

Chapter 5

PRELAUNCH AND IN-FLIGHT OPERATIONS

5-1 SCOPE

This chapter describes operation of the Block II PGNCS during prelaunch and in-flight phases of the Apollo mission. PGNCS operation and crew procedures have been correlated for the following major phases of the flight profile: IMU alignment, guidance monitor, optical measurements, thrust vector control, attitude control, S-4B takeover, and entry.

5-2 PREPARATION FOR LAUNCH AND PRELAUNCH IMU ALIGNMENT

Preparation for launch begins when the backup crew enters the spacecraft and begins the checkout before liftoff. After control circuits linking the spacecraft to the launch pad have been verified as operational, the PGNCS subsystems are energized and the PGNCS operational test is performed. Data on trajectory and launch coordinates is entered into the computer in preparation for prelaunch alignment of the IMU.

During prelaunch IMU alignment, the IMU stable member is aligned to and held earth referenced at a predetermined orientation with respect to an earth referenced coordinate system. Stable member prelaunch alignment is required since the PGNCS monitors Saturn guidance during earth ascent and must be able to assume control of Saturn booster steering during earth orbit insertion and translunar trajectory injection. Prelaunch stable member alignment is maintained until just prior to lift-off when the stable member is released to an inertially referenced coordinate system. This procedure establishes an inertial starting point from which the PGNCS can determine spacecraft velocity, position, and attitude.

Stable member alignment (figure 5-1) is accomplished by vertical erection and azimuth alignment. During vertical erection, the X accelerometer input axis is positioned to sense local gravity and the Y and Z accelerometer input axes are maintained in the horizontal plane. If the stable member drifts from this orientation, so that the outputs of the Y and Z accelerometers indicate a portion of local gravity, the CMC repositions the stable member through the stabilization loop.

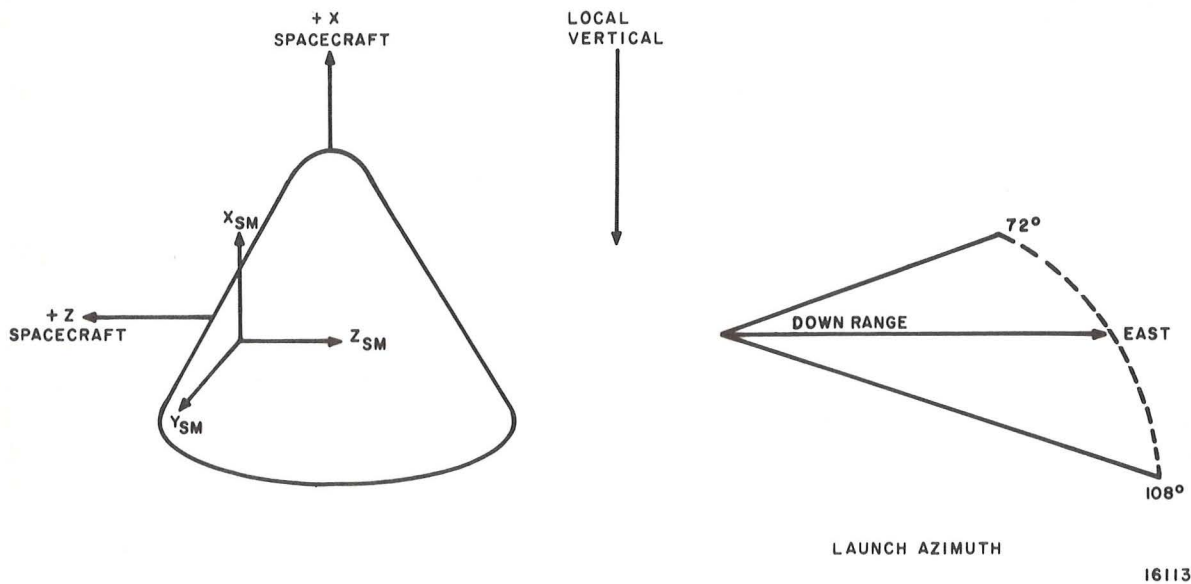


Figure 5-1. Prelaunch Alignment Axes Orientation

A computer controlled gyro compassing program aligns the stable member to and maintains the stable member at the desired azimuth. The desired azimuth of the down range accelerometer (dependent on the launch constraints) will vary from 72 to 108 degrees from true North. Gyro compassing is a self-alignment process: each gyro will sense a calculable portion of earth rate when the stable member is aligned to some particular orientation with respect to an earth referenced coordinate system. The computer compensates for earth rate torquing of the stable member gyros by sending a predetermined number of torquing pulses per unit of time to each IRIG torque ducosyn. If the stable member is not aligned to the desired azimuth, the gyro torquing pulses per unit time will not compensate for the earth rate torquing of the gyros. Consequently, the accelerometers originally located in the horizontal plane will be located in a different plane and will sense components of acceleration due to gravity. The computer interprets the acceleration data from the accelerometer loops as error signals. The error signals are used by the computer to calculate the necessary additional gyro torquing pulses per unit time to drive the stable member to the desired azimuth alignment.

After the desired azimuth of the stable member has been obtained, it is also maintained by the gyro compassing program. The east 25 IRIG will sense a component of earth rotation when the stable member is misaligned in azimuth. The resultant signal is used by the computer to reposition the stable member, thus compensating for earth rate and bias drift until launch.

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

To accomplish the task of prelaunch IMU alignment, (figure 5-2) the inertial subsystem is cycled through the IMU turn-on mode, coarse align mode and into the fine align mode. The inertial subsystem remains in the fine align mode during vertical erection and gyro compassing of the IMU. Accelerometer outputs and IMU gimbal angles are provided to the computer. The computer uses the accelerometer and gimbal angle information to control ISS moding and to generate the commands to initiate the positioning of the IMU stable member.

The ground crews mount the dust covers on the APTPS. Installation is accomplished with the optics shaft axis at 0° . This optics position must be maintained until dust cover ejection (after second stage engine cutoff).

The backup crew leaves the spacecraft after disconnecting the GSE and securing the navigation station by folding up the work table, installing the hand controller on the center couch, and checking PGNCS indicator lamps and controls.

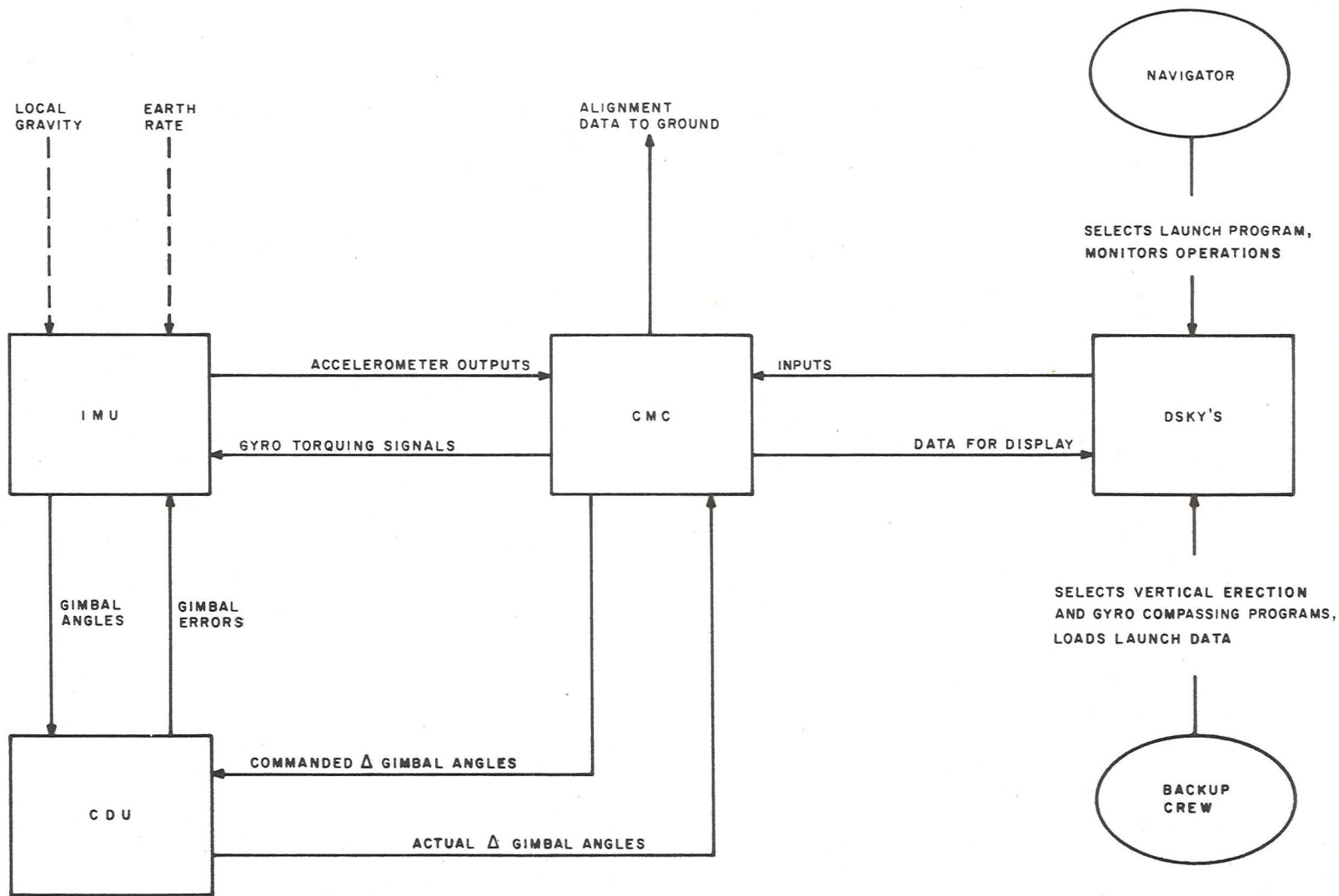
The flight crew enters the spacecraft about 2-3/4 hours before liftoff. The navigator selects the required computer program. The status of IMU alignment is monitored by the navigator on the DSKY and by the ground station telemetry and post installation ground support equipment.

5-3 GUIDANCE MONITOR

The PGNCS performs the function of guidance monitor during the earth ascent phase and the translunar injection phase of the Apollo mission. During these phases, the PGNCS monitors flight profile and mission sequencing.

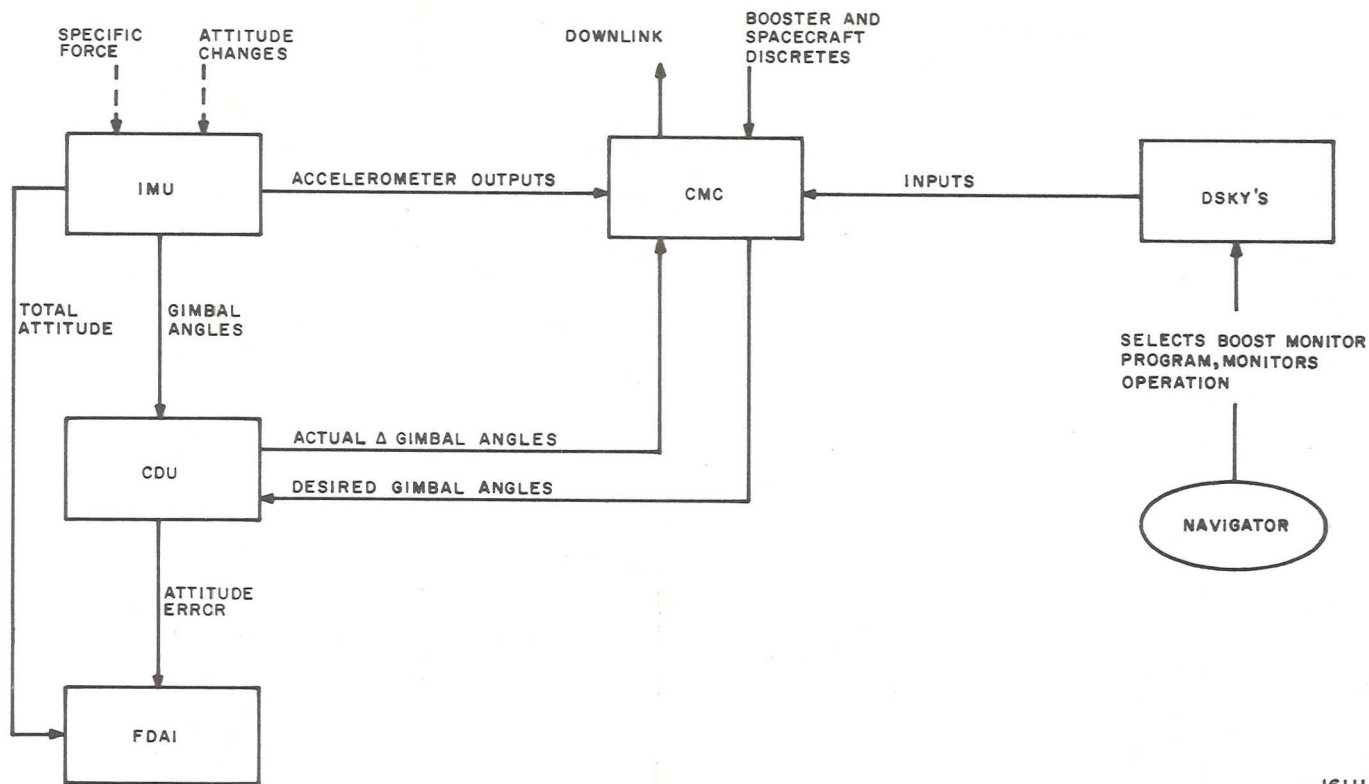
During guidance monitor, the CMC computes the difference between the desired spacecraft attitude and the actual spacecraft attitude. The astronaut can send attitude error signals from the PGNCS to Saturn instrumentation for use as steering signals by setting a switch on the main D and C panel. The CMC also computes and updates an abort re-entry program which can be initiated during the earth ascent phase at the command of the astronaut.

The inertial and computer subsystems (figure 5-3) are used for the guidance monitor functions. The inertial subsystem is operated in the attitude control mode. Changes in velocity due to engine thrust and gravitational fields are supplied to the computer by accelerometer loops. Spacecraft attitude, as determined from the gimbal angle resolvers, is used as total attitude inputs to the FDAI. The CMC computes the difference between the actual IMU gimbal angles (spacecraft attitude), as indicated by the CDU, and the desired gimbal angles (desired spacecraft attitude), as specified by the pitch program. The computed differences are converted to analog values in the CDU and displayed as attitude error signals on the FDAI. Discretes, such as guidance release and liftoff, generated by the boost guidance equipment are received by the CMC. Trajectory information, such as velocity, position, attitude, and time are available to the ground tracking stations through downlink.



16112

Figure 5-2. Prelaunch IMU Alignment



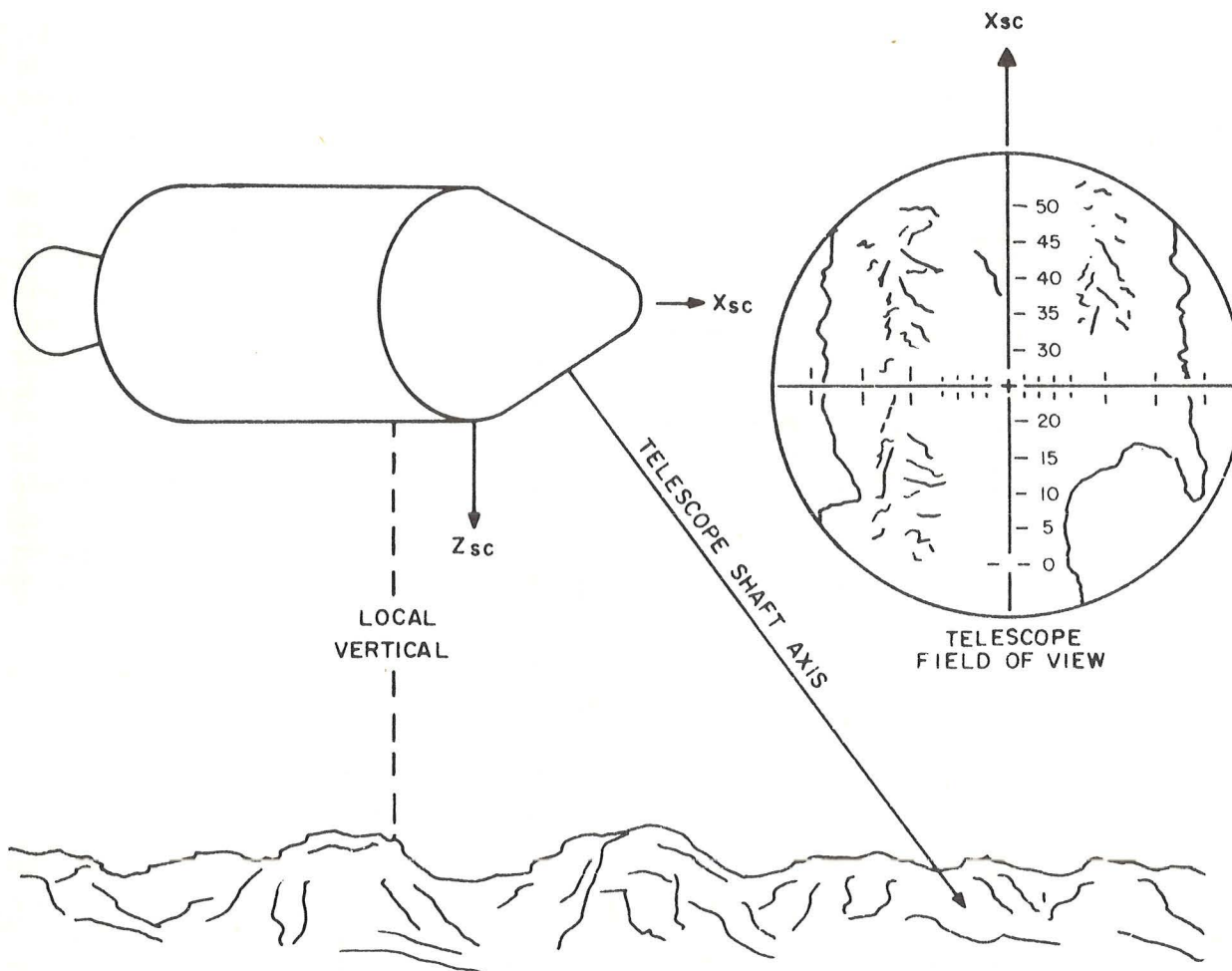
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Figure 5-3. Guidance Monitor

5-4 ORBITAL NAVIGATION

During earth or lunar orbits, velocity and position data is updated by taking navigational measurements. Earth and lunar orbit sightings are taken using well defined landmarks or using landmarks or the horizon and a prominent star as reference targets.

During orbital navigation, the spacecraft is orientated with the Z axis approximately down and the X axis in the direction of motion. (See figure 5-4.) This orientation points the optical axes toward the earth or lunar surface. The spacecraft is referenced to local vertical through computer control.



15167

Figure 5-4. Orbital Navigation Sighting

In preparation for orbital navigation measurements, the navigator mounts the optical eyepieces and adjusts instrument panel and interior spacecraft lighting. To assure maximum accuracy of orbital navigation measurements, the navigator verifies that the IMU has been fine aligned within the past 15 minutes. During the orbital navigation measurements, the IMU is operated in the inertial reference mode.

5-4.1 LANDMARK NAVIGATIONAL MEASUREMENT. Because of the high angular rate of landmark targets with respect to the spacecraft, the SCT, with its large field of view, is used for tracking and taking optical measurements. The chosen landmark targets are close to the orbital ground path so that a target image acquired near the horizon is tracked along a path which passes beneath the spacecraft.

