

# PRELIMINARY

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## DESCRIPTION OF COMMAND MODULE BLOCK II DISPLAYS, CONTROLS AND PNGS INTERFACES

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# PRELIMINARY

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## 1.0 GENERAL

The purpose of this Memo is to provide a description of the Block II Displays and Controls and also to provide a list of the PNGS Interfaces with other S/C Systems. For the purposes of this Memo the Displays and Controls have been divided into the following four groups:

1. Lower Equipment Bay (LEB) Displays
2. Lower Equipment Bay Controls
3. Main Display Console (MDC) Displays
4. Main Display Console Area Controls

The interfaces have been divided according to other Systems.

## 2.0 LEB DISPLAYS

### 2.1 Scanning Telescope

The scanning telescope is a single-line-of-sight, low power,  $60^{\circ}$  field of view instrument used for making navigation measurements in earth or lunar orbit, or for general use such as acquisition of landmarks and stars for sextant sightings. The telescope has two degrees of mechanical freedom to deflect the line-of-sight with respect to the navigation base: 1) a shaft axis, normal to the local conical surface of the spacecraft, permitting unlimited rotation to the optics assembly, and 2) a trunnion axis perpendicular to the shaft axis permitting unlimited rotation of the line of sight away from the shaft axis. Due to interference between the line of sight and the optics well, the useful rotation about the trunnion axis is limited to less than  $70^{\circ}$ . The telescope shaft axis is electrically coupled to the sextant shaft axis. The telescope line of sight may be directed as follows: 1) fixed along the shaft axis, 2) fixed at  $25^{\circ}$  trunnion angle with shaft axis slaved to the sextant, or 3) slaved to the sextant star line of sight, in which case it is controlled by the hand controller, the CGS, or the tracker.

A back-up mechanical control for each axis is provided by means of a gearbox which is driven by the universal tool. Telescope line-of-sight angles with respect to the navigation base are read on mechanical counters through viewing windows on the telescope base.

## 2.2 Sextant

The sextant is a precision, two-line-of-sight, high power instrument used to make star-to-planet angle measurements for navigation purposes and to make star direction measurements for orienting the IMU and the spacecraft in inertial space.

This instrument is a 28 power, 1.8 degree field of view telescope containing a beamsplitter, redirection mirror elements, and an articulating mirror all outboard of the objective element of the telescope. The beamsplitter divides the entering light to the telescope and directs approximately 20 percent along the focal axis of the instrument and 80 percent of the light is reflected by the articulating mirror. These two light paths constitute the landmark and star lines of sight respectively. Measurement of the angle the reflecting mirror element makes with respect to the head of the instrument and navigation base when the star is coincident with the landmark in the field of view constitutes the navigational sighting desired.

The sextant, like the telescope, has two degrees of mechanical freedom to deflect the line of sight with respect to the navigation base:

- 1) a shaft axis which permits  $\pm 270^\circ$  rotation of the optics assembly and
- 2) a trunnion axis perpendicular to the shaft axis which permits rotation of the line of sight from  $-10^\circ$  to  $+90^\circ$  of useful rotation. However, actual navigational sightings are limited to  $58^\circ$  between landmark and star as vignetting of the star line of sight occurs beyond this angle.

The sextant star line of sight may be controlled by 1) the CGC  
2) manually by use of the optics hand controller or 3) by the tracker.

A star tracker and horizon photometer are mounted on the sextant head for use in automatic tracking of a star and for determining the true horizon in navigation measurements.

## 2.3 DSKY

The astronaut-computer interface is accomplished through the DSKY. The DSKY provides two types of display; numerical display and condition display.

### 2.3.1 Numerical Display

A numerical display is associated with the computer keyboard for display of called-up data, verification of inserted data and computer requests for astronaut action or data. Three 2-digit decimal readouts identify: 1) the current program (PROGRAM) being processed by the computer, 2) the current VERB being processed by the computer and 3) the current NOUN being processed by the computer. Computer activated VERB-NOUN flashes indicate to the astronaut a request for data or action. Three 5-digit plus an algebraic sign ~~decimal~~ readouts (REGISTER 1, 2 and 3) are provided for data display.

### 2.3.2 Condition Display

A condition display is associated with the computer keyboard for display 1) activity (COMPUTER ACTIVITY AND UPLINK ACTIVITY), 2) status (OPERATOR ERROR, AUTO, HOLD, FREE, NO ATTITUDE, STANDBY and KEY RELEASE) and cautions (GIMBAL LOCK, TEMP, PROGRAM, RESTART and TRACKER).

The following is a functional description of these displays:

COMPUTER ACTIVITY

Indicates the computer is solving some meaningful program.

UPLINK ACTIVITY

Indicates the computer is receiving input from the Uplink Program.

OPERATOR ERROR

Keyboard and Display Program has encountered some improper operating condition.

AUTO

Execute CGC program. If no program active, stay at present attitude until CGC or Hand Controller commands a change.

HOLD

Hold present attitude. CGC execute hand controller inputs only.

FREE

Free Drift/Minimum Impulse. CGC executes Minimum Impulse and Hand Controller inputs only. Rotational Hand Controller output is angular acceleration.

