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Crew Software Interface
CSI 21002

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Final Version

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

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FOREWORD

This material is for training purposes only and should not be used as a source of operational data. All numerical data, displays, and checklist references are intended only as examples. Consult the applicable Certification Plan outlined in your certification guide or Crew Training Catalog to determine any prerequisites before using this document. This training package should be studied before attending any classroom session or lesson for which this is a prerequisite.

REVISION LOG

Rev. letter	Change no.	Description	Date
Basic		USA number issued; supersedes TD249. Updated for the solid state MMU; reworded CRT references to reflect current MEDS terminology, and added reference that an IDP should be ON for 30 seconds prior to power off	03/31/2003
A		Reviewed for OI-30 changes. Added copyright. Minor format and editorial changes. DCR# 159	08/04/2004
B		Biennial review. Added final version statement due to end of shuttle program.	04/14/2006

LIST OF EFFECTIVE PAGES

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

Page No.	Change No.
Foreword	Rev. B
i-ii	Rev. B
1-1 – 1-7	Rev. B
2-1 – 2-8	Rev. B
3-1 – 3-5	Rev. B
4-1 – 4-17	Rev. B
A-1 – A-2	Rev. B
B-1 – B-3	Rev. B
C-1 – C-3	Rev. B

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1.0   PASS SOFTWARE STRUCTURE

1.1   INTRODUCTION

This workbook is intended to introduce the reader to the interface between the crew and the shuttle Primary Avionics Software System (PASS) running in the General Purpose Computers (GPCs). A description of the PASS will be followed by a description of the orbiter display hardware and operations. The Backup Flight System (BFS) interface is similar to that of PASS but will not be discussed in this workbook.

1.2   OBJECTIVES

After reading this section, the student should be able to:

• Identify and describe the types of software that make up the PASS

• Describe the structure of PASS software

• Describe the nominal GPC configurations for all phases of flight

1.3   MAJOR FUNCTIONS

Two types of software that make up PASS may be processed by the GPCs onboard the shuttle orbiter, system software and applications software. System software is the housekeeping software that runs the GPCs and can be thought of as analogous to an operating system in a common computer. Applications software is the software that runs the orbiter.

Applications software is divided into three functional categories called major functions. The major functions are defined as follows:

a. Guidance, Navigation, and Control (GNC): All flight-critical software is contained in this major function. Flight-critical functions include navigation sensor management, aerosurface control for maneuvers, and trajectory calculations.

b. Systems Management (SM): All non-avionics systems are managed via this major function, including the electrical, environmental, and communications systems. Payload-related software is also contained in the SM major function.

c. Payloads (PL): This major function contains utility software that is used only in the event of a malfunction. Future flights may include some payload support software in PL; however, PL is generally unsupported. An unsupported major function is defined as any major function that, at a given time, is not being processed by any of the GPCs.

1.4   OPERATIONAL SEQUENCES AND MAJOR MODES

The major functions consist of segments of software called Operational Sequences (OPS). Each OPS contains software sufficient for control of a particular phase of flight; for example, OPS 1 controls the ascent phase. Each OPS consists of one or more Major Modes (MMs) of software. This structure of the PASS software is illustrated in Figure 1-1. Major modes contain software that controls a particular sub-phase of a phase of flight; for example, MM 102 controls the first stage of the OPS 1 ascent phase. Although not a true OPS, system software is also referred to as OPS 0.
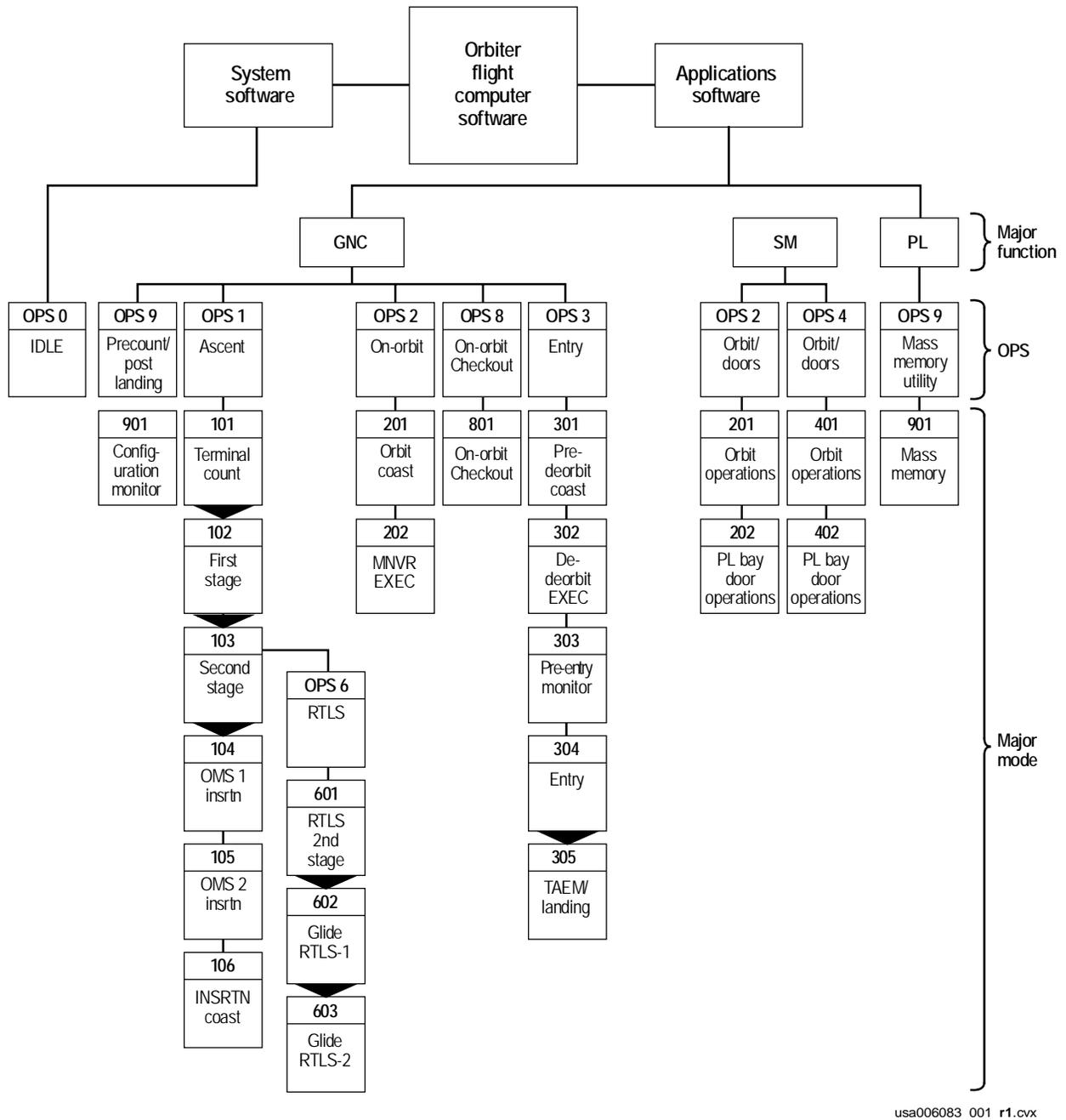
usa006083 001 **r1**.cvx

Figure 1-1. PASS software structure

Figure 1-2 illustrates a typical mission profile and the processing sequence of MM software within each flight phase. Prelaunch, the PASS GPCs process GNC, OPS 9, MM 901 software, or GNC OPS 901, for short. Note that OPS 901 in the PL major function is not the same software as GNC OPS 901.
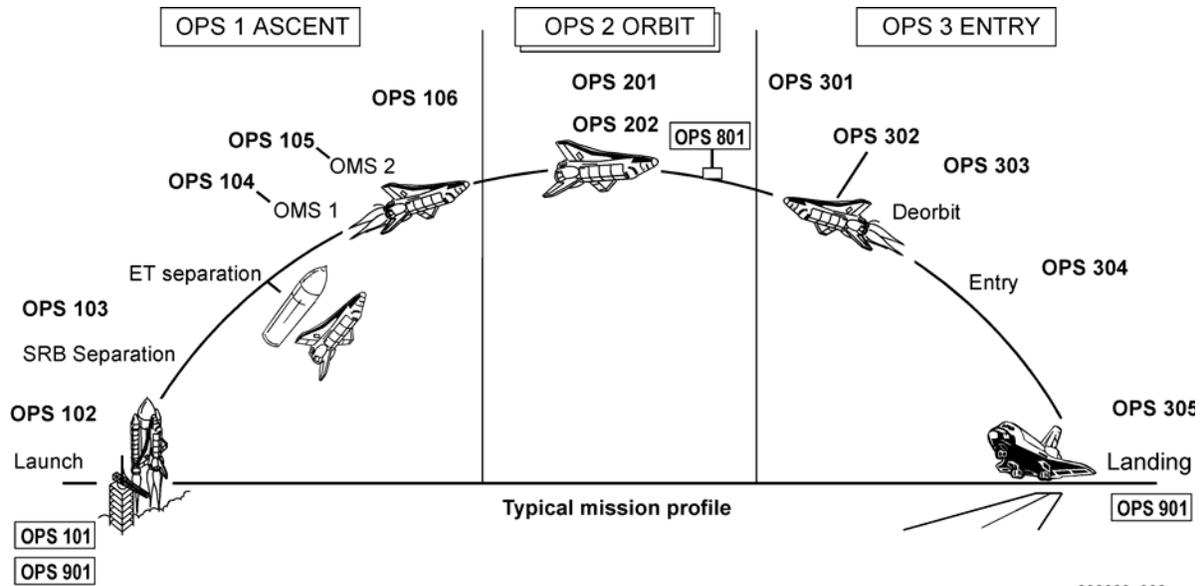
Figure 1-2. Mission phases with corresponding OPS and major modes

Approximately 20 minutes before launch, the GPCs are loaded with new software (OPS 1) from the orbiter Modular Memory Units (MMUs). The process of reconfiguring the GPC software from one OPS to another is called an OPS transition. All major modes of an OPS are loaded into the GPC during an OPS transition so that all of the software required to support a particular phase of flight is resident in GPC memory. The OPS 9 to OPS 1 transition prelaunch is commanded via ground support. The flight crew performs subsequent OPS transitions during the mission. The crew procedure for performing OPS transitions is discussed later.

After the OPS 1 transition, the GPCs begin processing GNC OPS 101 for terminal countdown. At Solid Rocket Booster (SRB) ignition on lift-off, the GPCs begin processing GNC OPS 102. The GPCs transition to subsequent OPS 1 major modes at various points along the ascent phase. The OPS 102 to 103 and OPS 103 to 104 transitions are performed automatically by the GPCs, based upon critical events, SRB separation and maneuver after External Tank (ET) separation, respectively. Subsequent MM transitions in OPS 1 are initiated manually by the crew. The automatic transitions are indicated by the dark triangles in Figure 1-1. The procedure to manually initiate MM transitions is discussed later. The vehicle establishes a safe orbit via burns of its Orbital Maneuvering System (OMS) engines in OPS 104 and OPS 105 (usually an OMS 1 burn is not required and only an OMS 2 burn is performed). OPS 106 provides orbit software in the interim between the ascent and orbit phases.

Once on orbit, the crew loads new software (OPS 2) from the MMUs into the GPCs. Vehicle control on orbit is maintained via the GNC OPS 201 software, while SM OPS 201 monitors and manages non-flight-critical and payload systems. During ascent and entry, the SM functions are performed by the BFS software. GNC OPS 202 is used for performing orbital maneuvers using the OMS engines, and SM OPS 202 is used for payload bay door operations. SM OPS 4 (see Figure 1-1) is not currently used but may be used in the future for additional payload operations. Typically, the day before entry, GNC OPS 801 software is temporarily processed on orbit to perform a checkout of the vehicle flight control and navigation systems that are used on entry.

The GPCs are reconfigured by the crew to process GNC OPS 3 for entry, beginning in MM 301. The GPCs transition to subsequent major modes at various points along the entry phase. The deorbit burn is executed in OPS 302. Vehicle preparation for entry into the atmosphere is performed by the crew in OPS 303. Atmospheric entry is achieved while in OPS 304. The final phases of entry, Terminal Area Energy Management (TAEM) and landing, are performed in OPS 305. Note from Figure 1-1 that all OPS 3 transitions, except the final MM transition, are manually performed by the crew. Postlanding, the GPCs again process the GNC OPS 901 software for vehicle safing.

For a GPC to successfully transition from one MM to another, or from one OPS to another, the transition must be "legal." A "legality tree" of transitions is predefined in the system software and allows the crew to perform certain manual transitions and prevents others. Most of the illegal transitions are those that are illogical as well; for example, there would be no need to transition the GPCs back to OPS 101 (terminal countdown) from any postlaunch MM. Hence the system software will not allow such a transition. The legal transitions are outlined in the Data Processing System (DPS) Dictionary of the Flight Data File (FDF).

Each MM has an associated DPS display called a major mode page, which provides the flightcrew with information and data specific to the MM subphase of flight. MM pages are interactive, which means that the crew can use MM pages to interact with the software. This is done by making keyboard inputs, referred to as item entries, to the MM page. Item entries are discussed in detail in Section 4.

In addition to MM pages, PASS provides interactive DPS displays called Specialist Functions, or SPEC pages. Some SPEC pages are used to interact with the system software (system-level SPECs), while others are used to perform specific tasks within major functions. The Display Functions, or DISP pages, are a third type of DPS display. Unlike MM and SPEC pages, DISP pages are non-interactive and are used by the crew only for viewing the values and status of certain parameters.

The emphasis of the following sections in this workbook is on accessing the three types of DPS displays, describing some of their common features, and discussing the means of crew interaction with the pages. A complete description of all DPS displays (MM, SPEC, and DISP pages) is given in the DPS Dictionary.

