

7 MDM FF3 Card 2 Ch 1,2:

MPS E3 STATUS/AMBER LITE ON
RH EVENT SEQUENCE A/B/C/D/E COMPUTER CONT
DOPPLER EXTRACTOR - UNIT 2
RCS CMD ROLL/PITCH/YAW LEFT/RIGHT LAMP B
RCS CMD PITCH UP/DOWN B
AFT DAP AUTO (LIGHT)/SELECT A (LIGHT)
OMS R ENG ACTR SELECT STBY 1/STBY 2
AFT DAP MANUAL (LIGHT)/SELECT B (LIGHT)
AFT RCS JETS VERNIER (LIGHT)/NORMAL (LIGHT)
RT PLB/W VENTS 4&7 OPEN/CLOSE CMD 2B
LEFT PLB/W VENTS 4&7 OPEN/CLOSE CMD 1B
RT PLB VENT 6 OPEN/CLOSE/PURGE 1/PURGE 2 CMD 1B
LEFT PLB VENT 5 OPEN/CLOSE CMD 1B

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Segment

MDM FF3 Card 5 Ch 1:

RCS FAIL/OMS-TVC FAIL
OMS LEFT-ENG/RT-ENG ABNORMAL
FC CHANNEL FAIL
FCS SATURATE
IMU/RH RHC/LH RHC/NAV SENSOR/GYRO ACCEL FAIL
RIGHT RCS/FWD RCS LEAK DET

MDM FF3 Card 10 Ch 1,2:

MPS E3 STATUS/RED LITE ON
AFT ROTATION ROLL/PITCH/YAW DSCR/ACCEL/PULSE (LIGHTS)
AFT TRANSLATION X/Y/Z NORM/PULSE/HIGH (LIGHTS)
SM BU C&W A CMD 3/TONE A CMD 3/ALERT A CMD 3
RT PLB/W VENTS 4&7 OPEN/CLOSE CMD 2A
LEFT PLB/W VENTS 4&7 OPEN/CLOSE CMD 1A
RT PLB VENT 6 OPEN/CLOSE/PURGE 1/PURGE 2 CMD 1A
LEFT PLB VENT 5 OPEN/CLOSE CMD 1A

8 MDM FF3 Card 5 Ch 0:

RJDF 2 JET F4R/F4D/F5L/F5R CMD A
ACCEL ASSY 3 BITE
DPLR XTRTR 2 START D TIME/TEST MODE DISCRETES

MDM FF4

1 RCS FWD FU TNK OUT PRESS
RCS FWD FU TNK TEMP-1

2 MDM FF4 Card 4 Ch 0,2:

FCS MON CHAN 3 RESET/OVERRIDE A
FCS CHAN 2 RESET/OVERRIDE C
RH BODY FLAP UP/DOWN B
MPS ME-3 SHUTDOWN CMD B
RJDF 2 TRICKLE CURRENT CONTINUITY 3
RCS FWD FU MANF ISOL VLV 3 OPEN/CLOSE
MPS ENG LIMIT CONTROIL #3 ENABLE/INHIBIT/AUTO
RT PLB VENT 3 OPEN/CLOSED-2
RT FWD VENTS 1&2 OPEN/CLOSED/PURGE IND-2
LEFT PLB VENT 6 OPEN 2/CLOSED 2/PURGE IND 2
RT PLB/W VENTS 4&7 OPEN/CLOSED-1
LEFT PLB VENT 5 OPEN/CLOSED-2

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Segment

2 MDM FF4 Card 8 Ch 0:

RJDF 2 JET F3F/F3L/F3U/F3D CHAMBER PRESS IND

MDM FF4 Card 9:

RJDF 2 JET F3F/F3L/F3U/F3D DRIVER
AFT DAP SELECT A-B/B-B
AFT DAP AUTO/MANUAL B
ENTRY ROLL MODE AUTO D
AFT ROTATION ROLL/PITCH/YAW DISC RATE B/ACCEL
B/PULSE B
AFT RCS JETS NORM B/VERNIER B
AFT TRANSLATION X/Y/Z NORM B/PULSE B/HIGH B

MDM FF4 Card 12:

FCS MON CHAN 4 RESET/OVERRIDE A
RH +/- PITCH/ROLL/YAW - TRIM B
RCS FWD OX MANF ISOL VLV 3 OPEN/CLOSED
RH RHC TRIM INHIBIT B
FCS RH PITCH/ROLL-YAW AUTO/CSS MODE C
RH BODY FLAP AUTO/MANUAL C
RH SPEED BRAKE/THROT AUTO/MAN C
LEFT PLB VENT 6 PURGE 2 IND 2
ENTRY ROLL MODE AILERON D

MDM FF4 Card 15:

RH SBTC TAKEOVER-C
RH RHC +/- PITCH/ROLL TRIM-B
ET SEP MANUAL ENABLE B/INITIATE B/AUTO B

3 RCS FWD OX/FU THRUST INJ TEMP - F3F/F3L/F3U/F3D

4 DUMMY

5 RH RHC R/P/Y - CMD C
RT RUDDER PEDAL-CMD C
RH SBTC - CMD C

6 ACCEL ASSY 4 LAT/NORM ACCEL

7 MDM FF4 Card 2 Ch 2:

OMS - R ENG ACTR SELECT ACTIVE-1/ACTIVE-2
RT PLB VENT 3 OPEN/CLOSE CMD 2B

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Segment

7 RT PLB/W VENTS 4&7 OPEN/CLOSE CMD 1B
LEFT PLB VENT 6 OPEN/CLOSE/PURGE 1/PURGE 2 CMD 2B
LEFT PLB VENT 5 OPEN/CLOSE CMD 2B

MDM FF4 Card 5 Ch 1:

FWD - EVENT TIMER - LIFT-OFF START

MDM FF4 Card 10 Ch 2:

SM BU C&W A CMD 4/TONE A CMD 4/ALERT A CMD 4
RT PLB VENT 3 OPEN/CLOSE CMD 2A
RT PLB/W VENTS 4&7 OPEN/CLOSE CMD 1A
LEFT PLB VENT 6 OPEN/CLOSE/PURGE 1/PURGE 2 CMD 2A
LEFT PLB VENT 5 OPEN/CLOSE CMD 2A

8 MDM FF4 Card 5 Ch 0:

RJDF 2 JET F3F/F3L/F3U/F3D CMD A
ACCEL ASSY 4 LAT/NORM BITE

MDM FA1

1 ET LH2/LO2 ULLAGE PRESS NO 1
MPS ENG NO 1 HE SUPPLY/RGLTR OUTLET PRESS
MPS LH2 ENG MANF PRESS

2 RCS L AFT HE FU/OX TANK PRESS 1/PRESS 2/TEMP 1
RCS L AFT FU/OX TNK OUT PRESS/TEMP 1/ULLAGE PRESS
RCS L/R AFT OX/FU MANF PRESS -1/2
OMS L POD FUEL TNK ULLAGE PRESS
OMS L POD HE TNK PRESS 1/TEMP-UPPER
OMS R POD OXDZR TNK ULLAGE PRESS
OMS L ENG OX INLET PRESS
OMS-L ENG PNEU SUPPLY PRESS 2
OMS-L ENG RGLTR OUT PRESS
OMS-PBK HE TNK PRESS 2
OMS-PBK OX/FU AFT COMPARTMENT QTY

3 OMS L ENG ACTV P/Y ACTR POSN IN

4 RCS R AFT FU/OX THRUST INJ TEMP-R1A,R1R,R1U
RCS L AFT FU/OX THRUST INJ TEMP-L5L,L1A,L1L,L1U,L5D

5 MDM FA1 Card 3 Discretes:
RT INBD (OUTBD) ELEVON ACTR 1 FAIL
RUDDER ACTR 1 FAIL
MPS ENG 1 (2,3) P ACTR A FAIL

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5

LH SRB TILT ACTR A FAIL
RH SRB ROCK ACTR A FAIL
RJDA 1 TRICKLE CURRENT CONTINUITY 1,5L
ET - LH2 LOW LEVEL LIQ SENSOR NO. 4
MPS LH2 INBD FILL VLV (REPLENISH VLV) CLOSED
MPS E-1 LH2 PREVLV OPEN A
ET SEPARATION A
LH SRB SEPARATION INDICATION B
OMS PBK (LEFT-POD) FU ISOL VALVE A POSN OP (CL)
OMS - LEFT POD VAPOR ISOL VLV 1 POSN OP
OMS - LEFT ENG PURGE VLV 1 POSN OP
OMS - LEFT ENG ARM PRESS (ARM) CMD 2 OP
OMS - RT POD OX XFD (FU XFD) VLV A POSN OP (CL)
ET UMB DR LCH 1 LKD (STWD) IND 1
RCS RT AFT FU (OX) MANF ISOL VLV-1 (HE OX/FU
PRESS VLV-A) OP (CL)
RCS RT AFT FU (OX) XFD VLV-3/4/5 OP (CL)

MDM'FAI Card 5:

RJDA 1 JETS (L1A,L1L,L1U,R1A,R1R,R1U,L5D,L5L)
CHMBR P IND
RGA 1 R (P,Y) SMRD IND

MDM FAI Card 8:

RJDA 1 JET DRIVER (L1A,L1L,L1U,R1A,R1R,R1U,L5D,L5L)
ET LAUNCH UMB CL/OUT DR OP (CL,LTCHD,LTCH REL IND)-1
ET LAUNCH UMB CL/OUT DR RDY-TO-LTCH IND 1 (2,3)

MDM FAI Card 11:

LEFT INBD (OUTBD) ELEVON ACTR 1 FAIL
SPEED BRAKE ACTR 1 FAIL
MPS 1 (2,3) Y ACTR A FAIL
LH ROCK SRB ACTR A FAIL
RH TILT SRB ACTR A FAIL
MPS - LOX LOW LVL LIQUID SNSR #4
MPS - ENG 1 LOX PRE VLV OP
LEFT AFT VENTS 8&9 CL (OP, PURGE) 1
OMS - PBK OX ISOL VLV A1 POSN OP (CL)
OMS - LEFT POD HE ISOL VLV A POSN OP
OMS - PBK OX TNK (L POD OX TNK, L POD FU TNK)
LVL LOW
OMS - LEFT POD OX (FU) XFD VLV A POSN OP (CL)
OMS - PBK OX (FU) DUMP VLV A1 POSN OP (CL)
RCS - LEFT AFT OX (FU) ISOL VLV-1 OP (CL)
RCS - LEFT AFT OX (FU) TANK ISOL VLV-1 (2) OP/CL