NO ATTITUDE

This indicates that the ISS is not suitable as a reference. (ISS DELAY, during COARSE ALIGN MODE).

STANDBY

Indicates that the CGC is in Standby State.

RELEASE KEYBOARD

Indicates that internal program has attempted to use Keyboard and Display System Program and found it busy.

GIMBAL LOCK

Middle gimbal angle greater than  $\pm 75^\circ$

TEMP

Deviations in IMU temperature greater than  $\pm 5^\circ$  F. from normal

PROGRAM

Controlled by program. Indicates that some program check has failed.

RESTART

1. Parity Fail - Indicates that a word has been incorrectly transferred from memory, or
2. TC Trap - Indicates that the computer is in an endless control loop, or
3. Rupt Lock - Indicates that the computer has been interrupted for 30 millisec, or

4. ~~Night Watchman - Indicates that computer has not accomplished a CCS NEW JOB within 1.28 secs.~~

5. May be triggered by program.  
(TEST ALARM)

**TRACKER**

Indicates the Bar of Star Presence when the Optics are in COMPUTER mode and the computer is making a coarse acquisition.

2.4 G&N Indicator Control Panel

2.4.1 Description

This panel provides display in the LEB of the condition indicators for the G&C system and the indicator for S/C Master Caution System.

The panel contains the following five annunciators:

1. ISS
2. CGC
3. PGNS
4. MASTER ALARM
5. STAR ACQUIRED

The following is a functional description of these displays:

Light Legend	C/W Category	Malfunction	Illuminated by
ISS	W	IMU FAIL	<ol style="list-style-type: none"> <li>1. Loss of 3200 cps microsyn excitation, or</li> <li>2. Loss of 800 cps wheel excitation, or</li> <li>3. Gimbal servo error signal greater than 5.5 V rms.</li> </ol>
		PIPA FAIL	<p>During specific force phases:</p> <ol style="list-style-type: none"> <li>1. Delta V registers incrementing at maximum rate, or</li> <li>2. No "P" or "N" pulses in one clock period, or</li> <li>3. Both "P" and "N" pulse at same time.</li> </ol>

Light Legend	C/W Category	Malfunction	Illuminated by
		ISS CDU FAIL	<ol style="list-style-type: none"> <li>1. CDU fine error in excess of 1 V rms, or</li> <li>2. CDU coarse error in excess of 2.5 V rms, or</li> <li>3. Read counter up lines incrementing at too high a rate, or</li> <li>4. <math>\cos(\theta - \phi)</math> below 3.5 V, or</li> <li>5. Loss of +14 V supply</li> </ol>
CGC	W	CGC POWER FAIL	<ol style="list-style-type: none"> <li>1. Loss of LGC +28 V, or</li> <li>2. Loss of +3 V supply, or</li> <li>3. Loss of +13 V supply</li> </ol>
		CGC CIRCUIT ALARM	<ol style="list-style-type: none"> <li>1. Counter Fail - Counter increment in progress 30 millise., or</li> <li>2. Scaler Fail - Loss of 2.048 mc oscillator and associated timing.</li> </ol>
PGNS	C	GIMBAL LOCK	Middle gimbal angle greater than $\pm 75^\circ$
		IMU TEMP	Deviations in IMU temperature greater than $\pm 5^\circ\text{F}$ from normal
		PROGRAM ALARM	Controlled by program. Indicates that some program check has failed.
		RESTART	<ol style="list-style-type: none"> <li>1. Parity Fail - Indicates that a word has been incorrectly transferred from memory, or</li> <li>2. TC Trap - Indicates that the computer is in an endless control loop, or</li> <li>3. Rupt Lock - Indicates that the computer has been interrupted for 30 millise., or</li> <li>4. Night Watchman - Indicates that computer has not accomplished a CCS NEW JOG within 1.28 secs.</li> </ol>

Light Legend	C/W Category	Malfunction	Illuminated by
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5. ~~May be triggered by program (TEST ALARM)~~

During non specific force phases:

PIPA FAIL

1. Delta registers incrementing at maximum rate, or
2. No "P" or "N" pulses in one clock period, or
3. Both "P" or "N" pulses in one clock period.

OSS CDU FAIL

1. CDU fine error in excess of 1 V rms, or
2. CDU coarse error in excess of 2.5 V rms, or
3. Read counter up lines incrementing at too high a rate, or
4.  $\cos(\theta - \phi)$  below 3.5 V, or
5. Loss of +14 V supply.

MASTER ALARM

W

Alerts the astronaut to a fault condition as displayed on the G&N Indicator Control Panel or in the MDC Caution/Warning matrix.

STAR ACQUIRED

Indicates the star tracker has acquired a star.