1.5   MEMORY CONFIGURATIONS

A GPC's memory consists of lower memory, where software is loaded for processing, and upper memory for software storage only (see Figure 1-3). System software (OPS 0) is loaded into a portion of the GPC's lower memory during the Initial Program Load (IPL). The IPL of the GPCs is nominally done pre-launch but may be performed by the crew during flight in the event of a malfunction. Once it is processing system software, a GPC may be loaded with one of the various modules of OPS applications memory. It is then referred to as a Memory Configuration (MC). There are eight PASS memory configurations and each is assigned a number, as shown in Figure 1-3. Each MC corresponds to one OPS.

MC#	Applications Software
1	*GNC* Ops 1/6 (Ascent/RTLS)
2	*GNC* Ops 2 (On-Orbit)
3	*GNC* Ops 3 (Entry)
4	*SM* Ops 2 (On-Orbit)
5	*SM* Ops 4 (On-Orbit)
6	*PL* Ops 9 (Preflight and On-Orbit)
8	*GNC* Ops 8 (On-Orbit Checkout)
9	*GNC* Ops 9 (Pre/Postflight)
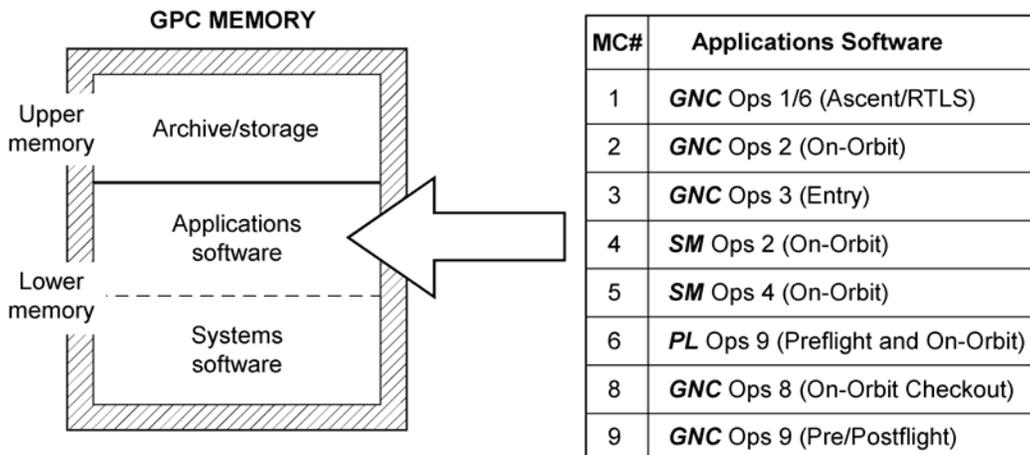
td249_003.cnv

Figure 1-3. GPC memory and applications software memory configurations

There is only enough room in a GPC's lower memory for the software necessary for the current mission phase. For example, only MC 1 is loaded for ascent. When orbit is achieved, the crew must load new software into the GPC's lower memory from the MMUs to perform on-orbit functions. Entirely new software is loaded for entry (MC 3). Entry software (GNC OPS 3) is also stored in the upper memories of the PASS GPCs, called the G3 Archive. The G3 Archive provides a source of entry software in addition to that available on the MMUs.

Five GPCs are onboard the orbiter. Nominally GPCs 1, 2, 3, and 4 are used for PASS, and GPC 5 is used for the BFS. Figure 1-4 shows the typical GPC configuration for the ascent, on-orbit, and entry phases of flight.

During the ascent phase of flight, all four PASS GPCs nominally process MC 1 software. GPC 5 processes the BFS software. On orbit, GPCs 1 and 2 typically process MC 2 software, while GPC 4 is the SM machine processing MC 4. GPCs 3 and 5 are normally "put to sleep" by the crew on orbit. Sleep is a GPC state whereby no software processes, and the GPC enters a power conservation mode. During entry, all four PASS GPCs process MC 3 software. It is important to remember that *a GPC can be loaded with and processing only one MC at a time*.

ASCENT

PASS GNC	PASS GNC	PASS GNC	PASS GNC	BFS
GPC 1	GPC 2	GPC 3	GPC 4	GPC 5

ON ORBIT

PASS GNC	PASS GNC	SLEEP	PASS SM	SLEEP
GPC 1	GPC 2	GPC 3	GPC 4	GPC 5

ENTRY

PASS GNC	PASS GNC	PASS GNC	PASS GNC	BFS
GPC 1	GPC 2	GPC 3	GPC 4	GPC 5

td249_004.cnv
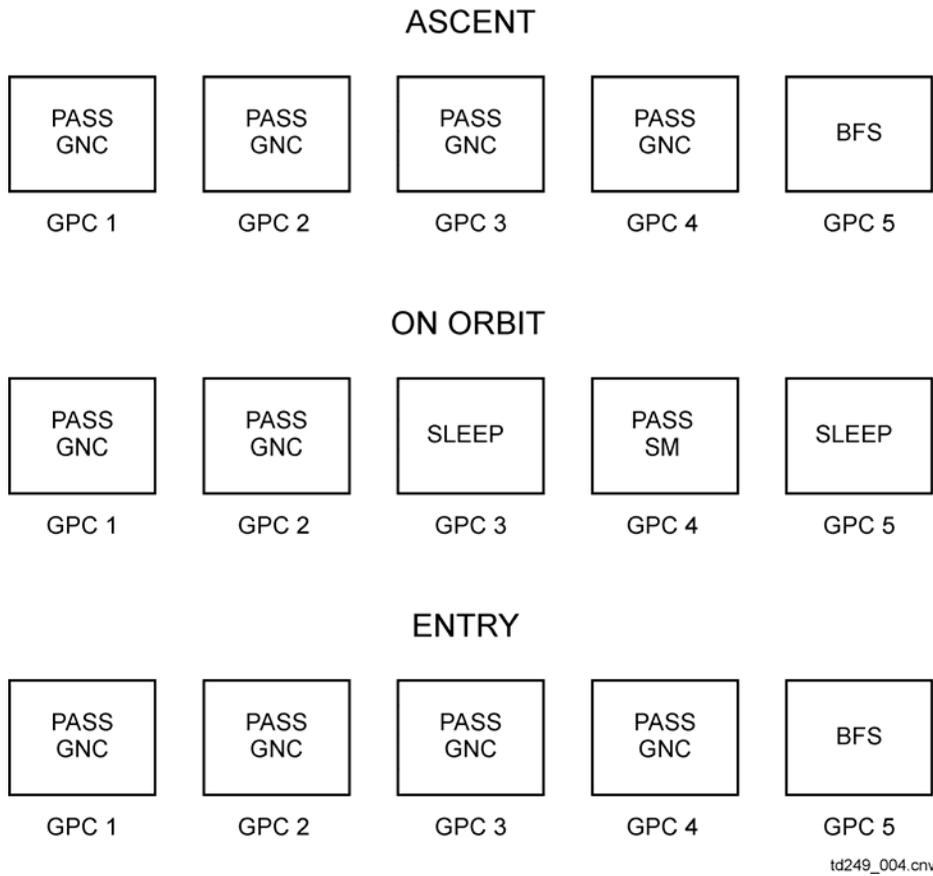
Figure 1-4. Typical GPC configurations for ascent, on-orbit, and entry phases

2.0   DISPLAY HARDWARE

2.1   OBJECTIVES

After reading this section, the student should be able to:

- Describe the functions of the Integrated Display Processor (IDP)/Cathode Ray Tube (CRT) switches: POWER, MAJ FUNC, and SEL (Select)

- Describe the function of keyboard keys

2.2   FORWARD COCKPIT MDUS

The Multifunction Electronic Display System (MEDS) in the forward shuttle cockpit includes nine Multifunction Display Units (MDUs), as shown in Figure 2-1 and two keyboards. MDUs can be configured to display a variety of data from the IDPs, including DPS displays, flight instruments, and other instrumentation known as subsystem displays. Only the use of PASS DPS displays is discussed in this workbook. DPS displays can be activated via the MDU edgekeys by selecting DPS from the MEDS Main Menu.

IDPs 1, 2, and 3 control the forward cockpit MDUs. Each CRT MDU is dedicated to a single IDP, while other MDUs can be controlled by two IDPs. On Panel C2, between the two forward keyboards (see Figure 2-2), are the POWER, MAJ FUNC, and SEL switches for the three forward IDP/CRTs.

The MDUs are full-color liquid crystal displays that replaced the monochrome CRTs and mechanical instruments that were used before MEDS. Operationally, the CRT MDUs are dedicated as DPS displays. The term "CRT" may be used here to refer to the DPS display from a given IDP, regardless of which MDU is actually being used. For example, CRT 3 can be used to refer to the DPS display on any MDU commanded by IDP 3. Located toward the bottom of each DPS display is a box with its commanding IDP number inside it.
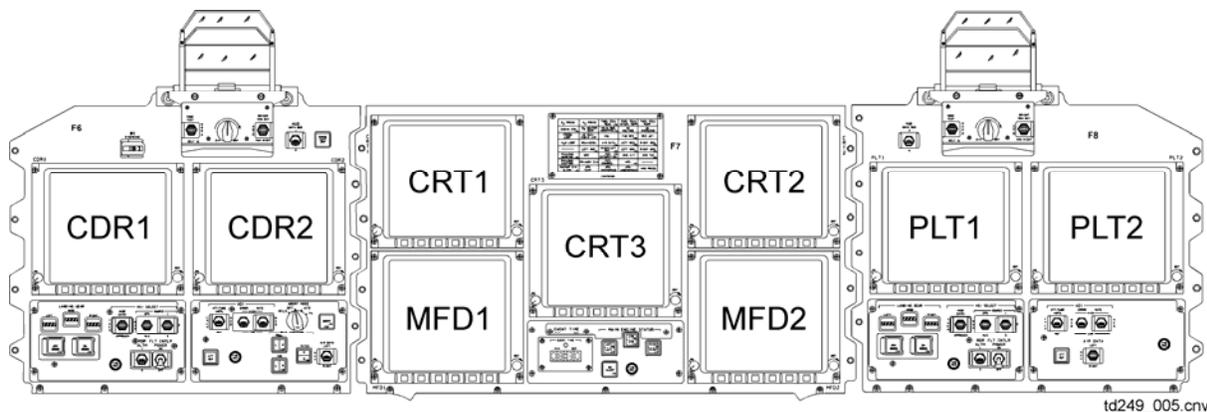
Figure 2-1. Forward cockpit displays
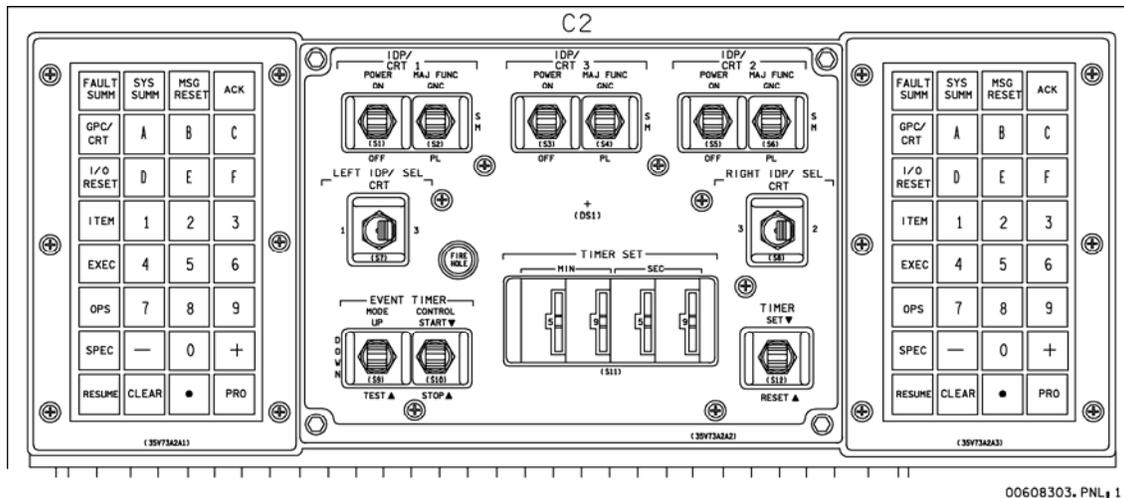
Figure 2-2. Panel C2

2.3 IDP/CRT POWER SWITCH

The left switch of each set of IDP/CRT switches is the IDP/CRT POWER switch. It is a two-position switch designated as follows:

ON - When placed in the ON position, power is applied to the IDP and the CRT MDU.

OFF - When placed in the OFF position, no power is applied to the IDP or CRT MDU.

An IDP should not be powered OFF unless it has been powered ON for at least 30 seconds.

2.4 IDP/CRT MAJ FUNC SWITCH

The right switch of each set of IDP/CRT switches is the IDP/CRT MAJ FUNC (major function) switch. It is a three-position switch labeled GNC (up position), SM (middle), and PL (down), corresponding to the three types of major function software. The crew can interact with a particular major function on a DPS display if the major function is supported; that is, if at least one GPC is processing that major function. The crew can choose which supported major function to interact with by selecting the desired position of the MAJ FUNC switch for that IDP/CRT. *The GPCs recognize the MAJ FUNC switch position, and a GPC processing the selected major function will respond by taking control of the DPS display.*

To illustrate the use of this switch, consider the on-orbit example where both GNC and SM are supported (see Figure 1-4). With the IDP/CRT 1 MAJ FUNC switch selected to the GNC position, the GPCs are in effect being told that the crew wishes to interact with GNC software; hence, a GNC GPC will drive the display (for multiple GPCs in one major function, the mechanism to select which GPC drives the display is discussed later). If the MAJ FUNC switch is moved from GNC to the SM position, the GNC GPC gives up command of the display, and the SM GPC takes over.

If the MAJ FUNC switch is moved to an unsupported position, the GPC commanding the display retains command; however, a system-level display (GPC Memory page) is shown. For example, on ascent and entry, nominally, only GNC is supported; if either the SM or PL switch position is selected, the default page appears. Selection of the PL position in any phase of flight results in the display of the default page, because PL is normally unsupported.