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Segment

5 RCS - LEFT AFT HE OX (FU) PRESS VLV-A OP (CL)
RCS - LEFT AFT OX (FU) MANF ISOL VLV-5 OP (CL)

6 HYDR SYS 1 SUPPLY PRESS A/B

7 MPS ENG NO 1 LH2/LOX INLET PRESS/TEMP
LH/RH PRESS A SRM CHAMBER
LH/RH VOLTAGE IGN PIC CAP A

8 L/R INBD/OUTBD ELEVON POSN FDBK-1
SPEED BRAKE/RUDDER/BODY FLAP POSN FDBK-1

9 L/R INBD/OUTBD PRI DELTA PRESS 1

10 RGA 1 R/P/Y RATE
LH/RH RATE PITCH/YAW GYRO A

11 MDM FA1 Card 2 Ch 0,1:

RJDA 1 JET L1A (L1L, L1U, R1A, R1R, R1U, L5D, L5L) CMD A
MPS ENG 1 P ACTR A BYPASS (RESET)
MPS ENG 2 P (Y) ACTR A BYPASS (RESET)
LH SRB TILT ACTR A BYPASS (RESET)
RH SRB ROCK ACTR A BYPASS (RESET)
LEFT INBD (OUTBD) ELEVON ACTR 1 BYPASS (RESET)
RT INBD (OUTBD) ELEVON ACTR 1 BYPASS RESET
SPEED BRAKE BYPASS (RESET) 1
RUDDER BYPASS (RESET) 1
BODY FLAP UP (DOWN) CMD 1

MDM FA1 Card 7:

ET UMB DR CL LCH 1 STOW (LOCK) CMD 1A
ET LAUNCH-UMB CL/OUT DR CLOSE (LATCH) CMD 1A
LEFT AFT VENTS 8&9 CL (OP, PURGE) CMD 1A
MPS E-1 LO2 (LH2) PREV LV OP (CL) CMD B
REPLACE LH2 ULLAGE PRESS NO 1 XDCR
MPS E-1 MAINSTAGE CMD A
MPS LH2 REPLENISH VLV OPEN CMD
MPS LH2 MANF REPRESS NO 1 OP CMD
OMS - RT ENG CONTROL VLV 1 COIL 2 OP
OMS - LEFT POD VAPOR ISOL VLV 1 OP
OMS - LEFT POD FU (OX) ISOL VLV A CMD 2 OP (CL)
OMS - LEFT/RT POD FU (OX) XFD VLV A CMD 2 OP (CL)
RCS - LEFT AFT XFD VLV-3/4/5 GPC CL (OP) A
RCS - LEFT AFT FU (OX) TANK A ISOL VLV 1/2 GPC
CL (OP) B

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Segment

11

RCS - LEFT AFT MANF ISOL VLV-1 (5) GPC OP A
RCS - LEFT AFT MANF ISOL VLV-3 GPC CL A (B)
RCS - LEFT AFT HE PRESS VLV-A.GPC OP (CL) A

MDM FA1 Card 10:

RJDA 1 JET L1A (L1L,L1V,R1A,R1R,R1U,L5D,L5L) CMD B
MPS ENG 1 Y ACTR A BYPASS (RESET)
MPS ENG 3 Y (P) ACTR A BYPASS (RESET)
RH TILT SRB ACTR A BYPASS (RESET)
RH ROCK SRB ACTR A BYPASS (RESET)
BODY FLAP ENA CMD 1

MDM FA1 Card 12:

MPS LO2 RECIRC VLV 1 CL CMD A
MPS SIG COND PWR NO 1 ON CMD
MPS LH2 RTLS INBD (OUTBD) D/V OPEN CMD C
MPS LO2 INBD ALL VLV OP CMD A
MPS RTLS MANF REPRESS 1 OP CMD B
MPS E-3 LO2 PREVLV OP (CL) CMD C
MPS E-3 LH2 PREVLV OP (CL) CMD C
REPLACE LO2 ULLAGE PRESS NO 1 XDCR
MPS LH2 FDLN RLF S/O VLV CL CMD C
MPS E-3 MAINSTAGE CMD B
MPS E-3 EMERG SHT DN INH CMD A
OMS - PBK OX ISOL VLV A1 OP (CL)
OMS - PBK FU ISOL VLV A1 OP (CL)
OMS - LEFT ENG PURGE VLV 1 OP
OMS - PBK OX DUMP VLV A1 OP (CL)
OMS - PBK FU DUMP VLV A1 OP (CL)
HYD SYS 1 LDG GR ISOL VLV OP

MDM FA1 Card 15:

ET UMB DR CL LCH 1 STOW (LK) CMD 1B
ET LAUNCH UMB CL/OUT DOOR LCH CMD 1B
LEFT AFT VENTS 8&9 CL (OP, PURGE) CMD 1B
MPS LO2 FDLN RLF S/O VLV CL CMD B
MPS E-2 LO2 PREVLV OP (CL) CMD A
MPS E-2 LH2 PREVLV OP (CL) CMD A
MPS LH2 INBD FILL VLV OP (CL) CMD B
LH2 RTLS MANF REPRESS 2 OP CMD B
MPS E-2 EMER SHT DN INH CMD B
OMS - LEFT ENG CONTROL VLV 1 COIL 2 OP
OMS - LEFT POD HE ISOL VLV A OP
OMS - LEFT POD TK VLVS B CMD 1 OP (CL)
ET/ORB SEP CAMERAS - HTR ON CMD

Prom
Segment

11

OMS - LEFT POD XFD VLVS B CMD OP (CL)
OMS - RT POD XFD VLVS B CMD OP (CL)
RCS - RT AFT OX XFD V-3/4/5 GPC OP (CL) B
RCS - RT AFT FU XFD V-3/4/5 GPC OP (CL) B
RCS - RT AFT TK ISOL V-1/2 GPC OP (CL) A
RCS - RT AFT MANF ISOL VLV-1 GPC OP
RCS - RT AFT MANF ISOL V-3 (-5) GPC CL A
RCS - LEFT AFT MANF ISOL V-3 GPC CL B
RCS - RT AFT HE PRESS VLV-A GPC CL (OP) A

MDM FA2

1

ET LH2/LO2 ULLAGE PRESS NO 2
MPS ENG NO 2 HE SUPPLY/RGLTR OUTLET PRESS
MPS LOX ENG MANF PRESS

2

RCS R AFT HE FU/OX TNK PRESS 1/PRESS 2/TEMP 1
RCS R AFT FU/OX TNK OUT PRESS/TEMP 1/ULLAGE PRESS
RCS L/R AFT OX/FU MANF PRESS -3/4/5
OMS R POD FU TNK ULLAGE PRESS
OMS R POD HE TNK PRESS 1/ TEMP UPPER
OMS L POD OXDZR TNK ULLAGE PRESS
OMS R POD OX/FU AFT COMPARTMENT QTY
OMS R ENG OX INLET/PRESSURE
OMS R ENG RGLTR OUTPRESSURE
OMS R ENG PNEU SUPPLY PRESS 2
OMS PBK HE TANK PRESS 1/TEMP

3

OMS - L ENG STBY P/Y ACTR POSN IN

4

RCS L AFT FU/OX THRUST INJ TEMP-L3A,L3L,L3D
RCS R AFT FU/OX THRUST INJ TEMP-R3A,R3R,R3D,R5D,R5R

5

MDM FA2 Card 3 Discrettes:

RT INBD (OUTBD) ELEVON ACTR 2 FAIL
RUDDER ACTR 2 FAIL
MPS ENG 1 (2,3) P ACTR B FAIL
SRB LH TILT ACTR B FAIL
SRB RH ROCK ACTR B FAIL
RJDA 2 TRICKLE CURRENT CONTINUITY 3,5R
ET - LH2 LOW LEVEL LIQ SENSOR NO. 2
MPS - LH2 OUTBD FILL VLV CLSD
MPS E-2 LH2 PREV LV OP-A
MPS LH2 FEED DISC VLV CLSD-A
ET SEPARATION B
RH SRB SEPARATION IND B
QMS PBK (LEFT-POD) FU ISOL VLV B POSN OP (CL)

Prom
Segment

5

OMS - LEFT POD VAPOR ISOL VLV 2 POSN OP
OMS - LEFT ENG PURGE VLV 2 POSN OP
OMS - RT ENG ARM PRESS (ARM) CMD 2 OP
OMS - RT POD OX XFD VLV B POSN OP (CL)
OMS - RT POD FU XFD VLV B POSN OP (CL)
OMS - PBK HE ISOL VLV A POSN OP
OMS - PBK VAPOR ISOL VLV 1 POSN OP
ET UMB DR LCH 1 LKD (STWD) IND 2
RCS - RT AFT FU MANF ISOL VLV-3(5) OP (CL)
RCS - RT AFT OX MANF ISOL VLV-3(5) OP (CL)
RCS - RT AFT FU TNK ISOL VLV-1/2 (OP (CL)
RCS - RT AFT OX TNK ISOL VLV-1/2 OP (CL)
RCS - RT AFT HE FU PRESS VLV-B OP (CL)
RCS - RT AFT HE OX PRESS VLV-B OP (CL)

MDM FA2 Card 5:

RJDA 2 JET CHMBR PRESS IND L3L (L3D,L3A,R3A,R3R,R3D,R5R,R5D)
RGA 2 R (P,Y) SMRD IND

MDM FA2 Card 8:

RJDA 2 JET DRIVER L3A (L3L,L3D,R3A,R3R,R3D,R5R,R5D)
ET RT UMB CL/OUT DR CLSD (OP,LTCHD) IND 2
ET RT UMB CL/OUT DR LTCH REL IND 2

MDM FA2 Card 11:

LEFT INBD (OUTBD) ELEVON ACTR 2 FAIL
SPEED BRAKE ACTR 2 FAIL
MPS ENG 1 (2,3) Y ACTR B FAIL
SRB LH ROCK ACTR B FAIL
SRB RH TILT ACTR B FAIL
MPS LOX LOW LVL LIQ SNSR 2
MPS ENG 2 LOX PREVLV OP
MPS LO2 FD DISC VLV CL A
MPS LOX INBD FILL VLV CL
MPS LO2 OVERBD B/V CL B
RT AFT VENTS 8&9 CL (OP,PURGE) 2
OMS - PBK OX ISOL VLV B1 POSN OP (CL)
OMS - LEFT POD OX ISOL VLV B POSN OP (CL)
OMS - LEFT POD HE ISOL VLV B POSN OP
OMS - PBK FU TNK LVL LOW
OMS - LEFT POD OX (FU) XFD VLV B POSN OP (CL)
OMS - RT POD OX (FU) TNK LVL LOW
OMS - PBK OX (FU) DUMP VLV B1 POSN OP (CL)
RCS LEFT AFT FU (OX) MANF ISOL VALVE-3 OP (CL)
RCS LEFT AFT OX (FU) XFD VLV-3/4/5 OP (CL)

Prom
Segment

6 HYDR SYS 2 SUPPLY PRESS A/B
7 MPS ENG NO 2 LH2/LOX INLET PRESS/TEMP
LH/RH PRESS B SRM CHAMBER
LH/RH VOLTAGE IGN PIC CAP B
8 L/R INBD/OUTBD ELEVON POSN FDBK-2
SPEED BRAKE/RUDDER/BODY FLAP POSN FDBK-2
9 L/R INBD/OUTBD ELEVON PR1 DELTA PRESS 2
10 RGA 2 R/P/Y RATE
LH/RH RATE PITCH/YAW GYRO B