3.0 LEB CONTROLS

3.1 G&N Indicator Control Panel

3.1.1 Description

This panel contains the Optics Subsystem controls, the attitude impulse control, the reticle brightness control, the condition lamps control, a MASTER ALARM reset control, and <sup>an up telemetry control.</sup> ~~the placards listing the computer~~  
~~VERB NOUNS and the MAJOR MODES.~~

3.1.2 Optics Controls

3.1.2.1 Mode Control

<u>Position</u>	<u>Function</u>	<u>Function Description</u>
UP	COMPUTER	Position enables control of the Optics Subsystem by the Computer. The computer controls modes and LOS drive of SXT and SCT. Renders other Optics controls inoperative.
CENTER	MANUAL	Position enables control of Optics Subsystem Manually. The astronaut controls modes and LOS drive of the SXT and SCT.
DOWN	OPTICS ZERO	Position drives the SXT and SCT shaft and trunnion angles to zero. The encoder registers of the CGC are also zeroed.

### 3.1.2.2 Controller Speed Control

<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
UP	HI	Provides maximum LOS drive rate of 20°/sec shaft and 10°/sec trunnion while in the DIRECT mode and a max LOS drive rate of 10°/sec shaft and trunnion while in the RESOLVED mode.
CENTER	MED	Provides maximum LOS drive rate of 2°/sec shaft and 1°/sec trunnion while in the DIRECT mode and a maximum LOS drive rate of 1°/sec shaft and trunnion while in the RESOLVED mode.
DOWN	LO	Provides maximum LOS drive rate of 0.2°/sec shaft and 0.1°/sec trunnion while in the DIRECT mode and a maximum LOS drive rate of 0.1°/sec shaft and trunnion while in the RESOLVED mode.

### 3.1.2.3 Controller Coupling Control

<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
UP	DIRECT	Provides direct control of SXT LOS (integrator loops) with optics hand controller. Fore-aft motion of the controller will provide increase-decrease control of the SXT trunnion. Right-left motion of the controller will provide increase-decrease

<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
		(clockwise-counterclockwise) control of the SXT shaft.
DOWN	RESOLVED	Provides resolved control of SXT LOS (integrator loops) with optics hand controller. Fore-aft motion of the controller will provide up-down image motion. Right-left motion of the hand controller will provide right-left image motion.

#### 3.1.2.4 Tracker Control

<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
UP	TRACK	Slaves the SXT shaft and trunnion servos to the star tracker. The SXT will automatically track the star. The SCT trunnion is controlled by the optics hand controller and the SCT shaft follows the SXT shaft.
CENTER	ACQUIRE	Energizes the tracker and photometer electronics. The SCT and SXT shaft and trunnion servos are controlled by the optics hand controller. When a star is acquired by the tracker a STAR PRESENCE discrete is applied to the CGC and the Star Acquired indicator is illuminated.
DOWN	OFF	De-energizes the tracker and photometer electronics. The Tracker switch is functional with the Optics Mode switch in the MANUAL position. With the Optics Mode switch in the COMPUTER position the tracker switch is inoperative and the tracker functions of ACQUIRE and TRACK are controlled by the CGC.

#### 3.1.2.5 Telescope Trunnion Control

<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
UP	SLAVED TO SXT	Slaves the telescope trunnion LOS to the SXT trunnion LOS. Provides

<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
		complete control of telescope LOS by the optics hand controller.
CENTER	0°	Drives the telescope trunnion to 0°. This puts the telescope LOS on the landmark during star-landmark nav. measurements.
DOWN	OFFSET 25°	Drives the telescope trunnion to 25°. This provides a 110° FOV as the shaft is rotated through 360°.

### 3.1.2.6 Optics Hand Controller

#### Function

This is a two-degree-of-freedom controller which provides manual control of the optics LOS. The drive rates are proportional to stick displacements and the direction of LOS motion in response to stick motion is controlled by the Controller Coupling switch. 3.1.2.3.

### 3.1.2.7 Mark Button

#### Function

This momentary push button is used to notify the CGC of superimposition of the proper target images. The button applies a discrete to the CGC which causes it to note the optics angles, time of measurement, and if the ISS is operating, the IMU gimbal angles.

### 3.1.2.8 Mark Reject Button

#### Function

This momentary push button is used to notify the CGC the MARK was not acceptable. The button applies a discrete to the CGC which causes the mark data to be cleared and the program to recycle to the start of the mark routine.

### 3.1.2.9 Reticle Brightness Control

#### Function

Regulates the brightness of the SCT and SXT reticles and the SCT digital readouts.

### 3.1.2.10 Optics Door Control

#### Function

Provides control with the universal tool of the optics external protective door cover.

### 3.1.3 Attitude Impulse Controller

#### Function

This 3 degree-of-freedom stick controller provides signals to the CGC which causes the Digital Autopilot to apply small impulses to the spacecraft by means of the RCS.

### 3.1.4 Condition Lamps Control

#### Position

#### Function

#### Functional Description

UP

ON

Applies excitation to the 3 conditions lamps (ISS, CGC and PGNS) on the Condition Annunciator Assembly to enable them to be illuminated by the detection circuitry.

CENTER

OFF

Removes excitation from the 3 condition lamps (ISS, CGC and PGNS) on the Condition Annunciator Assembly.

DOWN

TEST

Applies excitation to test circuitry for all the condition lamps (ISS, CGC, PGNS, and MASTER ALARM) on the Condition Annunciator Assembly.