Although the PL major function software is not normally used for any flight, the PL position of the IDP/CRT MAJ FUNC switches is nominally used. By selecting PL, the GPCs are in effect being told that the crew does not want to interact with either GNC or SM GPCs. This allows the crew to then assign the display to an OPS 0 GPC via keyboard entry, as discussed in Section 4 (an OPS 0 GPC is one that processes system software only). In fact, *the only way that the crew can interact with an OPS 0 GPC is to first take the IDP/CRT MAJ FUNC switch to an unsupported position.* One nominal procedure performed with OPS 0 GPCs is the Freeze Dry operation (refer to the DPS Overview 21002 Workbook).

2.5   IDP/CRT SEL SWITCHES

Directly below the three sets of IDP/CRT switches are two IDP/CRT SEL switches. Because there are only two forward keyboards, each has the capability of talking to two of the forward IDPs. Keyboard bars are displayed to the left and/or right of the IDP identifier box on the DPS display. The red bar represents the commander's (left) keyboard. The yellow bar represents the pilot's (right) keyboard. The IDP/CRT SEL switch on the left controls IDP assignment for the left, or commander's, keyboard. It has two positions, 1 and 3. The function of each position is listed below:

a.   (left) position - The left keyboard is connected to IDP 1 and a red bar is displayed to the left of IDP 1's identifier box on the DPS display.

b.   (right) position - The left keyboard is connected to IDP 3 and a red bar is displayed to the left of IDP 3's identifier box on the DPS display.

The SEL switch on the right controls IDP assignment for the right, or pilot's, keyboard. The function of each position is as listed below:

a.   (right) position - The right keyboard is connected to IDP 2 and a yellow bar is displayed to the right of IDP 2's identifier box on the DPS display.

b.   (left) position - The right keyboard is connected to IDP 3 and a yellow bar is displayed to the right of IDP 3's identifier box on the DPS display.

When both keyboards are selected to IDP 3, the crew should take care not to use both keyboards simultaneously. The keystrokes from both keyboards will mix and the result will be scrambled input. *Before using a keyboard, the crew should verify that the IDP/CRT SEL switch position is selected for the display for which the keyboard inputs are intended.*

2.6 AFT STATION MDUS

In addition to the forward displays, there are two MDUs (CRT 4 and AFD 1) and a supporting IDP in the aft crew station. IDP/CRT 4 and its associated keyboard are found on panel R11, shown in Figure 2-3. The IDP/CRT POWER switch is next to the keyboard and the MAJ FUNC switch is just below the power switch. This keyboard can communicate only with IDP 4, so there is no associated IDP/CRT SEL switch. Neither of the forward keyboards can communicate with IDP 4. There is no keyboard bar associated with the aft keyboard. IDP 4's DPS display does have an IDP identifier box.
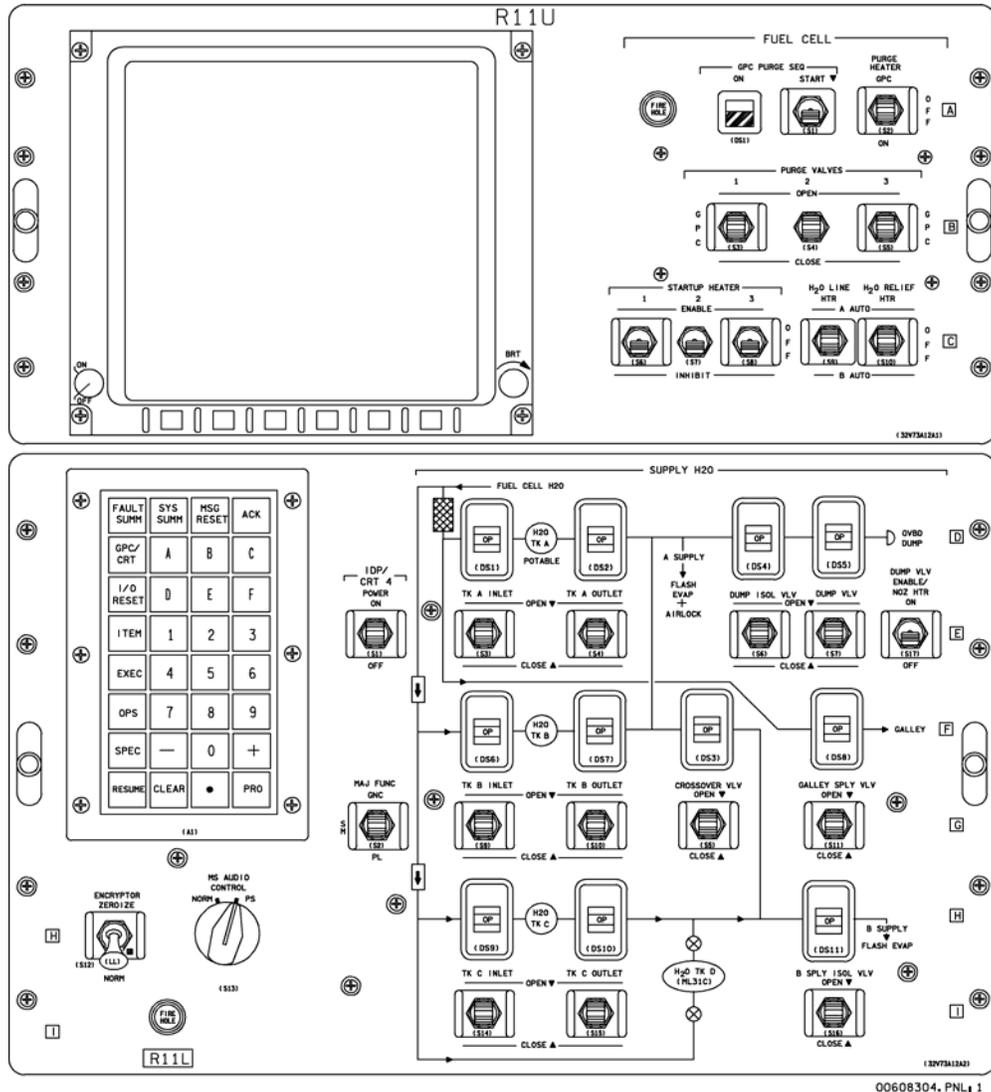
Figure 2-3. Panel R11

2.7 THE KEYBOARD

Each keyboard is composed of a 4 by 8 matrix of pushbutton keys, as shown in Figure 2-4. The keys are described as follows:

a. Sixteen alphanumeric keys designated 0 through 9 and A through F, for decimal and hexadecimal numbering systems.

b. Two sign keys (+ and -) serving the dual roles of sign indicators and delimiters. A delimiter is used to separate discrete keyboard entries from their associated data, as discussed in Section 4.

c. One decimal point key for use in entering data with decimal notation.

d. Thirteen special function keys. Some of these are single-stroke command keys and some are keys that start or finish a multistroke command sequence. A key that starts a command sequence is a command initiator and requires a command terminator key to be depressed to tell the IDP the keyboard entry is complete.
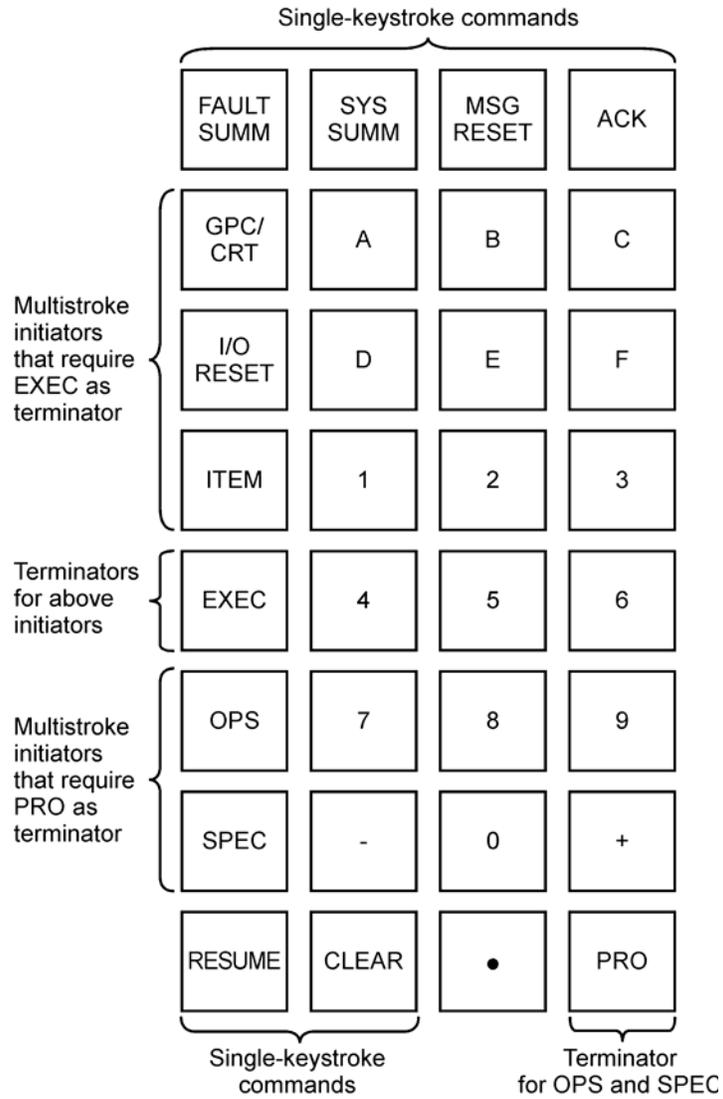
Figure 2-4. Keyboard found on panels C2 and R11

A summary of the key functions is given below. Subsequent sections describe their use for particular keyboard operations.

Key	Description
ACK	The Acknowledge key acknowledges receipt of a fault message on the fault message line the first time the key is depressed by causing the message to go static and turning off the SM Alert light and tone. The fault message line is the second to last line on DPS displays (see Figure 3-1). Subsequent depressions of the key will scroll through any additional fault messages in the message buffer one at a time in the order in which the messages were received.
MSG RESET	The Message Reset key operates as a single-keystroke command that clears both the currently annunciated fault message and the buffer message indicator (if any) from the fault message line. Depressing this key will also extinguish the SM Alert light and tone.
SYS SUMM	This key is used to invoke a Systems Summary Display Function (DISP) page (see Figure 4-9). The particular display called is determined by the selected major function and active OPS.
FAULT SUMM	This key is used to invoke the Fault Summary DISP page (see Figure 4-8). It operates as a single keystroke command. The FAULT display can be accessed in every major function and OPS.
GPC/CRT	The GPC/CRT key initiates a multistroke keyboard entry, allowing the selection of a particular GPC to drive a particular IDP's DPS display (see Section 4).
I/O RESET	The Input/Output (I/O) Reset key attempts to restore a GPC's I/O configuration to its original status prior to any I/O error detection. It is a command initiator and requires a terminator keystroke (see Section 4).
ITEM	The Item key is used as a multikeystroke command initiator for changing the value of defined parameters or implementing configuration changes on a given display (see Section 4).
EXEC	The Execute key acts as a terminator for the initiators GPC/CRT, I/O RESET, and ITEM keys. When depressed, the specified command is executed.

Key	**Description**
OPS	The OPS key serves as a multi-keystroke command initiator to load desired OPS into one or more GPCs. It is also used to transition from major mode to major mode within an OPS (see Section 4).
SPEC	The Specialist Function/Display Function key acts as a multikeystroke command initiator to select a defined SPEC or DISP page within a given OPS (see Section 4). In addition, this key provides the capability to freeze a DPS display. A single depression of the SPEC key freezes the display so it may be statically viewed. The display remains frozen until another key (other than ACK, MSG RESET, or another SPEC) is depressed.
PRO	The Proceed key serves as a terminator to the OPS and SPEC keys. The completed command sequence initiates the selection of a desired OPS, SPEC, or DISP.
RESUME	The Resume key is used to terminate a displayed SPEC or DISP. Control is restored to the underlying display upon depression of this key (see Section 4).
CLEAR	Depression of the Clear key clears the last echoed keystroke from the bottom line (scratch pad line) of the DPS display (see Figure 3-1). For each depression, one additional keystroke is removed, proceeding from right to left. After a command sequence is completed, a single depression of the Clear key erases the static command from the scratch pad line.

3.0   STANDARD DISPLAY CHARACTERISTICS

3.1   OBJECTIVES

After reading this section, the student should be able to recognize the standard display features, formats, and symbols.

3.2   STANDARD FORMAT

Recall from Section 1 that there are three types of DPS displays: major mode pages, SPEC pages, and DISP pages. A standard format exists so that certain data fields are common to all DPS displays. The common data fields are shown in Figure 3-1 and are described in the text that follows.
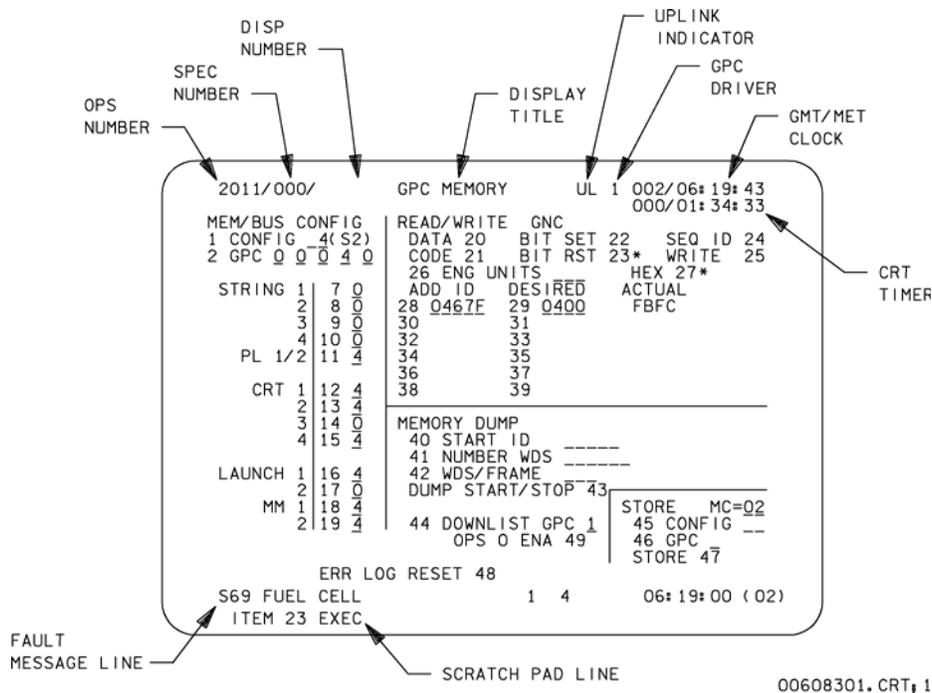
Figure 3-1. Data fields common to all displays

OPS number. The four-digit field in the upper left corner of the first line designates the number of the OPS being processed by the GPC driving the display. The first digit represents the OPS; the next two digits indicate the major mode. Hence, the first three digits indicate the major mode page. The last digit is always a "1."