11 MDM FA2 Card 2:

RJDA 2 JET L3A (L3L,L3D,R3A,R3R,R3D,R5R,R5D) CMD A
MPS ENG 1 P ACTR B BYPASS (RESET)
MPS ENG 2 P (Y) ACTR B BYPASS (RESET)
RH SRB ROCK ACTR B BYPASS (RESET)
LH SRB TILT ACTR B BYPASS (RESET)
LEFT INBD (OUTBD) ACTR 2 BYPASS (RESET)
RT INBD (OUTBD) ACTR 2 BYPASS (RESET)
SPEED BRAKE BYPASS (RESET) 2
RUDDER BYPASS (RESET) 2
BODY FLAP UP (DOWN) CMD 2

MDM FA2 Card 7:

ET UMB DR CL LCH1 STOW (LOCK) CMD 2A
ET RT UMB-CL/OUT DR CLOSE (LATCH) CMD 2B
RT AFT VENTS 8&9 CL (OP,PURGE) CMD 2A
MPS E-1 LO2 (LH2) PREV LV CL (OP) CMD C
REPLACE LH2 ULLAGE PRESS NO 2 XDCR
MPS LH2 FEED DISC VLV CL (OP) CMD C
MPS E-1 MAINSTAGE CMD B
MPS - LH2 MANF REPRESS NO 2 OP CMD
OMS - RT ENG CNTRL VLV 2 COIL 2 OP
OMS - LEFT POD VAPOR ISOL VLV 2 OP
OMS - LEFT POD TANK VLVS A CMD 1 OP (CL)
OMS - LEFT POD XFD VLVS A CMD 1 OP (CL)
OMS - RT POD XFD VLVS A CMD 1 OP (CL)
OMS - PBK VAPOR ISOL VLV 1 OP
RCS - LEFT AFT OX (FU) XFD V-3/4/5 GPC CL (OP) B
RCS - LEFT AFT TNK ISOL V-1/2 GPC CL (OP) A
RCS - LEFT AFT MANF ISOL VLV-3 GPC OP (-5 GPC CL A)
RCS - LEFT AFT MANF ISOL V-1 GPC CL A (B)
RCS - LEFT AFT HE PRESS VLV-B GPC OP (CL) A

Prom
Segment

11

MDM FA2 Card 10:

RJDA 2 JET L3A (L3L,L3D,R3A,R3R,R3D,R5R,R5D) CMD B
MPS ENG 1 Y ACTR B BYPASS/RESET
MPS ENG 3 P (Y) ACTR B BYPASS/RESET
SRB ACTR B LH ROCK BYPASS (RESET)
SRB ACTR B RH TILT BYPASS (RESET)
BODY FLAP ENA CMD 2

MDM FA2 Card 12:

MPS LO2 ACC RECIRC VLV 2 CL CMD A
MPS LO2 OVERBD B/V CL CMD C
MPS SIG COND PWR NO 2 ON CMD
MPS LH2 OUTBD FILL VLV OP (CL) CMD
MPS LO2 INBD FILL VLV OP (CL) CMD B
MPS E-3 LO2 (LH2) PREVLV CL (OP) CMD A
REPLACE LO2 ULLAGE PRESS #2 XDCR
LH2 RTLS MANF REPRESS 2 OP CMD C
MPS E-3 EMER SHT DN INH CMD B
OMS - PBK OX (FU) ISOL VLV B1 OP (CL)
OMS - PBK OX (FU) DUMP VLV B1 OP (CL)
OMS - LEFT ENG PURGE VLV 2 OP
HYD SYS 2 LDG GR ISOL VLV OP

MDM FA2 Card 15:

ET UMB DR CL LCH 1 STW CMD 2B
ET RT UMB CL/OUT DR LCH CMD 2A
RT AFT VENTS 8&9 CL (OP,PUR) CMD 2B
MPS LO2 FDLN RLF S/O VLV CL CMD A
MPS E-2 LO2 (LH2) PREVLV CLS (OP) CMD B
MPS LH2 INBD FILL VLV OP CMD A
MPS LO2 FEED DISC VLV CL (OP) CMD C
MPS E-2 MAINSTAGE CMD A
MPS E-2 EMERG SHT DN INH CMD A
OMS - L ENG CNTRL VLV 2 COIL 2 OP
OMS - L POD HE ISOL VLV B OP
OMS - L POD FU (OX) ISOL VLV B CMD 2 OP (CL)
OMS - L POD (R POD) FU (OX) XFD VLV B CMD 2 OP (CL)
RCS RT AFT XFD VLV-3/4/5 GPC CL (OP) A
RCS RT AFT FU (OX) TNK ISOL VLV-1/2 GPC OP (CL) B
RCS RT AFT MANF ISOL VLV-3 (-5) GPC OP A
RCS RT AFT MANF ISOL VLV-1 GPC CL A
RCS LEFT AFT MANF ISOL VLV-1 GPC CL B
RCS RT AFT HE PRESS VLV-B GPC OP (CL) A

Prom
Segment

MDM FA3

- 1 ET LH2/LO2 ULLAGE PRESS NO 3
MPS ENG NO 3 HE SUPPLY/RGLTR OUTLET PRESS

- 2 RCS L AFT HE FU TNK PRESS 2/TEMP 1
RCS L AFT FU TNK OUTPRESS/TEMP 1
RCS L AFT OX TNK OUTPRESS
RCS L AFT HE OX TNK PRESS 2
RCS L/R AFT OX/FU MANF VLV 2
OMS L POD FU/OX TNK TOTAL QTY
OMS L POD HE TNK PRESS 2
OMS L POD OX/FU AFT COMPARTMENT QTY
OMS L ENG CHAMBER FU INLET PRESSURE
OMS L ENG BI-PROP VLV 1/2 POSN OP
OMS L ENG PNEU SUPPLY PRESS 1
OMS PBK OXDZR TANK TEMP/ULLAGE PRESS

- 3 OMS R ENG STBY P/Y ACTR POSN IN

- 4 RCS R AFT FU/OX THRUST INJ TEMP-R2R,R2U,R2D
RCS L AFT FU/OX THRUST INJ TEMP-L2L,L2U,L2D

- 5 MDM FA3 Card 3 Discretes:

RT INBD (OUTBD) ELEVON ACTR 3 FAIL
RUDDER ACTR 3 FAIL OUTPUT
MPS 1 (2,3) P ACTR C FAIL
SRB LH TILT ACTR C FAIL
SRB RH ROCK ACTR C FAIL
RJDA TRICKLE CURRENT CONTINUITY 2
ET - LH2 LOW LVL LIQ SENSOR NO 1
MPS LH2 RTLS OUTBD D/V CL
MPS E-1 LH2 PREVLV OP B
LH SRB SEP IND A
OMS - PBK FU ISOL VLV A2 POSN OP (CL)
OMS - RT POD FU ISOL VLV B POSN OP (CL)
OMS - RT POD VAPOR ISOL VLV 1 POSN OP
OMS - RT ENG PURGE VLV 1 POSN OP
OMS - LEFT ENG ARM/PRESS CMD 1 OP
OMS - LEFT ENG ARM/CMD 1 OP
OMS - PBK HE ISOL VLV B POSN OP
OMS - PBK VAPOR ISOL VLV 2 POSN OP
ET UMB DR CL LCH 2 LOCKED (STOWED) IND 2
RCS RT AFT FU (OX) MANF ISOL VLV-2 OP (CL)
RCS RT AFT OX (FU) TNK ISOL VLV-3/4/5/ OP (CL)
RCS LEFT AFT OX (FU) XFD VLV-1/2 OP (CL)

MDM FA3 Card 5:

RJDA 1 JET L2L (L2U,L2D,R2R,R2U,R2D) CHMBR PRESS IND
RGA 3 R (P,Y) SMRD IND

MDM FA3 Card 8:

RJDA 1 JET L2L (L2U,L2D,R2R,R2U,R2D) DRIVER
MPS L02 ACCUM RECIRC VLV 1 OP
MPS E-3 LH2 PREVLY OP B
ET LEFT UMB CL/OUT DR OP (CL) IND 2
ET RT UMB CL/OUT DR LTCHD (LCH REL) IND 1
ET RT UMB DR RDY-TO-LCH IND 1 (2,3)

MDM FA3 Card 11:

LEFT INBD (OUTBD) ELEVON ACTR 3 FAIL
SPEED BRAKE ACTR 3 FAIL
MPS ENG 1 (2,3) Y ACTR C FAIL
SRB RH TILT ACTR C FAIL
SRB LH ROCK ACTR C FAIL
MPS - LOX LOW LVL LIQ SNSR NO 1
MPS - LOX FEED DISC VLV OP (CL)
MPS - LOX OUTBD FILL VLV CLS
MPS - L02 OVERBD B/V CLSD A
AFT VENTS 8&9 CLSD (OP, PUR) 1
OMS - PBK OX ISOL VLV AZ POSN OP (CL)
OMS - RT POD OX ISOL VLV B POSN CL (OP)
OMS - RT POD HE ISOL VLV A POSN OP
OMS - LEFT ENG PRESS VLV POSN OP
OMS - PBK OX DUMP VLV AZ POSN OP (CL)
OMS - PBK FU DUMP VLV AZ POSN OP (CL)
RCS - LEFT AFT OX (FU) MANF ISOL VLV-2 OP (CL)
RCS - LEFT AFT OX (FU) TNK ISOL VLV-3/4/5 A OP (CL)
RCS - LEFT AFT HE OX (FU) PRESS VLV-B OP (CL)

HYDR SYS 3 SUPPLY PRESS A/B

MPS ENG NO 3 LH2/LOX INLET PRESS/TEMP
LH/RH PRESS C SRM CHAMBER

L/R INBD/OUTBD ELEVON POSN FDBK-3
SPEED BRAKE/RUDDER/BODY FLAP POSN FDBK-3

L/R INBD/OUTBD ELEVON PRI DELTA PRESS 3

RGA 3 R/P/Y RATE

LH/RH RATE PITCH/YAW GYRO C

Prom
Segment

11 MDM FA3 Card 2:

RJDA 1 JET L2L (L2U,L2D,R2R,R2U,R2D) CMD A
MPS ENG 1 P ACTR C BYPASS (RESET)
MPS ENG 2 P (Y) ACTR C BYPASS (RESET)
SRB ACTR C LH TILT BYPASS (RESET)
SRB ACTR C RH ROCK BYPASS (RESET)
LEFT INBD (OUTBD) ELEVON ACTR 3 BYPASS (RESET)
RT INBD (OUTBD) ELEVON ACTR 3 BYPASS (RESET)
SPEED BRAKE BYPASS (RESET) 3
RUDDER BYPASS (RESET)
BODY FLAP UP (DOWN) CMD 3

MDM FA3 Card 7:

ET UMB DR CL LCH 2 STOW (LOCK) CMD 2A
ET RT UMB CL/OUT DR LCH CMD 1A
ET LEFT UMB CL/OUT DR CL CMD 2
RT AFT VENTS 8&9 CL (OP,PURGE) CMD 1A
MPS E-1 LO2 PREV LV OP (CL) CMD A
MPS E-1 LH2 PREV LV OP (CL) CMD A
REPLACE LH2 ULLAGE PRESS NO 3 XDCR
MPS LH2 FEED DISC VLV CL (OP) CMD A
MPS - E1 EMERG SHT DN INH CMD A
OMS - RT ENG CONTROL VLV 1 COIL 1 OP.
OMS - RT POD VAPOR ISOL VLV 1 OP
OMS - RT POD TNK VLVS A CMD 1 OP (CL)
OMS - PBK VAPOR ISOL VLV 2 OP
RCS - LEFT AFT OX XFD VLV 1/2 GPC CL (OP) B
RCS - LEFT AFT FU (OX) TK ISOL V 3/4/5 A GPC OP (CL)
RCS - LEFT AFT MANF ISOL VLV-2 GPC OP
RCS - LEFT AFT MANF ISOL VLV-4 GPC CL A
RCS - RT AFT MANF ISOL VLV-4 GPC CL B

MDM FA3 Card 10:

RJDA JET L2L (L2U,L2D,R2R,R2U,R2D) CMD B
MPS ENG 1 Y ACTR C BYPASS (RESET)
MPS ENG 3 Y (P) ACTR C BYPASS (RESET)
SRB RH TILT ACTR C BYPASS (RESET)
SRB LH ROCK ACTR C BYPASS (RESET)
BODY FLAP ENA CMD 3

MDM FA3 Card 12:

MPS LO2 ACC RECIRC VLV 1 CL CMD B
MPS LO2 OVERBD B/V CL CMD A
MPS LH2 RTLS INBD (OUTBD) D/V OPEN CMD A
LH2 RTLS MANF REPRESS 1 OP CMD A

Prom
Segment

11

MPS LO2 FDLN RLF S/O VLV CL CMD C
LEFT SRB BUS C RPC C ON CMD
RT SRB BUS C RPC C ON CMD
OMS - PBK OX (FU) ISOL VLV A2 OP (CL)
OMS - RT ENG PURGE VLV 1 OP
OMS - PBK OX (FU) DUMP VLV A2 OP (CL)
HYD SYS 3 LDG GR ISOL VLV OP

MDM FA3 Card 15:

ET UMB DR CL LCH 2 STOW (LOCK) CMD 2B
ET RT UMB CL/OUT DR LCH CMD 1B
RT AFT VENTS 8&9 CL (OP, PURGE) CMD 1B
MPS LH2 FDLN RLF S/O VLV CL CMD A
MPS E-2 LO2 PREVLV OP (CL) CMD C
MPS LO2 FEED DISC VLV CL (OP) CMD A
MPS E-2 MAINSTAGE CMD B
MPS - LO2 MANF REPRESS NO 1 OP CMD
OMS - LEFT ENG CONTROL VLV 2 COIL 1 OP
OMS - RT POD HE ISOL VLV A OP
OMS - RT POD OX/FU ISOL VLV B CMD 2 OP (CL)
ET/ORB SEP CAMERAS ON CMD
OMS - PBK HE ISOL VLV B OP
RCS - RT AFT XFD VLV-1/2 GPC CL (OP) A
RCS - RT AFT OX/FU TNK ISOL VLV 3/4/5 A GPC OP (CL)
RCS - RT AFT MANF ISOL VLV-2 GPC OP
RCS - RT AFT MANF ISOL VLV-4 GPC CL A
RCS - LEFT AFT MANF ISOL VLV-4 GPC CL B
RCS - LEFT AFT FU XFD VLV-1/2 GPC CL (OP) B

MDM FA4

1

DUMMY

2

RCS R AFT HE FU TNK TEMP 1/PRESS 2
RCS R AFT FU TNK TEMP 1/OUT PRESS
RCS R AFT OX TNK OUT PRESS
RCS R AFT HE OX TNK PRESS 2
RCS L/R AFT OX/FU MANF VLV 4
OMS R POD OX/FU TNK TOTAL QTY
OMS R POD HE TNK PRESS 2
OMS R ENG FU INLET/CHAMBER PRESS
OMS R ENG BI PROP VLV 1/2 POSN OP
OMS R ENG PNEU SUPPLY PRESS 1
OMS PBK FU TANK TEMP/ULLAGE PRESS

3

OMS R ENG ACTV P/Y ACTR POSN IN

Prom
Segment

5 RCS R AFT FU/OX THRUST INJ TEMP-R4R,R4U,R4D
RCS L AFT FU/OX THRUST INJ TEMP-L4L,L4U,L4D

5 MDM FA4 Card 3:

RT INBD (OUTBD) ELEVON ACTR 4 FAIL
RUDDER ACTR 4 FAIL OUTPUT
MPS ENG 1 (2,3) P ACTR D FAIL
SRB LH TILT ACTR D FAIL
SRB RH ROCK ACTR D FAIL
RJDA 2 TRICKLE CURRENT CONTINUITY 4
ET - LH2 LOW LVL LIQ SENSOR NO 3
MPS LH2 RTLS INBD D/V CLSD
MPS E-2 LH2 PREVLV OP B
MPS - LH2 FEED DISC VLV CL (OP) B
RH SRB SEP IND A
OMS - PBK FU ISOL VLV B2 POSN OP (CL)
OMS - RT POD FU ISOL VLV A POSN OP (CL)
OMS - RT POD VAPOR ISOL VLV 2 POSN OP
OMS - RT ENG PURGE VLV 2 POSN OP
OMS - RT ENG ARM/PRESS (ARM) CMD 1 OP
ET UMB DR CL LCH 2 LOCKED (STOWED) IND 1
RCS - RT AFT FU (OX) MANF ISOL VLV OP (CL)
RCS - RT AFT FU (OX) TK ISOL VLV-3/4/5 B OP (CL)

MDM FA4 Card 5:

RGA 4 YAW SMRD IND

MDM FA4 Card 8:

RJDA 2 JET L4L (L4U,L4D,R4R,R4U,R4D) DRIVER
MPS LO2 ACC RECIRC VLV 2 OP
MPS E-3 LH2 PREVLV OP A
ET RT UMB CL?OUT DR OP (CL) IND 1
ET LEFT UMB CL/OUT DR LCHD (LTCH REL) IND 2

MDM FA4 Card 11:

LEFT INBD (OUTBD) ELEVON ACTR 4 FAIL
SPEED BRAKE ACTR 4 FAIL
MPS ENG 1 (2,3) Y ACTR D FAIL
SRB LH ROCK ACTR D FAIL
SRB RH TILT ACTR D FAIL
MPS - LOW LVL LIQ SNSR NO 3
MPS - ENG NO 3 LOX PREVLV OP
L AFT VENTS 8&9 OP (CL, PURGE) IND 2
OMS - PBK OX ISOL VLV B2 POSN OP (CL)

Prom
Segment

5 OMS - RT POD OX ISOL VLV A POSN OP (CL)
OMS - RT POD HE ISOL VLV B POSN OP
OMS - RT ENG PRESS VLV POSN OP
OMS - PBX OX (FU) DUMP VLV B2 POSN OP (CL)
RCS - LEFT AFT FU (OX) MANF ISOL VLV-4 OP (CL)
RCS - LEFT AF OX (FU) TNK ISOL VLV-3/4/5 B OP (CL)
RCS - RT AFT OX (FU) XFD VLV-1/2 OP (CL)

6 DUMMY

7 DUMMY

8 L/R INBD/OUTBD ELEVON POSN FDBK-4
SPEEDBRAKE/RUDDER/BODY FLAP POSN FDBK-4

9 L/R INBD/OUTBD ELEVON PRI DELTA PRESS 4

10 RGA 4 R/P/Y RATE

11 MDM FA4 Card 2:

RJDA 2 JET L4L (L4U,L4D,R4R,R4U,R4D) CMD A
MPS ENG 1 P (Y) ACTR D BYPASS (RESET)
MPS ENG 2 P (Y) ACTR D BYPASS (RESET)
SRB RH ROCK ACTR D BYPASS (RESET)
SRB LH TILT ACTR D BYPASS (RESET)
LEFT INBD (OUTBD) ELEVON ACTR 4 BYPASS (RESET)
RT INBD (OUTBD) ELEVON ACTR 4 BYPASS (RESET)
SPEED BRAKE BYPASS (RESET) 4
RUDDER BYPASS (RESET) 4

MDM FA4 Card 7:

ET UMB DR CL LCH 2 STOW (LOCK) CMD 1A
ET LEFT UMB CL/OUT DR LCH CMD 2A
ET RT UMB CL/OUT DR CL CMD 1
LEFT AFT VENTS 8&9 OP (CL,PURGE) CMD 2A
MPS - LH2 RECIRC DISC VLV OP (CL) CMD
MPS - LH2 FEED DISC VLV CL (OP) CMD B
MPS - E1 EMERG SHT DN INH CMD B
OMS - RT ENG CONTROL VLV 2 COIL 1 OP
OMS - RT POD VAPOR ISOL VLV 2 OP
OMS - RT POD FU (OX) ISOL VLV A CMD 2 OP (CL)
RCS - LEFT AFT XFD VLV-1/2 GPC CL (OP) A
RCS - LEFT AFT FU (OX) TNK ISOL V 3/4/5 B GPC OP (CL)
RCS - LEFT AFT MANF ISOL VLV-4 GPC OP
RCS - LEFT AFT MANF ISOL VLV-2 GPC CL A
RCS - RT AFT MANF ISOL V-2 GPC CL B

Prom
Segment

11 MDM FA4 Card 10:

RJDA 2 JET L4L (L4U,L4D,R4R,R4U,R4D) CMD B
MPS ENG 1 Y ACTR D BYPASS (RESET)
MPS ENG 3 Y (P) ACTR D BYPASS (RESET)
SRB RH TILT ACTR D BYPASS (RESET)
SRB LH ROCK ACTR D BYPASS (RESET)

MDM FA4 Card 12:

MPS LO2 ACC RECIR VLV 2 CL CMD B
MPS LO2 OVERBD B/V CL CMD B
MPS SIG COND PWR #3 ON CMD
MPS LH2 RTLS INBD (OUTBD) D/V OP CMD B
MPS E-3 LO2 (LH2) PREVLV OP (CL) CMD B
REPLACE LO2 ULLAGE PRESS #3 XDCR
LH2 RTLS MANF REPRESS 1 OP CMD C
MPS, E-3 MAINSTAGE CMD A
OMS - PBK OX (FU) ISOL VLV B2 OP (CL)
OMS - RT ENG PURGE VLV 2 OP
OMS - PBK OX (FU) DUMP VLV B2 OP (CL)

MDM FA4 Card 15:

ET UMB DR CL LCH 2 STOW (LOCK) CMD 1B
ET LEFT UMB CL/OUT DOOR LATCH CMD 2B
LEFT AFT VENTS 8&9 CL (OP, PURGE) CMD 2B
MPS LH2 FDLN RLF S/O VLV CL CMD B
MPS LO2 OUTBD FILL VLV OP (CL) CMD
MPS E-2 LH2 PREVLV OP (CL) CMD C
MPS LO2 FEED DISC VLV CL (OP) CMD B
LH2 RTLS MANF REPRESS 2 OP CMD A
MPS - LO2 MANF REPRESS NO 2 OP CMD
OMS - LEFT ENG CONTROL VLV 1 COIL 1 OP
OMS - RT POD HE ISOL VLV B OP
OMS - RT POD TK VLVS B CMD 1 OP (CL)
RCS RT AFT OX XFD V-1/2 GPC CL (OP) B
RCS RT AFT FU (OX) TNK ISOL V-3/4/5 B GPC CL (OP)
RCS RT AFT MANF ISOL VLV-4 GPC OP
RCS RT AFT MANF ISOL VLV-2 GPC CL A
RCS LEFT AFT MANF ISOL VLV-2 GPC CL B
RCS RT AFT FU XFD VLV-1/2 GPC CL (OP) B

APPENDIX E
UPLINK LOADS/MEMORY CONFIGURATIONS

APPENDIX E - UPLINK LOADS/MEMORY CONFIGURATIONS

| MEMORY CONFIGURATIONS | | | | | | | | | | |
|--|----------------------------|---------------------------|----------------------------|--------------|-----------------|-------------------------|-------------------------|---------------------------|---------------------------|-----|
| OPS CODE | MC 1 GNC 1.6 ASC/ABT | MC 2 GNC 2 ON-ORBIT | MC 3 NOM ENTRY GNC 3 | MC 4 SM 2 | MC 0 OPS 000 | MC 6 SM 8 MM UTIL | MC 7 SM 9 INIT/CO | MC 8 GNC 8 ON-ORBIT | MC 9 GNC 9 PRECOUNT | BFS |
| 2-STAGE BUFFER CLEAR (1000001) | X | X | X | X | X | X | X | X | X | X |
| SPC BUFFER CLEAR (1000010) | | | | X | | | | | | X |
| 2-STAGE BUFFER EXECUTE (1000011) | X | X | X | X | X | X | X | X | X | X |
| WORD BY WORD CORRECTION (10000100) | X | X | X | X | X | X | X | X | X | |
| G-MEM CONTIGUOUS (0000001) | | X | | X | X | X | X | X | X | X |
| G-MEM SCATTER (0000010) | | X | | X | X | X | X | X | X | X |
| MDM SINGLE (0000101) | X | X | X | X | X | X | X | X | X | X |
| MDM MULT (0000011) | X | X | X | X | X | X | X | X | X | X |
| MDM SPC MULT (0000100) | | | | X | | | | | | X |
| EQUIV DEU (0000101) | X | X | X | X | X | X | X | X | X | |
| MMJ SM INTERFACE (1000010) | | | | X | | X | | | | |
| UL ACTIVITY ON (1000110) | X | X | X | X | X | X | X | X | X | |
| UL ACTIVITY OFF (1000110) | X | X | X | X | X | X | X | X | X | |
| KU BAND ANTENNA CNTL (0000111) | | | | X | | | | | | |
| IMJ REFSMAT (0001000) | | X | X | | | | | | | X |

APPENDIX E - Continued

| OPS CODE | MC 1 | MC 2 | MC 3 | MC 4 | MC 0 | MC 6 | MC 7 | MC 8 | MC 9 | BFS |
|---|---------|----------|-----------|------|---------|---------|---------|----------|----------|-----|
| | GNC 1.6 | GNC 2 | NOM ENTRY | SM 2 | OPS 000 | SM 8 | SM 9 | GNC 8 | GNC 9 | |
| | ASC/ABT | ON-ORBIT | GNC 3 | | | MM UTIL | INIT/CO | ON-ORBIT | PRECOUNT | |
| ORBITER STATE VECTOR (0001001) | X | X | X | | | | | | | X |
| REND VEH STATE VECTOR (0001010) | | X | | | | | | | | |
| GUIDANCE POLYNOMIAL PPOLYI (0001011) | X | | | | | | | | X | |
| GUIDANCE POYNOMINAL PSII (0001100) | X | | | | | | | | X | |
| GUIDANCE POLYNOMIAL THET 1, 1 (0001101) | X | | | | | | | | X | |
| GUIDANCE POLYNOMIAL THET 1, 2 (0001110) | X | | | | | | | | X | |
| LAUNCH TARGETING (0001111) | X | | | | | | | | X | X |
| ON-ORBIT GUIDANCE TARGETS PEG 7 (0010000) | | X | | | | | | | | |
| DE-ORBIT GUIDANCE PEG 7 (0010001) | | X | X | | | | | | | X |
| IMU GYRO BIAS (0010010) | | X | X | | | | | | | X |
| IMU ACCELEROMETER (BIAS (0010011) | | X | X | | | | | | | X |
| DEORBIT GUIDANCE PEG 4 (0010100) | | X | X | | | | | | | X |
| TABLE MAINTENANCE BLOCK UPDATE (0100001) | | | | | X | | | | | X |
| GUIDANCE POLYNOMIAL THET I (0100011) | X | | | | | | | | X | |
| GUIDANCE POLYNOMIAL THET I, 3 (0100100) | X | | | | | | | | X | |

APPENDIX E - Continued

MEMORY CONFIGURATIONS

| OPS CODE | MC 1 GNC 1.6 ASC/ABT | MC 2 GNC 2 ON-ORBIT | MC 3 NOM ENTRY GNC 3 | MC 4 SM 2 | MC 0 OPS 000 | MC 6 SM 8 MM UTIL | MC 7 SM 9 INIT/CO | MC 8 GNC 8 ON-ORBIT | MC 9 GNC 9 PRECOUNT | BFS |
|---|----------------------------|---------------------------|----------------------------|--------------|-----------------|-------------------------|-------------------------|---------------------------|---------------------------|-----|
| GUIDANCE POLYNOMIAL PHI 1 (0101000) | X | | | | | | | | X | |
| INSERTION GUIDANCE TARGET, PEG 4 (0101101) | X | | | | | | | | | X |
| VENT TIMELINE (0110001) | | X | | | | | | | | |
| DELTA NAV (0100000) | X | | X | | | | | | | X |
| DEORBIT LANDING SITE PARAMETERS (0010101) | | X | X | | | | | | | X |
| TORS STATE VECTOR (0010110) | | | | X | | | | | | X |
| KU BAND ANTENNA BIAS MATRIX (0010111) | | | | X | | | | | | |
| ADI INERTIAL QUATERNION (0011000) | | X | X | | | | | X | | X |
| ATTITUDE TIMELINE (0011001) | | X | | | | | | | | |
| PAYLOAD DATA LOAD (0011010) | | | | X | | | | | | |
| PSP CONFIGURATION TABLE (0011011) | | | | X | | | | | | |
| VEHICLE INERTIA MATRIX (0011100) | | X | | | | | | | | |
| ADI REFERENCE QUATERNIONS (0011101) | | X | X | | | | | X | | X |
| ADI BIAS I.VLIH QUAT (0011110) | | X | X | | | | | X | | X |
| DEORBIT TACAN PARA (0011111) | | X | X | | | | | | | X |

APPENDIX E - Concluded

MEMORY CONFIGURATIONS

| OPS CODE | MC 1 GNC 1.6 ASC/ABT | MC 2 GNC 2 ON-ORBIT | MC 3 NOM ENTRY GNC 3 | MC 4 SM 2 | MC 0 OPS 000 | MC 6 SM 8 MM UTIL | MC 7 SM 9 INIT/CO | MC 8 GNC 8 ON-ORBIT | MC 9 GNC 9 PRECOUNT | BFS |
|--------------------------------------|----------------------------|---------------------------|----------------------------|--------------|-----------------|-------------------------|-------------------------|---------------------------|---------------------------|-----|
| TIME EXECUTED SIO (TEC) (0101110) | | | | | X | | | | | |
| RCS QUANTITY MONITORING (0110010) | | X | | | | | | | | |

APPENDIX F
SYSTEM FAULT MESSAGES

| CRT ID | FAULT MESSAGE | | PASS OPS AVAIL | BFS OPS AVAIL | ALRM CL | SOFTWARE DRIVEN CAUTION & WARNING LIGHT | CONDITIONS |
|--------|---------------|-------------|----------------|---------------|---------|---|------------------------------------|
| | MAJOR FIELD | MINOR FIELD | | | | | |
| | BCEPL | | Yes | No | 3 | | ● PL 1/2 BYPASS |
| | | A | Yes | Yes | 3 | | ● FF1 INPUT PROM SEQS 1, 2 BYPASS |
| | | ADTA | Yes | Yes | 3 | | ● FF1 ADTA BYPASS |
| | | B | Yes | Yes | 3 | | ● FF1 INPUT PROM SEQS 2, 6 BYPASS |
| | | C | Yes | Yes | 3 | | ● FA1 INPUT PROM SEQS 1, 2 BYPASS |
| | | D | Yes | Yes | 3 | | ● FA1 INPUT PROM SEQS 3, 10 BYPASS |
| | BCESTRG 1 | IMU | Yes | Yes | 3 | | ● FF1 IMU BYPASS |
| | | MLS | Yes | No | 3 | | ● FF1 MSBLS BYPASS |
| | | MTU | Yes | Yes | 3 | | ● FF1 MTU BYPASS |
| | | NSP | Yes | Yes | 3 | | ● FF1 NSP DISCRETES |
| | | STKR | Yes | No | 3 | | ● FF1 STU BYPASS |
| | | TAC | Yes | Yes | 3 | | ● FF1 TACAN/RA BYPASS |
| | | PASS | No | Yes | 3 | | ● FAIL SYNC ON FF1/FA1 |
| | | A | Yes | Yes | 3 | | ● FF2 INPUT PROM SEQS 1, 2 BYPASS |
| | | ADTA | Yes | Yes | 3 | | ● FF2 ADTA BYPASS |
| | | B | Yes | Yes | 3 | | ● FF2 INPUT PROM SEQS 2, 6 BYPASS |
| | | C | Yes | Yes | 3 | | ● FA2 INPUT PROM SEQS 1, 2 BYPASS |
| | | D | Yes | Yes | 3 | | ● FA2 INPUT PROM SEQS 3, 10 BYPASS |
| | BCESTRG 2 | IMU | Yes | Yes | 3 | | ● FF2 IMU BYPASS |
| | | MLS | Yes | No | 3 | | ● FF2 MSBLS BYPASS |
| | | MTU | Yes | Yes | 3 | | ● FF2 MTU BYPASS |
| | | TAC | Yes | Yes | 3 | | ● FF2 TACAN/RA BYPASS |
| | | PASS | No | Yes | 3 | | ● FAIL SYNC ON FF2/FA2 |
| | | A | Yes | Yes | 3 | | ● FF3 INPUT PROM SEQS 1, 2 BYPASS |
| | | ADTA | Yes | Yes | 3 | | ● FF3 ADTA BYPASS |
| | | B | Yes | Yes | 3 | | ● FF3 INPUT PROM SEQS 2, 6 BYPASS |
| | | C | Yes | Yes | 3 | | ● FA3 INPUT PROM SEQS 1, 2 BYPASS |
| | | D | Yes | Yes | 3 | | ● FA3 INPUT PROM SEQS 3, 10 BYPASS |
| | BCESTRG 3 | IMU | Yes | Yes | 3 | | ● FF3 IMU BYPASS |
| | | MLS | Yes | No | 3 | | ● FF3 MSBLS BYPASS |
| | | MTU | Yes | Yes | 3 | | ● FF3 MTU BYPASS |
| | | NSP | Yes | Yes | 3 | | ● FF3 NSP DISCRETES |
| | | STKR | Yes | No | 3 | | ● FF3 STU BYPASS |
| | | TAC | Yes | No | 3 | | ● FF3 TACAN/RA BYPASS |
| | | PASS | No | Yes | 3 | | ● FAIL SYNC ON FF3/FA3 |