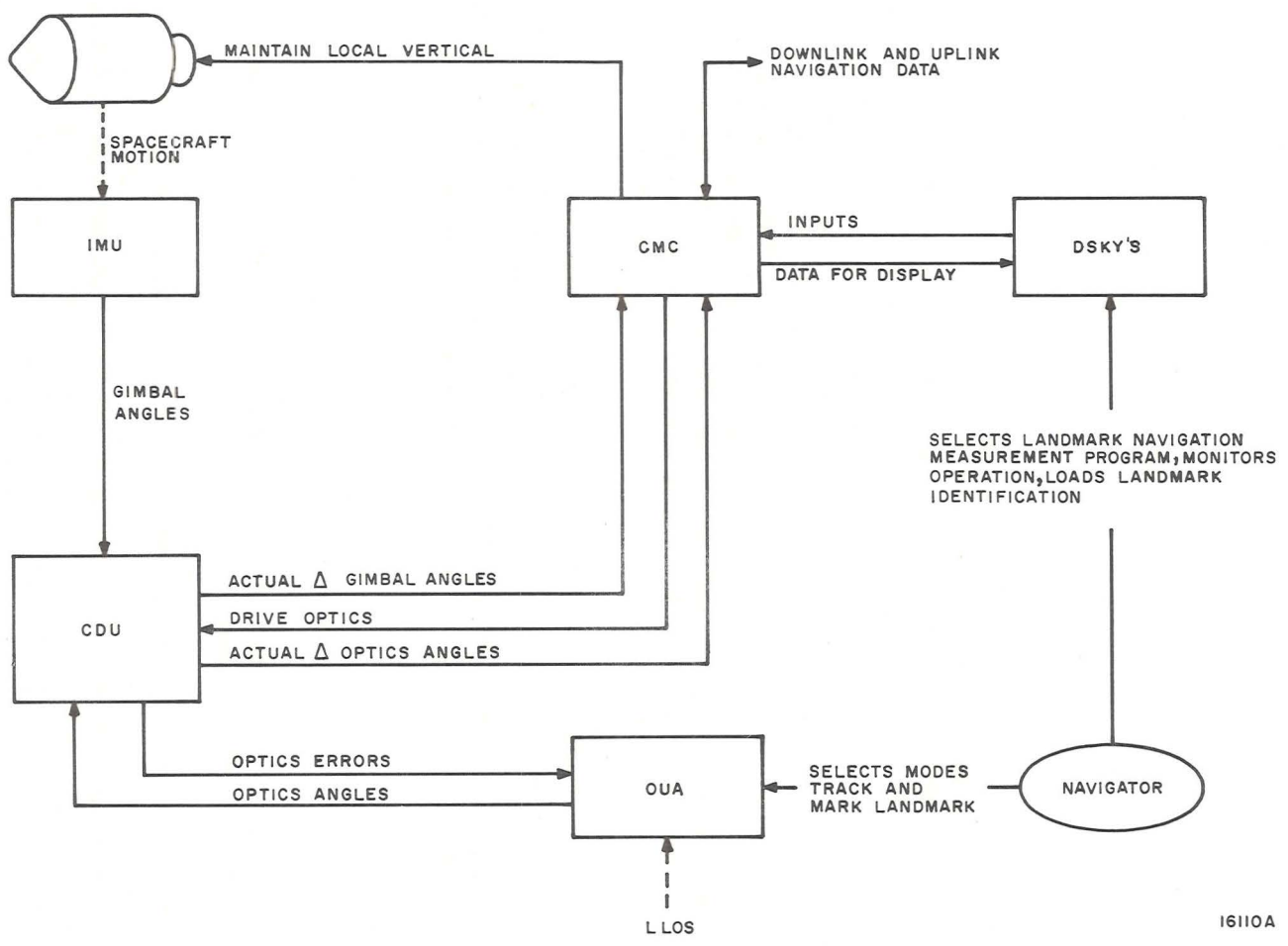
The navigator applies power to the optical subsystem, selects the zero optics mode, verifies that the optics has zeroed, refers to the procedures checklist to obtain the code number for orbital navigation and enters that number into the computer DSKY. (See figure 5-5.) The OPTICS MODE switch is set to MANUAL and the TELESCOPE TRUNNION switch is set to SLAVE TO SXT. When the landmark latitude, longitude and attitude is set into the computer, the optics shaft and trunnion angles are driven to the required angles. The navigator places the optics in manual resolved mode, centers the landmark in the telescope using the optics hand controller, and presses the mark pushbutton. Three equally spaced marks are taken on each target. The computer subsystem records the optical and inertial angles and the time when the mark pushbutton is pressed. The specific code number for the landmark sighted is then entered into the computer and the optics shaft and trunnion portions of the CDU are driven to the required values.

With the inertial subsystem in the attitude control mode, the CDU provides gimbal angle changes to the computer. The computer uses the angular information to calculate the spacecraft orientation with respect to the stable member. The CDU also provides changes in the optical angles defining landmark direction with respect to the spacecraft. The computer uses the CDU inputs to calculate the landmark direction relative to the stable member.

Resultant position and velocity data is sent to MSFN by downlink telemetry and is checked for accuracy by comparison with ground calculations.

5-4.2 STAR HORIZON NAVIGATIONAL MEASUREMENT. The SXT is used to measure the angle between an earth landmark or horizon and a target star.

To perform a star horizon navigational measurement, the navigator selects the computer program, zeros the optics and optics channels of the CDU, and selects a target star. The target must be a rising star on a bright horizon with less than 57° azimuth relative to the orbital plane of the spacecraft. After the SLAVE TO SXT mode is entered and the star acquired in the SCT, the navigator verifies that the target star is in the SXT field of view by observing the star image on the calibrated shaft axis crosshair.



16110A

Figure 5-5. Orbital Navigation

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

The command module rolls approximately 75° to point the LLOS toward a bright portion of the earth's horizon. After the astronaut has acquired the horizon in the SXT, and has centered the star and horizon in the SXT field of view, the mark pushbutton is pressed to send the optics angles to the computer.

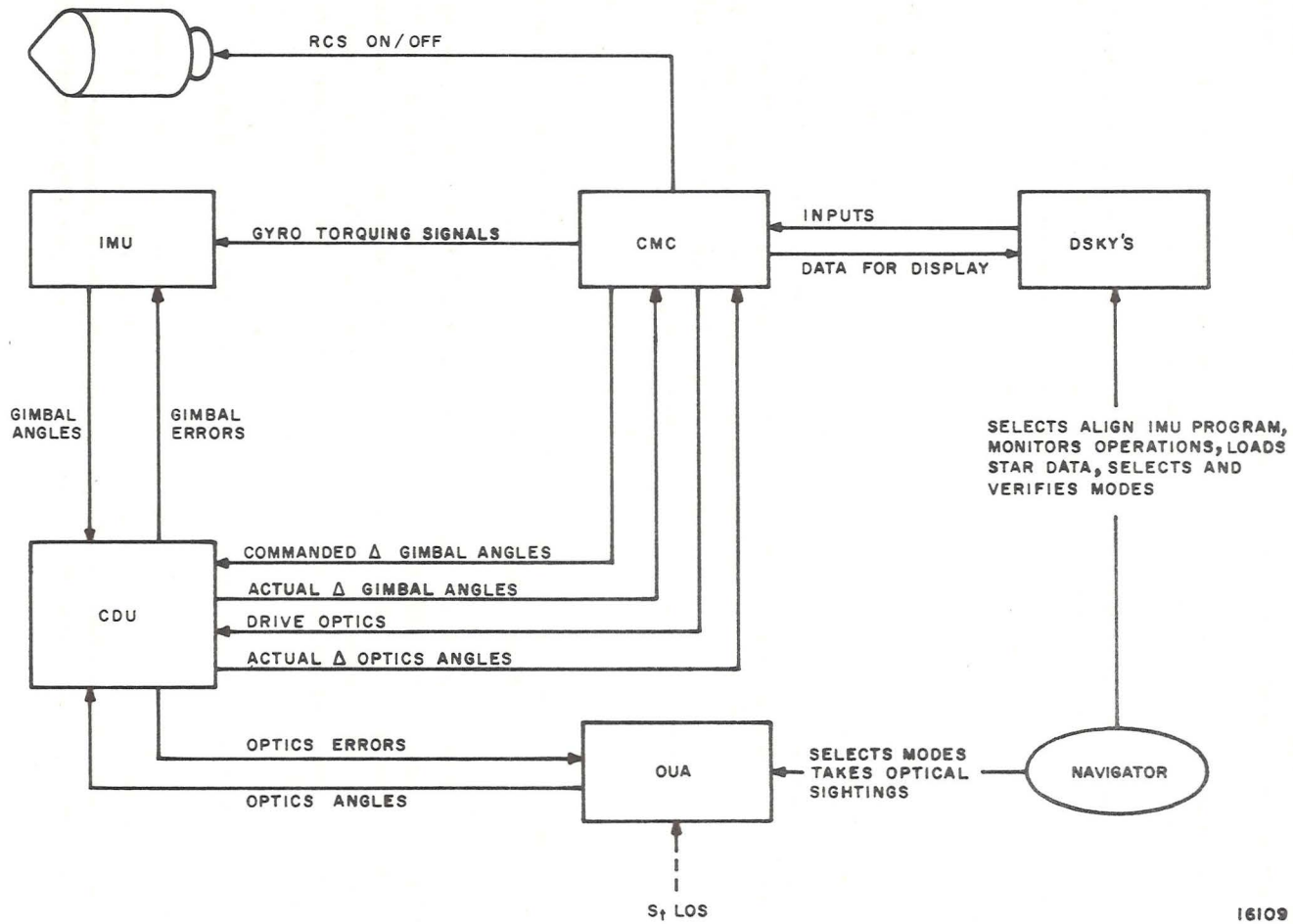
The inertial subsystem operates in the attitude control mode with the CDU providing gimbal angles to the computer. The optical subsystem is operated in the zero optics, manual, and computer modes with the optical portion of the CDU providing shaft and trunnion angles to the computer. The MARK commands are provided to the computer. The computer uses the CDU inputs to calculate the landmark direction relative to the stable member. MSFN receives the positional data at the time the MARK occurs through the downlink telemetry. The values are verified by ground computers and relayed back to the navigator.

5-5 IN-FLIGHT IMU ALIGNMENT

In-flight IMU alignment consists of using optical sightings to align the stable member to an inertial frame of reference. The CMC has geocentric coordinates of 28 stars stored in its fixed memory. The catalog of stars is used as the primary reference for alignment and navigational measurements. The IMU requires alignment each time the inertial subsystem is energized or after prolonged operation. As a general rule, the IMU will be aligned just prior to applying thrust to the spacecraft, prior to making orbital navigation sightings, and when the PGNCS is used for spacecraft attitude control. During the alignment process, the navigator is at the navigation station (lower D and C panel).

Basically the alignment procedure consists of two steps, coarse and fine alignment. In the coarse align mode, the stable member is approximately positioned to the desired orientation. In the fine align mode, the stable member is precisely aligned with respect to the inertial frame. Either an in-flight initial alignment or an update alignment may be required. If the inertial subsystem is in the standby mode, an initial alignment is performed and the subsystem is cycled through the IMU turn on, coarse align, and fine align modes. If the IMU has been aligned but has not been recently realigned, an update alignment may be required. The update alignment requires only the precise orientation of the fine align mode.

To accomplish alignment of the IMU, the navigator selects the required computer program (initial or update IMU alignment) and the target stars. (See figure 5-6.) With the initial alignment program selected, the IMU gimbal angles are set to zero and the spacecraft is maneuvered for coarse align sightings on two target stars. The navigator centers each star on the SXT optical field of view, operating the optics in the zero optics and manual modes, and initiates a MARK command. After each sighting, a star code number is entered into the computer. The CMC records the optics angles and the time and uses the recorded data to calculate the coarse align stable member orientation. After the computer has coarse aligned the stable member through the CDU, it maneuvers the spacecraft to obtain the fine align stars. With the optical subsystem in the computer mode, the optical portion of the CDU receives shaft and trunnion angle commands from the computer to point the SXT S_tLLOS toward the target star for the



16109

Figure 5-6. In-Flight IMU Alignment

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

fine alignment measurements. The two fine align stars are separately acquired in the center of the SXT field of view and a MARK command is initiated after each star is centered. Using the measured optical angles, the fine align star components are transformed into stable member axes by CMC programs. The existing stable member orientation is compared to the desired stable member orientation to determine the alignment requirements and the stable member is then torqued into position. A final check of the alignment can be performed by sighting on two additional stars.

If an update alignment is performed, the required computer program is selected and the spacecraft maneuvered into position for taking fine align sightings. Upon completion of sightings, the stable member is torqued into position.

5-6 MIDCOURSE NAVIGATION

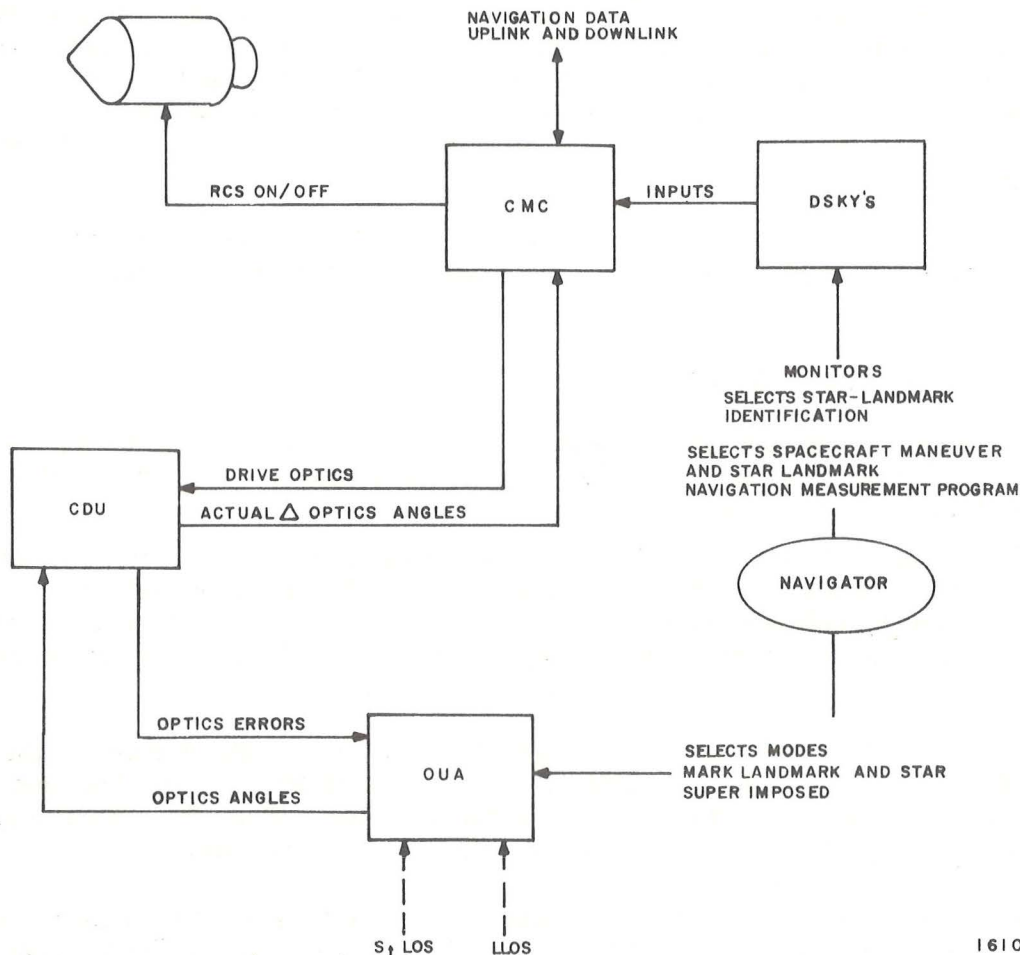
A midcourse navigation measurement is accomplished by using the SCT for coarse acquisition and the SXT for final measurement of an angle between a star and a well defined landmark.

The catalog of 28 star coordinates stored in the CMC fixed memory is used as the primary reference for navigational measurements. The stars are selected for uniform distribution on the celestial sphere so that for a random optical shaft axis direction a reference star is not more than 31 degrees away. Brightness and compatibility with midcourse navigation are also factors in star selection.

The landmarks are outstanding geographic locations on the surface of the earth or moon. The earth landmarks used are selected points of demarkation between land and water that are clear of cloud cover during the mission. When the optical angle is obtained a MARK command is sent to the computer by the navigator.

The MARK command sends the angle between the S_t LOS and LLOS and time of measurement to the CMC. (See figure 5-7.) The recorded data defines a cone in space with the apex at the landmark. (See figure 5-8.) The size of the cone is dependent on the measured angle which is equal to one-half the cone angle. The cone axis is parallel to the S_t LOS. For any arbitrary point on the surface of the cone, the angle between the landmark and star is the same. Therefore, one sighting defines the spacecraft position somewhere on the surface of the cone. The point on the cone surface nearest the present estimated position becomes an improved estimate of position at the time of the sighting.

Since the spacecraft moves in accordance with dynamic laws, departure from a computed trajectory is sufficiently small to permit linear reduction of the navigation problem by a running fix technique. This technique avoids dependence on a preprogrammed trajectory. It consists of improving or updating the velocity and position



16108

Figure 5-7. Midcourse Navigation

information with each succeeding optical measurement. At the time of translunar injection, the CMC contains an indication of velocity and position, which has been calculated from the inertial subsystem velocity measurements, and data on gravitational fields. Solving the equations of motion, the projected position data is obtained by extrapolation and an estimated trajectory is established. Whenever a navigational measurement is taken, the velocity and position information is used in conjunction with the landmark and star coordinates to predict or estimate the angle that should be measured. If the current estimates of position and velocity are correct and there is no instrument error, the measured angle is equal to the predicted angle. If the measured and predicted angles are not equal, the difference is used to update the estimated velocity and position. The CMC calculates the new estimate and verifies its calculation with MSFN.

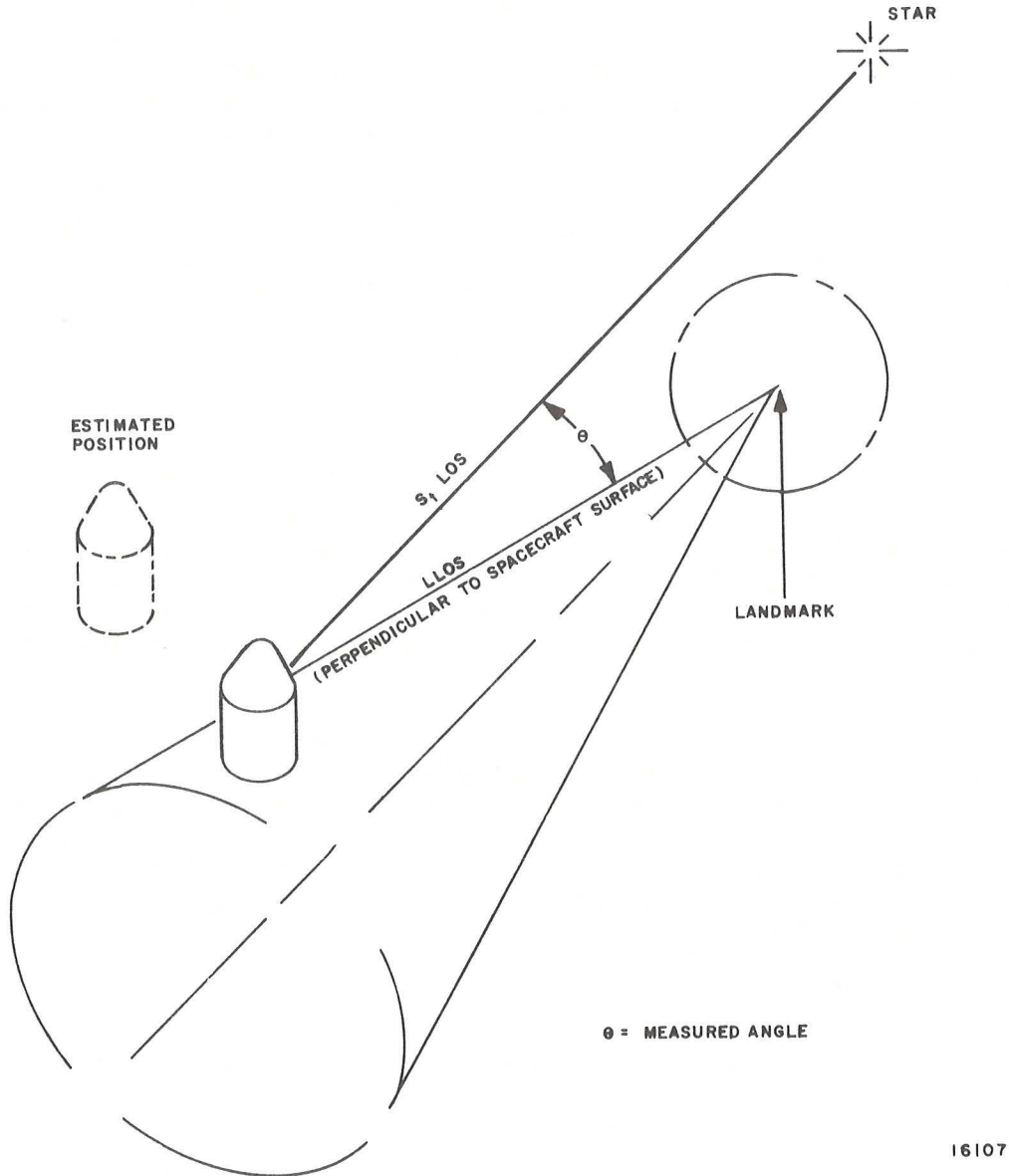


Figure 5-8. Midcourse Position Determination

The process of taking navigation measurements and converting to linear terms around the present best estimate is performed throughout the midcourse flight. The velocity and position data determines whether a velocity correction is required to maintain a satisfactory trajectory.