### 3.1.5 Master Alarm Reset Switch

#### Function

Actuation of this push button switch resets the Master Caution System, de-energizing the annunciator and associated audio tone.

### 3.1.6 Up Telemetry Switch

#### Position

#### Function

#### Functional Description

UP

ACCEPT

Enables the CGC to receive data from the telemetry equipment. Switch position applies "ACCEPT UPLNK" discrete to CGC if switch on MDC is in ACCEPT position.

<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
DOWN	BLOCK	Blocks the telemetry data from getting to the CGC. This switch is in parallel with a similar switch on the MDC.

### 3.2 DSKY

The computer keyboard is used to manually insert or call up data from the computer. The keyboard consists of 10 digital pushbuttons, 2 algebraic sign pushbuttons, and 7 instruction pushbuttons.

The pushbuttons are:

<u>Button</u>	<u>Functional Description</u>
0 thru 9	Digits
+	Signifies next five digits are positive
-	Signifies next five digits are negative
VERB	Signifies next two digits are verb code
NOUN	Signifies next two digits are noun code
CLR	Clear data in numeric display
STBY	Puts computer in power saving standby mode
KEY REL	Releases keyboard from manual operation for display of program data or requests
ENTR	Enters keyboard data into program
<del>ENTR</del> RSET	Resets DSKY caution lights under program control

### 3.3 Rotational Hand Controller

The rotational hand controller is a 3 degree-of-freedom controller used for manual attitude control. Normally the controller will be mounted on the left arm rest of the right hand couch. For use at the Navigation Station it is removed from the arm rest and fastened to a panel on the right hand side of the navigation station.

By appropriate switching (external to the control itself) it is possible to obtain the following attitude control functions: Rate Command

Control, Acceleration Command Control, Minimum Impulse, or Direct Control. The control is designed so that attitude control signals can be inserted in either direction into any one axis, any two axes, or all three axes simultaneously.

#### 4.0 MDC DISPLAYS

##### 4.1 Flight Director Attitude Indicator (FDAI)

The FDAI combines three display functions pertaining to spacecraft orientation. Total attitude, attitude errors and body angular rates are indicated for the pitch, roll, and yaw axes. There are two FDAI's on the MDC.

###### 4.1.1 Total Attitude

Total attitude is displayed on the gimballed attitude ball. It has 360° of freedom in the pitch, roll, and yaw axes. The ball is marked in pitch from pole to pole and in yaw from 270° - 0 - 90°. Roll is marked from 0° to 359° in 10° increments in a CCW direction about the case surrounding the ball.

###### 4.1.2 Attitude Errors

The attitude errors are displayed by the attitude error needles of the FDAI. The roll error indicator is at the top, pitch on the right, and yaw at the bottom with the meter indices moving over the face of the ball. The pitch and yaw attitude error needles represent  $\pm 15^\circ$  error for full scale deflection in Monitor and  $\pm 5^\circ$  for all others. The roll attitude error needles represents  $\pm 50^\circ$  full scale deflection in entry and monitor and  $\pm 5^\circ$  for all others.

###### 4.1.3 Attitude Rates

The attitude rates are displayed about the face of the FDAI, with roll at the top, pitch on the right side, and yaw at the bottom. The rates displayed are derived from the SCS BMAG's when placed in an electrical rate configuration.

##### 4.2 SPS Engine Gimbal Angle Indicator

The SPS Engine Gimbal Angle indicators display angular displacements of the SPS Engine Gimbals from their null references. This display

is time shared with the S-II and S-IV B Fuel and Oxidizer pressures which are displayed until after completion of second stage boost and Translunar Injection.

During normal thrusting the engine gimbals are positioned by the G&C System through the OCDU DC analog output.

During backup thrusting the engine gimbals are positioned by the SPS Engine Gimbal Position Controls.

#### 4.3 Attitude Set Indicator

The attitude set indicators provide manual updating capabilities of the Attitude Reference Subsystem of the SCS and as a backup reference in the event of an CGC failure. Normally, the Gyro Display Coupler resolver shaft angle is compared, in the indicator, with the shaft position reference of the indicator resolver. The resultant differential signal may be used to align the GDC and FDAI or, to manually position the S/C to a desired attitude (this manual S/C positioning is a backup to the PGNS). During CGC backup, the IMU gimbal angle is compared in the indicator with the shaft position reference of the indicator resolver. The resultant differentiation signal is displayed by the error needles of the FDAI.

### 5.0 MAIN DISPLAY CONSOLE AREA CONTROLS

#### 5.1 Rotational Hand Controller

The rotational hand controller is a 3-degree-of-freedom controller used for manual attitude control. There are two rotational controllers, one is mounted on the right arm rest of the left couch and one is mounted on the left arm rest of the right couch. The controller at the right couch may be moved to the Navigation Station.