| CRT ID | FAULT MESSAGE | | PASS | BFS | ALRM CL | SOFTWARE DRIVEN CAUTION & WARNING LIGHT | CONDITIONS |
|------------|---------------|-------------|-----------|-----------|--------------|---|---|
| | MAJOR FIELD | MINOR FIELD | OPS AVAIL | OPS AVAIL | | | |
| BCE STRG 4 | A | Yes | Yes | 3 | | | ● FF4 INPUT PROM SEQ 1, 2 BYPASS |
| | ADTA | Yes | Yes | 3 | | | ● FF4 ADTA BYPASS |
| | B | Yes | Yes | 3 | | | ● FF4 INPUT PROM SEQ 2, 6 BYPASS |
| | C | Yes | Yes | 3 | | | ● FA4 INPUT PROM SEQ 1, 2 BYPASS |
| | D | Yes | Yes | 3 | | | ● FA4 INPUT PROM SEQ 3, 10 BYPASS |
| | PASS | No | Yes | 3 | | | ● FAIL SYNC ON FF4/FA4 |
| CRT BITE | 1 | Yes | Yes | 3 | | | ● DEU1 BITE INDICATION |
| | 2 | Yes | Yes | 3 | | | ● DEU2 BITE INDICATION |
| | 3 | Yes | Yes | 3 | | | ● DEU3 BITE INDICATION |
| | 4 | Yes | Yes | 3 | | | ● DEU4 BITE INDICATION |
| GPC | BITE | Yes | Yes | 3 | | | ● FORCE CLOSE ANY PROCESS |
| | CONF | Yes | No | 3 | | | ● NOT ALL TARGET GPC'S IN RUN MODE ● NO TARGET GPC IN RUN MODE |
| | SUM | No | Yes | 3 | | | ● BFS GPC CHECKSUM ON PROTECTED FAIL |
| | 1 | Yes | No | 2 | * BACKUP C/W | | ● GPC1 FAIL IND |
| | 2 | Yes | No | 2 | * BACKUP C/W | | ● GPC2 FAIL IND |
| | 3 | Yes | No | 2 | * BACKUP C/W | | ● GPC3 FAIL IND |
| | 4 | Yes | No | 2 | * BACKUP C/W | | ● GPC4 FAIL IND |
| | 5 | Yes | No | 2 | * BACKUP C/W | | ● GPC5 FAIL IND |
| I/O ERROR | CRT1 | Yes | Yes | 3 | | | ● I/O ERROR IN DEU1 INITIALIZATION ● ERROR IN DEU1 MSG I/O OR CHECKSUM + ● I/O ERROR IN DEU1 CRITICAL FORMAT LOAD |

* A GPC FAIL will also result in the annunciation of a GPC status Matrix light and the C&W 'GPC' light.

+ Supported in PASS only.

| CRT ID | FAULT MESSAGE | PASS OPS AVAIL | BFS OPS AVAIL | ALRM CL | SOFTWARE DRIVEN CAUTION & WARNING LIGHT | CONDITIONS |
|-------------|---------------|----------------|---------------|---------|--|---|
| MAJOR FIELD | MINOR FIELD | | | | | |
| I / O ERROR | CRT 2 | Yes | Yes | 3 | | <ul style="list-style-type: none"> ● I/O ERROR IN DEU2 INITIALIZATION ● ERROR IN DEU2 MSG I/O OR CHECKSUM + ● I/O ERROR IN DEU2 CRITICAL FORMAT LOAD |
| | CRT 3 | Yes | Yes | 3 | | <ul style="list-style-type: none"> ● I/O ERROR IN DEU3 INITIALIZATION ● ERROR IN DEU3 MSG I/O OR CHECKSUM + ● I/O ERROR IN DEU3 CRITICAL FORMAT LOAD |
| | CRT 4 | Yes | Yes | 3 | | <ul style="list-style-type: none"> ● I/O ERROR IN DEU4 INITIALIZATION ● ERROR IN DEU4 MSG I/O OR CHECKSUM + ● I/O ERROR IN DEU4 CRITICAL FORMAT LOAD |
| | FA 1 | Yes | Yes | 3 | | <ul style="list-style-type: none"> ● I/O ERROR ON FA1/P1 ● I/O ERROR ON FA1/P2 |
| | FA 2 | Yes | Yes | | | <ul style="list-style-type: none"> ● I/O ERROR ON FA2/P1 ● I/O ERROR ON FA2/P2 |
| | FA 3 | Yes | Yes | 3 | | <ul style="list-style-type: none"> ● I/O ERROR ON FA3/P1 ● I/O ERROR ON FA3/P2 |
| | FA 4 | Yes | Yes | 3 | | <ul style="list-style-type: none"> ● I/O ERROR ON FA4/P1 ● I/O ERROR ON FA4/P2 |
| | FF 1 | Yes | Yes | 3 | | <ul style="list-style-type: none"> ● I/O ERROR ON FF1/P1 ● I/O ERROR ON FF1/P2 |
| | FF 2 | Yes | Yes | 3 | | <ul style="list-style-type: none"> ● I/O ERROR ON FF2/P1 ● I/O ERROR ON FF2/P2 |
| | FF 3 | Yes | Yes | 3 | | <ul style="list-style-type: none"> ● I/O ERROR ON FF3/P1 ● I/O ERROR ON FF3/P2 |
| | FF 4 | Yes | Yes | 3 | | <ul style="list-style-type: none"> ● I/O ERROR ON FF4/P1 ● I/O ERROR ON FF4/P2 |
| | LA 1 | No | Yes | 3 | | <ul style="list-style-type: none"> ● I/O ERROR ON LA1/P1 ● I/O ERROR ON LA1/P2 |
| LF 1 | No | Yes | 3 | | <ul style="list-style-type: none"> ● I/O ERROR ON LF1/P1 ● I/O ERROR ON LF1/P2 | |

+ Supported in PASS only.

| CRT ID | FAULT MESSAGE | | PASS | BFS | ALRM CL | SOFTWARE DRIVEN CAUTION & WARNING LIGHT | CONDITIONS |
|--------|---------------|-------------|-----------|-----------|---------|---|---|
| | MAJOR FIELD | MINOR FIELD | OPS AVAIL | OPS AVAIL | | | |
| | I/O ERROR | MMU | Yes | No | 3 | | <ul style="list-style-type: none"> ● CHECKSUM ERROR OR I/O ERROR ON MMU TRANSACTION ● FORMAT NOT FOUND IN BUFFER FOLLOWING RETRIEVAL FROM MMU ● DATA XFER ON CHECKSUM ERROR ON GPC-GPC OVERLAY VIA MM OR LDB |
| | | PCM | Yes | Yes | 3 | | <ul style="list-style-type: none"> ● I/O ERROR ON PCMMU |
| | | PL1 | Yes | Yes | 3 | | <ul style="list-style-type: none"> ● I/O ERROR ON PF1/PI ● I/O ERROR ON PF1/P2 |
| | | PL2 | Yes | Yes | 3 | | <ul style="list-style-type: none"> ● I/O ERROR ON PF2/PI ● I/O ERROR ON PF2/P2 |
| | ILLEGAL ENTRY | | Yes | Yes | 5 | | <ul style="list-style-type: none"> ● OPS UNDEFINED OR OPS NOT RESIDENT AND NOT OVERLAY INITIATOR ● OPS REQUEST CONTAINING INVALID MODE NUMBER ● PRO NOT COMPATIBLE WITH CURRENT FORMAT OR STEP IN CONTROL SEGMENT ● REQUESTED OPS NOT A LEGAL TRANSITION * ● NO TARGET GPC IN CONFIG TABLE WHEN OPS SELECTED * ● REQUEST REDUNDANT OPERATION OF SIMPLEX OPS * ● REQUEST MEMORY RECONF WHEN GPCs NOT IN OPS OO RUN * ● ATTEMPT TO ASSIGN PRIME GPC WHEN SELECTED GPC IS NOT PART OF AN RS ● REQUEST FOR DEU INIT WHEN GPC NOT IN OPS OO OR PL OPS 9 * ● NORMAL GMT UPDATE GREATER THAN 15 MS |

* Supported in PASS only.

| CRT ID | FAULT MESSAGE | | PASS | BFS | A L R M C L | SOFTWARE DRIVEN CAUTION & WARNING LIGHT | CONDITIONS |
|--------|---------------------------|-------------|--------------|--------------|----------------------------|--|---|
| | MAJOR FIELD | MINOR FIELD | OPS AVAIL | OPS AVAIL | | | |
| | | | Yes | Yes | 5 | * | <ul style="list-style-type: none"> • GMT OR MET DELTA UPDATE NOT ENTERED AND UPDATE REQUESTED • EXTERNAL DATA OUT OF LIMITS • INVALID ITEM NO. FOR DATA LOAD • ATTEMPT TO LOAD DATA VIA DISPLAY • INSUFFICIENT DIGITS ENTERED FOR ENG UNITS • ADD ID ON ODD WORD BOUNDARY WHEN 32 BIT FLOATING POINT OPTION IS SELECTED • SEQ READ REQ WITH NO ADD ID • EXEC LOAD WITH NO DATA • ATTEMPT TO WRITE INTO PROTECTED MEMORY WHEN MODE IS NOT CODE • SCALE CODE WITH BB 10 or A#1, 2 • EXEC LOAD WITH NO ADD ID • ADDRESS EXCEEDS MEMORY SIZE • DL DUMP ITEM EXEC IN MC1 • NO DUMP ADDRESS SPECIFIED • SELECTION OF DISPLAY NOT ASSOCIATED WITH CURRENT OPS • SPEC NOT ALLOWED IN CURRENT OPS * • TWO ACTIVE NON-RESIDENT FORMATS WHEN ANOTHER REQUESTED * • REQUEST SPEC WHEN TWO ARE ACTIVE • GPC DETECTED INPUT MSG SYNTAX ERROR |
| | I L L E G A L E N T R Y | | | | | | |

* Supported in PASS only.

| CRT ID | FAULT MESSAGE | | PASS OPS AVAIL | BFS OPS AVAIL | ALRM C L | SOFTWARE DRIVEN CAUTION & WARNING LIGHT | CONDITIONS |
|--------|---------------|-------------|----------------|---------------|----------|---|---|
| | MAJOR FIELD | MINOR FIELD | | | | | |
| | ILLEGAL ENTRY | | Yes | Yes | 5 | | <ul style="list-style-type: none"> ● EXEC NOT COMPATIBLE WITH CURRENT FORMAT OR STEP IN CONTROL-SEGMENT ● EXEC, OR ITEM WHEN NEW FORMAT IS BEING RETRIEVED ● INPUTS OTHER THAN MSG RESET, CLEAR, FAULT OR ACK IN MIDST OF OPS TRANSACTION ● GPC/CRT KEY ENTRY WITH CRT # 1-4, GPC # 0-5 |
| | MM OFF / BSY | | Yes | No | 3 | | <ul style="list-style-type: none"> ● OPS NOT IN ACTIVE GPC AND MMU OFF/BUSY ● REQUESTED MMU TRANSACTION WHEN MMU IS OFF/BUSY |
| | TIME | MTU | Yes | No | 3 | | ● AUTOMATIC TIME SOURCE CHANGE |
| | | TONE | Yes | No | 3 | | ● TIME MGT TIME TONE |

* Supported in PASS only.