SPEC number. Directly to the right of the OPS number is a three-digit field that displays the number of the active SPEC. When called up, a SPEC overlays the major mode page. This field is blank if no SPEC is selected.

DISP number. The last three-digit field in the upper left corner represents the DISP number. When called up, a DISP overlays the SPEC and major mode pages. This field is blank if no DISP is currently being displayed.

Display title. Centered on the top line is the title of the display.

Uplink indicator. Directly to the right of the display title is a two-space field. When an uplink to the vehicle is in progress, a flashing "UL" is displayed. Otherwise, this field is blank.

GPC driver. To the right of the uplink indicator is a one-digit field. A number in this field indicates the particular GPC (1, 2, 3, 4, or 5) that is commanding the IDP's DPS display.

GMT/MET clock. This field displays the Greenwich Mean Time (GMT) or the Mission Elapsed Time (MET) in DDD/HH:MM:SS. The field is updated every second. GMT or MET is selected via a keyboard entry to the TIME SPEC, as described in Section 4.

CRT Timer. Directly below the GMT/MET clock is a CRT timer field also displayed in days, hours, minutes, and seconds (DDD/HH:MM:SS). This field is updated every second, and can be set via a keyboard entry to the TIME SPEC, as described in Section 4.

Fault message line. The second line from the bottom is reserved for fault messages. Illegal keyboard entry messages and systems fault messages are displayed on this line. Fault messages are discussed in Section 4.

Scratch pad line. The bottom line of the display echoes keyboard entries made by the crew. Command initiators (OPS, SPEC, ITEM, GPC/CRT, and I/O RESET) flashes on the scratch pad line until the command is terminated. The keystrokes remain on the scratch pad line in a static mode until (a) a new command is initiated, (b) the Clear key is depressed, or (c) the major function switch position is changed. Syntax errors detected by the IDP result in a flashing "ERR" on the scratch pad line following the keyboard entry, as discussed in Section 4.

3.3   SPECIALLY DEFINED SYMBOLS

Special symbols include an asterisk "*" and a set of parameter status indicators. Parameter status indicators are displayed in "overbright" intensity for quick recognition. These special symbols are defined as follows and are illustrated in Figure 3-2.

M   This symbol indicates missing data. It is displayed directly to the right of the affected parameter, as shown on SM SYS SUMM 1 in Figure 3-2. The parameter value may be blanked or the last value received by the GPC may be displayed. If data is missing for a parameter that has no numerical value associated with it, an M is used to indicate the parameter status. An example of this is on GNC SYS SUMM 1 in Figure 3-2.

H This symbol indicates that a parameter is off-scale high. This indicates that a transducer limit has been reached and that the scale is registering its highest possible value. The actual parameter being measured may, in fact, be higher than the recorded data, but the instrument in use does not have the capacity to measure the value. Off-scale-high indicators do not appear on the display until several (normally two) consecutive readings have verified this finding. This symbol is displayed to the right of the data affected (see SM SYS SUMM 1).

L This symbol indicates off-scale-low parameters. This means that the parameter value displayed is the lowest possible reading due to transducer limitations. The actual value of the parameter may exceed the displayed value, but the range of the hardware is not defined to evaluate this reading. As with the "H," the off-scale-low indicator is not displayed until a set number of consecutive readings have verified this status (see SM SYS SUMM 1).

```
 2011/094/078        SM SYS SUMM 1      4 000/02:48:16
                                          000/00:00:00
           EMERGENCY
 SMOKE        1/A     2/B   DC VOLTS     1/A     2/B     3/C
 AV BAY 1-  0.0  -  0.0       FC        31.4    31.4    31.2
        2-  0.0  -  0.0       MAIN      31.2    31.1    31.3
        3-  0.0  -  0.0       CNTL AB   30.1    30.1    30.0
 dP/dT      ±.00                   BC   30.0    30.0    30.0
                                   CA   30.0    30.0    30.0
           CABIN              ESS       29.9    30.0    30.0
 PRESS     15.7↑       AC
 PPO2       3.04   3.04     VOLT Φ A     117     114M     0↓
 FAN ΔP     6.43                Φ B     117     114M     0↓
 HX OUT T   145H                Φ C     117     114M     0↓
 O2 FLOW    0.0L   0.0L     AMPS Φ A     2.2     3.0     2.4
 N2 FLOW    0.0L   0.0L          Φ B     2.2     3.2     2.4
                                Φ C     2.      3.2     2.1
 IMU FAN   A    B*   C      FUEL CELL
  ΔV  FC1   FC2   FC3        AMPS        156     158     0L↓
 SS1   23    26    26        REAC VLV     OP      OP     CL↓
 SS2   18    22    13        STACK T    +202   +300H  +100↓
 SS3    9    13    13        EXIT  T     151     151     151
 TOTAL AMPS    463           COOL  P      61      61      61
           KW    14            PUMP

  SYS SUMM
```

00608305.CRT 1

Figure 3-2. Parameter status indicators

```
1031/051/018    GNC SYS SUMM 1      4 000/00:04:04
                                      000/00:04:04
RCS   JETISOL
MANFFAILVLV     SURF     POS   MOM   DPS    1 2 3 4 5
  F1    OP     L OB                       GPC    |
   2    CLM      IB                   MDM FF    |
   3    OP     R IB                       FA    |
   4    OP       OB
   5           AIL
  L1    OP     RUD                    FCS CH 1 2 3 4
   2    OP     SPD BRK                          M
   3    CLM    BDY FLP
   4    OP
   5                                 NAV    1 2 3 4
  R1    OP                            IMU  ? M ?
   2    OP                            ACC    M
   3    CLM    CNTLR   1 2 3          RGA    M
   4    OP     RHC   L                TAC
   5                 R                MLS
                     A                ADTA
               THC   L
                     A
               SBTC  L
                     R
```

00608306.CRT;1

```
2011/001/006    GPC/BUS STATUS      4 000/02:30:53
                                      000/00:00:00
        GPC| 1    2    3    4    5
       MODE| RUN  RUN  RUN  RUN  HALT
        OPS| G2   G2   0    S2   0
STRING 1 FF| *              |    |
         FA| *              |    |
       2 FF|      *         |    |
         FA|      **        |    |
       3 FF|      **        |    |
         FA|      *         |    |
       4 FF| *              |    |
         FA| *              |    |

       PL 1| |    |    |    *
          2| |    |    |    **
   LAUNCH 1| |    |    |    **
          2| |    |    |    |
      CRT 1| *    |    |    |
          2| |    |    |    *
          3| |    |    |    |
          4| |    |    |    |

SPEC 6 PRO
```

00608307.CRT;1

Figure 3-2. Parameter status indicators (concluded)

↑   This symbol, displayed to the right of the affected parameter, indicates a parameter driven out-of-limits high, as shown on SM SYS SUMM 1 in Figure 3-2. The value displayed is a true reading but has equaled or exceeded the operational high limit established by the software. The Fault Detection and Annunciation (FDA) software keeps track of the low and high limits for each parameter and annunciates any violation of these limits to the crew by displaying the appropriate "↑" or "↓" next to the parameter on the appropriate display. If the transducer limit is the same as the operational limit, the H symbol overrides the ↑ symbol. (Several (normally two) consecutive readings verify this status before the ↑ symbol is displayed.)

↓   This symbol is the counterpart to the "↑" symbol. It indicates that a parameter value is equal to or less than the operational low limit. The value displayed is outside the software limits placed upon the parameter. When the software limit established is the same as the transducer limit, the L symbol takes precedence over the ↓ symbol. A set number of consecutive readings verifies this indication before the ↓ is displayed. In addition, the ↓ symbol is used to indicate a discrete state that does not agree with the nominal state. For example, a high-pressure gas supply valve state reading "closed" when its position is normally "open" would drive the ↓ symbol.

     The ↓ is also used to indicate that a hardware unit has been declared failed by a GPC, as shown in the GNC SYS SUMM 1 page of Figure 3-2.

?   This symbol indicates a Redundancy Management (RM) dilemma, as shown on the GNC SYS SUMM 1 page in Figure 3-2. A dilemma is annunciated if two hardware units measuring the same parameter disagree, and the software cannot isolate which of the two is failed. As a result, a "?" will be displayed for both units.

*   This symbol indicates an active state, as on the GPC/BUS status page in Figure 3-2. It is also used to show the selected item of mutually exclusive items. An example of this is shown on the TIME SPEC of Figure 4-3.

4.0   KEYBOARD OPERATIONS

4.1   OBJECTIVES

After reading this section, the student should be able to:

- Describe how to implement OPS transitions and MM transitions

- Describe how to call up and remove DPS displays

- Recognize that only some DPS displays are retained during different types of transitions

- Recognize the item numbering scheme and be able to implement various types of item entries

- Explain how to assign a GPC to an IDP

4.2   OPS TRANSITIONS

As introduced in Section 1, the process of loading and processing a new memory configuration in GPC lower memory is called an OPS transition. *There are three criteria that must be met before the crew can perform an OPS transition via keyboard entry.*

1. The transition must be legal, as described in Section 1.

2. The display used for the keyboard entry must have its MAJ FUNC switch in the position of the desired major function software.

3. A GPC that is targeted for the new software must be commanding the display used for the keyboard entry.

As an example, consider the OPS transition to load SM OPS 2 into GPC 4 for SM orbit operations. If the crew uses IDP 1 for the keyboard entry, the IDP/CRT 1 MAJ FUNC switch must be in the SM position to meet criterion 2, and GPC 4 must be driving the display to meet criterion 3. Finally, the transition must be allowed by the system software legality tree to meet criterion 1. An additional requirement states that GPC 4 must be "targeted" in the software for the OPS transition. Defining target GPCs is done via keyboard entry to the Memory/Bus Configuration table on the GPC MEMORY page (see Figure 4-4) and is discussed in the DPS Overview 21002 Workbook.

Once the criteria are met, the crew with a three-step keyboard entry can command the OPS transition.

1. Depress the OPS key.

2. Key in the three numbers of the desired OPS. The first digit specifies the OPS and the next two digits specify the major mode. Generally, a new OPS is called from mass memory by its first major mode.

3. Depress the PRO (Proceed) key.

Continuing with the preceding example, once the criteria for the OPS transition are met, to perform the SM OPS 2 transition using IDP 1 the crew would use the left keyboard, ensure that the left IDP/CRT SEL switch is in the "1" position, and input the following keystrokes:

| OPS | 2 | 0 | 1 | PRO |

td249_013.cnv
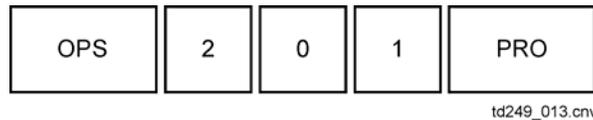
If the three criteria for the OPS transition are not met, an "Illegal Entry" message appears on the fault message line as a result of the keyboard entry, and the OPS transition does not begin.

If the OPS transition is successfully commanded, the targeted GPC(s) will stop processing their old OPS, temporarily process only system software (OPS 0), load all the MMs of the new memory configuration from mass memory, and begin processing the new OPS. The immediate indication to the crew that the OPS transition is completed is that the display used to command the transition displays the appropriate MM page. An updated OPS number appears in the upper left corner.

4.3   MAJOR MODE TRANSITIONS

To transition a GPC from processing one MM to another within an OPS does not require mass memory access for additional software since all major modes of an OPS are resident in GPC memory. However, only one major mode at a time is processed by a GPC, and the GPC must transition from processing one MM to another. As pointed out in Section 1, the time-critical major mode transitions are performed automatically by the GPCs. Other MM transitions are performed manually by the crew. This is done via the same sequence of keyboard inputs as in an OPS transition, after the same criteria as for an OPS transition are met.

Again continuing with the preceding example, to transition GPC 4 from SM OPS 201 to SM OPS 202 using IDP 1, the crew places IDP/CRT 1 MAJ FUNC switch in the SM position and verifies that GPC 4 is driving the display. Then, using the left keyboard with the IDP/CRT SEL switch in the "1" position, the following keyboard inputs are made:

td249_014.cnv
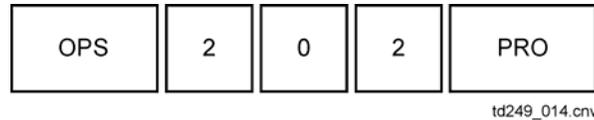
As discussed in Section 1, a legality tree of MM transitions is active in the system software; if the requested MM transition is not allowed, an "Illegal Entry" appears on the fault message line. If the transition is successful, as in this example, the immediate indication to the crew is the display of the appropriate major mode page with an updated OPS number.