5-7 MIDCOURSE CORRECTION AND THRUST VECTOR CONTROL

During the Apollo flight thrust maneuvers such as translunar injection, lunar orbit injection, transearth injection and midcourse corrections are performed. All the maneuvers performed during these phases result in plane and/or orbital changes.

The purpose of midcourse correction is to change spacecraft velocity during the transearth and translunar portions of the flight and to monitor the thrusting to determine the resultant trajectory parameters. Midcourse corrections are accomplished after midcourse navigation has determined that velocity corrections are needed.

The purpose of a thrust maneuver is to change the velocity and position of the spacecraft, such that, the free-fall trajectory will carry the spacecraft to a required aim point. The thrust is provided by the SPS engine.

Prior to a midcourse correction or thrust vector control maneuver, the IMU will be aligned with respect to an inertial frame with the X PIPA input axis along the desired thrust vector. (See figure 5-9.) The spacecraft center of gravity is determined. The computer positions the SPS engine through error signals developed in the optics portion of the CDU. After an ullage maneuver, the computer issues on-off discrettes to the SPS engine. (For small midcourse corrections, the astronaut makes translation maneuvers using the RCS.)

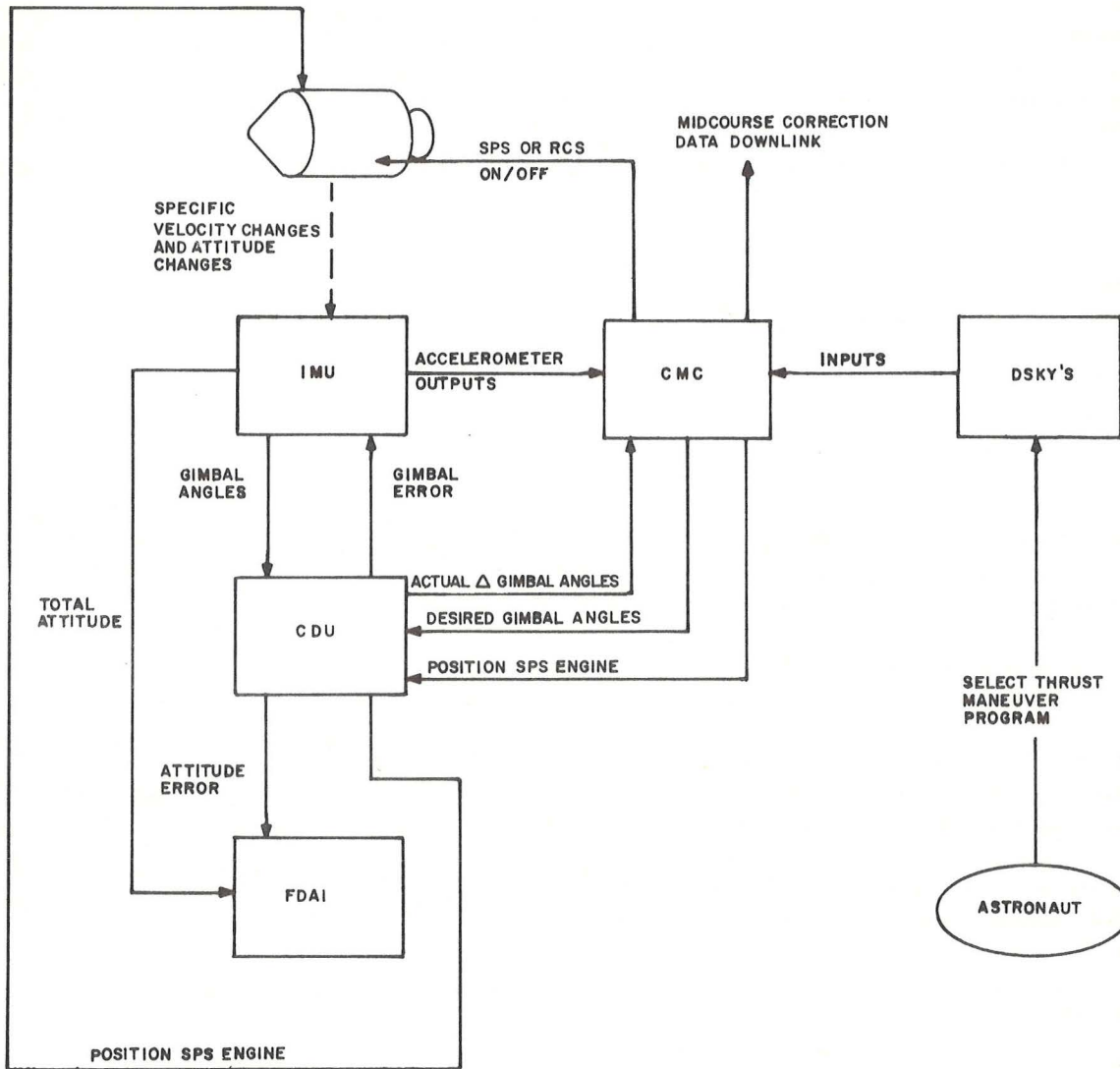
A thrust is applied to the spacecraft, the accelerometer loops provide changes in velocity and the CDU provides attitude change data to the computer. The computer uses this data to determine the spacecraft's changing position, velocity, and attitude.

Velocity to be gained is displayed on the computer DSKY. Attitude error signals and total attitude is displayed by the FDAI. Upon completion of the maneuver, velocity and positional data is displayed and checked with MSFN.

5-8 ATTITUDE CONTROL

The attitude of the spacecraft is changed frequently during the flight for the following reasons:

- (1) To direct antennas for communications.
- (2) To change orientation with respect to the sun for thermal controls.
- (3) To observe celestial bodies.
- (4) To align the spacecraft in preparation for a velocity correction.



16106

Figure 5-9. Midcourse Correction and Thrust Vector Control

The PGNCS can generate spacecraft attitude control signals by three methods:

- (1) Automatic computer control.
- (2) Rotation control (computer aided manual control).
- (3) Minimum impulse controller (computer aided manual control).

Computer control (see figure 5-10) is used in orienting the spacecraft to a given star field or alignment for thrusting. The astronaut uses the SC CONT switch along with the rotation control to position the spacecraft. The three position switch selects the means of controlling spacecraft attitude after the rotation control is released. The attitude can be either held at a position selected by the astronaut, allowed to drift or be controlled by the computer. The minimum impulse is used when taking optical sightings to make small changes in the spacecraft rotational rate.

The inertial and computer subsystems are used in the attitude control function. The CDU is pulsed by the computer to change the gimbal angles. Attitude error and IMU gimbal angles are displayed on the FDAI. The CMC uses the attitude error signals to determine the need for commanding RCS on-off discretes.

5-9 ENTRY

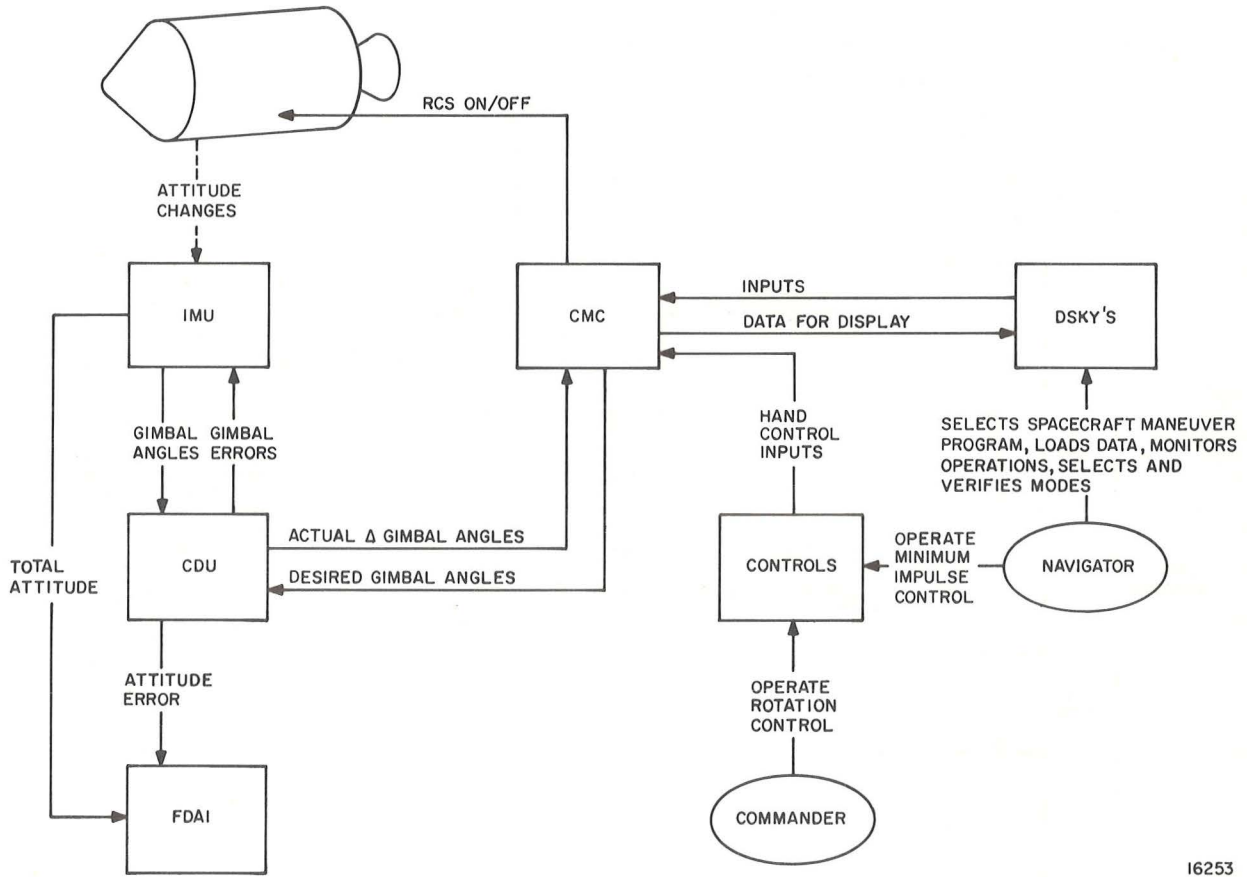
The entry attitude of the command module has certain aerodynamic characteristics associated with it as it enters and travels in the earth's atmosphere. These aerodynamic characteristics develop lift and drag vectors that oppose the acceleration vector and affect the trajectory of the command module. (See figure 5-11.) The PGNCS attitude control mode is used during the entry function to control the lift to drag ratio.

Prior to entry, the CMC entry program is selected, the service module is jettisoned and the command module is oriented to the entry attitude. The computer receives pre-calculated lift and drag ratios from ground control and provides a signal representing desired roll angles to the outer gimbal CDU. This signal is compared with the actual roll angle signal from the IMU, and the difference error signal is applied to the RCS roll jets on the command module. The module rolls about the entry roll axis, varying the lift-drag ratio and thereby maintaining the module on the proper trajectory. The stabilization loop senses spacecraft rotation and cancels the difference error signal when the proper angle is reached.

To keep the command module in the entry "corridor" (difference between under-shoot or g-limit condition and overshoot or skip-out condition), the CMC uses velocity increments from the accelerometers and attitude inputs from the CDU to compute steering commands. The steering commands are used to fire roll reaction control jets on the command module.

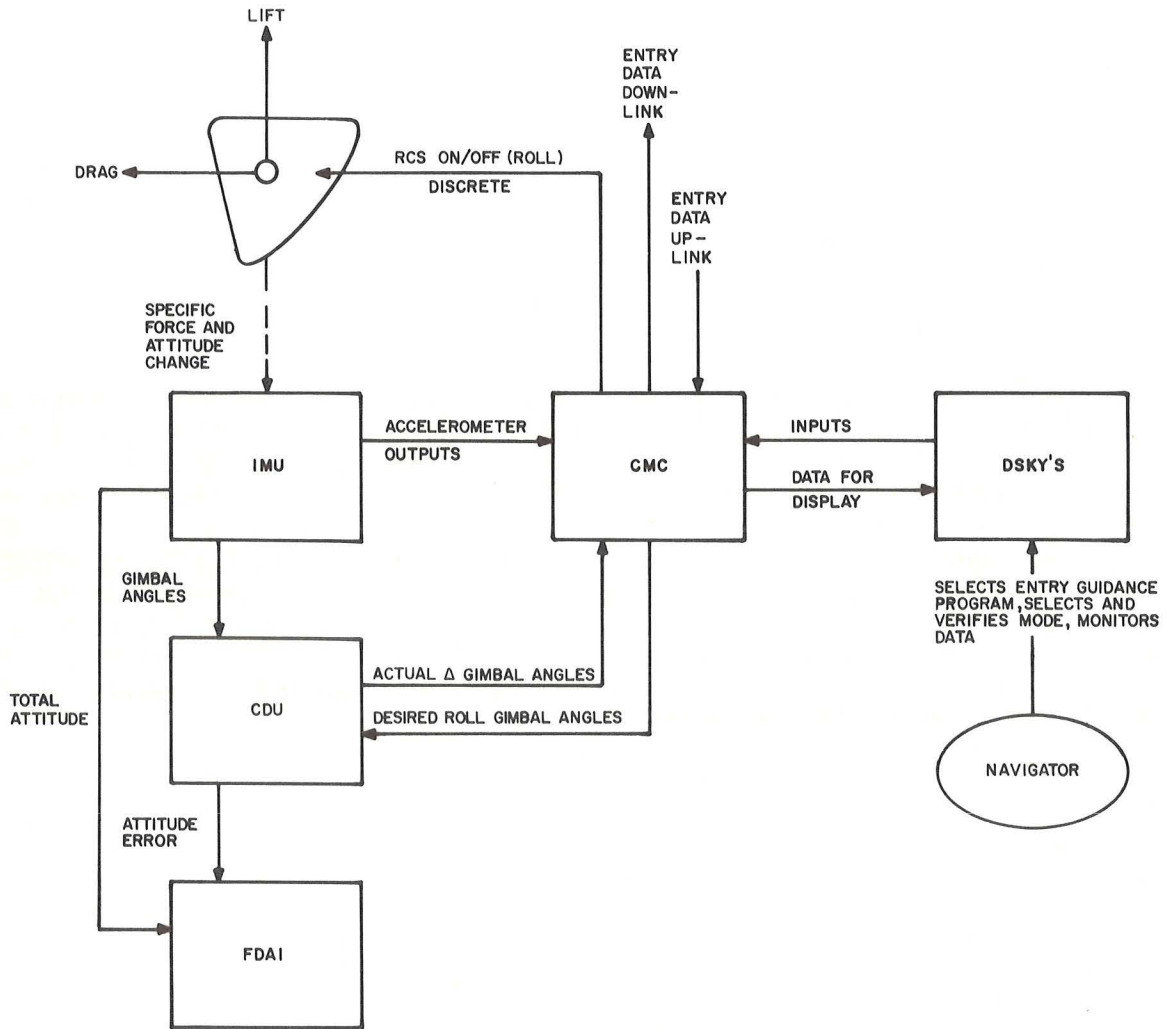
Upon entry into the atmosphere (.05 g indication on main D and C panel), the astronaut starts the elapsed time event time clock. During the entry phase, the astronaut monitors the attitude indicator, entry monitor display, and DSKY to assure proper attitude, velocity, and roll control. This procedure is followed until the Earth Landing System parachutes are deployed.

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM



16253

Figure 5-10. Attitude Control



16249

Figure 5-11. Entry

Chapter 6

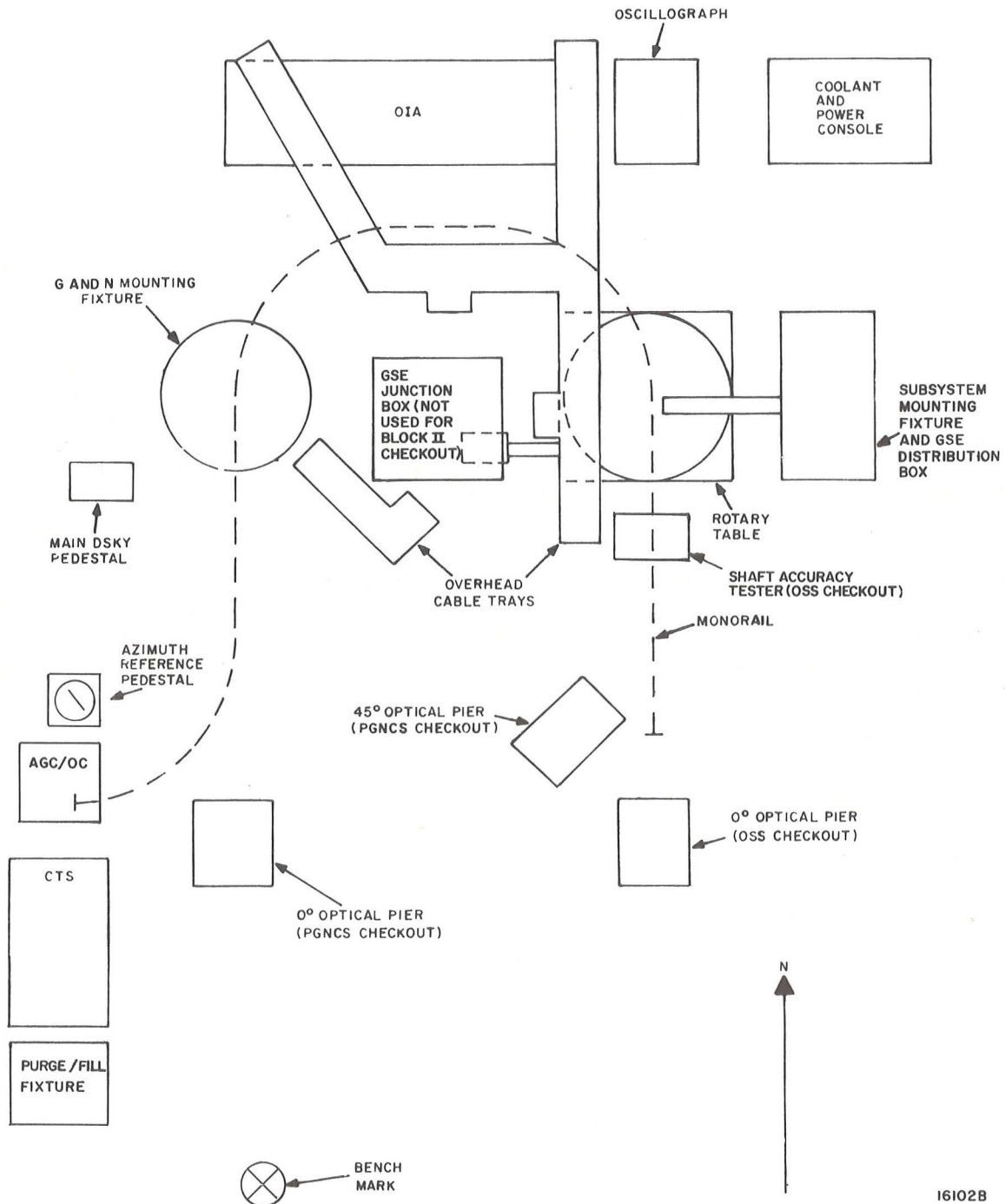
CHECKOUT AND MAINTENANCE EQUIPMENT

6-1 SCOPE

This chapter contains a list of test equipment and tools necessary to complete checkout of the Block II PGNCS and the PGNCS subsystems. The test equipment is listed in alphabetical order in table 6-I. The tools are listed in alphabetical order in table 6-II. Table 6-III lists the job description cards (JDC's) which contain operation and front-panel calibration procedures for the ground support equipment (GSE). The layout of equipment in test stations at Kennedy Space Center (KSC), the Manned Spacecraft Center (MSC), and North American Aviation (NAA) is shown in figures 6-1, 6-2, and 6-3, respectively. The test stations are environmentally controlled and provide precision checkout of the PGNCS and the PGNCS subsystems. Each test station contains the test equipment required to check out the PGNCS and the PGNCS subsystems except for the following test equipment.