#### 5.2 Translational Hand Controller

The translational hand controller is a T handle configuration with up-down, right-left, and in-out motions simultaneously. The controller is mounted on the left arm rest of the left couch. Translation commands can be initiated simultaneously that will result in a composite maneuver. Counterclockwise rotation of the controller will initiate a Mission Early Termination during high altitude and translunar inject phases. It initiates an abort during

ascent if the launch escape tower is attached. Clockwise rotation of the controller will disable the PGNS control.

5.3 MDC Controls

5.3.1 CGC ATT

<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
UP	IMU	Provide normal IMU referenced attitude
DOWN	GDC	Provides single axis GDC attitude to CGC. Provides body axis att. error display only (ball display's fixed). In this position CGC can't command RCS or SPS.

5.3.2 FDAI SCALE Selects ATT ERROR and RATE Scales for the FDAI

<u>Position</u>	<u>Function</u>	
	ERR	RATE
UP	5	1
CENTER	5	5
DOWN	50/15	50/10

5.3.3 FDAI SELECT Selects either or both FDAI's

<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
UP	1-2	Selects source selected by "SOURCE" switch for display on FDAI #1 and the other source is displayed on FDAI #2.
CENTER	2	FDAI #2 displays source selected by "SOURCE" switch. FDAI #1 is dead.
DOWN	1	FDAI #1 displays source selected by "SOURCE" switch. FDAI #2 is dead.

5.3.4 FDAI SOURCE Selects the source of signals displayed on the FDAI

<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
UP	CGC	Displays IMU Gimbal Angles on the Ball. Displays ICDU error generation on error needles.

	<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
	CENTER	ATT SET	Displays difference between ATT SET dials and total attitude reference selected by ATT SET Sw.
	DOWN	GDC	Displays <del>SC</del> <sup>GDC</sup> angles on the ball. Displays BMAG error on error needle.
5.3.5	ATT SET	Selects the source of total attitude for the ATT SET resolvers	

	<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
	UP	IMU	Applies IMU gimbal angle 1X resolver signal to ATT Set resolvers. FDAI error needles display difference. Needles zeroed by moving SC or ATT SET dials.
	DOWN	GDC	Applies GDC resolver signal to ATT SET resolvers. FDAI error needles display difference. Needles zeroed by moving SC or ATT SET dials. New attitude reference established by depressing GDC ALIGN button. This causes GDC to drive to null the error, hence the GDC and ball go to ATT SET dial value.

5.3.6, 7, 8 MANUAL ATTITUDE (6) ROLL, (7) PITCH, (8) YAW Operative with SC CONTROL Sw in SCS position

	<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
	UP	DIRECT	Provides direct RCS firing as a result of moving the rotational controller out of detent (2.5°) by applying direct input to solenoid driver amps.
	CENTER	RATE CMD	Provides proportional rate command from rotational controller with input from BMAG in rate configuration.
	DOWN	MIN IMP	Provides Minimum Impulse capability through the rotational controller.

	<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
5.3.9	LIMIT CYCLE		
	UP		Provides pseudo-rate capability

	<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
	DOWN	OFF	Disables pseudo-rate.
5.3.10	ATT DEADBAND	Selects 5° or 0.5° deadband	
	<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
	UP	MAX	Provides 5° deadband for SCS SC CONTROL
	DOWN	MIN	Provides 0.5° deadband for SCS SC CONTROL
5.3.11	RATE		
	<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
	UP	HIGH	Provides high (Entry) rate capability for SCS SC CONTROL. 2.0°/sec pitch, yaw; 19°/sec roll.
	DOWN	LOW	Provides low (Normal) rate capability for SCS SC CONTROL. 0.3°/sec for all axes.
5.3.12	DIRECT RCS		
	<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
	UP		Enables DIRECT RCS control through rotational control hard stops. Energizes Direct Coils in RCS.
	DOWN	OFF	Disables DIRECT RCS.
5.3.13, 14, 15, 16	SCS CHANNEL	ROLL (13) A/C (14) B/D, (15) PITCH, (16) YAW	
	<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
	UP	ON	Enables RCS jets.
	DOWN	OFF	Disables RCS jets. Roll jets may be disabled in pairs.
5.3.17	SC CONTROL - SOURCE		
	<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
	UP	CGC	G&N system-computer controlled SC attitude and TVC thru digital autopilot. Switch position applies "Autopilot Control" discrete to CGC.

	<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
	CENTER	SCS	SCS system controls SC attitude and TVC.
	DOWN	HYBRID TVC	IMU-CDU difference generates steering error for SCS system. No digital autopilot. Similar function to Block I control (technological backup).
5.3.18	SC CONTROL - CGC		
	<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
	UP	AUTO	CGC positions SC in response to computer program or hand controllers.
	CENTER	ATT SYNC (HOLD)	CGC positions SC in response to hand controllers and then holds attitude. Switch position applies "HOLD" discrete to CGC.
	DOWN	DRIFT (FREE)	CGC responds to hand controller or minimum impulse control to generate SC rate. Switch position applies "FREE" discrete to CGC.
5.3.19, 20, 21	BMAG MODE - (19) ROLL, (20) PITCH, (21) YAW		
	<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
	UP	RATE 2	Set #2 BMAGS provide rate display on FDAI. No BMAG attitude reference.
	CENTER	ATT 1 RATE 2	Set #1 BMAGS provide attitude reference. Set #2 BMAGS provide rate display on FDAI.
	DOWN	RATE 1	Set #1 BMAGS provide rate display on FDAI. No BMAG attitude reference.
5.3.22	SPS THRUST		
	<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
	UP	NORMAL	Enables Normal SPS ignition through CGC or THRUST ON button. Switch position applies "SPS Ready" discrete to CGC.
	CENTER	OFF	Disables SPS thrust.
	DOWN	DIRECT ON	Applies +28 v to solenoids.