4.4   ACCESS OF SPEC OR DISP PAGES

Within each OPS, certain SPEC and DISP pages are available. A complete list of available displays is found in the DPS Dictionary. The steps for calling up a SPEC or a DISP are as follows:

1. Depress the SPEC key. The SPEC key is used in calling both SPEC and DISP pages.

2. Key in the SPEC or DISP number omitting all leading zeros. SPEC and DISP numbers have three digits. They are differentiated by their numbering scheme. The display is a DISP only if the first digit is a 9, or if the last digit is a 6-9.

3. Depress the PRO key.

The following keystrokes would result in the display of DISP page 006.

td249_015.cnv
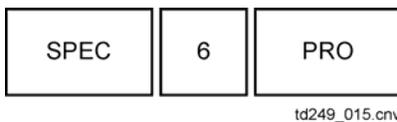
Major mode pages, SPEC pages, and DISP pages represent the three levels of DPS displays. The display hierarchy is illustrated in Figure 4-1. Major mode pages form the "base" page. A SPEC that overlays the MM base page may be called up; the base page remains active under the SPEC. The third level of display, a DISP page, may be called to overlay the SPEC. Recall from Section 1 that MM and SPEC pages are interactive, while DISPs are noninteractive. The keyboard entries to select new MM pages, SPECs, and DISPs and entries to move from one level of DPS display to another are also shown in Figure 4-1.

A SPEC need not be selected to call a DISP. If a DISP is on the display and another SPEC or DISP is called, the current DISP is terminated (i.e., removed from the display). The terminated DISP can be viewed again only by entering the calling command once more.

If a SPEC is selected and a DISP is called to overlay it, the SPEC is retained underneath the DISP. If another SPEC is then selected, the underlying SPEC is terminated, as is the DISP over it. The terminated SPEC can be viewed again only if it is recalled.

The RESUME key is used as a single-keystroke entry to terminate the SPEC or the DISP currently being displayed and to restore the underlying display. If the display being terminated is a DISP, control is restored to the underlying SPEC, or to the MM page if no SPEC has been selected. If a SPEC display is terminated, control is restored to the MM page.

The RESUME key cannot be used to transition from one OPS major mode display to another, nor can it be used to page backwards through OPS displays.
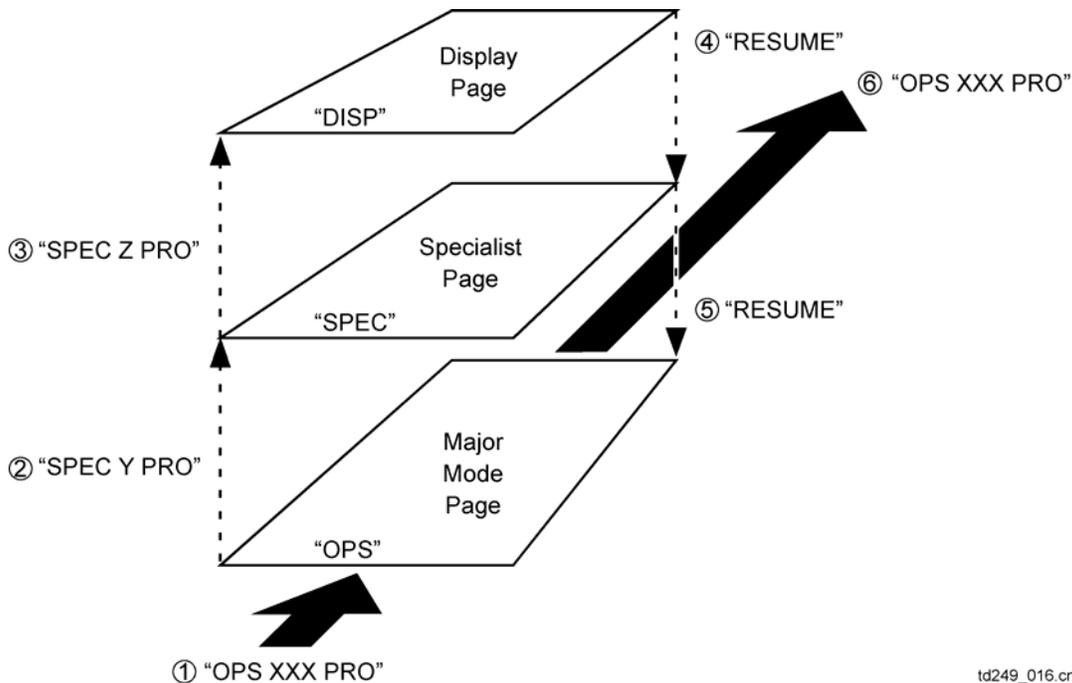
**Figure 4-1. DPS display hierarchy and keyboard entries
resulting in display changes**

When an MDU is supporting all three levels of DPS displays, OPS transitions and major function switch throws cause some displays to be resumed. The summary of display retention is given in Figure 4-2 and described below.

As an example of display retention for major function changes, consider the case of IDP 1 supporting a major mode page, overlayed by a SPEC, overlayed by a DISP in the GNC major function. If the IDP/CRT 1 MAJ FUNC switch is taken to SM or PL, then back to GNC, the original SPEC would be displayed with the major mode page active underneath; the DISP page is not retained.

On a MM transition, both a SPEC and a DISP would be retained through the transition. The new major mode page would be active underneath (recall that the OPS number on the display is updated to inform the crew the transition is complete). It makes sense that SPECs and DISPs are retained on MM changes if one keeps in mind that some MM changes are automatic on time-critical events, and that the crew may not want to have to recall the displays after the events.

On an OPS transition, neither SPECs nor DISPs are retained through the transition because this involves loading an entirely new software module. The SPECs and DISPs may be called up again after the transition, if they are available in the new OPS.
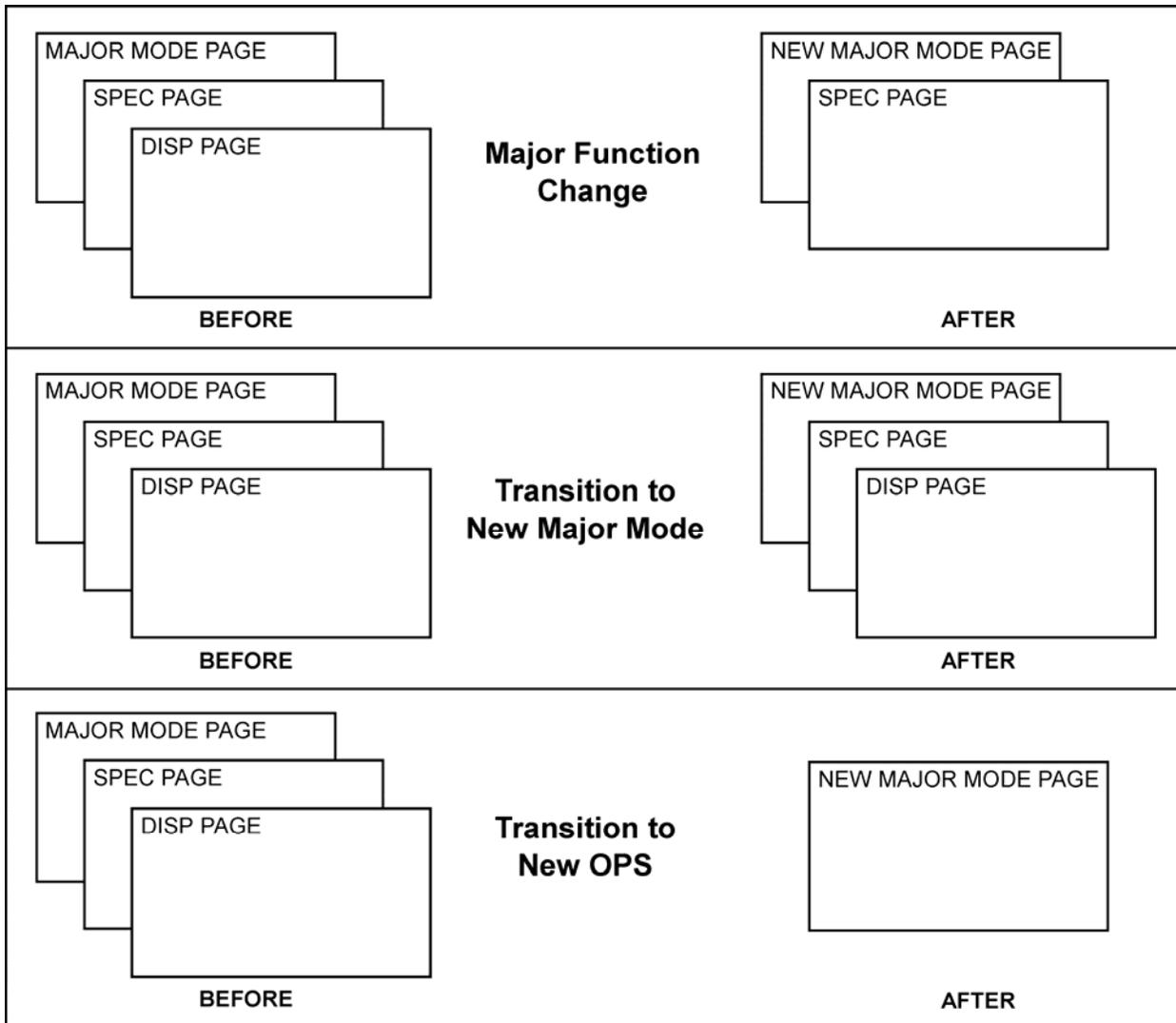
Figure 4-2. Summary of display retention

4.5   ITEM ENTRIES

Within major mode and SPEC pages, keyboard operations may be performed by the crew to alter the status or data fields of certain parameters. Those parameters, which may be altered, are identified on the display by item numbers, which are a maximum of two digits. The keyboard operation to alter a parameter is referred to as an item entry. There are two basic types of item entry, those that change the status or configuration of a parameter, or "toggle" entries and those that change the data associated with a parameter, or "data" entries. Figure 4-3 shows SPEC 2, the "TIME" SPEC, which is used here to demonstrate item entries. SPEC 2 allows the crew to interact with various clocks onboard the orbiter.

Typical purposes of toggle item entries include selecting or deselecting a parameter, indicating or executing an action, and altering software configurations. The general procedure to execute the toggle item entry is as follows:

1. Depress the ITEM key.

2. Key in the ITEM number.

3. Depress the EXEC key.

As an example, on SPEC 2 the crew may select either GMT or MET to be displayed on the GMT/MET clock (or mission timer) by selecting either item 1 or 2. The asterisk next to the item number shows which selection is currently displayed. To toggle the clock to display GMT, the keyboard entry would be:

| ITEM | 1 | EXEC |

td249_018.cnv
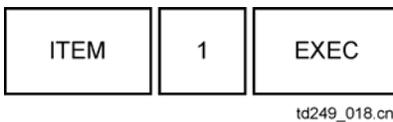
The scratch pad line on the display appears as ITEM 1 EXEC.

Item data entries allow the crew to load or change data in the software. Typical purposes of this operation include initializing parameters, changing software limits, and specifying memory locations. The procedure used in performing an item data entry is as follows:

1. Depress the ITEM key.

2. Key in the item number. Not all item numbers are displayed. Some item numbers are implied by their surrounding item numbers and must be inferred.

3. Key in a delimiter ("+" or "-"). A delimiter separates item numbers from their corresponding data. The delimiter whose sign corresponds to the sign of the data is used.

4. Key in the data. Usually, the data size is indicated with an underline for each digit. As a general rule, leading and trailing zeros need not be entered. Remember that the sign of the delimiter is the sign of the data.

5. Depress the EXEC key.

The CRT TIMER "SET" line on SPEC 2 has been highlighted in Figure 4-3 to illustrate some features of item data entries. This line is used to set the CRT Timer for countups or countdowns to certain mission events. The "9" in front of "SET" refers to Item 9, the hours data field. Items 10 (minutes) and 11 (seconds) are not displayed on the SPEC but may be accessed by the crew and are referred to as implied item numbers. The bracket ([ ]) to the right of "SET" indicates that the sign of the data may be entered as either positive (+) or negative (-). For item numbers that do not display a bracket, the sign of the corresponding data is assumed to be positive. In the case of the CRT Timer, a (-) indicates a countdown, and (+) indicates a countup from the set time.

```
                    ( 9)   ( 1O)   ( 11)

  9 SET []  __ __  □  __ __  □  __ __
                   □       □
                HOURS   MINUTES  SECONDS
```

```
  2011/002/    TIME                    2 000/01:01:00
                                         000/00:00:00
  MISSION TIME                    TONE
     GMT 1                          3  __ __ __MSN T
     MET 2                          6
  CRT TIMER
     9 SET []__ __ __              20[]        CRT T
  START 12 STOP 13
     14 START AT __ __ __MSN T     23 DURATION 01
     17 COUNT TO        MSN T
  MTU
     24  GMT Δ []__ /__-__-_____
     28  MET Δ []
         UPDATE 32                   MET RESET 33
  GMT TIME                                       GPC
                            GMT          |TRY| 1 A1
        MTU ACCUME 1|D78/02:34:06.108|   34| 2 A1
                   2|D78/02:34:06.108|   35| 3 A1
                   3|D78/02:34:06.108|   36| 4 A1
               CPC |D78/02:34:06.108|   37| 5 A1

  TIME SYNC 38
```
00608308.CRT:1

Figure 4-3. SPEC 2

For example, to set the CRT timer for a 30-second countdown, the keyboard entry would be:

| ITEM | 1 | 1 | - | 3 | 0 | EXEC |

td249_020.cnv
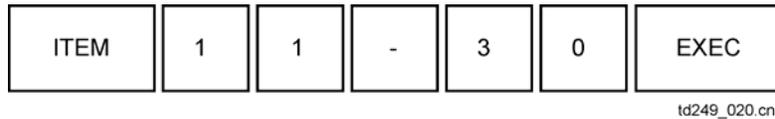
The scratch pad line appears as ITEM (11) - 30 EXEC. The data entries will appear on the CRT TIMER SET line (items 9 and 10 automatically display 0's in this case), and the CRT timer data field in the upper right corner of the display displays 30 seconds. The countdown is started with a toggle entry to item 12, CRT TIMER START. The keyboard entry is:

| ITEM | 1 | 2 | EXEC |

td249_021.cnv
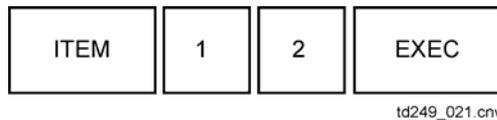
The scratch pad line appears as ITEM 12 EXEC.