- a. AGC/CTS operations console*
- b. Azimuth reference prism*
- c. Degausser assembly*
- d. Purge/fill fixture*

* One provided for each field site.



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Figure 6-1. Universal Test Station Layout (KSC)

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

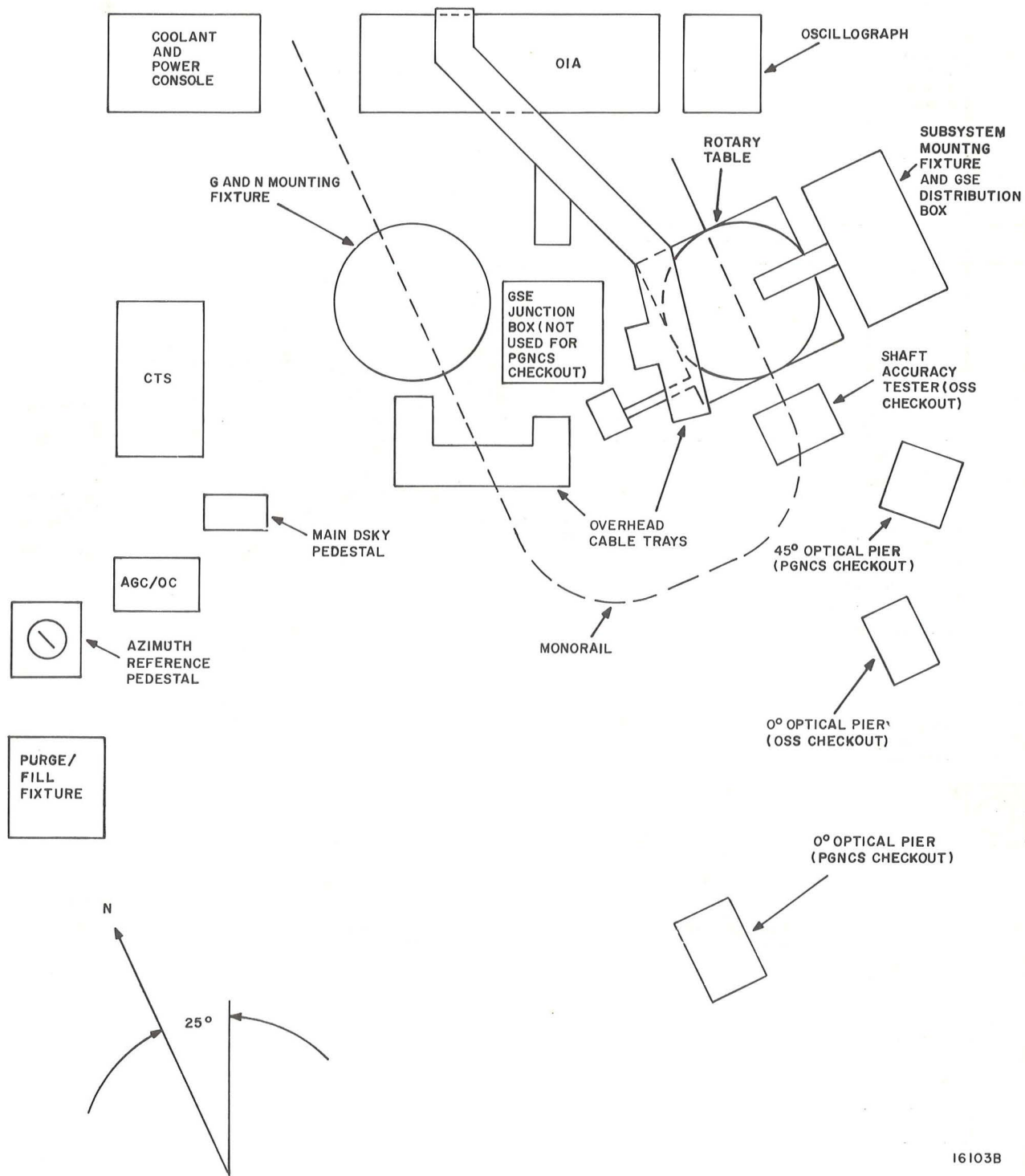
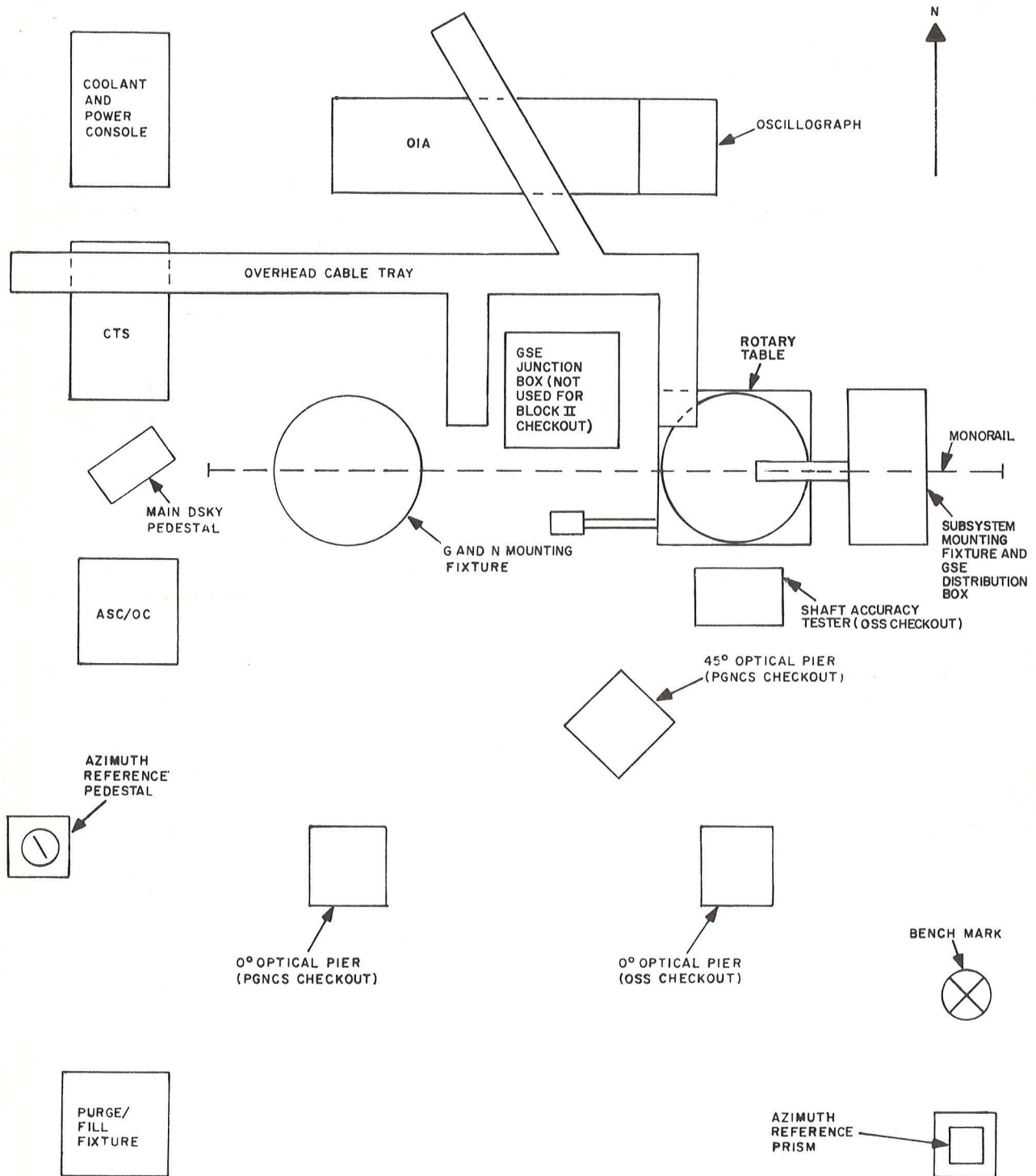


Figure 6-2. Universal Test Station Layout (MSC)

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Figure 6-3. Universal Test Station Layout (NAA)

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

Table 6-I. Checkout and Maintenance Test Equipment

Equipment and Part Number	Short Nomenclature	Description and Use	Remarks
Adjustable Mirror Pedestal Assembly, 1019759	adjustable mirror	Serves as alignment reference device when aligning auto-collimator assemblies during PGNCS checkout	none
AGC Calibration Console, 2014049-021	computer calibration console	Checks calibration of CMC clock oscillator and provides frequency reference to auxiliary calibration system	none
AGC Connector Covers, 2014399-011, 1006425-006	CMC connector covers	Provides protection for CMC and DSKY electrical connectors during transit or storage	none
AGC GSE Interconnection Set, G and N, 2014255-041 and -051 (See remarks)	interconnect kit, CMC-GSE-PGNCS	Provides cables and buffer circuit assembly for interconnecting CMC to GSE and PGNCS	Use -051 with computer test set -071. The modification (ECP 536) increases the diagnostic capabilities of the test equipment.
AGC GSE Interconnection Set, Subsystem, 2014268-031	interconnect kit, CMC-GSE-CSS	Provides cables and mounting bracket for interconnecting CMC to GSE and CTS	none
AGC Handling Fixture, 2014282-031	CMC handling fixture	Provides mounting and protection for CMC prior to installation and during handling	none

Table 6-I. Checkout and Maintenance Test Equipment

Equipment and Part Number	Short Nomenclature	Description and Use	Remarks
Apollo Optical Sextant Cover 1902654-011	SXT optical cover	Mounted on APTPS SXT cover and baffle assembly to provide protection during shipping and storage and to allow purging of SXT	none
Apollo Optical Sextant Crown Cover, 1902661-011	SXT crown cover	Protects SXT after APTPS SXT crown half and plug assembly is installed	none
Apollo Optical Telescope Cover, 1902651-021	SCT optical cover	Mounted on APTPS SCT cover and baffle assembly to provide protection during shipping and storage and to allow purging of SCT	none
Apollo Optical Telescope Crown Cover, 1902659-011	SCT crown cover	Protects SCT after APTPS SCT crown half and plug assembly is installed	none
Auxiliary Calibration Console, 2014059-021	auxiliary calibration console	Checks calibration of CMC clock oscillator	none
Component Mounting Plate, 2900677-011	component mounting plate	Used with subsystem mounting fixture; provides mounting for selected PGNCs components during ISS and OSS checkout	none
Computer Simulator (drawer assembly), 2014048-011	computer simulator	Simulates CMC signals, loads, and outputs for ISS and OSS checkout	none

(Sheet 2 of 9)

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

Table 6-I. Checkout and Maintenance Test Equipment

Equipment and Part Number	Short Nomenclature	Description and Use	Remarks
Computer Test Set, 2014042-061 and -071 (See remarks)	CTS	Checks operation of CSS	Use -071 with AGC GSE interconnection set, G and N -051. The modification (ECP 536) increases the diagnostic capabilities of the test equipment.
Degausser, 1900299-021	degausser	Demagnetizes ducosyns of 16 PIP's and 25 IRIG's during ISS and PGNCS checkout	none
Electrical Adapter Cable Assembly Set (Block I Series 100 or Block II), 2901074-011	adapter cable set	Provides capability for continuity checks and signal monitoring	none
Electrical Adapter Cable Assembly Set (Basic), 2901075-021 (includes breakout box)	adapter cable set	Provides capability for continuity checks and signal monitoring	none
Electrical Adapter Cable Assembly Set (Block II), 2901076-021	adapter cable set	Provides capability for continuity checks and signal monitoring	none
Electronic Level, 1901328	electronic level	Part of rotary table calibration set. Used to align adjustable mirror and shaft accuracy tester rotary table	none

Table 6-I. Checkout and Maintenance Test Equipment

Equipment and Part Number	Short Nomenclature	Description and Use	Remarks
Filling and Purging Fixture, 1902371-011	purge/fill fixture	Purges and fills all components requiring coolant	none
G and N Coolant and Power Console, 1902134-031	coolant and power console	Part of OITS. Provides cooling, power, and precision voltage monitoring during PGNCS, ISS, or OSS checkout	none
G and N Mounting Fixture, 2900067-051 or -061	G and N mounting fixture	Serves as mounting fixture for selected PGNCS components for PGNCS, ISS, and OSS checkout	-051 and -061 change mounting for signal conditioner and harness "A" (ECP 654).
G and N Transportation Cart Assembly, 1900000-041	G and N transportation cart	Used for local transportation of PGNCS components	-031 or -041 can be used with Block II components
GSE Coolant Interconnect Hose Set, 2900405-011	GSE coolant hoses	Connects PGNCS components to coolant and power console	none
GSE Distribution Box, 2900024-031	GSE distribution box	Part of OITS. Provides test interconnection during PGNCS, ISS, and OSS checkout	none
GSE P&M Cable Kit, 2014064-011	P&M cables	Interconnects CTS to buffer circuit assembly	none

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

Table 6-I. Checkout and Maintenance Test Equipment

Equipment and Part Number	Short Nomenclature	Description and Use	Remarks
IMU Mounting Fixture, 2900000-021	IMU mounting fixture	Mounts IMU to rotary table for ISS checkout	none
IMU Pressure Seal Tester, 1900804-011	IMU pressure seal tester	Checks for leakage of pressure seals in IMU case during PGNCS checkout	none
IMU Snap-on Bellows, 1900802-011	IMU snap-on bellows	Allows for expansion of coolant in IMU during storage	none
Interconnect Cable Set, 2900025-011	interconnect cables	Part of OITS. Interconnects GSE and PGNCS components during PGNCS, ISS, and OSS checkout	none
Interconnect Cable Set, 2900712-051, -061, and -071	interconnect cables	Part of OITS. Interconnects GSE and PGNCS components during PGNCS, ISS, and OSS checkout	-071 insures proper telemetry interface (ECP 581) -051 and -061 change cables for PSA moisture seal compatibility (ECP 529).
ISS Connector Covers, 2900065-021	ISS connector covers	Provides protection for indicator control panel, PEA, signal conditioner, and PGNCS interconnect cables electrical connectors during transit or storage	none
Operation Console, 2014024-021	AGC/OC	Provides mounting, power, test connections, and cooling for CSS	none

(Sheet 5 of 9)

Table 6-I. Checkout and Maintenance Test Equipment

Equipment and Part Number	Short Nomenclature	Description and Use	Remarks
Optics Covers, 1022980-011	optics covers	Provides protection for OUA optics during transit or storage	none
Optics-Inertial Analyzer, 2900023-051	OIA	Part of OITS. Provides control signals and monitoring and measurement facilities for use during PGNCS, ISS, and OSS checkout	none
Optics-Inertial Test Set, 2900022-041	OITS	Provides control signals and monitoring and measurement facilities for use during PGNCS, ISS, and OSS checkout	none
Optics/Nav Base Mounting Fixture, 2900072-011	optics/nav base mounting fixture	Provides mounting for optical unit on rotary table and test interconnections during OSS checkout	none
Oscillograph Console Assembly, 1900000-021	oscillograph	Part of OITS. Monitors and records signals from OIA	none
Portable Light Assembly, 1019837-021, -031	portable light assembly	Illuminates SXT and SCT reticle during OSS checkout	-021 contains SCT adapter assembly.
Portable Temperature Controller, 2900060-031	PTC	Provides IMU temperature control during local transportation and storage	-031 extends range of variable resistor (R16) from 0-2 to 0-5 kilohm.

(Sheet 6 of 9)

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

Table 6-I. Checkout and Maintenance Test Equipment

Equipment and Part Number	Short Nomenclature	Description and Use	Remarks
PSA Test Point Adapter, 2900037-031	PSA test point adapter	Part of OITS. Provides test interconnections for use with OIA	none
PTA/PEA Mounting Fixture, 2900066-021	PEA mounting fixture	Provides mounting for PEA on rotary table during ISS checkout and on G and N mounting fixture during PGNCS checkout	none
PTA/PEA Test Point Adapter, 2900145-011	PEA test point adapter	Provides test interconnections for use with OIA	none
Remote Optics Controller, 1902056-021	remote optics controller	Positions optical unit during OSS checkout	none
Resolver Circuit Tester, 2900708-011	resolver circuit tester	Provides simulated loads for IMU and OUA resolvers during PGNCS, OSS, and ISS checkout	none
Retroreflecting Prism Assembly, 1019840	retroreflecting prism	Used in aligning OSS targets and checking SCT shaft accuracy	none
Rotary Table, 1900926-021	rotary table	Serves as a mounting and test platform for selected PGNCS components during ISS and OSS checkout	none
Rotary Table Calibration Set, 1900810-011	rotary table calibration set	Contains all equipment necessary to perform rotary table calibration	none

Table 6-I. Checkout and Maintenance Test Equipment

Equipment and Part Number	Short Nomenclature	Description and Use	Remarks
SCM/PSAAM Calibration and Test Console, 2900895-031 and -041	SPCU	Used for pre-installation acceptance testing of operational or flight qualification signal conditioners	031 contains 0 volt computer reference for 4 and 14 volt outputs (ECP 522). 041 provides 28 vdc low to SCA optics and resolver CDU modules.
SXT Shaft Zero Check Fixture 2901755-011	SXT shaft zero check fixture	Checks accuracy of SXT shaft zero during OSS checkout.	none
Shaft Accuracy Tester, 1019769	shaft accuracy tester	Checks accuracy of SXT shaft during OSS checkout	none
Subsystem Mounting Fixture, 2900070-021	subsystem mounting fixture	Provides mounting for selected PGNCSS components during ISS and OSS checkout	none
Theodolite and Support Assembly, 1017447	theodolite	Aligns 0° autocollimator assembly and 45° autocollimator assembly	none
Universal DSKY Handling Fixture, 2014013-011	DSKY handling fixture	Provides mounting and protection for DSKY during handling and transit. Provides mounting for DSKY in AGC/OC	none

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

Table 6-III. List of Operating Procedure JDC's for GSE

Equipment Nomenclature	JDC Description	JDC Number
Auxiliary input	Applying auxiliary signals to digital voltmeter, phase angle voltmeter, dual beam oscilloscope, and counter	18103
	Applying PSA test point adapter and PTA/PEA test point adapter signals to dual beam oscilloscope	18204
	Applying PSA test point adapter signals to dual beam oscilloscope	18104
	Operation - general	18050
Counter (OIA)	Applying auxiliary signals	18103
	Count clock frequency pulses that occur during interval determined by "D" input events	18020
	Count number of input events that occur during any preselected time interval	18018
	Count number of input events that occur during interval determined by "D" input events	18019
	Determine correct operation of N_1 switches, time base circuitry, and count-chain circuitry	18021
	Determine correct operation of N_2 switch	18022
	Forward or reverse count	18017
	Performance verification	19261
Counter-timer (CTS)	Count number of pulses during a time interval	05402
	Measure frequency	05401
	Measure period between leading edges of pulses	05403
	Measure time between pulses using the internal frequency standard	05404

(Sheet 1 of 7)