5.3.23 DIRECT ULLAGE

Function

When depressed commands a +x acceleration using the direct reaction jet control solenoids.

5.3.24 THRUST ON

Function

When depressed causes manual SPS ON through the SCS engine ON/OFF logic (Lights at Thrust ON).

5.3.25 SPS ENG VALVES Selects A or B solenoids and drivers

<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
UP	A	
CENTER	OFF	
DOWN	B	

5.3.26, 27 SPS GMBL DRIVE (26) PITCH, (27) YAW

<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
UP	1	Selects SCS TVC Servo #1.
CENTER	AUTO	
DOWN	2	Selects SCS TVC Servo #2.

5.3.28, 29 SCS TVC (28) PITCH, (29) YAW

<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
UP	AUTO	Applies body axis attitude error plus vehicle rate plus trim to TVC gimbal servo.
CENTER	MAN RTD	Provides direct stick input to TVC gimbal servo amps with vehicle rate damping.

<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
DOWN	DIRECT	Provides direct stick input to TVC gimbal servo amps with no vehicle rate damping.

5.3.30, 31, 32, 33 SPS GIMBAL MOTORS <sup>30</sup> (30) 1 PITCH (31) 2, (32) 1 YAW (33) 2

<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
UP	1 or 2	Servo motor in run configuration.
CENTER		Starts servo motor.
DOWN	OFF	De-energizes gimbal servo motor.

5.3.34 ΔV CG Selects proper gain for TVC as a function of vehicle configuration

<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
UP	LEM/CSM	Selects gain in SCS for LEM ON. Switch position applies "LEM attached" discrete to CGC for gain change.
DOWN	CSM	Selects gain in SCS for LEM OFF.

5.3.35 IMU CAGE

Function

This switch has a protective cover to the OFF position. Switch closure causes the IMU gimbals to be coarse aligned to zero independent of the CGC by a relay in the PSA. The relay closure applies an "IMU CAGE" discrete to the CGC.

5.3.36 ENTRY - EMS ROLL

<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
UP		Enables EMS Roll Display.
DOWN	OFF	De-energizes EMS Roll Display.

5.3.37 ENTRY - 0.05 G

<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
UP		R-Y coupling-Single axis AGD - GDC Yaw channel drives EMS roll display.
DOWN	OFF	

5. 3. 38 LAUNCH VEH - SPS

<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
UP	AOA	Selects Launch Vehicle Angle of Attack Display on the LV AOA/SPS Pc indicator.
DOWN	Pc	Selects SPS fuel pressure on the LV AOA/SPS Pc indicator.

5. 3. 39 LAUNCH VEH - SPS

<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
UP	SII/SIV B	Selects Launch Vehicle Fuel Pressure display on the LV Fuel Pressure/SPS Gimbal indicator.
DOWN	GPI	Selects SPS Gimbal Position display on the LV Fuel Pressure/SPS Gimbal indicator.

5. 3. 40 GDC ALIGN -

Function  
 Pushbutton Switch - Enables alignment of the GDC resolvers and FDAI to the attitude displayed on attitude set dials.

5. 3. 41 BLOCK UPTLM

<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
UP		Enables the CGC to receive data from the telemetry equipment. Switch position applies "ACCEPT UPLNK" discrete to CGC if switch in LEB is in ACCEPT position.
DOWN		Blocks the telemetry data from getting to the CGC. This switch is in parallel with a similar switch on the G&N Indicator Control Panel in the LEB.

5. 3. 42 SIV B GUIDANCE

<u>Position</u>	<u>Function</u>	<u>Functional Description</u>
UP	LV	LV IU controls SIV B.
DOWN	.CM	CGC controls SIV B (controls INJ SEQU STRT, CUT OFF CMD, ROLL, PITCH, YAW) Switch position applies "SC CONTROL OF SATURN" discrete to CGC.