For multiple data entries, the crew has the option of making the entries with one command sequence to save time. The procedure is the same as for single data entries, except consecutive data entries may be loaded by using a delimiter to separate each parameter. Item entries are computed sequentially, so the item number need not be

entered for each parameter following the one you have already entered. Enter another delimiter and the next item number appears, ready to receive its associated data. To skip an item number, hit a delimiter twice. In this way, any amount of item numbers may be skipped until the desired item number is reached. This process of making multiple data entries with one command sequence is referred to as "stringing" item entries.

To illustrate stringing data entries, if, in the previous example, the crew wanted the 30-second CRT TIMER countdown to start at a particular mission time; e.g., 2 hours: 30 minutes: 15 seconds MET, the crew can use the CRT TIMER "START AT" feature. The keyboard input would be:

| ITEM | 1 | 4 | + | 2 | + | 3 | 0 | + | 1 | 5 | EXEC |

td249_022.cnv

The scratch pad line will appear as ITEM (14) + 2 (15) + 30 (16) + 15 EXEC. The data entries appear on the CRT TIMER START AT line. The 30-second countdown on the CRT timer automatically begins when the MET (displayed on the mission timer) matches the "START AT" time. As an example of skipping item numbers, if the crew wanted the CRT TIMER countdown to begin at 2 hours: 0 minutes: 15 seconds MET, the keyboard input would be:

| ITEM | 1 | 4 | + | 2 | + | + | 1 | 5 | EXEC |

td249_023.cnv

The scratch pad line appears as ITEM (14) + 2 (16) + 15 EXEC.

Where the sign of the data is not required to be specified (no [ ]), both the "+" and the "-" keys may be used interchangeably as delimiters. However, to avoid improper data entry, it is good practice to always use the "+" key as a delimiter, unless an item specifically requires negative data.

Note that there is a limited amount of room on the scratch pad line. Command sequences that exceed the scratch pad line limit cannot be executed and, therefore, must be broken up into smaller sequences. Also note that toggle item entries may not be strung together and must be executed one at a time.

4.6   GPC ASSIGNMENT TO AN IDP'S DPS DISPLAY

There are various ways to assign a GPC to drive a particular IDP's DPS display. One way to drive such a display is with the IDP/CRT MAJ FUNC switch. Recall from Section 2 that the position of the MAJ FUNC switch is in effect telling the GPCs which type of software (or GPC), GNC, SM, or PL the crew wishes to interact with on that particular IDP's DPS Display. For example, in the case of the typical orbit configuration (GPCs 1 and 2 are GNC; GPC 4 is SM; and PL is unsupported), placing a MAJ FUNC switch in SM will assign GPC 4 to that IDP. When the MAJ FUNC switch is in GNC,

either GPC 1 or GPC 2 is assigned to that IDP. Because there is more than one GNC GPC in this case, exactly which GPC is assigned is determined by IDP assignments resident in the system software. These assignments can be viewed on the Memory/Bus Configuration table on the GPC MEMORY display, which may be called up as SPEC 0 (see PASS software structure). See Figure 4-4. The GPC assignments to CRTs 1 through 4 are actually Display Keyboard (DK) data bus assignments that may be changed by the crew via item entries to Items 12 through 15, respectively. There is one table of assignments per MC. The assignments for an MC are implemented when an OPS transition is performed to load that MC. This table of CRT assignments provides a means of dividing each IDP's DK bus among the GNC GPCs, when multiple GNC GPCs are processing. Further discussion of the Memory/Bus Configuration table is provided in the DPS Overview 21002 Workbook.

```
  2011/000/        GPC MEMORY        1 002/06:19:43
                                       000/01:34:33
 MEM/BUS CONFIG  │ READ/WRITE   GNC
 1 CONFIG _2(G2) │  DATA 20   BIT SET 22   SEQ ID 24
 2 GPC 1 2 0 0 0 │  CODE 21   BIT RST 23*  WRITE  25
                 │  26 ENG UNITS ___     HEX 27*
   STRING 1│ 7 2 │  ADD ID  DESIRED   ACTUAL
         2│ 8 1  │ 28 0467F 29 0400   FBFC
         3│ 9 1  │ 30       31
         4│10 2  │ 32       33
    PL 1/2│11 0  │ 34       35
                 │ 36       37
    CRT 1│12 1   │ 38       39
        2│13 2   │
        3│14 0   │ ──────────────────────────
        4│15 2   │ MEMORY DUMP
                 │  40 START ID   _____
 LAUNCH 1│16 0   │  41 NUMBER WDS _____
        2│17 0   │  42 WDS/FRAME  __
     MM 1│18 1   │ DUMP START/STOP 43
        2│19 2   │                    ┌─────────────
                 │ 44 DOWNLIST GPC 1  │ STORE   MC=02
                 │    OPS 0 ENA 49    │ 45 CONFIG __
                 │                    │ 46 GPC   _
                 │                    │  STORE 47
          ERR LOG RESET 48
   GPC/CRT 12 EXEC
```

00608302.CRT;1

Figure 4-4. GPC MEMORY page

Another way to change the GPC assignment is with the GPC/CRT key. The keyboard steps for selecting a GPC to command a given DPS display are as follows:

1.   Depress the GPC/CRT key.

2.   Key in the desired GPC number (1, 2, 3, 4, or 5).

3.   Key in the desired IDP number (1, 2, 3, or 4).

4.   Depress the EXEC key.

For example, to assign GPC 1 to IDP 2, the following keystrokes would be made:

GPC/CRT	1	2	EXEC
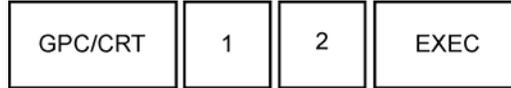
td249_025.cnv

The scratch pad line appears as shown in Figure 4-4.

If the GPC/CRT keyboard entry specifies a valid assignment, it overrides any current assignment made by the CRT assignment table in the software, as well as any previous GPC/CRT key assignment. A GPC/CRT keyboard entry is valid if (a) the major function processed by the assigned GPC matches the MAJ FUNC switch position or (b) the MAJ FUNC switch position is in an unsupported major function.

For example, again using the standard orbit GPC configuration, assume that GPC 1 is driving IDP 1 and the IDP/CRT 1 MAJ FUNC switch is in the GNC position. Because GPC 2 is also a GNC GPC, a GPC/CRT key assignment of GPC 2 to IDP 1 is valid. However, a GPC/CRT key assignment of GPC 4 (SM) to IDP 1 is invalid as long as the IDP/CRT 1 MAJ FUNC switch is in GNC. In this case, the reassignment does not occur. GPC 1 retains command of the display. In other words, *the position of the IDP/CRT MAJ FUNC switch overrides GPC/CRT key assignments.* If the IDP/CRT 1 MAJ FUNC switch was taken to the unsupported PL position, any GPC processing GNC, SM, or OPS 0 could be assigned to IDP 1. As discussed in Section 2, this is useful because it provides a means of assigning an OPS 0 GPC to an IDP. In fact, *to interface with an OPS 0 GPC, the MAJ FUNC switch must be in an unsupported position.*

The GPC/CRT key can also be used to isolate, or deassign, an IDP from communication with all GPCs. PASS can drive only three IDPs at one time, so one IDP is always deassigned from PASS. The command sequence to deassign an IDP looks like this:

GPC/CRT	0	Y	EXEC

td249_026.cnv

where Y is the desired IDP. The IDP drives a big X over the deassigned IDP's DPS Display as an indication to the crew that the data on the display is not being updated by the GPCs and should not be used (see Figure 4-5). The IDP annunciates the POLL FAIL message in the lower right corner of the DPS display to inform the crew that the GPC is no longer attempting to communicate with the IDP.

```
2011/094/078      SM SYS SUMM 1      4 000/02:48:16
                                       000/00:00:00
        EMERGENCY
SMOKE       1/A    2/B     DC VOLTS    1/A    2/B    3/C
AV BAY 1-  0.0 -  0.0      FC         31.4   31.4   31.2
       2-  0.0 -  0.0      MAIN       31.2   31.1   31.3
       3-  0.0 -  0.0      CNTL AB    30.1   30.1   30.0
dP/dT      ±.00                  BC    30.0   30.0   30.0
                                CA    30.0   30.0   30.0
        CABIN              ESS         29.9   30.0   30.0
PRESS      14.9            AC
PPO2        3.04    3.04     VOLT Ø A   117    117    117
FAN ΔP      6.43                 Ø B   117    117    117
HX OUT T     53                 Ø C   117    117    117
O2 FLOW     0.0L   0.0L     AMPS Ø A   2.2    3.0    2.4
N2 FLOW     0.0L   0.0L          Ø B   2.2    3.2    2.4
                                Ø C   2.2    3.2    2.1
IMU FAN   A    B*   C     FUEL CELL
  ΔV FC1  FC2  FC3         AMPS       156    158    148
SS1   23   28   26         REAC VLV    OP     OP     OP
SS2   18   22   13         STACK T   +202   +300H  +202
SS3    9   13   13         EXIT  T    151    151    151
TOTAL AMPS    463          COOL  P     61     61     61
      KW       14          PUMP
GPC/CRT 02 EXEC                            POLL FAIL
```

00608309.CRT: 1

Figure 4-5. Result of deassigning a DPS display

4.7   RESETTING I/O CONFIGURATIONS

When a GPC detects a problem in Input/Output (I/O) communication with a piece of equipment, the fault is annunciated and may terminate the GPC I/O with the equipment. Discussion of GPC-detected errors can be found in the DPS Hardware and Systems Software Workbook (DPS HW/SW 21002). Two common causes of communication errors are the powering down of equipment or an error in a data transmission. In these two cases, if the equipment is powered up or if the error has been corrected, the GPC's I/O with the equipment may be restored to the nominal configuration. Restoration of the I/O is done through the I/O RESET key in the affected major function. If an I/O RESET is performed on a GNC GPC, all the GNC GPCs are restored to nominal I/O configuration. If it is performed on the SM GPC, only the SM GPC's I/O configuration is restored to nominal. In other words, *I/O RESETs are major function dependent in PASS*. To reset I/O configurations, the procedure is as follows:

1.   Select the desired position of the IDP/CRT MAJ FUNC switch.

2.   Depress the I/O RESET key.

3.   Depress the EXEC key.

The completed command on the scratch pad line looks like this: I/O RESET EXEC.

If the powered-down equipment has been powered on or if a problem with a piece of equipment has been fixed, an I/O RESET resumes communication. It does not cause another fault message annunciation. If the GPC still has a problem communicating with any piece of its assigned equipment, a fault message reannunciates after an I/O RESET and communication is not restored. The termination of nominal I/O between a GPC and a piece of its assigned equipment is called a commfault.

4.8   KEYBOARD OPERATOR ERRORS

There are two types of incorrect keyboard entries, those that have incorrect logic and those with incorrect syntax. Keyboard inputs having correct syntax are sent by the IDP to the GPCs for processing. However, if the command is logically incorrect, the GPC displays an "Illegal Entry" on the fault message line (see Figure 4-6). Syntax errors are detected by the IDP, which displays a flashing "ERR" immediately to the right of the erroneous entry on the scratch pad line. The crew response to syntax errors is simply to depress the CLEAR key. Whereupon, the "ERR" and the last keystroke will disappear. Subsequent depressions of the CLEAR key will remove single keystrokes, proceeding from right to left. This feature enables the crew to CLEAR back to the portion of the command that was incorrect, correct it, and proceed.
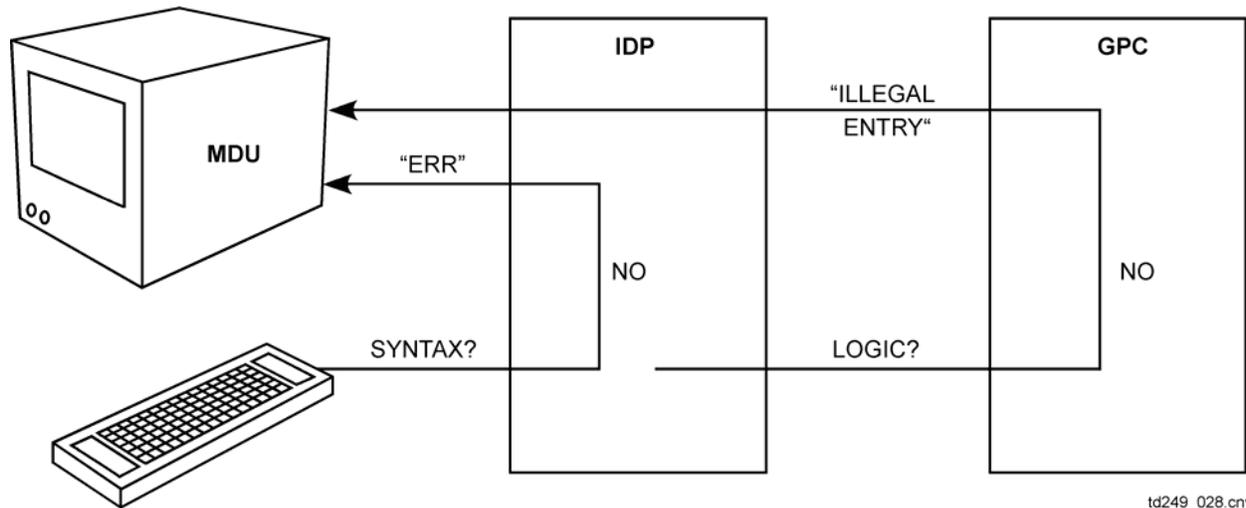
Figure 4-6. Keyboard operator errors

The following examples illustrate various types of keyboard entries with invalid syntax and the IDP logic behind the error detection. The IDP immediately annunciates "ERR" upon detection of the error.