Table 6-III. List of Operating Procedure JDC's for GSE

Equipment Nomenclature	JDC Description	JDC Number
Current source monitor panel	Measure voltages	18216
Digital recorder	Operation and interpretation of data	18043
Digital voltmeter	Applying auxiliary signals	18103
	Applying internal signals	18000
	Applying PSA test point adapter signals	18002
	Applying PTA/PEA test point adapter signals	18202
	Automatic measurement of ac or dc voltage	18037
	Measurement of ac voltage	18236
	Measurement of dc voltage	18235
	Performance verification	19260
Dual beam oscilloscope	Adjustment	19362
	Adjustment of scope A upper beam vertical plug-in unit	19360
	Adjustment of scope B lower beam vertical plug-in unit	19361
	Applying auxiliary signals	18103
	Applying internal signals	18000
	Applying oscillograph signals to scope "B", channel 2	18011
	Applying PSA test point adapter and PTA/PEA test point adapter signals	18204

(Sheet 2 of 7)

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

Table 6-III. List of Operating Procedure JDC's for GSE

Equipment Nomenclature	JDC Description	JDC Number
Dual beam oscilloscope (cont)	Applying PSA test point adapter signals	18002
	Applying PSA test point adapter signals	18104
	Applying PTA/PEA test point adapter signals	18202
	Applying reference signals	18001
	Applying two signals simultaneously to scope "B"	18010
	Frequency measurements	18008
	Performance verification	19263
	Phase shift measurements using upper beam differential amplifier	18006
	Pulse monitoring using scope "B", channel 1	18009
	Time measurements	18007
Electrical adapter cable assembly set	Signal monitoring and continuity tests	18052
Electronic counter (auxiliary calibration console)	Operating the counter to measure frequency	05400
Fill and purge fixture	Fill and purge G and N system components	18045
Galvanometer	Measure voltages	18216

(Sheet 3 of 7)

Table 6-III. List of Operating Procedure JDC's for GSE

Equipment Nomenclature	JDC Description	JDC Number
G and N coolant and power console	Operation and interconnections for G and N system, ISS, and OSS testing	18046
Gimbal position control panel	Operation - general	18244
Inertial components temperature controller	Provide IMU heat	18049
Oscillograph	Adjustment of dc amplifiers	19363
	Adjustment of phase sensitive demodulators	19364
	Adjustment of phase sensitive demodulators (800 cps reference)	18027
	Adjustment of phase sensitive demodulators (3200 cps reference)	18028
	Applying signals to dual beam oscilloscope scope "B", channel 2	18011
	Electric writing	18023
	Ink writing	18024
	Installation of ink cartridge	18032
	Installation of ink pen	18033
	Installation of paper	18034
Operation of dc amplifiers	18026	
Operation of phase sensitive demodulators	18031	

(Sheet 4 of 7)

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

Table 6-III. List of Operating Procedure JDC's for GSE

Equipment Nomenclature	JDC Description	JDC Number
Oscillograph (cont)	Performance verification of dc amplifiers	19264
	Performance verification of phase sensitive demodulators	19265
	Performance verification of phase sensitive demodulators	19268
Oscilloscope - (CTS)	Measure pulse characteristics	05405
Phase angle voltmeter	Applying auxiliary signals	18103
	Applying internal signals	18000
	Applying PSA test point adapter signals	18002
	Applying PTA/PEA test point adapter signals	18202
	Indication of phase sensitive null	18042
	Measurement of fundamental rms voltages	18039
	Measurement of in-phase and quadrature components	18041
	Measurement of phase angle	18040
	Measurement of total rms voltage	18038
	Performance verification	19262
Performance verification	19266	
Portable temperature controller	Providing heat to the IMU	18249

(Sheet 5 of 7)

Table 6-III. List of Operating Procedure JDC's for GSE

Equipment Nomenclature	JDC Description	JDC Number
Primary signal selector panel	Applying auxiliary signals through auxiliary input panel to digital voltmeter, phase angle voltmeter, dual beam oscilloscope, and counter	18103
	Applying internal signals to digital voltmeter, phase angle voltmeter, and dual beam oscilloscope	18000
	Applying PSA test point adapter and PTA/PEA test point adapter signals through auxiliary input panel to dual beam oscilloscope	18204
	Applying PSA test point adapter test point signals through auxiliary input panel to dual beam oscilloscope	18104
	Applying PSA test point adapter signals to dual beam oscilloscope, phase angle voltmeter, and digital voltmeter	18002
	Applying PTA/PEA test point adapter signals to dual beam oscilloscope, phase angle voltmeter, and digital voltmeter	18202
	Applying reference signals to dual beam oscilloscope	18001
	Voltage measurement on dual beam oscilloscope of signals through primary signal selector panel	18005
PSA test point adapter	Applying signals through primary signal selector panel to digital voltmeter, phase angle voltmeter, and dual beam oscilloscope	18002
	Applying signals via auxiliary input panel and primary signal selector panel to dual beam oscilloscope	18104

(Sheet 6 of 7)

Table 6-III. List of Operating Procedure JDC's for GSE

Equipment Nomenclature	JDC Description	JDC Number
PSA test point adapter (cont)	Applying signals via auxiliary input panel and primary signal selector panel to dual beam oscilloscope (PSA test point adapter and PTA/PEA test point adapter)	18204
Purge/fill fixture	Purge and fill PGNCS components	18045
Signal generator	Adjustment	18012
	Operation	18013

(Sheet 7 of 7)

Chapter 7

CHECKOUT

7-1 SCOPE

This chapter contains flowgrams which outline checkout procedures for the PGNCS and the PGNCS subsystems. Checkout is performed in the G and N laboratories of KSC, MSC, and NAR. A master flowgram for the PGNCS and one for each of the PGNCS subsystems precedes more detailed preparation and checkout flowgrams. Each master flowgram references the detailed flowgrams which in turn reference the JDC's required to fulfill the checkout function.

Information regarding packing, shipping, and handling of any component of the PGNCS will be found in Packing, Shipping, and Handling Manual, ND-1021038.

7-2 PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

7-2.1 PREPARATION. The PGNCS master flowgram (figure 7-1) specifies the conditions leading to a PGNCS checkout and specifies the mandatory sequence to be followed. Prepare the PGNCS for checkout in accordance with figure 7-2 which gives the sequential listing of JDC's to be performed. Table 7-I lists PGNCS components and the GSE required for a PGNCS checkout. Tables 7-II, 7-III, and 7-IV list the interconnect cabling required for a PGNCS checkout.

7-2.2 CHECKOUT. Check out the PGNCS in accordance with figure 7-3 which gives the sequential listing of JDC's to be performed. Upon completion of checkout and necessary maintenance, prepare the PGNCS for storage, shipment, or subsystem checkout in accordance with figure 7-1.

7-2.3 TEST DESCRIPTIONS. The following paragraphs provide descriptions of tests performed during PGNCS laboratory testing.

7-2.3.1 Master Initialization. This procedure establishes initial conditions, after system turn-on, required for the performance of various system tests.

The test insures that equipment is in the proper power mode, measures the temperature deviation of the IRIG's and PIP's, sets all erasable locations in the computer to zero, coarse aligns the IMU gimbals to zero, and inhibits the computer activity control to prevent excessive cycling, leaving the computer activity lamp on.

7-2.3.2 Standby Control Test. During this test, the G and N system standby requirements are verified. The 28 vdc standby bus voltage, 3200 cps suspension power, CMC master clock sync, +4 and +14 vdc CMC power supplies, IRIG and PIPA standby temperatures, and BMAG attitude signals are checked.

The test is initiated by applying power to the CMC, placing the ISS in the standby mode, and obtaining an input bus voltage of 28 vdc.

The IMU standby bus voltage is set to insure that nominal voltage is available for the temperature control system, for magnetic suspension of the inertial components, and for the CMC.

The temperature deviation voltage is measured to obtain the IRIG and PIPA temperatures and the difference between the temperatures. One hour after entering standby (hour allows time for the IRIG and PIPA temperatures to stabilize), the IRIG and PIPA instantaneous temperature deviation voltages are recorded. These voltage measurements are converted to temperature values. The calculated temperature is added to the nominal IRIG temperature and nominal PIPA temperature to obtain the actual IRIG and PIPA temperatures.

Proper operation of the ducosyn magnetic suspension system in the standby mode is verified. Verification is accomplished by measuring the 3200 cps suspension power frequency on the counter and then measuring the 3200 cps feedback voltage.

The CMC master clock sync, which supplies synchronization pulses to the PGNCS power supplies, is checked. The CMC master clock sync is connected to the computer auxiliary calibration console and the frequency is monitored for 15 minutes (9 printouts on the printer) to insure that the frequency does not deviate by more than the specified amount. The CMC master clock sync is then connected to the oscilloscope and the amplitude, pulse width, rise time, and noise of the signal are measured to insure that the CMC develops proper synchronization pulses.

The CMC +4 and +14 vdc power supply outputs are used in the CMC to provide necessary internal power for CMC operation. If the CMC is in the standby mode, the power supply loads are switched so that only scaler and timing pulses are generated and are externally available. The CMC +4 and +14 vdc supply outputs then are measured. Operation of the CMC through the +4 and +14 vdc supplies tolerance ranges is verified. Fail detect circuits beyond the tolerance ranges are also verified.

A logic one is forced into bit 8 of channel 13 through DSKY entries, allowing the CMC to accept BMAG pitch, roll, and yaw attitude signals. Locations 42, 43, and 44 are then exercised to verify that the BMAG counters accept the BMAG attitude information.

7-2.3.3 G and N System Operational Test. This test is a gross check of the PGNCS operation. The test consists of a computer/DSKY interface test (performance of a

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

computer-controlled DSKY test to verify correct DSKY character displays), a manual DSKY keyboard test (verification of correct key-character display operation), an alarm and interrupts test (check of computer program error sensing capabilities), computer self-check, and a computer-controlled test of PIPA and IRIG operation. The PIPA and IRIG tests are performed at normal, low, and high prime power voltage levels.

The tests are initiated with the cradle assembly of the G and N mounting fixture set to 32.5 degrees, the system in ISS standby, and the computer operating. The computer/DSKY interface test is the +11 option of the self-check routine (A+11 in the CMC SMODE register) to check the electroluminescent displays on the DSKY. This check is accomplished by entering 00011 and the VERB/NOUN combination that initiates the self-test on/off switch program into the DSKY. This sequence illuminates all possible displays on the DSKY. The subroutine then puts a + zero in the SMODE register which does not allow the computer to automatically check for a malfunction; the operator must watch the DSKY for the proper displays specified in the JDC. Next, the VERB for the test lights routine is entered in the DSKY to illuminate all DSKY lights and alarm display panel lights concurrently for 5 seconds, after which the DSKY and alarm lights go out, leaving +88888 in row 1, row 2, and row 3.

The manual DSKY keyboard test is initiated with the proper VERB/NOUN and address. The DSKY is observed for acceptance and display of +12345 in row 1 and -67890 in row 2. The test is completed by pressing CLR pushbutton twice so that row 1 and row 2 are blank.

The alarm and interrupts test is entered into the DSKY manually and checks the following CMC fail circuits:

- 1) parity fail
- 2) RUPT lock
- 3) TC trap
- 4) night watchman.

Each fail circuit generates a restart in the CMC when an error is detected. The restart is displayed as follows: RESTART condition, PGNCS, and G/N CAUTION lamps are lighted; DSKY VERB/NOUN code is displayed, and DSKY row 1, row 2, and row 3 display 00000. The RSET pushbutton is pressed and VERB 36 (fresh start) is entered into the DSKY after each fail circuit is checked. Provision is made either for the use of both DSKY's and testing from both stations, or for the use of only one DSKY at a time.

The PIPA's are checked by positioning the OG, IG, and MG at 45°; each PIPA then senses a portion of local gravity. If the PIPA's are operating correctly, the accumulative reading should be the established value of local gravity. IRIG performance is checked by measuring the horizontal component of earth rate ($\cos \lambda$).

The ISS is put in the operate mode and the prime power is adjusted to 28 vdc, measured at the PSA input. The CMC self-check is then performed for 5 minutes by entering VERB 21, NOUN 27, and address 77767. After the 90 second time delay, the PIPA loops are closed; the closure is indicated by a butterfly pattern on the PIPA monitor oscilloscope.

The PIPA and IRIG tests are initiated by entering VERB 57 (perform system test) and address 00004 (IMU check). After approximately 12 minutes, VERB 06 and NOUN 66 flash and row 1 and row 2 display the local gravity vector (cm/sec^2) measured by the PIPA's. VERB 34 is entered to advance into the IRIG test. When VERB 06 and NOUN 66 flash again, the horizontal component of earth rate ($\cos \lambda$), measured by the IRIG's, is displayed in row 1 and row 2. The local gravity and earth rate indications are recorded and compared with test site values. The PIPA and IRIG tests are then repeated with the prime power adjusted to the low voltage and high voltage limits.

7-2.3.4 Operate Control Test. This test provides an operate control test for IMU time delay, gimbal ambiguity, 1X sine and cosine signals, standby to operate temperature transient, 800 cps power supply thermistor, temperature monitor 1 thermistor, PIPA calibration module thermistor, auto cage, inertial temperature control point, heater telemetry discrete, blower telemetry discrete, manual IMU cage, master alarm, and normalization.

The prime power is adjusted for 28 vdc in standby mode. The IMU time delay test is conducted by measuring the time required for the ISS to upmode from standby to operate. This time delay, which is gyro runup time, should be 90 seconds. During the 90 second delay period, the IRIG and PIPA pulse torque power supply is inhibited, the CDU's are zeroed, the IRIG's are caged, and the gimbals are driven and held at zero. Loss of +28 vdc CMC prime power at any time causes the power supply to be inhibited. At the completion of the time delay test, the CDU's are zeroed, all gimbals are coarse aligned to 225° (through DSKY inputs), and the system is downmoded to standby. The PIP and IRIG temperatures are allowed to stabilize one hour and then temperatures are recorded. The system is then upmoded to operate, the time delay is monitored, and automatic caging is verified.

During automatic caging and gimbal ambiguity operation, the IMU gimbal resolvers drive the 1X sine signals to zero volt rms and the 1X cosine signals to 28 volts rms, with the IMU gimbal angles initially at 225° . Verification is accomplished through DSKY inputs, displays of IMU angles, and measurement of the 1X resolver sine and cosine outputs of each gimbal axis.

With the ISS in the operate mode and the IMU gimbals coarse aligned to 0° , the PIPA temperature is checked during the first 15 minutes after switching from the standby to the operate mode to monitor temperature transients. The IRIG temperature is checked 30 minutes after switching to the operate mode to monitor temperature transients. One hour is allowed for the IRIG and PIPA temperature to stabilize in the operate mode with gimbals held at zero. These temperatures are then compared with the stabilized temperatures of the standby mode.

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

To test the 800 cps power supply, the temperature monitor 1, and the PIPA calibration module thermistors, the resistances of the following thermistors are measured at the PSA test point adapter: 800 cps, 5% P/S (in the PSA), temp monitor 1 (in CMC - erasable driver), and PIPA cal mod (PIPA cal mod).

The heater telemetry discrete is checked during the ON cycle. Voltage at the interface is 26.5 vdc. The blower telemetry discrete cycles on and off with a heater duty cycle of approximately 45 percent. The ON state is 0 volt rms and the OFF state is 28 volts rms. The blower may not cycle during G and N laboratory tests.

During operate temperature stabilization, manual IMU cage is performed by coarse aligning the three gimbals to 2 degrees and monitoring the gimbal angles on the DSKY. The IMU cage command button is held and caging is verified by measuring the gimbal 1X resolver sine windings for null. Upon release of the cage command button, the contents of channel 12 are checked to determine that the cage command is no longer present.

Continuity tests of the master alarm circuitry through the PSA is checked using the interface load test section of the test control panel.

7-2.3.5 G and N System Power Supplies Test. This test checks the amplitude, frequency, and phase relationship of the PGNCS power supplies at nominal high and low bus voltages using input bus A; it also checks the input voltages of bus B.

A master initialization condition is established to zero the IMU gimbals and to clear CMC erasable memory while this test is performed. The optics power is turned on so all system voltages are available. The crossbar control and DVM are used to measure the following voltage amplitudes and noise levels:

- 1) 28 vdc (operate IMU)
- 2) 28 vdc (optics)
- 3) 28 volts, 800 cps, 1% (IMU)
- 4) 28 volts, 800 cps, 1% (optics)
- 5) 28 vdc (computer TP)
- 6) 28 volts, 3200 cps, 1% (feedback)
- 7) -28 vdc
- 8) +4 vdc (CMC)
- 9) +14 vdc (CMC)

- 10) 120 vdc (PIPA)
- 11) +4 vdc (CDU)
- 12) 115 volts, 400 cps
- 13) 28 volts, 800 cps (reference voltage)
- 14) 28 vdc (X PIPA PVR)
- 15) 28 vdc (Z PIPA PVR)
- 16) 28 vdc (Y PIPA PVR)
- 17) 28 volts, 800 cps, 5%, A \emptyset , B \emptyset

Using the counter, test point adapter, and primary signal selector panel, frequencies of the following voltages are measured: outputs of the IMU and optics 28 volt, 800 cps, 1% power supplies and the 28 volt, 3200 cps, 1% feedback. Peak-to-peak amplitude of the 3200 pps sync pulse for the 28 volt, 3200 cps, 1% power supply is checked using the auxiliary panel and the dual beam oscilloscope. The time difference is measured between the leading edge of the 3200 pps set pulse ($\emptyset A - 3\mu$ sec) input to the 3200 cps power supply and the first positive going zero crossover of the 28 volt, 3200 cps power supply output to determine phasing.

The system is downmoded to OIA on and G and N power transferred to bus B to make measurements of bus B inputs, and then downmoded and returned to bus A.

Using the phase angle voltmeter and test point adapter, the phase angle between phase A and phase B of the IMU 28 volt, 800 cps, 5% power supply is measured. The phase angle of the optics 28 volt, 800 cps, 5% power supply is also checked. The above voltages, frequencies, and measurements are repeated at low and high bus A inputs.

The CMC +4 and +14 vdc power supplies are measured with and without loading, using the interface load test and the crossbar control to check regulation.

7-2.3.6 CMC Output Test. This test checks the discrete outputs of the RCS jet and SCS command interface, and the pulse train outputs of the main engine command and downlink interface.

The semiautomatic interface test checks a portion of the input-output control circuitry. This test is evaluated by observing the frequency and waveform measurements on the computer test set (CTS) and observing the DSKY displays. Discrete outputs are measured on the CTS digital counter voltmeter (DCVM). Interfaces checked during the semiautomatic interface test are as follows:

- 1) pitch, yaw, and roll RCS jets
- 2) engine on
- 3) S-4B injection sequence start
- 4) S-4B cutoff.

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

The sequence for checking these interfaces is programmed so that, once the test is initiated, the test advances from one phase to another by pressing ENTR.

The downlink telemetry waveform and the delay between downlink sync pulse and data pulse are checked at a word rate of 55 pps. The delay between the downlink sync pulse and data pulse is also checked at a word rate of 10 pps. A check of downlink to fast fail circuitry is made by programming a word rate of 300 pps at the CTS and then checking DSKY displays and the contents of channel 33.

7-2.3.7 CMC Input Test. This test checks all CM spacecraft inputs to the CMC. The results are checked by interrogation of CMC channels and registers.

All spacecraft input signals to in-bits of channels 30, 31, 32, 33 and 16 are simulated by the computer test set (CTS) at the spacecraft interface. This test insures that the spacecraft input signals are received by the CMC and that the signals create the desired response within the PGNCS. Rotational hand controller input signals are also simulated by the CTS and the reaction within the PGNCS is monitored for each signal.

The uplink data input signals are tested by preparing an uplink tape, using the keyboard in the tape prepare mode. The tape is prepared per instructions given in the JDC. The tape is read (press EXECUTE) into the CMC in-link counter (erasable assignment 00045). When overflow occurs (bit 16-1), pinball displays the contents on the DSKY. This test verifies that the uplink telemetry is being received by the CMC and that the PGNCS is reacting accordingly.