## 6.0 PGNS ELECTRICAL INTERFACES

The following lists tabulate all electrical interfaces between the G&N and the remainder of the spacecraft, or booster. In each list the following code is used:

1. First number - numerically assigned for use of these lists only.
2. Three digit number; when present, is the appropriate computer interface control code.
3. Interface type:
  - DE: d-c input to computer "in bit"
  - SD: Switch closure of dc
  - DC: DC proportional analog voltage
  - 800 cps: Analog 800 cps suppressed carrier or 800 cps power
  - 400 cps: 400 cps power
  - CB: Computer dc output under program control
  - XC: Computer transformer output continuous signal
  - X-: Computer transformer output special signal
  - Y-: Computer transformer input special signal
  - YG: Computer transformer input into counter
  - XA: Computer transformer output under counter control
  - 28<sup>V</sup>DC: 28<sup>V</sup>DC power
  - DSKY: Associated with either or both of the Display and Keyboards
  - E. L. Associated with computer data display through electroluminescent panel
  - STATUS: Associated with white status lights
  - CAUTION: Associated with yellow caution lights
  - WARNING: Associated with red warning lights
  - LEB Annunciator: Lights of the Lower Equipment Bay condition annunciator on the G&N Indicator control panel

NAV Panel Light: Status light on navigation control panel

Counter: Degrees and decimal degrees counter

Eyepiece: Eyepiece

4. Interface name: The name assigned to the function is underlined.
5. Number in parentheses is that used in minutes of the Integrated Guidance and Control Implementation Meetings at MSC.
6. Description of Interface

6.1 Mode Control

1. 004 DE Ullage Thrust Present (106), Signal from Saturn indicates SIVb engine is burning to cause G&N thrust acceleration integration.
2. 007 DE Lift Off (108), Signal from Saturn indicates first motion of booster.
3. 068 DE Guidance Reference Release (109), Signal from Saturn indicates to G&N that the Saturn booster guidance has ceased gyro torquing to local launch vertical trajectory plane framework.
4. \_\_\_ R SIVb Discrete Power (112), Computer 28<sup>V</sup>DC through resistor to power discretely "ullage thrust", "Lift off" and "guidance release".
5. 066 DE SIVb Separate/Abort (42), Signal from mission sequences indicates that SIVb is staged and is interpreted as an abort if occurs early.
6. 060 DE LEM Attached (44), Indicates LEM is attached to CSM
7. 067 DE SM Separate (43), Signal from mission sequences indicates the SM is staged.
8. 065 DE Free function (59), Indicates astronaut has selected the "free" mode of G&N attitude control wherein the G&N responds ~~only~~ to hand controller <sup>or min. impulse controller</sup> acceleration commands.
9. 040 DE Hold function (58), Indicates astronaut has selected the "hold" mode of the G&N attitude control wherein the G&N holds present spacecraft attitude except when responding to hand controller velocity commands.
10. \_\_\_ \_\_\_ Auto function (-), (Indicated by not free or not Hold). Indicates that the astronaut has selected the "AUTO" mode of the G&N attitude control wherein the G&N commands spacecraft position according to computer program or hand controller velocity commands.

6.1 Mode Control (Cont.)

11. 082 DE SPS Ready (41), Indicates that the astronaut has completed the engine start checklist and the G&N can proceed with engine RCS ullage-SPS firing cycle.
12. 158 DE SC Control of Saturn (105), Indicates that the pilot has chosen to have the Apollo G&N guide Saturn.
13. 159 DE G&N Autopilot Control (26), Indicates the pilot has chosen primary G&N control of RCS and SPS engines for attitude and thrust vector control.
14. \_\_\_ SD IMU Cage, Contact closure on main panel to cause IMU gimbal to be coarse aligned to zero.
15. 083 DE ACCEPT UPLNK, Signals the astronaut has selected by a main panel switch or LEB panel switch to enable ground up-telemetry to enter the computer.

6.2 Analog Signals

1.	DC	Pitch SPS Gimbal (1) drive signal from G&N	
2.	DC	Yaw SPS Gimbal (2) drive signal from G&N	
3.	800 cps	Pitch Error (6)	} G&N error signals to attitude error needles of FDAIs for error display - also used in early Block II flights to SCS as "Technological Backup"
4.	800 cps	Yaw Error (8)	
5.	800 cps	Roll Error (7)	
6.	800 cps	Sine Inner (3)	} IMU gimbal signals to FDAIs for indication of vehicle total attitude.
7.	800 cps	Cosine Inner (3)	
8.	800 cps	Sin Middle (5)	
9.	800 cps	Cos Middle (5)	
10.	800 cps	Sin Outer (4)	
11.	800 cps	Cos Outer (4)	
12.	DC	Pitch Error (101)	} G&N error signals from Apollo CM to Saturn instrument unit for spacecraft steering of Saturn.
13.	DC	Yaw Error (103)	
14.	DC	Roll Error (102)	

### 6.3 Engine & Jet Control

1. 801 CB +X, + pitch jet (9)
2. 806 CB -X, - pitch jet (10)
3. 805 CB -X, + pitch jet (11)
4. 802 CB +X, - pitch jet (12)
5. 803 CB +X, + yaw jet (13)
6. 808 CB -X, - yaw jet (14)
7. 807 CB -X, + yaw jet (15)
8. 804 CB +X, - yaw jet (16)
9. 813 CB +Z, + roll jet (17)
10. 816 CB -Z, - roll jet (18)
11. 815 CB -Z, + roll jet (19)
12. 814 CB +Z, - roll jet (20)
13. 809 CB +Y, + roll jet (21)
14. 812 CB -Y, - roll jet (22)
15. 811 CB -Y, + roll jet (23)
16. 810 CB +Y, - roll jet (24)
17. 011 CB SPS engine on/off (25), output signal when present indicates SPS firing command; when disappears indicates SPS shutdown.
18. 407 SD Injection Sequence Start (104), output signal from G&N indicating command which starts SIVb engine firing sequence.
19. 409 SD SIVb cutoff command, output signal from G&N indicating command to shutdown SIVb engine.
20. \_\_\_\_\_ SD \_\_\_\_\_ Saturn 28<sup>V</sup> DC switched during SC control of Saturn at main panel to power discretely "Injection Sequence Start" and "SIVb cutoff command".