1. **OPS 20 PRO   OPS 201 EXEC**

    An OPS keystroke must be followed by three digits, followed by the PRO key.

2. **SPEC PRO   SPEC 6 EXEC**

    A SPEC keystroke must be followed by one, two, or three digits, followed by the PRO key.

3. **GPC/CRT 1 EXEC   GPC/CRT 12 PRO**

    A GPC/CRT keystroke must be followed by two digits, followed by the EXEC key.

4. **I/O RESET PRO**

An I/O RESET keystroke must be followed only by the EXEC key.

5. **ITEM 111   ITEM 11 + EXEC   ITEM 11 + 2 PRO**

An ITEM keystroke must be followed by one or two hexadecimal characters. An EXEC key may directly follow, or a delimiter may follow. If a delimiter is entered, it must be followed by hexadecimal characters (or another delimiter if jumping to the next item number). The EXEC key must be the terminator.

The following examples illustrate various types of keyboard entries that have correct syntax (the IDP passes the command on to the GPC) but are logically incorrect. The GPCs annunciate "Illegal Entry" upon detection of the error.

1. **GPC/CRT 71 EXEC GPC/CRT 25 EXEC**

The GPC number must be 0, 1, 2, 3, 4, or 5. The IDP number must be 1, 2, 3, or 4.

2. **ITEM 1 EXEC   if Item 1 requires data entry.**

ITEM 1 + 2 EXEC   if Item 1 is a "toggle" entry.

The IDP does not know whether an item on a display requires data or not. Both of the above commands have correct syntax. So, the IDP passes them on to the GPC, which annunciates "Illegal Entry" in both cases.

4.9   FAULT MESSAGES

Fault Messages are comprised of six fields (see Figure 4-7).
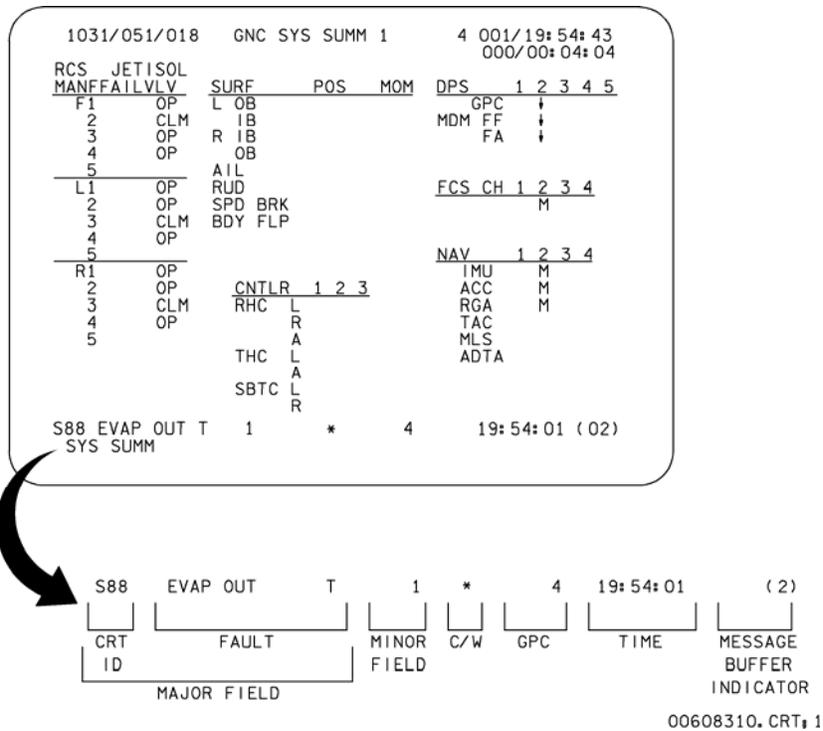
Figure 4-7. Fault message line

The major field: The major field is a 14-character field. The first three characters indicate the CRT ID and the remaining characters constitute the FAULT.

> *CRT ID* - The first three characters of the major field identify the display on which more information about the annunciated failure can be found. An S or a G followed by a two-digit number indicates the major function (S for SM and G for GNC) and the number of the SPEC or the DISP. If no display is associated with the fault, this field is blank. In the example in Figure 4-7, "S88" is the CRT ID and means that information on the fault can be found on SPEC 88 in the SM major function.

> *Fault* - The remaining characters identify the problem or the subsystem group associated with the fault. In the same example, "EVAP OUT T" indicates that the fault is detected in the flash evaporator subsystem.

The minor field: The minor field is a four-character field that further identifies the fault. It specifies the subdivision, the direction, the location, the parameter, or the specific unit of the subsystem or the problem identified in the major field. In the example fault message, "1" means that temperature sensor 1 is the area in which the fault is detected.

C/W: This field is used only with Caution and Warning (C&W) class 2 messages. An asterisk appears in this column to denote that the condition is a class 2 alarm and results in a master alarm tone until the crew depresses the Master Alarm pushbutton.

GPC: The GPCs that detected this fault are identified in this field. This characteristic aids the crew in locating or identifying internal GPC or I/O errors.

Time: This field indicates the time at which the fault occurred. The time is MET and is displayed in hours, minutes, and seconds (HH:MM:SS).

Message Buffer Indicator: The message displayed on the fault message line is not necessarily the most recent fault message. Unless the fault message line was previously cleared, the crewmember will not see any new messages that come in. In that case, the crewmembers can see whether a new message has been annunciated by looking at a two-digit field with parentheses. This field is called the message buffer indicator and is located on the far right of the fault message line. The message buffer indicator shows the number of messages remaining in the fault buffer that have not been viewed by the crew on the fault message line. In the example in Figure 4-7, the "EVAP OUT T" message was followed by two more messages (as indicated by the "2" in the buffer indicator) before the crew cleared the "EVAP OUT T" message. If there are no fault messages in the buffer, this field is blank. A crewmember may view the buffer messages by looking at the FAULT display (see Figure 4-8), or by depressing the ACK key to scroll through the fault messages in the buffer and display them one at a time on the fault message line.

4.10   THE FAULT SUMMARY DISPLAY

An historical summary of fault messages is provided via the FAULT display (see Figure 4-8). The FAULT display is a DISP available in all OPS. It is selected for viewing by depression of the FAULT SUMM key.

The FAULT display consists of 15 fault message lines. They appear in reverse chronological order; the oldest message appears on the bottom. When a new fault message is generated, it appears on the first line. The other messages are pushed down and the 15th message disappears. The format of the fault messages on the FAULT display is the same as that of the fault message line, except on the FAULT display, the time field includes days as well as hours, minutes, and seconds (DDD/HH:MM:SS). In the example in Figure 4-8, the two fault messages following the "EVAP OUT T" message were "I/O ERROR MMU," followed by "FUEL CELL." "ILLEGAL ENTRY" messages are not recorded on the fault summary.

Sometimes, a subsystem failure or malfunction results in the output of several fault messages, some of which may be identical. The FDA logic can prevent the annunciation of identical fault messages. When a fault message is generated, its major and minor fields are compared to those of the top message of the display. If the fields are the same and if the new fault message has occurred within 4.8 seconds of the top message, the new message is inhibited.

The FAULT display may also be selected by the keyboard entry "SPEC 99 PRO." However, this command clears all fault messages from the FAULT display and the fault message line. This capability is useful if and when the fault messages displayed are no longer significant (i.e., they are old or they have been handled). The FAULT display is cleared nominally about 2 minutes before launch to start the ascent phase with a "clean slate."

```
2011/021/099        FAULT            1  001/19:54:43
                                        000/01:43:00


        CRT        FAULT      C/W    GPC       TIME
        ID

        S69 FUEL CELL                 1   4  001/19:54:35
            I/O ERROR      MMU        1   4  001/19:54:02
        S88 EVAP OUT T     1    *         4  001/19:54:01
            GPC            2    *     1   4  001/19:54:00
            RM DLMA        IMU  *     12  4  001/19:45:23
            BCE STRG 3     ADTA       12  4  001/19:20:03
        S66 CABIN                         4  001/18:53:00






        S88 EVAP OUT T     1    *         4   19:54:01 (02)
        FAULT SUMM
```

00608311.CRT;1
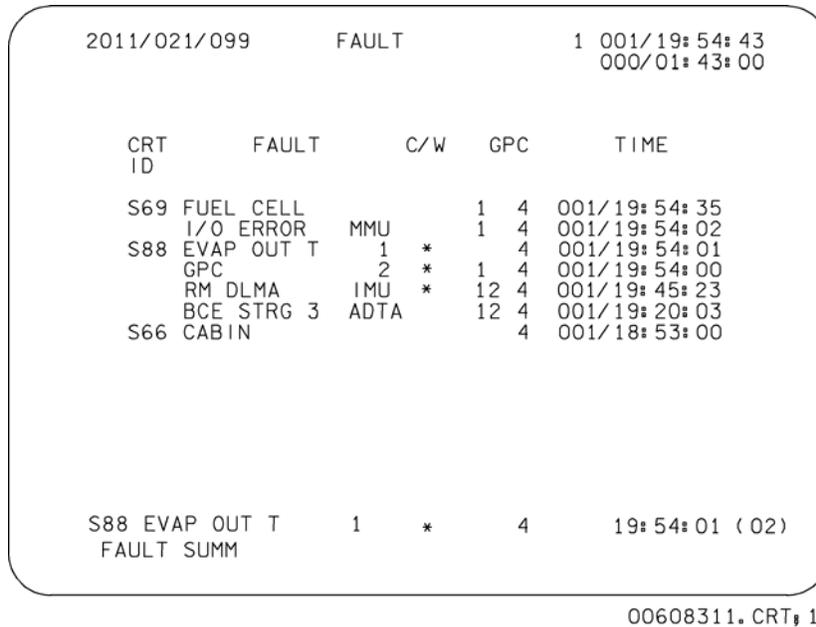
Figure 4-8. Fault Summary display

4.11   SYSTEMS SUMMARY DISPLAYS

Systems Summary displays provide systems status information that can be quickly accessed to aid diagnosis of a problem. When a C&W alarm occurs, the crew can call a SYS SUMM display that has general information from several systems to pinpoint the problem to a specific system. They continue troubleshooting the problem on system-specific SPECs, DISPS, and hardware panels. There are four PASS SYS SUMM displays, shown in Figure 4-9. They are DISPs and provide display information only.

The SYS SUMM displays are major function specific and are called with the SYS SUMM key for quick access. If the IDP major function switch is in GNC and the SYS SUMM key is pressed, then GNC SYS SUMM 1 will appear. GNC SYS SUMM 1 is DISP 18, so it may also be called with a SPEC 18 PRO.

The SYS SUMM key is a toggle function. For example, if the IDP MAJ FUNC switch is in SM on orbit and the SYS SUMM key is depressed, SM SYS SUMM 1 (DISP 78) appears. If you press SYS SUMM again, SM SYS SUMM 2 (DISP 79) appears. If you press SYS SUMM once more, SM SYS SUMM 1 reappears. The same toggle function exists in GNC between GNC SYS SUMM 1 and GNC SYS SUMM 2.

```
1031/051/018   GNC SYS SUMM 1      4/000/00:04:04
                                     000/00:04:04
RCS  JETISOL
MANFFAILVLV   SURF    POS   MOM   DPS    1 2 3 4 5
   F1     OP   L OB                 GPC
   2     CLM    IB               MDM FF
   3      OP   R IB                  FA
   4      OP    OB
   5            AIL
   L1     OP   RUD               FCS CH 1 2 3 4
   2      OP   SPD BRK                     M
   3     CLM   BDY FLP
   4      OP
   5                             NAV    1 2 3 4
   R1     OP                      IMU    M
   2      OP   CNTLR  1 2 3       ACC    M
   3     CLM   RHC   L            RGA    M
   4      OP         R            TAC
   5                 A            MLS
               THC   L            ADTA
                     A
               SBTC  L
                     R
                                    00608312.CRT 1
```

GNC SYS SUMM 1 – Available:
GNC OPS 1, 6, 2, 8, 3

(a) GNC SYS SUMM 1 display

```
2011/   /019   GNC SYS SUMM 2      1 000/01:41:58
                                     000/00:52:39
                              OMS      L      R
                              TK P  HE 4800   4800
                                  OXID  252    252
                                    FU  232    257
           JETISOL         N2 TK  P 2250   2250
RCS    OXID   FU FAIL VLV      REG  P  327    327
FWD HE P2864 2896              P  VJV  CL     CL
   TK P 245  245            ENG IN  P
   QTY  63   67                 OXID  252    252
MANF 1 P 244 244      OP           FU  257    257
   2 P   0    0       OP        VLV 1   0      0
   3 P   0    0       OP            2   0      0
   4 P 244  244       OP
   5                  OP                  JETISOL
AFT HE P2808 2872          HE P2808 2784  OXID  FU FAIL VLV
   TK P 245  245        R TK P 245  245
   QTY  68   74            QTY  68   70
MANF 1 P 252 256      OP    1 P 252  256       OP
   2 P 252  256      OP    2 P 252  256       OP
   3 P 252  256      OP    3 P 252  256       OP
   4 P 252  256      OP    4 P 252  256       OP
   5                  OP    5                  OP
SYS SUMM
                                    00608313.CRT 1
```