7-2.3.8 Optics Coordinate Transformation Control Test. This test checks the operation of the optics when it is in the manual resolved mode. In the manual resolved mode, up-down and left-right optics hand controller motion should produce up-down and left-right image motion in the SXT or SCT field-of-view.

In addition, this test verifies the ability of the RETICLE BRIGHTNESS thumbwheel on the indicator control panel to control the brightness of the SXT and SCT reticle patterns and the TPAC dials.

The manual resolved mode is checked as follows: The shaft angle is set to 225 degrees and the trunnion angle is set to 10 degrees using the optics hand controller. The optics angle measurement is monitored on the DSKY.

The optics is then placed in resolved mode, the controller speed switch is set to MED, and the oscillograph is set up to monitor the SCT trunnion tachometer output. An object is observed through the SCT in the center of the field-of-view, and the optics hand controller is quickly displaced 45 degrees in the upper right-hand quadrant. When the object leaves the SCT field-of-view, the MARK button on the indicator control panel and the EVENT MARKER pushbutton on the oscillograph control panel are pressed simultaneously. The time between the rise of the SCT trunnion tachometer output and the event marker indication is determined on the oscillograph. The shaft angle is monitored on the DSKY. This time is an indication of the optics slewing rate in the resolved mode.

The RETICLE BRIGHTNESS thumbwheel operation is verified by observing the SXT reticle, SCT reticle, and TPAC dials while the thumbwheel is rotated from fully off to fully on.

7-2.3.9 Zero Optics Test. This test checks the performance of the zero optics servo loops to insure that the optics lines-of-sight (LOS) are driven to zero within a specified time after the zero optics command is given and that the servo loops can drive the system sufficiently close to zero. In addition, the test qualifies the SCT trunnion and the SCT shaft motor drive amplifier output signals.

To determine time-to-zero, the optics LOS are driven to a +180 degree shaft angle and a +75 degree trunnion angle. The zero optics command is given and the SCT shaft and trunnion tachometer signals are monitored on the oscillograph. The elapsed time between the steady state nulls of the tachometer signals is an indication of the time-to-zero of the zero optics servo loops.

The DSKY indications are monitored after the system has stopped driving to determine how close the zero optics servo loops drive the system to zero. The tolerance on the allowable displacement of the LOS from fine resolver electrical zero is determined on system capability, not on system requirements.

The SCT trunnion and shaft motor drive amplifier test points are monitored to qualify their output signals while the optics is slewing at maximum rate in HI CONTROLLER speed switch position. The tolerances on the signals from the test points to be qualified are set to insure that the proper signals are being monitored, not to insure that the system is operating properly.

7-2.3.10 Optics Slew Rate Test. This test checks the maximum trunnion and shaft slew rates of SXT and SCT, with the controller speed switch at HI, MED, and LO; the smoothness of drive with the controller speed switch at LO; and shaft and trunnion drift rates in the MAN mode.

After establishing master initialization, the maximum slew rates are measured with the controller speed switch at HI. The SCT and SXT tachometers and MDA's are monitored for both trunnion and shaft loops. Slewing is started from zero optics, or known position, and is time-limited to prevent driving the optics into the mechanical stops at high slewing rates. The shaft axis is slewed in both directions while the trunnion axis is slewed only through increasing angles with the controller speed switch at HI.

With the controller speed switch at MED, both trunnion and shaft axes are slewed in both directions. The SXT and SCT trunnion and shaft tachometer in-phase outputs are measured on the PAVM. These signals are also recorded with the oscillograph, and steady state tachometer voltages of both SXT and SCT are determined from the traces. In addition, smoothness is determined from the irregularities of the SCT traces.

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

With the controller speed switch at LO, both trunnion and shaft axes are slewed and the same measurements made as those for the MED position. In addition, each axis is individually driven into the stop and, while held against the stop, measurements are made with the PAVM. The signals measured are CDU trunnion fine error, SXT trunnion MDA P/A output, SCT trunnion tach, CDU shaft fine error, and SXT shaft MDA P/A output.

In zero optics mode, the quadrature voltage of the four MDA P/A outputs are measured with the PAVM. On completion of the quadrature measurements, the optics are placed in MAN mode and the MARK pushbutton actuated. The MARK pushbutton is actuated again after approximately one minute. After each MARK, the display of shaft angle, trunnion angle, and time on the DSKY is recorded and the data from the two MARK actuations used to compute drift rate.

7-2.3.11 Optics Positional Accuracy Test. This test checks SXT landmark line-of-sight (LLOS) and star line-of-sight (S_tLOS) parallelism and SXT S_tLOS positional accuracy. During the test the SCT is slaved to the SXT. The SXT shaft LOS angle is displayed on the first row of the DSKY, and the SXT trunnion LOS angle on the second row.

The misalignment between the SXT LLOS and S_tLOS when the system is in the zero optics mode is checked with a variable deviation wedge (VDW) and a 5 inch autocollimator (target no. 1). The SXT S_tLOS is covered and the VDW dial set to zero. By sighting through the SXT LLOS and adjusting the G and N mounting fixture, the SXT LLOS is coarse aligned to the projected reticle of the 5 inch autocollimator through the VDW in the vertical plane. Fine alignment is accomplished by adjusting the VDW. Then the SXT LLOS is covered and the SXT S_tLOS is aligned in the vertical plane to the projected reticle by adjusting the VDW. The two VDW readings are converted to LOS misalignment. The tolerance on the misalignment of the SXT S_tLOS to the SXT LLOS at the G and N system level is determined from the 64X resolver alignment error, SXT trunnion stiction, observation errors, and GSE errors.

SXT S_tLOS trunnion accuracy tests are made using the SXT LLOS as the zero reference. The SXT shaft angle is set to 270 degrees placing trunnion motion in the horizontal plane. The SXT LLOS is then aligned to the 5 inch autocollimator in the horizontal plane using the VDW. Using the VDW reading and the alignment angle between the 0 degree target (target no. 1) and 45 degree target (target no. 3) obtained from JDC 12223, the VDW is placed in front of the 45 degree target and set to yield a true 45 degree angle. The SXT S_tLOS is aligned to the projected reticle of the 45 degree target through the VDW by using the optics hand controller, and the trunnion angle is displayed on the DSKY. Incremental angles (30 arc-second increments) around 45 degrees are also checked by adjusting the VDW and by realigning the SXT S_tLOS to the projected reticle with the optics hand controller. The tolerance for SXT trunnion accuracy for the incremental angles around 45 degrees is determined from the SXT 64X resolver alignment and 64X resolver functional error. The granularity of the trunnion CDU pulse is 9.8877 arc-seconds per pulse.

The SCT trunnion accuracy in the 25 degree and 0 degree offset modes is checked to insure proper operation. First, the SCT LOS is aligned to the SCT target autocollimator (target no. 2) when the SCT trunnion angle is at zero. Then the system is set to each offset mode. The applicable reticle mark should be aligned to the target autocollimator.

The 25 degree and 0 degree offset mode operation checks are coarse checks to insure that the SCT trunnion reacts as specified.

The resolution at the center of the field-of-view of the SXT LLOS and S_tLOS is checked by observing the resolution patterns in the 5 inch autocollimator. The SCT resolution is checked by observing the resolution patterns on the SCT resolution card.

7-2.3.12 Semiautomatic Mode Test. This test is designed to verify the IMU CDU moding, CDU repeating accuracy, CDU command accuracy, CDU command rate, and attitude error positioning commands. The test is under CMC program control but provides operator control intervals to make analog measurements.

After a master initialization is established, the IMU CDU's are zeroed. The DSKY display registers contain the CDU angles. The IMU goes through coarse align (to 0 degree gimbal angle) eight times to insure that the gimbals are coarse aligned within 1 CDU bit (160 arc-seconds). The total attitude sine in-phase and total null is then checked through a DSKY display of the gimbal angles.

At gimbal angles of 45 degrees, the total attitude output and IMU ac D/A output are tested by checking the display of the gimbal angles. The CDU repeating accuracy is checked by placing the system in the fine align mode, waiting 90 seconds, and then reading the CDU angles on the DSKY. The CDU zero mode is then entered, after which the system is returned to the fine align mode. The difference in the initial and final CDU angles is a measure of the CDU repeating accuracy. The system is again sequenced through fine align; 90 seconds elapse to allow the mode switch to occur; and, at the completion of the mode switching, the CDU angles are read and stored by the computer.

The IMU zero mode is initiated; then the IMU zero discrete is left on for 320 milliseconds, after which the IMU returns to the fine align mode. Four seconds are allowed for the CDU's to synchronize with the gimbal angles. The computer calculates and the DSKY displays the difference in the initial and final CDU readings.

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

The PGNCS is sequenced through the plus gimbal lock test and each gimbal is aligned to +71 degrees. Next, the system is sequenced through a total attitude cosine in-phase and total null test with each gimbal at +90 degrees.

The CDU command accuracy test is verified at +135 degrees by DSKY displays. The middle gimbal is then coarse aligned to +45 degrees to take it out of the gimbal lock situation. The CDU repeating accuracy is checked with the gimbals and CDU's at the present position. Next, the IMU is coarse aligned to 225 degrees, the middle gimbal is removed from gimbal lock by coarse aligning it to 315 degrees, and CDU repeating accuracy is again checked. The IMU is coarse aligned to 315 degrees, the total attitude outputs test takes place, the CDU repeating accuracy is verified once more, and the CDU difference is displayed on the DSKY in octal. The minus gimbal lock test is then completed with the IMU gimbals aligned to +289 degrees. The IMU is coarse aligned to zero.

The IMU CDU command rate test commands a gimbal to be coarse aligned to 170 degrees. The program then obtains the time when the associated CDU counter indicates 10 degrees and 160 degrees. The CDU command rate is calculated by dividing the difference in CDU readings by the elapsed time between the two angles. The results are displayed and the test is repeated for the other two CDU's.

In the IMU CDU fine fail test, the IMU is coarse aligned to zero gimbal angle and the CDU's are zeroed. The operator commands the IMU to fine align to 1 degree. The zero CDU discrete is then set, causing the CDU fine error fail gate to energize which will initiate the IMU CDU zero mode.

In the IMU CDU coarse fail test, the operator loads +37.5 degrees when the program requests the gimbal angles to which the IMU is to be aligned. The IMU is then coarse and fine aligned to these angles. The CDU under test is zeroed, causing the CDU coarse error fail gate to energize.

In the optics rate test, the trunnion is first commanded to -19.775 degrees to keep it from moving and the shaft is commanded to 180 degrees. The time at which the shaft CDU counter indicates 10 degrees and 160 degrees is obtained. The shaft CDU rate is calculated by dividing the difference in CDU readings by the elapsed time between the two angles. The results are displayed and the test is repeated by commanding the trunnion to 32.5 degrees. The time at which a CDU pulse occurs at 1 degree and at 30 degrees is obtained and the trunnion CDU rate is calculated and displayed. Minus 19.775 degrees is placed in the trunnion command register. The computer

obtains the time when the optics CDU's are equal to the angle in the accumulator. The test is completed at different angles with scaling corrections so that results for the trunnion CDU rate test will have the same scaling as the results for the shaft CDU rate test. The computer calculates and displays the CDU rate. After displaying the trunnion CDU rate, a VERB NOUN combination is entered to terminate the test.

7-2.3.13 IMU Performance Test. This test determines three IRIG coefficients: bias drift (BD), drift due to acceleration along the input axis (ADIA), and drift due to acceleration along the spin reference axis (ADSR). In addition, the PIPA scale factor (SF) and PIPA bias (A_B) are determined. The PIPA precision voltage reference (PVR) and PIPA torque current are measured. The test is computer controlled and requires six stable member orientations to determine the biases and first order acceleration sensitive gyro drift coefficients.

After a master initialization is established and the G and N mounting fixture is set to a position that simulates spacecraft attitude, the PIPA PVR and PIPA torque current are measured.

The actual test is initiated by entering VERB 57 and 00001 into the DSKY. The IMU CDU's are zeroed, the IMU is coarse aligned, and the middle gimbal is driven to zero. This allows the operator to reposition the navigation base without worrying about gimbal lock. The nav base tilt angle codes are displayed.

After the displays have been verified, VERB 33 is entered into the DSKY to proceed, and VERB 34 is entered to increment the stable member position number and to schedule the horizontal gyro drift test. The computer uses the nav base tilt angle code to obtain vectors from fixed memory which describe the orientation of the nav base. The stable member position code selects the desired stable member orientation routine. The computer also calculates (using the information provided by the selected routine) the coarse align gimbal angles to align the stable member to the desired orientation. The IMU is fine aligned and the inertial CDU's are read to determine the present stable member orientation in order to calculate the amount of misalignment from the desired orientation. The gyros are then torqued to complete the alignment of the stable member. Every second the three PIPA counters are read and zeroed to call on a computer routine to process the PIPA counts. The routine initially uses a new set of slopes and time constants. The length of time for these parameters is obtained from fixed memory. Successive entries to the routine will decrement the length of time for these parameters until it has been reduced to zero and a new set of parameters is entered.

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

The next routine obtains the difference in the extrapolated and actual velocity as measured by the PIPA's. The stable member variables are extrapolated for this measurement. This includes the extrapolated velocities along south and east, the angular velocities of the stable member axes, and the incremental gimbal angles (alignment angles). The register containing the length of time in the optimum estimator is decremented every second. In the vertical drift test, the south gyro is torqued by the amount the stable member has drifted due to earth rate since the last time it was torqued, in order to keep the stable member horizontal. After the optimum estimator has gone to zero, a test is initiated to determine if the vertical drift test is complete. At the completion of a horizontal drift test, the gyros are torqued by the alignment angles calculated by the optimum estimator in order to realign the stable member in preparation for a PIPA scale factor test. VERB 33 must be entered to proceed to the PIPA scale factor test. VERB 34 increments the stable member position code and schedules the next horizontal drift test.

In the scale factor test, the vertical PIPA counter in the computer is zeroed. The computer monitors the vertical PIPA to determine when a PIPA data pulse occurs. The time and PIPA pulses at the start of the test are saved. If the IMU is not in the coarse align mode, the south and east gyros are torqued to compensate for earth rate in order to keep the PIPA under test vertical. The check is repeated 18 times and the PIPA reading routine is entered at the end of this test to obtain the final time and final PIPA counts. The results of the PIPA scale factor test are calculated from the following equation:

(nominal PIPA SF) times (final PIPA counts minus initial PIPA counts) divided by (the final time minus the initial time).

Entering VERB 33 proceeds to the vertical drift test and entering VERB 34 increments the stable member position code and schedules the next gyro drift test. The vertical gyro drift test is begun by entering VERB 33 and loading the previously calculated value of east-west drift. The program places 3998 seconds into the length of time in the optimum estimator. The PIPA test is repeated with the south gyro being compensated for earth rate every second. The test results are displayed as follows:

Row 1 plus or minus 00000

Row 2 plus or minus xxx.xx meru (vertical gyro drift)

Row 3 SM position code.

7-2.3.14 G and N Fine Align Test. This test determines system accuracy in aligning the PIPA input axes to a prescribed orientation. The orientation is defined using the result of optical sightings. The amount of stable member misalignment is determined the instant that stable member torquing is complete.

The fine align test consists of three basic steps; two of the six alignment errors measured by the test are determined from the performance of each basic step. In each step, two optical targets are used to define the relationship between the navigation base and the local vertical coordinate systems. The computer assumes that the data provided by the CDU's is correct and it coarse aligns the stable member with respect to the optical measurements. The system's coarse align mode positions the PIPA axes to the ideal orientation within the limitations of the coarse align mode. The targets are then used to establish the relationship between the coarse aligned PIPA axes and the local vertical triad. The system's fine align mode is used to finally position the PIPA axes to the ideal orientation. That is, two PIPA's are in the optically defined horizontal plane and the third is parallel to the optically defined vertical. The two horizontal axes represent the test axes for the basic step.

When fine align is complete, the PIPA outputs are used to determine the angles between the horizontal plane and the corresponding PIPA input axes. These angles represent the misalignments measured by the test and are the result of the errors in the determination of the ideal PIPA versus local vertical relationship, the instrument imperfections which are contributory to alignment inaccuracy, and the misalignments of the PIPA input axes with respect to the ideal PIPA orientation.

7-2.3.15 IRIG Scale Factor Test. The IRIG scale factor test determines the accuracy of stable member response to torquing. IRIG scale factor is defined as the amount of stable member angular rotation about an IRIG input axis resulting from a known IRIG torque input from the CMC.

During this test the effect of earth rate on an IRIG is minimized by aligning the IRIG input axis to be tested along an east or west direction. The test is run three times, and the average plus and minus scale factor error is calculated for each gyro.

The test is initiated by entering VERB 57 (perform system test) and 00005 (IRIG scale factor test) into the DSKY. The selected program displays the following on the DSKY: VERB 6 (decimal display), NOUN 61 (target azimuth and elevation), navigation base azimuth in row 1, and the site latitude in row 2. If the navigation base azimuth and site latitude are correctly displayed, VERB 33 (proceed with data) is entered into the DSKY. If the information is incorrect, it is updated before entering VERB 33.

After an IRIG test position is entered into the DSKY, the gyro drift enable discrete (bit 6 of channel 14) is set to turn on the gyro power supply and allow computer pulsing of the gyros. The system is automatically sequenced through CDU zero, coarse align, and fine align ending with the selected IRIG aligned east or west, another IRIG aligned north or south, and the remaining IRIG in a vertical alignment.

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

The computer loads the gyro counter with 16,383 pulses (equivalent to 3.8125 degrees of stable member rotation). Each gyro torquing pulse issued decrements the gyro counter by one.

At the first loading of the gyro counter, the computer allows the IRIG to be pulsed for two periods of 320 milliseconds each and reloads the gyro counter with the first set of pulses between the two loading periods. This operation allows a total of 2048 pulses or 0.3515 degree of gimbal rotation and insures that the CDU is on the linear portion of the CDU error curve when the test starts.

The computer CDU counter is zeroed and the CDU is monitored for the first pulse resulting from the above torquing. When the first CDU pulse is detected, the contents of the gyro counter are stored and 2048 CDU counts (with a polarity opposite that of the first pulse) are placed in the CDU counter. Thus, as the IRIG is pulsed by the gyro counter causing a change in stable member orientation and CDU angle, the CDU counter approaches zero. 2048 CDU pulses correspond to 22.5 degrees of gimbal movement.

The IRIG that is aligned north or south and the IRIG that is aligned vertically sense calculable portions of earth rate and the loop response forces the stable member to move, thus causing the IRIG under test to be moved from its east or west alignment. This results in the IRIG under test sensing a portion of earth rate and introduces an error into scale factor measurements. Therefore, after the first gyro counter decrementing and every other time thereafter, the computer returns the north or south IRIG and the vertical IRIG to their original positions.

During the entire test, the gyro counter is reloaded with 16,383 pulses for eight or nine times after it decrements to zero. By the end of this time, the gimbal should have moved 22.5 degrees and the CDU counter should have decremented to zero. If the CDU counter does not go to zero after the gyro counter is reduced the ninth time, alarm number 1411 is displayed to indicate that the scale factor error is too large or the CDU does not function.

If the CDU counter goes to zero on the eighth or ninth time, the gyro counter content is saved. With a perfect IRIG scale factor, the final content of the gyro counter equals the initial content and the scale factor error is zero. The difference between the initial and final gyro counter content is obtained and the scale factor error is calculated as follows:

+ scale factor error is equal to initial gyro counter content minus final gyro counter content times $1/7.6$

- scale factor error is equal to 37777 minus difference between the initial and final gyro counter content times $1/7.6$

where $1/7.6$ is the scale factor constant that converts the difference in initial and final gyro counter readings to parts per million error.

The DSKY displays VERB 06 and NOUN 66 with the \pm scale factor (in parts per million) displayed in row 1.

7-2.3.16 Gimbal Response Test. The gimbal response test measures the amount of torque motor current required to keep a gimbal moving and detects the frictional restraints of a gimbal. Also included in the gimbal response test is a step response test used to verify stabilization loop response after displacing the IRIG floats from null.

A master initialization is established and the IMU is coarse aligned to zero degrees. To prevent unnecessary cycling of the gyro torque enable relay, certain bits of location 00370 are set to logic 1 (continuous gyro torque enable).