1-16 are the 16 jets of the SM reaction control system or the 12 jets of the CM reaction control system. Switched by the SCS to SM or CM jets depending upon separation status. Jets are turned on by G&N for length of time signal is present.

#### 6.4 Maneuver Command Signals

1. 093 DE + pitch manual rotation (27)
2. 094 DE - pitch manual rotation (28)
3. 095 DE + yaw manual rotation (29)
4. 096 DE - yaw manual rotation (30)
5. 097 DE + roll manual rotation (31)
6. 098 DE - roll manual rotation (32)
7. 018 DE +X translation command (34)
8. 019 DE -X translation command (35)
9. 020 DE +Y translation command (36)
10. 021 DE -Y translation command (37)
11. 022 DE +Z translation command (38)
12. 023 DE -Z translation command (39)

Discrettes from the hand rotation controller indicating controller is out of detent and is commanding a fixed angular rate and direction about the indicated axis. (During "free" motion is acceleration and not rate.)

Discrettes from the hand translation controller indicating controller is out of detent and is commanding an acceleration in the direction indicated.

## 6.5 Computer Telemetry and Timing

1. 001 XC Master Clock, signal to synchronize spacecraft clock to the computer oscillator .
2. 017 X- Downlink data, serial downlink data from computer to telemetry.
3. 014 Y- Downlink start, signal indicating to computer to start sending serial downlink data.
4. 015 Y- Downlink end, signal indicating to computer to stop shifting out data and reload downlink register.
5. 016 Y- Downlink sync., timing for shifting out data into telemetry.
6. 024 YG Uplink zero, uplink data bit signifying zero.
7. 025 YG Uplink one, uplink data bit signifying one.

6.6 Backup Attitude Signals

1. 817 YG + PITCH BMAG
2. 818 YG - PITCH BMAG
3. 819 YG + ROLL BMAG
4. 820 YG - ROLL BMAG
5. 821 YG + YAW BMAG
6. 822 YG - YAW BMAG

} Angle increment data from the gyro display coupler of SCS Body Mounted Attitude Gyros used when IMU has failed as an attitude source so as to permit the computer to generate attitude error signals which may be displayed on FDAI.

6.7 Status Light Control

1. 441 SD CGC: to master caution and warning system indicating action of computer power failure or circuit alarm.
2. 429 SD ISS: to master caution and warning system indicating detection of IMU accelerometer, gyro, or CDU error.
3. 444 SD PGNS: to master caution and warning system indicating detection of IMU temperature out of limits, gimbal lock caution, computer restart, or program caution, and *tracker caution.*

6.8 Unused Capability

(Not connected to spacecraft systems but retained by NASA direction)

- |    |        |                      |   |   |
|----|--------|----------------------|---|---|
| 1. | 338 SD | G high light         | } | To signal lights intended on the entry monitor to indicate high or low entry.                   |
| 2. | 340 SD | G low light          |   |   |
| 3. | 029 XA | Entry velocity plus  | } | Intended for entry monitor to updown counter and comparator with SCS accelerometer integration. |
| 4. | 030 XA | Entry velocity minus |   |   |
| 5. | 078 XA | 909 bit cross out    | } | "Cross link" capability for two computers to communicate with each other.                       |
| 6. | 079 XA | 919 bit cross out    |   |   |
| 7. | 080 YG | 909 bit cross in     |   |   |
| 8. | 081 YG | 919 bit cross in     |   |   |

6.9 Power

1. 28 VDC AGC power buss A
2. 28 VDC AGC power buss B
3. 28 VDC IMU operate power buss A
4. 28 VDC IMU operate power buss B
5. 28 VDC IMU standby power buss A
6. 28 VDC IMU standby power buss B
7. 28 VDC Optics power buss A
8. 28 VDC Optics power buss B
9. 400 cps DSKY electroluminescent keyboard power - from master dimmer 115V nominal
10. DC or 400 cps MP DSKY status light power, from master dimmer, 5V nominal
11. DC or 400 cps DSKY caution light power, from master dimmer, 5V nominal
12. resist-  
ance DSKY numeric dimmer control, from master dimmer
13. 400 cps Optics reticles, power from SC for optics reticles
14. 800 cps 800 cps power, to SCS as 800 cps reference for FDAI and autopilot reference.
- ~~15. 28 VDC Test lights of status indicators on main panel DSKY under program control.~~
- <sup>15</sup>  
15. 28 VDC Power for AGC fail indication (45), to enable lighting of AGC warning light in the event AGC power breaker is out or AGC power has failed.