GNC SYS SUMM 2 – Available:
GNC OPS 1, 6, 2, 8, 3

(b) GNC SYS SUMM 2 display

```
2011/094/078    SM SYS SUMM 1     4 000/02:48:16
                                    000/00:00:00
        EMERGENCY        DC VOLTS   1/A   2/B   3/C
SMOKE    1/A    2/B      FC        31.4  31.4  31.2
AV BAY 1- 0.0 - 0.0      MAIN      31.2  31.1  31.3
       2- 0.0 - 0.0      CNTL AB   30.1  30.1  30.0
       3- 0.0 - 0.0          BC    30.0  30.0  30.0
dP/dT     ±.00               CA    30.0  30.0  30.0
                         ESS       29.9  30.0  30.0
       CABIN             AC
PRESS    14.9            VOLT Φ A   117   117   117
PPO2     3.04   3.04        Φ B   117   117   117
FAN ΔP   6.43              Φ C   117   117   117
HX OUT T   53            AMPS Φ A   2.2   3.0   2.4
O2 FLOW  0.0L  0.0L         Φ B   2.2   3.2   2.4
N2 FLOW  0.0L  0.0L         Φ C   2.2   3.2   2.1
IMU FAN  A   B*  C       FUEL CELL PH
  ΔV FC1  FC2  FC3       AMPS    156   158   148
SS1  23   26   26        REAC VLV  OP    OP    OP
SS2  18   22   13        STACK T +202  +300H +202
SS3   9   13   13        EXIT  T  151   151   151
TOTAL AMPS   463         COOL  P   61    61    61
      KW     14          PUMP
SYS SUMM
                                    00608314.CRT 1
```

SM SYS SUMM 1 – Available:
SM OPS 2

(c) SM SYS SUMM 1 display

```
2011/   /079    SM SYS SUMM 2     4 000/14:12:10
                                    000/04:08:06
        CRYO TK   1     2     3     4
        H2 PRESS 210   210   235   235
        O2 PRESS 830   830   850
        HTR T1 - 75  - 78  - 76  - 78
           T2 - 75  - 80  - 76  - 77
APU        1     2     3     HYD    1     2     3
TEMP EGT 1000   950   975    PRESS 2980  2990  3000
B/U EGT   980   945   975    RSVR T  80    85    80
OIL IN    200   180   180    QTY     55    58    54
   OUT    210   190   200
SPEED %   105   104   106    W/B
FUEL QTY   75    70    67    H2O QTY  85    80    90
PMP LK P   18    17    15    BYP VLV
OIL OUT P  65    70    70
                             THERM CNTL  1     2
  AV BAY                     H2O PUMP P    25    67
TEMP       95    95    98    FREON FLOW  2000  2150
FAN ΔP     .1    .1    .1    EVAP OUT T    39    40
SYS SUMM
                                    00608315.CRT 1
```

SM SYS SUMM 2 – Available:
SM OPS 2

(d) SM SYS SUMM 2 display

Figure 4-9. Systems Summary displays

APPENDIX A
ACRONYMS AND ABBREVIATIONS

ACK	Acknowledge
BFS	Backup Flight System
C&W	Caution and Warning
CRT	Cathode-Ray Tube (screen)
DISP	Display Function
DK	Display Keyboard
DPS	Data Processing System
ET	External Tank
EXEC	Execute
FAULT SUMM	Fault Summary
FDA	Fault Detection and Annunciation
FDF	Flight Data File
GMT	Greenwich Mean Time
GNC	Guidance, Navigation, and Control
GPC	General Purpose Computer
HEX	Hexadecimal
HW	Hardware
I/O	Input/Output
IDP	Integrated Display Processor
IPL	Initial Program Load
MAJ FUNC	Major Function
MC	Memory Configuration
MDU	Multifunction Display Unit
MEDS	Multifunction Electronic Display System
MET	Mission Elapsed Time
MM	Major Mode
MMU	Modular Memory Unit
MSG RESET	Message Reset
OMS	Orbital Maneuvering System
OPS	Operational Sequence
PASS	Primary Avionics Software System
PL	Payload
PRO	Proceed

RM	Redundancy Management
RTLS	Return to Launch Site
SEL	Select
SM	Systems Management
SPEC	Specialist Function
SRB	Solid Rocket Booster
SW	Software
SYS SUMM	Systems Summary
TAEM	Terminal Area Energy Management

APPENDIX B
BINARY/HEXADECIMAL CONVERSIONS

The keyboard provides the capability to use a hexadecimal (base 16) numbering system. The GPCs store information in bits using the binary (base 2) system, but the crew communicates with the GPCs in hexadecimal (hex). From time to time, it may be necessary to examine the binary coding of a hexadecimal value or vice versa. The crew uses the GPC MEMORY display to read GPC core memory to obtain hex values whose binary coding reveals status information. It may be necessary to decode the hex to determine whether a logic high (1) or a logic low (0) currently resides in a specific address location.

B.1   THE BINARY SYSTEM

The binary numbering system consists of 1s and 0s. Each digit of a binary number represents a power of two. The lowest power of two is on the right and the highest power of two is the digit furthest to the left in the binary number:

$$2^7 \ 2^6 \ 2^5 \ 2^4 \ 2^3 \ 2^2 \ 2^1 \ 2^0$$

Let's take a sample number and decode it so we can express it in the decimal (base 10) notation with which we are more familiar.

$$
\begin{aligned}
1\,0\,0\,1\,0\,1 \quad &= (1 \times 2^5) \ + \ (0 \times 2^4) \ + \ (0 \times 2^3) \ + \ (1 \times 2^2) \ + \ (0 \times 2^1) \ + \ (1 \times 2^0) \\
&= (1 \times 32) \ + \ (0 \times 16) \ + \ (0 \times 8) \ + \ (1 \times 4) \ + \ (0 \times 2) \ + \ (1 \times 1) \\
&= \ 32 \quad + \quad 0 \quad + \quad 0 \quad + \quad 4 \quad + \quad 0 \quad + \quad 1 \\
&= \ 37
\end{aligned}
$$

Therefore: $\mathbf{100101_2 = 37_{10}}$

Each of the base 2 digits is called a bit and can only be logic high (1) or logic low (0) so they indicate the current status of a discrete state. In the GPCs, data is stored in groups called words. A full word is 32-bits long and a half-word is 16 bits.

B.2   THE HEXADECIMAL SYSTEM

The hex numbering system consists of 16 possible numbers. We normally use a decimal numbering system, so we are familiar with 0-9 as the 10 possible numerals to use. For base 16, we need to use more symbols to represent the six extra numbers. For convention, the letters A-F have been adopted for this use. This means we use 0-F as the numerals for the hexadecimal system. Let's look at the decimal values corresponding to 0-F.

0 = 0	4 = 4	8 = 8	C = 12
1 = 1	5 = 5	9 = 9	D = 13
2 = 2	6 = 6	A = 10	E = 14
3 = 3	7 = 7	B = 11	F = 15

Let's take a sample hex number and convert it to decimal notation.

$$F\ 0\ 4\ C\ 6 = (F \times 16^4) + (0 \times 16^3) + (4 \times 16^2) + (C \times 16^1) + (6 \times 16^0)$$
$$= (F \times 65{,}536) + 0 + (4 \times 256) + (C \times 16) + (6 \times 1)$$
$$= (15 \times 65{,}536) + (4 \times 256) + (12 \times 16) + 6$$
$$= 983{,}040 + 1024 + 192 + 6$$
$$+ 984{,}262$$

Therefore: **$F04C6_{16} = 984{,}262_{10}$**

It is easy to see that hex is a less cumbersome way of expressing large numbers than decimal notation. Also remember, a data word is 32 bits. In hex, this 32-bit word can be expressed with 8 characters. A half-word can be expressed by 4 hex characters!

B.3   BINARY/HEXADECIMAL/DECIMAL CONVERSIONS

Use the following chart for aid in any binary/decimal conversion work. There are some practice examples following. Try your hand at some conversions.

Binary/Decimal/Hexadecimal Correspondences

Hexadecimal	Decimal	Binary
0_{16}	0_{10}	0000_2
1	1	0001
2	2	0010
3	3	0011
4	4	0100
5	5	0101
6	6	0110
7	7	0111
8	8	1000
9	9	1001
A	10	1010
B	11	1011
C	12	1100
D	13	1101
E	14	1110
F	15	1111

B.4   PRACTICE 1

Binary to Hex Conversion

Four bits convert to one hex digit, so starting from the right:

32 bits	1001	0110	1011	0100	1000	1100	1110	0111
8 hex digits	__	__	__	__	__	__	E	7

Digit 8: 0 1 1 1 $= (0 \times 2^3) + (1 \times 2^2) + (1 \times 2^1) + (1 \times 2^0)$

$=$ 0 + 4 + 2 + 1

$= 7_{16}$

Digit 7: 1 1 1 0 $= (1 \times 2^3) + (1 \times 2^2) + (1 \times 2^1) + (0 \times 2^0)$

$=$ 8 + 4 + 2 + 0

$= 14_{10}$

$= E_{16}$

B.5   PRACTICE 2

Hex to Binary Conversion

	A	9	0	4	F	6	7	D
	__	__	__	__	__	__	0111	1101

Digit 8: $D_{16} = 13_{10}$

$=$ 8 + 4 + 0 + 1

$= (1 \times 2^3) + (1 \times 2^2) + (0 \times 2^1) + (1 \times 2^0)$

$= 1101_2$

Digit 7: $7_{16} = 7_{10}$

$=$ 0 + 4 + 2 + 1

$= (0 \times 2^3) + (1 \times 2^2) + (1 \times 2^1) + (1 \times 2^0)$

$= 0111_2$

B.6   ANSWERS

Practice 1: 9 6 B 4 8 C E 7

Practice 2: 1010 1001 0000 0100 1111 0110 0111 1101

**APPENDIX C
QUESTIONS AND ANSWERS**

C.1   SECTION 1 QUESTIONS

1.   Describe the basic structure of PASS software.

2.   Describe the three types of DPS displays available in PASS.

3.   Describe the nominal GPC configuration for all phases of flight.

C.2   SECTION 2 QUESTIONS

1.   What is the function of the IDP/CRT POWER switch?

2.   What is the function of the IDP/CRT MAJ FUNC switch?

3.   What is the function of the IDP/CRT SEL switches?

4.   Which keyboard keys send a command with a single keystroke, and which keys either begin or terminate a multi-keystroke command sequence?

C.3   SECTION 3 QUESTIONS

1.   List the data fields that are common to all DPS displays.

C.4   SECTION 4 QUESTIONS

1.   List the three criteria that must be met before performing an OPS transition.

2.   Describe the keyboard entries to perform an OPS transition or major mode transition.

3.   Describe the keyboard entries to call up a SPEC or DISP page and the keyboard entry to remove the page.

4.   Describe the two types of item entries and the keyboard inputs to implement them.

5.   Describe the use of the GPC/CRT key.

6.   Explain the crew responses to acknowledge fault messages.

7.   What information does the FAULT Summary display provide, and how is it viewed?

8.   Describe the information provided by the fault message line.

C.5   SECTION 1 ANSWERS

1. PASS consists of system software and applications software. Applications software is divided into the GNC, SM, and PL major functions. Major functions consist of operational sequences, each of which controls a particular phase of flight. Finally, operational sequences consist of major modes, each of which controls a particular subphase of flight.

2. The three types of DPS displays are major mode pages, SPEC pages, and DISP pages. Major mode and SPEC pages are interactive, while DISPs are used for viewing only.

3. During ascent and entry, nominally GPCs 1, 2, 3, and 4 process PASS GNC software. GPC 5 processes the BFS software. On orbit, typically GPCs 1 and 2 process PASS GNC, and GPC 4 processes PASS SM software. GPCs 3 and 5 are not typically used on orbit and are "put to sleep."

C.6   SECTION 2 ANSWERS

1. The IDP/CRT POWER switch provides power to both the IDP and associated CRT MDU.

2. The IDP/CRT MAJ FUNC switch is used to select which major function to interact with on a DPS display.

3. The left IDP/CRT SEL switch allows the left keyboard to interact with either IDP 1 or IDP 3. The right IDP/CRT SEL switch allows the right keyboard to interact with either IDP 2 or IDP 3.

4. Single keystroke commands are sent with the FAULT SUMM, SYS SUMM, MSG RESET, ACK, RESUME, and CLEAR keys. Multistroke initiators GPC/CRT, ITEM, and I/O RESET require EXEC as their terminator. The OPS and SPEC keys require PRO as their terminator.

C.7   SECTION 3 ANSWERS

1. The data fields that are common to all DPS displays are the OPS, SPEC, and DISP number fields; display title; uplink indicator; GPC driver; GMT/MET clock and CRT Timer fields; and fault message and scratch pad lines.

C.8   SECTION 4 ANSWERS

1. To perform an OPS transition: it must be a legal transition, the display used for the keyboard entry must have its MAJ FUNC switch in the position of the desired type of software, and a GPC targeted for the OPS software must be driving the display.

2. The keyboard entries for OPS transitions and major mode transitions are as follows: depress the OPS key, key in the three numbers of the desired OPS, and depress the PRO key.

3. To call up a SPEC or DISP page: depress the SPEC key, key in the page number (1, 2, or 3 digits), and depress the PRO key. To remove a SPEC or DISP page, depress the RESUME key.

4. The two types of item entries are the "toggle" type and "data" type. To implement a toggle entry: depress the ITEM key, key in one item number, and depress the EXEC key. To implement a data entry: after the ITEM key and item number are input, key in a delimiter followed by the data, then depress the EXEC key.

5. The GPC/CRT key is used to assign a particular GPC to a particular IDP's DPS display. The keyboard input is as follows: depress the GPC/CRT key, key in the desired GPC number followed by the desired IDP number, then depress the EXEC key.

6. To acknowledge fault messages, depress the ACK key and/or the MSG RESET key.

7. The FAULT display provides a historical summary of fault messages. It is viewed by depressing the FAULT SUMM key.

8. The fault message line on the DPS display provides: a short description of the fault, a display page number that can be viewed for more information on the fault, a class 2 caution and warning indicator, an indicator as to which GPC(s) detected the error, the MET of the fault, and an indicator of how many more fault messages have not been viewed (or are "hidden" behind the current message).