Before gimbal torquing begins, static loop parameters of the following signals are measured: the in-phase gimbal error signal for each gimbal and the total voltage of the gimbal torque drive amplifiers for each gimbal.

IRIG torquing signals are supplied by the CMC by commands received through the DSKY, and the outer and inner gimbals are rotated plus and minus 360 degrees and the middle gimbal is rotated plus and minus 135 degrees. During the slew periods the fine and coarse CDU errors and gimbal torque motor current are monitored on the oscillograph to verify gimbal response and CDU operation.

The IRIG floats are initially displaced from null by applying 10, 5, and 5 vdc step inputs to the test input of the gimbal servo amplifier. The signal is removed after reaching a steady state. The time required for the servo error to reach a constant value is measured as an indication of loop response (within 5% of steady state value not exceeding 0.1 second). The number of overshoots after the test signal is removed is counted as a measure of loop stability. The number of oscillation peaks occurring before reaching and staying within the 5% band are measured. To measure response time and number of oscillations (a measure of damping coefficient), the oscillograph is set to a sensitivity which gives a 1 mm deflection equal to 5% of the steady state value. If a 5 volt step input is applied, the steady state gyro error will equal .5 volt. 5% of 500 mv would equal 25 mv, but no oscillograph sensitivity exists to handle that voltage; therefore, 20 mv/mm is used.

7-2.3.17 Spacecraft Display and Control Test. This test checks the interface between the PGNCS and other spacecraft systems by generating attitude error signals (FDAI interface test), steering signals for spacecraft control of S-4B booster (S-4B takeover test), and steering signals for thrust vector control commands (thrust vector control test). All of the checks involve computer operation and control of CDU outputs.

During the FDAI interface test, the computer generates attitude errors by pulsing the inertial CDU's to angles different from the gimbal angles. The resulting error output from the D/A converter (computer desired angles versus actual gimbal angles) is monitored on the GSE. Under flight conditions, attitude error is displayed on the FDAI.

During the S-4B takeover test, the PGNCS generates attitude error signals for guidance of the S-4B vehicle. The +28 vdc ISS power is routed to the inertial CDU's

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

and arms a set of relays that control the dc error output signals of the CDU's. The +28 vdc is also sent to the computer as the "spacecraft control of Saturn" discrete. This discrete normally signals the computer to enter steering control of S-4B program (this test does not check the discrete). The computer receives the discrete and sends the S-4B takeover discrettes to the CDU, energizing the control relays connecting the D/A dc outputs to the S-4B guidance electronics. After a short delay, the computer sends the ISS error counter enable discrete and pulses the CDU's. In the actual mission program, the computer will monitor the spacecraft response through PIP response and the ISS CDU's, and will control the S-4B steering by providing attitude error signals to the S-4B guidance system through the ISS CDU D/A converter outputs.

The thrust vector control test generates analog signals for positioning the service module propulsion system engine gimbals. During this test, 28 vdc is routed through the CDU to the computer. This discrete arms the TVC relays in the optics CDU but does not energize them. These relays are energized when the computer sends the TVC enable discrete to the CDU. The dc error signal outputs are then measured; normally these error outputs are sent to the SPS engine gimbal amplifiers. After a brief delay, the computer sends the optics error counter enable discrete and transmits CDU command increments. In normal TVC operation, the computer monitors spacecraft response through PIP response and ISS CDU's. The computer then controls the spacecraft by positioning the SPS engine through the optics CDU D/A converters.

7-2.3.18 Gyrocompassing Test. The purpose of this test is to determine the ability of the system to maintain a constant azimuth heading (angular measurement with respect to the North pole). An accurate azimuth heading is, in turn, a function of the system's leveling capability (maintaining selected stable member axes in a horizontal plane).

Assume the desired orientation is Z_{SM} down, X_{SM} north, and Y_{SM} east. If the Y_{SM} axis is not due east, the Y IRIG senses a portion of earth rate proportional to the angle offset. This portion of earth rate causes the stable member to rotate with respect to the earth about the Y_{SM} axis. This in turn tilts the X_{SM} axis out of the horizontal plane resulting in an X PIPA output. Therefore, the X PIPA output is also utilized for computing the IRIG torquing command for the Z (vertical) IRIG to position the Y_{SM} axis due east. In addition to gyrocompassing IRIG torquing commands, the IRIG's are also torqued to compensate for the earth's rotational rate. This procedure maintains the azimuth heading.

If the X_{SM} axis is not perfectly horizontal, the X PIPA senses a portion of the earth's gravity proportional to the angle offset. Therefore, the X PIPA output is utilized for computing the IRIG torquing command for the Y IRIG to reposition the X_{SM} axis in the horizontal plane. Similarly, the Y PIPA output is utilized for computing the IRIG torquing commands for the X IRIG to position the Y_{SM} axis in the horizontal plane. This procedure is known as system leveling.

During this test, the stable member is coarse aligned to the desired gyrocompass orientation. During coarse align, the IRIG's are forced to follow the stable member. The floats are against their physical stops and the IRIG outputs indicate approximately ± 1.5 degrees. The fine align routine is then initiated by closing the IMU stabilization loops. The stable member moves an amount equal to the indicated IRIG error about each stable member axis. After 90 seconds of fine align, the vertical erect routine is entered for 5 minutes. In this routine, the ZSM axis is aligned to within ± 0.5 degree of local vertical by utilizing the X and Y PIPA outputs to calculate the torquing commands for the Y and X IRIG's, respectively. The vertical erect routine is very similar to the gyrocompass routine except that the vertical erect routine possesses no azimuth control and the settling time is much shorter. The system is gyrocompassed at nominal bus voltage for the first 4-1/2 hours, then at low bus voltage for one hour, and at high bus voltage for one hour. CDU data is recorded approximately every ten minutes for the duration of the test (about 6-1/2 hours) to evaluate the dynamics of the gyrocompass. At the four hour point, the accuracy of the gyrocompass is determined by using the optical verification routine.

7-3 INERTIAL SUBSYSTEM

7-3.1 PREPARATION. The ISS master flowgram (figure 7-4) specifies the conditions leading to an ISS checkout and specifies the mandatory sequence to be followed. Prepare the ISS for checkout in accordance with figure 7-5 which gives the sequential listing of JDC's to be performed. Table 7-I lists PGNCS components and the GSE required for an ISS checkout. Table 7-V lists the interconnect cabling required for an ISS checkout.

7-3.2 CHECKOUT. Check out the ISS in accordance with figure 7-6 which gives the sequential listing of JDC's to be performed. Upon completion of checkout and necessary maintenance, prepare the ISS for shipment or PGNCS checkout in accordance with figure 7-4.

7-4 OPTICAL SUBSYSTEM

7-4.1 PREPARATION. The OSS master flowgram (figure 7-7) specifies the conditions leading to an OSS checkout and specifies the mandatory sequence to be followed. Prepare the OSS for checkout in accordance with figure 7-8 which gives the sequential listing of JDC's to be performed. Table 7-I lists PGNCS components and the GSE required for an OSS checkout. Table 7-VI lists the interconnect cabling required for an OSS checkout.

7-4.2 CHECKOUT. Check out the OSS in accordance with figure 7-9 which gives the sequential listing of JDC's to be performed. Upon completion of checkout and necessary maintenance, prepare the OSS for shipment or PGNCS checkout in accordance with figure 7-7.

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

7-5 COMPUTER SUBSYSTEM

7-5.1 PREPARATION. The CSS master flowgram (figure 7-10) specifies the conditions leading to a CSS checkout and specifies the mandatory sequence to be followed. A flowgram will be provided which will give the sequential listing of JDC's to be performed to prepare the CSS for checkout. Table 7-I lists PGNCS components and the GSE required for a CSS checkout. Table 7-VII lists the interconnect cabling required for a CSS checkout.

7-5.2 CHECKOUT. A flowgram will be provided which will give the sequential listing of JDC's to be performed for a CSS checkout. Upon completion of CSS checkout and necessary maintenance, prepare the CSS for shipment or PGNCS checkout in accordance with figure 7-10.

7-6 SIGNAL CONDITIONER ASSEMBLY

7-6.1 PREPARATION. Refer to table 7-I for equipment required to perform an SCA checkout.

7-6.2 CHECKOUT. The SCA master flowgram (figure 7-11) specifies the conditions leading to an SCA checkout and gives the sequential listings of JDC's to be performed. Upon completion of checkout, prepare the SCA for storage or PGNCS checkout in accordance with figure 7-11.

7-7 PRE-INSTALLATION ACCEPTANCE

PIA tests are performed on all spares prior to installing the spare in the spacecraft. PIA tests and procedural requirements are listed in table 7-VIII. Perform the procedures in the sequence listed for the applicable component prior to installing the spare component in the spacecraft. Auxiliary airborne equipment can be used to supplement test. (See paragraph 8-11.)

Table 7-I. Equipment Required for Checkout

Equipment	Used In				
	PGNCS	ISS	OSS	CSS	SCA
<u>PGNCS COMPONENTS</u>					
CDU	X	X	X		
CMC	X			X	
Indicator control panel	X		X		
IMU	X	X			
Main panel DSKY	X			X	
Nav base	X				
Navigation panel DSKY	X			X	
OUA	X		X		
PEA	X	X			
PGNCS interconnect harness group	X				
PSA	X	X	X		
SCA	X				X
<u>GSE</u>					
Adjustable mirror	X				
AGC/OC				X	
Auxiliary calibration console				X	

(Sheet 1 of 4)

Table 7-I. Equipment Required for Checkout

Equipment	Used In				
	PGNCS	ISS	OSS	CSS	SCA
CMC handling fixture	X			X	
Component mounting plate		X	X		
Computer calibration console				X	
Computer simulator		X	X		
Coolant and power console	X	X	X		
CTS	X			X	
Degausser	X	X			
DSKY handling fixture	X			X	
DSKY mounting stand	X				
Electronic level		X	X		
G and N mounting fixture	X		X		
GSE coolant hoses	X	X	X		
GSE distribution box	X	X	X		
IMU mounting fixture		X			
IMU pressure seal tester	X	X			
Interconnect cables	X	X	X		
Interconnect kit, CMC-GSE-CSS				X	

(Sheet 2 of 4)

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

Table 7-I. Equipment Required for Checkout

Equipment	Used In				
	PGNCS	ISS	OSS	CSS	SCA
Interconnect kit, CMC-GSE-PGNCS	X				
OIA	X	X	X		
Optics/nav base mounting fixture			X		
Oscillograph	X	X	X		
P&M cables	X			X	
PEA mounting fixture	X	X			
PEA test point adapter	X	X			
Portable light assembly			X		
PSA test point adapter	X	X	X		
PTC	X	X			
Purge/fill fixture	X	X	X		
Remote optics controller			X		
Resolver circuit tester	X	X	X		
Retroreflecting prism			X		
Rotary table		X	X		
Rotary table calibration set		X	X		
Shaft accuracy tester			X		
SXT shaft zero check fixture			X		
SPCU	X				X

(Sheet 3 of 4)

Table 7-I. Equipment Required for Checkout

Equipment	Used In				
	PGNCS	ISS	OSS	CSS	SCA
Theodolite	X		X		
Variable deviation wedge	X				
Vertical leveling mirror	X	X	X		
0° autocollimator assembly	X		X		
45° autocollimator assembly	X				

(Sheet 4 of 4)

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

Table 7-II. PGNCS Interconnect Harness Group Connections (PGNCS Checkout)

PGNCS Interconnect Harness		Connects to	
Designation	Plug	Jack	Equipment
A	P1	J1	PGNCS interconnect harness D
	P2	J2	PGNCS interconnect harness D
	P3	J3	PGNCS interconnect harness D
	P4	J4	PGNCS interconnect harness D
	P5	J5	PGNCS interconnect harness H
	P6	J9	G and N mounting fixture harness E
	P7	P3	Cable W155
	P8	P1	Cable W160
	P9	J53	CDU
	P10	J51	CMC
B	P13	J1	SXT
	P14	J2	SXT
	P18	J5	PSA
C	P12	J14	PEA
	P15	J2	IMU
	P16	J1	IMU
	P19	J6	PSA
D	J1	P1	PGNCS interconnect harness A
	J2	P2	PGNCS interconnect harness A
	J3	P3	PGNCS interconnect harness A
	J4	P4	PGNCS interconnect harness A
	P17	J2	G and N mounting fixture harness B
E	P24	J1	Indicator control panel
	P26	J7	PSA
F	P23	J1	SCT
	P28	J9	PSA
G	J6		Not used
	J7		Not used
	J8		Not used
	P20	J5	G and N mounting fixture harness C
	P21	J4	G and N mounting fixture harness C
	P22	J6	G and N mounting fixture harness D
	P29	J10	PSA
	P32	P2	Cable W163
H	J5	P5	PGNCS interconnect harness A
	P25	J9	Navigation panel DSKY
	P27	J8	PSA
	P30	P2	Cable W164
	P31	P3	Cable W164

Table 7-III. G and N Mounting Fixture Harness Connections (PGNCS Checkout)

G and N Mounting Fixture Harness			Connects to	
Designation	Part Number	Plug	Jack	Equipment
A	2900753	J1 P1 P2 P3 P4 P5	A1J3 J1 J1 J1 J1 J2	GSE distribution box CDU coldplate CMC coldplate IMU coolant inlet line PSA coldplate PEA coldplate
B	2900915	J2 P6	P17 J4	PGNCS interconnect harness D PSA
C	2900924	J3 J4 J5 P7 P8	P2 P21 P20 J2 J1	Cable W165 PGNCS interconnect harness G PGNCS interconnect harness G Signal conditioning module Signal conditioning module
D	2900925	J6 P9	P22 J3	PGNCS interconnect harness G Signal conditioning module
E	2900666	J7 J8 J9	P1 P1 P6	Cable W232 Cable W233 PGNCS interconnect harness A

Table 7-IV. GSE Interconnect Cable Connections (PGNCS Checkout)

Cable			Connects to	
Designation	Part Number	Plug	Jack	Equipment
W1	1900886	P1 P2	J1 J1	OIA Oscilloscope
W2	1900669	P1 P2	J2 J2	OIA Oscilloscope
W3	1900670	P1 P2	J3 J3	OIA Oscilloscope

(Sheet 1 of 6)

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

Table 7-IV. GSE Interconnect Cable Connections (PGNCS Checkout)

Cable			Connects to	
Designation	Part Number	Plug	Jack	Equipment
W4	1900671	P1	J4	OIA
		P2	J4	Oscillograph
W19	1900873	P1	J20	OIA
		P2	J3	Coolant and power console
W22	1902610	P1	J23	OIA
		P2	J6	CTS (Diagnostic tests only)
W26	1900921	P1	A30J1	OIA
		P2	Facility	Wall power
W27	1900871	P2	A30J2	OIA
		P2	J1	Coolant and power console
W28	1900872	P1	J2	Coolant and power console
		P2	Facility	Wall power
W33	1901404	P1	E1	OIA
		P2	E4	Oscillograph
W37	1901662	P1	Facility	Facility ground
		P2	E300	Rotary table
W64	1901676	P1	E1	G and N mounting fixture base
		P2	E300	Rotary table
W65	1900739	P1	J4	Current source monitor panel
		P2	J15	PSA test point adapter
W85	1901960	P1	A30J5	OIA
		P2	Facility	Auxiliary wall power
W120	2900456	P1	J19	OIA
		P2	J2	PSA

(Sheet 2 of 6)

Table 7-IV. GSE Interconnect Cable Connections (PGNCS Checkout)

Cable			Connects to	
Designation	Part Number	Plug	Jack	Equipment
W121	2900257	P1	J8	OIA
		P2	J9	OIA
		P3	J13	OIA
		P4	J14	OIA
		P5	J15	OIA
		P6	J57	GSE distribution box
W122	2900378	P1	J18	OIA
		P2	J17	OIA
		P3	J16	OIA
		P4	J22	OIA
		P5	J55	GSE distribution box
		P6	J59	GSE distribution box
		P7	J62	GSE distribution box
		P8	J58	GSE distribution box
W123	2900379	P1	J21	OIA
		P2	J24	OIA
		P3	J25	OIA
		P4	J26	OIA
		P5	J60	GSE distribution box
		P6	J63	GSE distribution box
		P7	J66	GSE distribution box
		P8	J67	GSE distribution box
W124	2900380	P1	J5	OIA
		P2	J6	OIA
		P3	J7	OIA
		P4	J64	GSE distribution box
		P5	J61	GSE distribution box
		P6	J65	GSE distribution box
W125	2901389	P1	J28	OIA
		P2	J29	OIA
		P3	J30	OIA
		P4	J50	GSE distribution box
		P5	J51	GSE distribution box
		P6	J54	GSE distribution box

(Sheet 3 of 6)

Table 7-IV. GSE Interconnect Cable Connections (PGNCS Checkout)

Cable			Connects to	
Designation	Part Number	Plug	Jack	Equipment
W126	2900381	P1	J10	OIA
		P2	J11	OIA
		P3	J12	OIA
		P4	J52	GSE distribution box
		P5	J53	GSE distribution box
		P6	J56	GSE distribution box
W127	2900327 (2 required)		E1	OIA
			E300	Rotary table
			E1 E80	GSE distribution box OIA
W128	2900458 (2 required)		E2	GSE distribution box
			E300	Rotary table
			E1 E300	Subsystem mounting fixture Rotary table
W129	2900459		E1 E3	Subsystem mounting fixture GSE distribution box
W130	2900460		E1 E300	Coolant and power console Rotary table
W140	2900457	P1 P2	J4 J34	Coolant and power console GSE distribution box
W145	2900589	P1 P2	A1J3 P1	Temperature indicator assembly (GSE distribution box) W171
W150	2900529	P1 P2	J2 J3	PSA test point adapter PSA
W155	2900662	P1 P2 P3 P4	J14 J19 56P7 P5	GSE distribution box GSE distribution box PGNCS interconnect harness A W166

(Sheet 4 of 6)

Table 7-IV. GSE Interconnect Cable Connections (PGNCS Checkout)

Cable			Connects to	
Designation	Part Number	Plug	Jack	Equipment
W159	2900675	P1 P2	J1 J15	PEA test point adapter PEA
W160	2900665	P1 P2 P3	56P8 J29 J9	PGNCS interconnect harness A GSE distribution box Main panel DSKY
W162	2901462	P1 P2	J18 J2	GSE distribution box PEA test point adapter
W163	2901615	P1 P2	J13 56P32	GSE distribution box PGNCS interconnect harness G
W164	2900669	P1 P2 P3	J33 56P30 56P31	GSE distribution box PGNCS interconnect harness H PGNCS interconnect harness H
W165	2900670	P1 P2	J26 J3	GSE distribution box G and N mounting fixture harness C
W166	2900671	P1 P2 P3 P4 P5	J24 J28 J3 J4 P4	GSE distribution box GSE distribution box PSA test point adapter PSA test point adapter W155
W167	2901211	P1 P2	J1 J1	PSA test point adapter PSA
W226	2014137-021	P1 P2 P3 P4	A52 J4 J5 J6	AGC test connector Buffer circuit assembly Buffer circuit assembly Buffer circuit assembly
W232	2014484-011	P1 P2 P3 P4	J7 J2 J7 P6	G and N mounting fixture harness E CTS CTS W259

(Sheet 5 of 6)

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

Table 7-IV. GSE Interconnect Cable Connections (PGNCS Checkout)

Cable			Connects to	
Designation	Part Number	Plug	Jack	Equipment
W233	2014483-011	P1	J8	G and N mounting fixture harness E CTS CTS CTS
		P2	J16	
		P3	J10	
		P4	J4	
W236	2014463-011	P1	J1	Buffer circuit assembly CTS
		P2	J5	
W237	2014462-011	P1	J2	Buffer circuit assembly CTS
		P2	J11	
W238	2014462-021	P1	J3	Buffer circuit assembly CTS
		P2	J17	
W239	2014462-031	P1	J9	Buffer circuit assembly CTS
		P2	J18	
W259	2014470-011	P1	CP1	AGC calibration system Digital ohmmeter Digital ohmmeter
		P2		
		P3		
		P4	J7	Buffer circuit assembly
		P5	J8	Buffer circuit assembly
		P6	J4	W232
		P7		Digital ohmmeter
		P8		Digital ohmmeter