APPENDIX G
LEGAL OPS/MODE TRANSITIONS

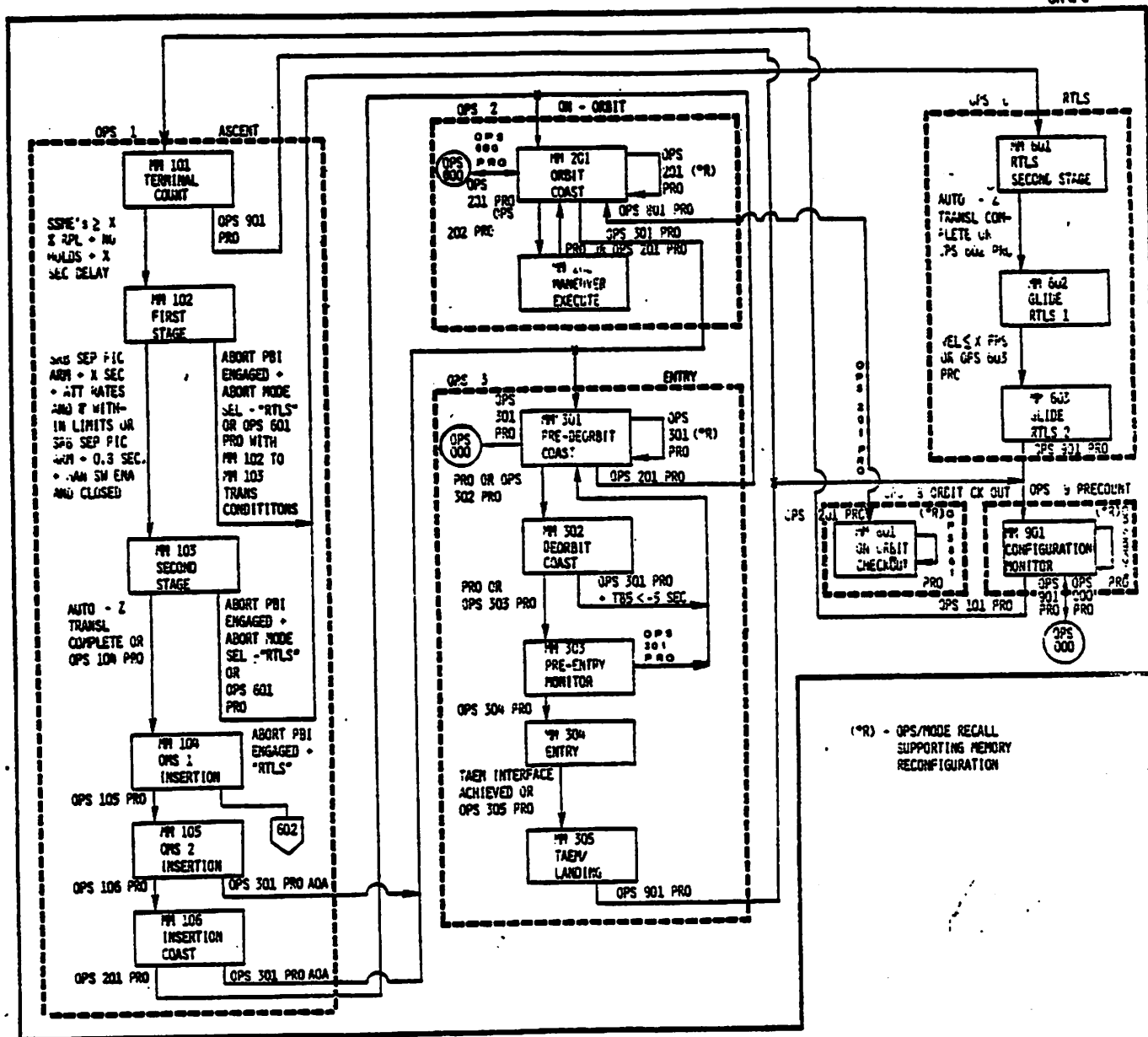
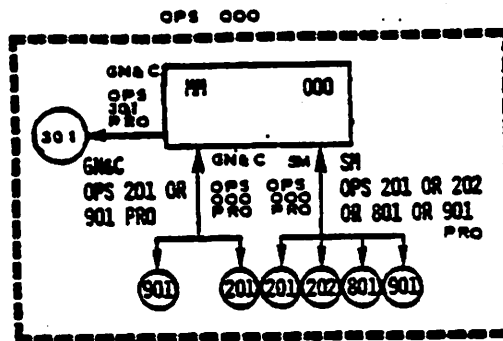


Figure G-1.- Legal OPS/mode transitions (sheet 1 of 2).

(*R) - OPS/MODE RECALL
SUPPORTING MEMORY
RECONFIGURATION



SM

PL

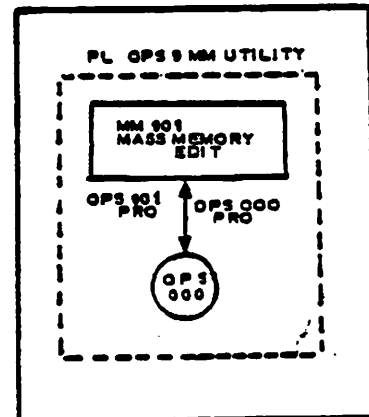
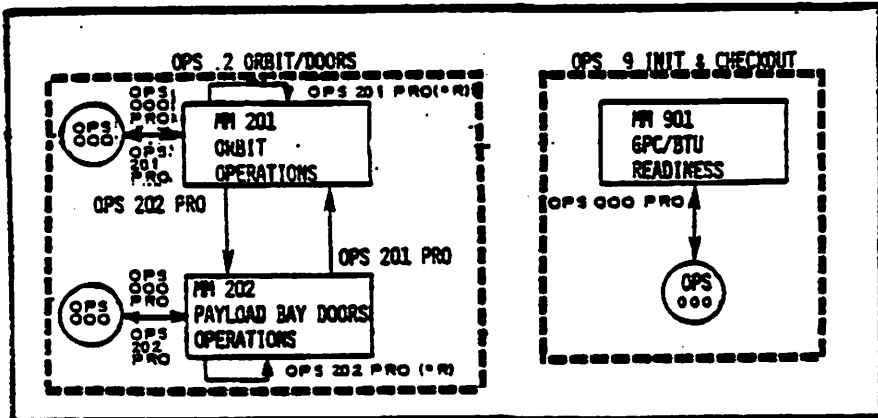


Figure G-1.- Legal OPS/mode transitions (sheet 2 of 2).

APPENDIX H
ACRONYMS/ABBREVIATIONS LIST

APPENDIX H - ACRONYMS/ABBREVIATIONS LIST

AA ACCELEROMETER ASSEMBLY
 ACCEL ACCELEROMETER
 ACK ACKNOWLEDGE
 ACT ACTIVATED
 ACTR ACTUATOR
 ACUM ACCUMULATOR
 ADD ADDRESS
 ADI ATTITUDE DIRECTOR INDICATOR
 ADTA AIR DATA TRANSDUCER ASSEMBLY
 ADU ANNUNCIATOR DISPLAY UNIT
 AID ANALOG INPUT, DIFFERENTIAL
 AIS ANALOG INPUT, SINGLE-ENDED
 AMI ALPHA MACH INDICATOR
 AOA ABORT ONCE AROUND
 AOD ANALOG OUTPUT, DIFFERENTIAL
 APC AFT POWER CONTROLLER
 APU AUXILIARY POWER UNIT
 ARS ATMOSPHERE REVITALIZATION SYSTEM
 ASA AEROSURFACE AMPLIFIER
 ASSY ASSEMBLY
 ATO ABORT TO ORBIT
 ATT ATTITUDE
 ATVCD ASCENT THRUST VECTOR CONTROL DRIVER
 AVVI ALTITUDE/VERTICAL VELOCITY INDICATOR

 BCE BUS CONTROL ELEMENT
 BFC BACKUP FLIGHT CONTROLLER
 BFS BACKUP FLIGHT SYSTEM
 BITE BUILT-IN TEST EQUIPMENT
 BRNG BEARING
 BSY BUSY
 BTU BUS TERMINAL UNIT
 B/V BLEED VALVE

 CAM COMPUTER ANNUNCIATION MATRIX
 C&D CONTROLS AND DISPLAYS
 C&W, C/W CAUTION AND WARNING
 CDR COMMANDER
 CICU COMPUTER INTERFACE CONDITIONING UNIT
 CL CLOSED
 CMC COMMAND MODULE COMPUTER
 CMD COMMAND
 CMPT COMPUTER
 CNTL, CNTRL CONTROL
 COMM COMMUNICATIONS
 COMP COMPARISON, COMPUTATION
 CON CONTACT
 COND CONDITIONER
 CONFIG CONFIGURATION
 CPDS COMPUTER PROGRAM DEVELOPMENT SPECIFICATION
 CPU CENTRAL PROCESSING UNIT

CRT CATHODE RAY TUBE
 CS COMMON SET
 CSM COMPUTER STATUS MATRIX
 CSTA CREW SOFTWARE TRAINING AID

 OBIA DATA BUS ISOLATION AMPLIFIER
 DOS DETAILED DESIGN SPECIFICATION
 DDU DISPLAY DRIVER UNIT
 DES DESELECT
 DEU DISPLAY ELECTRONICS UNIT
 D/H DISCRETE INPUT HIGH
 D/L DISCRETE INPUT LOW
 DISC DISCONNECT
 DISP DISPLAY FUNCTION
 DK DISPLAY/KEYBOARD
 D/L DOWNLIST, DOWNLINK
 DGH DISCRETE OUTPUT HIGH
 DOL DISCRETE OUTPUT LOW
 DPLR DOPPLER
 DPS DATA PROCESSING SUBSYSTEM
 DU DISPLAY UNIT

 ECLSS ENVIRONMENTAL CONTROL LIFE SUPPORT SUBSYSTEM
 EIU ENGINE INTERFACE UNIT
 EMER EMERGENCY
 EMI ELECTROMAGNETIC INTERFERENCE
 ENA ENABLE
 ENG ENGINE
 EPDC ELECTRICAL POWER DISTRIBUTION AND CONTROL SUBSYSTEM
 EPGS ELECTRICAL POWER GENERATING SUBSYSTEM
 EPS ELECTRICAL POWER SYSTEM
 ERR ERROR
 ET EXTERNAL TANK
 EXEC EXECUTE

 FA FLIGHT CRITICAL AFT
 FAULT SUMM FAULT SUMMARY
 FC FLIGHT CRITICAL
 FCOS FLIGHT COMPUTER OPERATING SYSTEM
 FCS FLIGHT CONTROL SUBSYSTEM
 FDA FAULT DETECTION AND ANNUNCIATION
 FDBK FEEDBACK
 FDLN FEEDLINE
 FDS FUNCTIONAL DESIGN SPECIFICATION
 FF FLIGHT CRITICAL FORWARD
 FL FILTER
 FML FAULT MESSAGE LINE
 FPC FORWARD POWER CONTROLLER
 FS FAIL-TO-SYNC
 FSSR FUNCTIONAL SUBSYSTEM SOFTWARE REQUIREMENTS

| | | | |
|----------|---|------------|--|
| FU | FUEL | LVL | LEVEL |
| FWD | FORWARD | LVLH | LOCAL VERTICAL LOCAL HORIZONTAL |
| GCIL | GROUND CONTROL INTERFACE LOGIC | MAJ FUNC | MAJOR FUNCTION |
| GMT | GREENWICH MEAN TIME | MAN | MANUAL |
| GNC | GUIDANCE, NAVIGATION AND FLIGHT CONTROL | MANF | MANIFOLD |
| GPC | GENERAL PURPOSE COMPUTER | MC | MEMORY CONFIGURATION |
| GR | GEAR | MCA | MOTOR CONTROL ASSEMBLY |
| GSE | GROUND SUPPORT EQUIPMENT | MCC | MISSION CONTROL CENTER |
| HDR | HIGH DATA RATE | MCD | MULTIFUNCTION CRT DISPLAY SYSTEM |
| HE | HELIUM | MCIU | MANIPULATOR CONTROLLER INTERFACE UNIT |
| HFE | HIGH FREQUENCY EXECUTIVE | MCM | MULTIPLEXER/DEMULTIPLEXER |
| HSI | HORIZONTAL SITUATION INDICATOR | ME | MAIN ENGINE |
| HSR | HARDWARE STATUS REGISTER | MEC | MASTER EVENTS CONTROLLER |
| HT | HALT | MED | MEDIUM |
| H/W | HARDWARE | MET | MISSION ELAPSED TIME |
| HYD | HYDRAULICS | MF | MAJOR FUNCTION |
| IC, ICC | INTER-COMPUTER COMMUNICATION | MFE | MID FREQUENCY EXECUTIVE |
| ID | IDENTIFICATION | MFO | MAJOR FUNCTION OVERLAY |
| I/F | INTERFACE | MIA | MULTIPLEXER INTERFACE ADAPTER |
| IGN | IGNITION | MLS, MSBLS | MICROWAVE SCANNING BEAM LANDING SYSTEM |
| IMU | INERTIAL MEASUREMENT UNIT | MM, MMU | MASS MEMORY UNIT |
| INBD | INBOARD | MGN | MONITOR |
| IND | INDICATION | MPS | MAIN PROPULSION SYSTEM |
| INH | INHIBIT | MS | MISSION SPECIALIST |
| INIT | INITIATION | MSEC | MILLISECOND |
| I/O | INPUT/OUTPUT | MSG | MESSAGE |
| IOP | INPUT/OUTPUT PROCESSOR | MTU | MASTER TIMING UNIT |
| IP | INSTRUMENTATION/PCMMU | NAV | NAVIGATION |
| IPL | INITIAL PROGRAM LOAD | NLG | NOSE LANDING GEAR |
| IPR | INPUT PROBLEM REPORT | NOM | NETWORK OUTPUT MULTIPLEXER |
| ISOL | ISOLATION | NORM | NORMAL |
| KB, KBU | KEYBOARD UNIT | NSP | NETWORK SIGNAL PROCESSOR |
| KYBD | KEYBOARD | N/W | NOSEWHEEL |
| LA | LAUNCH AFT | OF | OPERATIONAL FORWARD |
| LAT | LATERAL | OFT | ORBITER FLIGHT TEST |
| LB | LAUNCH/BOOST, POUND | OI | OPERATIONAL INSTRUMENTATION |
| LCH | LATCH | OMS | ORBITER MANEUVERING SYSTEM |
| LDB | LAUNCH DATA BUS | OP | OPEN |
| LDG | LANDING | OPS | OPERATIONAL SEQUENCE, OPERATIONS |
| LDR | LOW DATA RATE | ORB | ORBITER |
| LF | LAUNCH FORWARD | OSC | OSCILLATOR |
| LH | LEFT HAND | OUTBD | OUTBOARD |
| LH2 | LIQUID HYDROGEN | OWDE | ONE-WAY DOPPLER EXTRACTOR |
| LL | LAUNCH (SRB) LEFT | OX | OXIDIZER |
| LOX, LO2 | LIQUID OXYGEN | P | PRIMARY, PITCH |
| LR | LAUNCH (SRB) RIGHT | PASS | PRIMARY AVIONICS SOFTWARE SYSTEM |
| LRU | LINE REPLACEABLE UNIT | PBK | PUSHBUTTON INDICATOR |
| LTCH | LATCH | | PAYLOAD BAY KIT |

| | |
|--------|----------------------------------|
| PCM | PULSE-CODE MODULATION |
| PCMMU | PCM MASTER UNIT |
| PDI | PAYLOAD DATA INTERLEAVER |
| PET | PHASE ELAPSED TIME |
| PF | PAYLOAD FORWARD MOM |
| PFS | PRIMARY FLIGHT SYSTEM |
| PIC | PYRO-INITIATOR CAPACITOR |
| PL | PAYLOAD |
| PLB | PAYLOAD BAY |
| PLS | PAYLOAD SYSTEMS |
| PLT | PILOT |
| PNL | PANEL |
| POSN | POSITION |
| PRFLT | PREFLIGHT |
| PRI | PRIMARY |
| PRO | PROCEED |
| PROM | PROGRAMMABLE READ ONLY MEMORY |
| PRT | PORT |
| PT | PRIME GPC GMT |
| PUR | PURGE |
| PWR | POWER |
| QTY | QUANTITY |
| R | ROLL |
| RA | RADAR ALTIMETER |
| RAM | RANDOM ACCESS MEMORY |
| RCS | REACTION CONTROL SYSTEM |
| RCVR | RECEIVER |
| RD | REDUNDANT SET |
| RDR | RADAR |
| RDY | READY |
| RECIRC | RECIRCULATION |
| RG,RGA | RATE GYRO ASSEMBLY |
| RH | RIGHT HAND |
| RHC | ROTATIONAL HAND CONTROLLER |
| RJCS | REACTION JET CONTROL SYSTEM |
| RJDA | REACTION JET DRIVER AFT |
| RJDF | REACTION JET DRIVER FORWARD |
| RLF | RELIEF |
| RM | REDUNDANCY MANAGEMENT |
| RN | RUN |
| ROM | READ ONLY MEMORY |
| RPC | REMOTE POWER CONTROLLER |
| RPTA | RUDDER PEDAL TRANSDUCER ASSEMBLY |
| RS | REDUNDANT SET |
| RT | RIGHT |
| RTC | REAL-TIME COMPUTER |
| RTLS | RETURN TO LANDING SITE |
| S | SECONDARY |
| SBTC | SPEED BRAKE THRUST CONTROLLER |
| SCU | SEQUENCE CONTROL UNIT |
| SDPC | SHUTTLE DATA PROCESSING COMPLEX |

| | |
|----------|---------------------------------------|
| SEC | SECOND, SECONDARY |
| SEL | SELECT |
| SEQ | SEQUENCE, SEQUENTIAL |
| SEV | STATUS, ERROR AND VALIDITY |
| SF | SELECTION FILTER |
| SHT DN | SHUT DOWN |
| SIO | SERIAL INPUT/OUTPUT |
| SIP | SYSTEMS INTERFACE PROCESSING SOFTWARE |
| SM | SYSTEMS MANAGEMENT |
| SMRD | SPIN MOTOR RUN DETECTOR |
| SNSR | SENSOR |
| SPEC | SPECIALIST FUNCTION |
| SPI | SURFACE POSITION INDICATOR |
| SPL | SCRATCH PAD LINE |
| SPLY | SUPPLY |
| SRB | SOLID ROCKET BOOSTER SRT |
| SRT | SPECIAL RATED THRUST |
| SS | SPACE SHUTTLE |
| ST | STAR TRACKER |
| STAT | STATUS |
| STBY,SB | STANDBY |
| STON | SPACE TRACKING AND DATA NETWORK |
| STP | SELF-TEST PROGRAM |
| STRG | STRING |
| STS | SHUTTLE TRANSPORTATION SYSTEM |
| STU | STAR TRACKER UNIT |
| STWD | STOWED |
| SVC | SUPERVISOR CALL |
| S/W | SOFTWARE |
| SYNC | SYNCHRONIZATION |
| SYS | SYSTEM |
| SYS SUMM | SYSTEMS SUMMARY |
| TACAN | TACTICAL AIR NAVIGATION |
| TAEM | TERMINAL AREA ENERGY MANAGEMENT |
| TB | TALKBACK |
| TBD | TO BE DETERMINED |
| TBS | TO BE SUPPLIED |
| TDRS | TELEMETRY DATA RELAY SATELLITE |
| TEMP | TEMPERATURE |
| THC | TRANSLATIONAL HAND CONTROLLER |
| THROT | THROTTLE |
| TLM | TELEMETRY |
| TMP | TIME MANAGEMENT PROCESSOR |
| TNK,TK | TANK |
| T/RA | TACAN/RADAR ALTIMETER |
| TRKR | TRACKER |
| UI | USER INTERFACE |
| UMB | UMBILICAL |
| VAR | VARIABLE |
| VLV | VALVE |

| | |
|--------|---------------------|
| VU | VEHICLE UTILITY |
| WD,WDS | WORD(S) |
| WONG | WEIGHT ON NOSE GEAR |
| WOW | WEIGHT ON WHEELS |
| WT | WATCHDOG TIMER |
| XDCR | TRANSDUCER |
| XFEED | CROSSFEED |
| XMTR | TRANSMITTER |
| XPNDR | TRANSPONDER |
| XTRTR | EXTRACTOR |
| Y | YAW |
| μsec | MICROSECOND |
| msec | MILLISECOND |

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ALPHABETICAL INDEX

APPENDIX I
ALPHABETICAL INDEX

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