Table 7-V. GSE Interconnect Cable Connections (ISS Checkout)

Cable			Connects to	
Designation	Part Number	Plug	Jack	Equipment
W1	1900886	P1	J1	OIA
		P2	J1	Oscillograph
W2	1900669	P1	J2	OIA
		P2	J2	Oscillograph
W3	1900670	P1	J3	OIA
		P2	J3	Oscillograph
W4	1900671	P1	J4	OIA
		P2	J4	Oscillograph
W19	1900873	P1	J20	OIA
		P2	J3	Coolant and power console
W26	1900921	P1	A30J1	OIA
		P2	Facility	Wall power
W27	1900871	P1	A30J2	OIA
		P2	J1	Coolant and power console
W28	1900872	P1	J2	Coolant and power console
		P2	Facility	Wall power
W33	1901404	P1	E1	OIA
		P2	E4	Oscillograph
W37	1901662	P1	Facility	Facility ground
		P2	E300	Rotary table
W64	1901676	P1	E1	G and N mounting fixture base
		P2	E300	Rotary table
W65	1900739	P1	J4	Current source monitor panel
		P2	J15	PSA test point adapter

(Sheet 1 of 5)

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

Table 7-V. GSE Interconnect Cable Connections (ISS Checkout)

Cable			Connects to	
Designation	Part Number	Plug	Jack	Equipment
W68	1902284	P1	E300	Rotary table
		P2	E1	PEA coldplate
W85	1901960	P1	A30J5	OIA
		P2	Facility	Auxiliary wall power
W120	2900456	P1	J19	OIA
		P2	J2	PSA
W121	2900257	P1	J8	OIA
		P2	J9	OIA
		P3	J13	OIA
		P4	J14	OIA
		P5	J15	OIA
		P6	J57	GSE distribution box
W122	2900378	P1	J18	OIA
		P2	J17	OIA
		P3	J16	OIA
		P4	J22	OIA
		P5	J55	GSE distribution box
		P6	J59	GSE distribution box
		P7	J62	GSE distribution box
		P8	J58	GSE distribution box
W123	2900379	P1	J21	OIA
		P2	J24	OIA
		P3	J25	OIA
		P4	J26	OIA
		P5	J60	GSE distribution box
		P6	J63	GSE distribution box
		P7	J66	GSE distribution box
		P8	J67	GSE distribution box
W124	2900380	P1	J5	OIA
		P2	J6	OIA
		P3	J7	OIA
		P4	J64	GSE distribution box
		P5	J61	GSE distribution box
		P6	J65	GSE distribution box

(Sheet 2 of 5)

Table 7-V. GSE Interconnect Cable Connections (ISS Checkout)

Cable			Connects to	
Designation	Part Number	Plug	Jack	Equipment
W125	2901389	P1	J28	OIA
		P2	J29	OIA
		P3	J30	OIA
		P4	J50	GSE distribution box
		P5	J51	GSE distribution box
		P6	J54	GSE distribution box
W126	2900381	P1	J10	OIA
		P2	J11	OIA
		P3	J12	OIA
		P4	J52	GSE distribution box
		P5	J53	GSE distribution box
		P6	J56	GSE distribution box
W127	2900327 (2 required)		E1	GSE distribution box
			E80	OIA
W128	2900458 (2 required)		E1	OIA
			E300	Rotary table
W128	2900458 (2 required)		E2	GSE distribution box
			E300	Rotary table
W129	2900459 (2 required)		E1	Subsystem mounting fixture
			E2	Subsystem mounting fixture
W129	2900459 (2 required)		E1	Subsystem mounting fixture
			E3	GSE distribution box
W130	2900460		E1	Coolant and power console
			E300	Rotary table

(Sheet 3 of 5)

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

Table 7-V. GSE Interconnect Cable Connections (ISS Checkout)

Cable			Connects to	
Designation	Part Number	Plug	Jack	Equipment
W132	2901238	P1	P15	W146
		P2	P16	W146
		P3	P17	W146
		P4		Not used
		P5	J2	PEA test point adapter
		P6	J14	GSE distribution box
		P7	J10	GSE distribution box
		P8	J17	GSE distribution box
		P9		Not used
		P10	J18	GSE distribution box
W134	2901237	P1	P18	W146
		P2	J23	GSE distribution box
W136	2901032	P1	J24	GSE distribution box
		P2	J28	GSE distribution box
		P3	J3	PSA test point adapter
		P4	J4	PSA test point adapter
W140	2900457	P1	J4	Coolant and power console
		P2	J34	GSE distribution box
W141	2901153	P1	A1J3	Temperature indicator assembly (GSE distribution box)
		P2	J1	IMU coolant inlet line
		P3	J2	PEA coldplate
		P4		Not used
		P5	J1	CDU coldplate
		P6	J1	PSA coldplate
W146	2900351	P15	P1	W132
		P16	P2	W132
		P17	P3	W132
		P18	P1	W134
		P19	P1	W158
		P20	J2	IMU
		P21	J1	IMU
		J1		Not used

(Sheet 4 of 5)

Table 7-V. GSE Interconnect Cable Connections (ISS Checkout)

Cable			Connects to	
Designation	Part Number	Plug	Jack	Equipment
W148	2901595	P1 P2	J33 J8	GSE distribution box PSA
W149	2901596	P1 P2	J26 J10	GSE distribution box PSA
W150	2900529	P1 P2	J2 J3	PSA test point adapter PSA
W154	2901605	P1 P2 P3 P4	J19 J20 J4 J53	GSE distribution box GSE distribution box PSA CDU
W156	2901599	P1 P2 P3	J11 J12 J6	GSE distribution box GSE distribution box PSA
W158	2900664	P1 P2	P19 J14	W146 PEA
W159	2900675	P1 P2	J1 J15	PEA test point adapter PEA
W167	2901211	P1 P2	J1 J1	PSA test point adapter PSA
W168	2901130	P1	E300 E1	Rotary table OIA

(Sheet 5 of 5)

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

Table 7-VI. GSE Interconnect Cable Connections (OSS Checkout)

Cable			Connects to	
Designation	Part Number	Plug	Jack	Equipment
W1	1900886	P1	J1	OIA
		P2	J1	Oscillograph
W2	1900669	P1	J2	OIA
		P2	J2	Oscillograph
W3	1900670	P1	J3	OIA
		P2	J3	Oscillograph
W4	1900671	P1	J4	OIA
		P2	J4	Oscillograph
W19	1900873	P1	J20	OIA
		P2	J3	Coolant and power console
W26	1900921	P1	A30J1	OIA
		P2	Facility	Wall power
W27	1900871	P1	A30J2	OIA
		P2	J1	Coolant and power console
W28	1900872	P1	J2	Coolant and power console
		P2	Facility	Wall power
W33	1901404	P1	E1	OIA
		P2	E4	Oscillograph
W37	1901662	P1	Facility	Facility ground
		P2	E300	Rotary table
W64	1901676	P1	E1	G and N mounting fixture base
		P2	E300	Rotary table
W65	1900739	P1	J4	Current source monitor panel
		P2	J15	PSA test point adapter
W68	1902284	P2	E1	Optics/nav base mounting fixture (tracker junction box)
		P1	E300	Rotary table
W85	1901960	P1	A30J5	OIA
		P2	Facility	Auxiliary wall power

(Sheet 1 of 4)

Table 7-VI. GSE Interconnect Cable Connections (OSS Checkout)

Cable			Connects to	
Designation	Part Number	Plug	Jack	Equipment
W93	1902349	P1	P3	W152 Remote optics controller
		P2	J2	
W121	2900257	P1	J8	OIA
		P2	J9	OIA
		P3	J13	OIA
		P4	J14	OIA
		P5	J15	OIA
		P6	J57	GSE distribution box
W122	2900378	P1	J18	OIA
		P2	J17	OIA
		P3	J16	OIA
		P4	J22	OIA
		P5	J55	GSE distribution box
		P6	J59	GSE distribution box
		P7	J62	GSE distribution box
		P8	J58	GSE distribution box
W123	2900379	P1	J21	OIA
		P2	J24	OIA
		P3	J25	OIA
		P4	J26	OIA
		P5	J60	GSE distribution box
		P6	J63	GSE distribution box
		P7	J66	GSE distribution box
		P8	J68	GSE distribution box
W124	2900380	P1	J5	OIA
		P2	J6	OIA
		P3	J7	OIA
		P4	J64	GSE distribution box
		P5	J61	GSE distribution box
		P6	J65	GSE distribution box
W125	2901389	P1	J28	OIA
		P2	J29	OIA
		P3	J30	OIA
		P4	J50	GSE distribution box
		P5	J51	GSE distribution box
		P6	J54	GSE distribution box

(Sheet 2 of 4)

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

Table 7-VI. GSE Interconnect Cable Connections (OSS Checkout)

Cable			Connects to	
Designation	Part Number	Plug	Jack	Equipment
W126	2900381	P1	J10	OIA
		P2	J11	OIA
		P3	J12	OIA
		P4	J52	GSE distribution box
		P5	J53	GSE distribution box
		P6	J56	GSE distribution box
W127	2900327 (2 required)		E1	OIA
			E300	Rotary table
			E80	OIA
W128	2900458 (2 required)		E1	GSE distribution box
			E2	GSE distribution box
W129	2900459 (2 required)		E300	Rotary table
			E1	Subsystem mounting fixture
			E2	Subsystem mounting fixture
W130	2900460		E1	Subsystem mounting fixture
			E3	GSE distribution box
W136	2901032	P1	J24	Coolant and power console
		P2	J300	Rotary table
W140	2900457	P1	J24	GSE distribution box
		P2	J28	GSE distribution box
		P3	J3	PSA test point adapter
		P4	J4	PSA test point adapter
W140	2900457	P1	J4	Coolant and power console
		P2	J34	GSE distribution box

(Sheet 3 of 4)

Table 7-VI. GSE Interconnect Cable Connections (OSS Checkout)

Cable			Connects to	
Designation	Part Number	Plug	Jack	Equipment
W141	2901153	P1	A1J3	Temperature indicator assembly (GSE distribution box)
		P2		Not used
		P3		Not used
		P4		Not used
		P5	J1	CDU coldplate
		P6	J1	PSA coldplate
W147	2900603	P1	J16	GSE distribution box
		P2	J6	Optics/nav base mounting fixture (tracker junction box)
W148	2901595	P1	J33	GSE distribution box
		P2	J8	PSA
W149	2901596	P1	J26	GSE distribution box
		P2	J10	PSA
W150	2900529	P1	J2	PSA test point adapter
		P2	J3	PSA
W151	2900600	P1	J1	SCT
		P2	J2	SXT
		P3	J1	SXT
		P4	J3	Optics/nav base mounting fixture (tracker junction box)
		P5	J4	Optics/nav base mounting fixture (tracker junction box)
W152	2901597	P1	J2	Optics/nav base mounting fixture (tracker junction box)
		P2	J3	Optics/nav base mounting fixture (tracker junction box)
		P3	P2	W153 (indicator control panel)
		or P3	P2	W93 (remote optics controller)
		P4	J5	PSA
		P5	J9	PSA
		P6	J7	PSA

(Sheet 3A of 4)

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

Table 7-VI. GSE Interconnect Cable Connections (OSS Checkout)

Cable		Connects to		
Designation	Part Number	Plug	Jack	Equipment
W153	2900660	P1 P2	J1 P3	Indicator control panel W152
W154	2901605	P1 P2 P3 P4	J19 J20 J4 J53	GSE distribution box GSE distribution box PSA CDU
W167	2901211	P1 P2	J1 J1	PSA test point adapter PSA
W168	2901130	P1	E300 E1	Rotary table OIA

(Sheet 4 of 4)

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

Table 7-VII. GSE Interconnect Cable Connections (CSS Checkout)

Cable			Connects to	
Designation	Part Number	Plug	Jack	Equipment
W212	1006482-001	P1	J7	AGC/OC
		P2	J1	CTS
W213	1006482-002	P1	J8	AGC/OC
		P2	J7	CTS
W214	1006482-003	P1	J9	AGC/OC
		P2	J13	CTS
W215	1006482-004	P1	J4	AGC/OC
		P2	J2	CTS
W216	1006482-005	P1	J5	AGC/OC
		P2	J8	CTS
W217	1006482-006	P1	J6	AGC/OC
		P2	J14	CTS
W218	1006482-007	P1	J11	AGC/OC
		P2	J3	CTS
W219	1006482-008	P1	J12	AGC/OC
		P2	J9	CTS
W220	1006482-009	P1	J10	AGC/OC
		P2	J15	CTS
W221	1006482-010	P1	J1	AGC/OC
		P2	J10	CTS
W222	1006482-011	P1	J2	AGC/OC
		P2	J16	CTS
W223	1006482-012	P1	J3	AGC/OC
		P2	J4	CTS

(Sheet 1 of 2)

Table 7-VII. GSE Interconnect Cable Connections (CSS Checkout)

Cable			Connects to	
Designation	Part Number	Plug	Jack	Equipment
W268	2014486-021	P1	J9	Main panel DSKY AGC/OC
		P2	J1	
W267	2014493-021	P1	J9	Navigation panel DSKY AGC/OC
		P2	J3	
W226	2014137-021	P1	A52	AGC test connector
		P2	J4	Buffer circuit assembly
		P3	J5	Buffer circuit assembly
		P4	J6	Buffer circuit assembly
W227	2014199-021	P1	SC conn.	AGC
		P2	J2	AGC/OC junction panel assembly
		P3	J3	AGC/OC junction panel assembly
		P4	J4	AGC/OC junction panel assembly
		P5	J5	AGC/OC junction panel assembly
		P6	J1	AGC/OC junction panel assembly
W236	2014463-011	P1	J1	Buffer circuit assembly
		P2	J5	CTS
W237	2014462-011	P1	J2	Buffer circuit assembly
		P2	J11	CTS
W238	2014462-021	P1	J3	Buffer circuit assembly
		P2	J17	CTS
W239	2014462-031	P1	J9	Buffer circuit assembly
		P2	J18	CTS
W259	2014470-011	P1	CP1	AGC calibration system
		P2		Digital ohmmeter
		P3		Digital ohmmeter
		P4	J7	Buffer circuit assembly
		P5	J8	Buffer circuit assembly
		P6	J6	AGC/OC junction panel assembly
		P7		Digital ohmmeter
		P8		Digital ohmmeter

Table 7-VIII. PIA Test Requirements

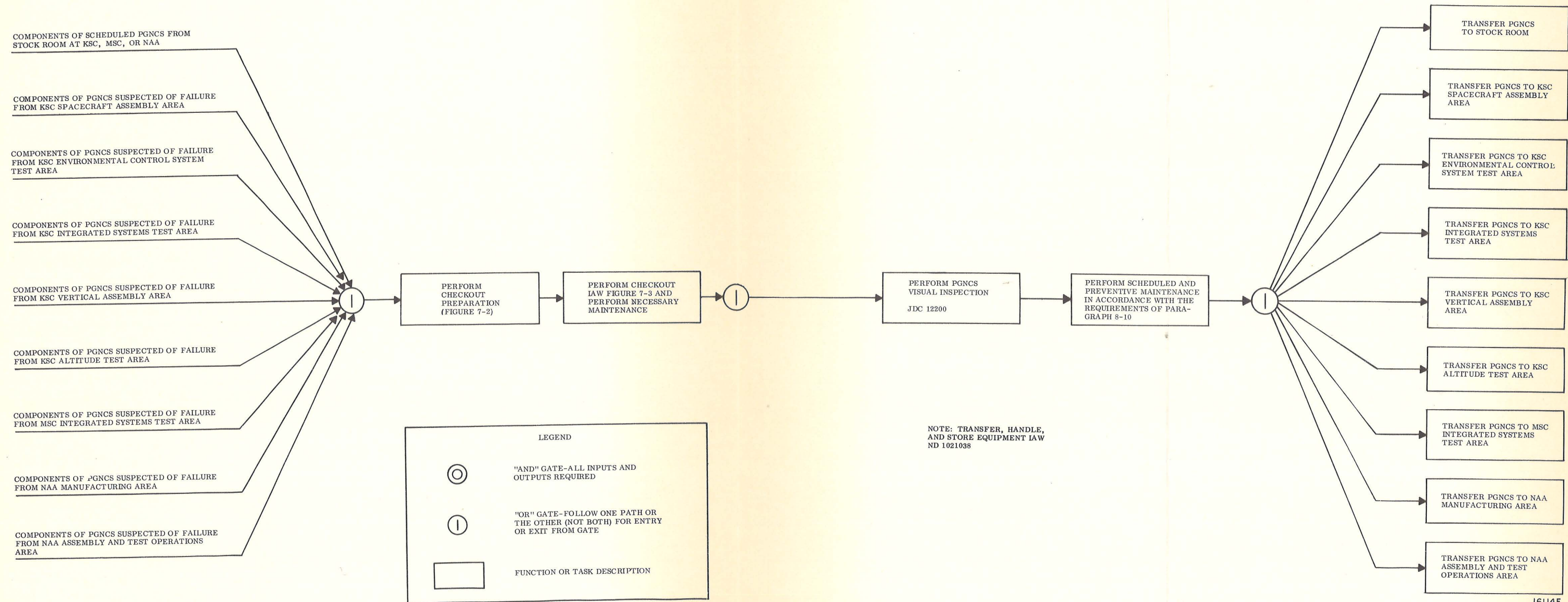
Component	Procedures for Subsystem Test Configuration	Procedures for System Test Configuration
CDU	Perform the following steps: 1. Prerequisite: ISS test preparation, figure 7-5. PIA test: figure 7-13. 2. Prerequisite: OSS test preparation, figure 7-8. PIA test: figure 7-13.	Perform JDC 12285. If necessary, use figure 7-2 for system setup.
CMC and/or DSKY	Perform the following steps: Prerequisite: CSS test preparation, figure 7-10A. PIA test: figure 7-10B.	Perform JDC 12286 for CMC and/or JDC 12287 for DSKY. If necessary, use figure 7-2 for system setup.
IMU and PEA	Perform the following steps: Prerequisite: ISS test preparation, figure 7-5. PIA test: figure 7-12.	Perform JDC 12288. If necessary, use figure 7-2 for system setup.
Interconnect harnesses A through H	Perform complete continuity test: JDC 18269.	Perform JDC's listed for interconnect harnesses A through H retest in table 8-IV. If necessary, use figure 7-2 for system setup.
Indicator control panel	Perform JDC 18273.	Perform JDC 12289. If necessary, use figure 7-2 for system setup.
OUA	Perform the following steps: Prerequisite: OSS test preparation, figure 7-8. PIA test: figure 7-9.	If unit history records indicate that OUA has previously passed an OSS checkout, perform JDC 12290. If necessary, use figure 7-2 for system setup.
OUA eyepieces	Perform JDC 03652.	None

(Sheet 1 of 2)

Table 7-VIII. PIA Test Requirements

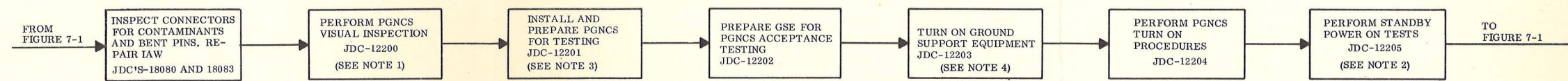
Component	Procedures for Subsystem Test Configuration	Procedures for System Test Configuration
PSA	Perform the following steps: 1. Perform 28 vdc filter test, JDC 18274. 2. Prerequisite: ISS test preparation, figure 7-5. PIA test: figure 7-14. 3. Prerequisite: OSS test preparation, figure 7-8. PIA test: figure 7-14.	Perform JDC 12291. If necessary, use figure 7-2 for system setup.
SCA	Perform SCA checkout in accordance with figure 7-11.	Perform JDC 12224. If necessary, use figure 7-2 for system setup.

(Sheet 2 of 2)



16114E

Figure 7-1. PGNCS Master Checkout Flowgram



NOTE 1: SEE TABLES 3-IC-2 AND 3-IC-3 FOR CONFIGURATION OF ROPE AND JUMPER MODULES.

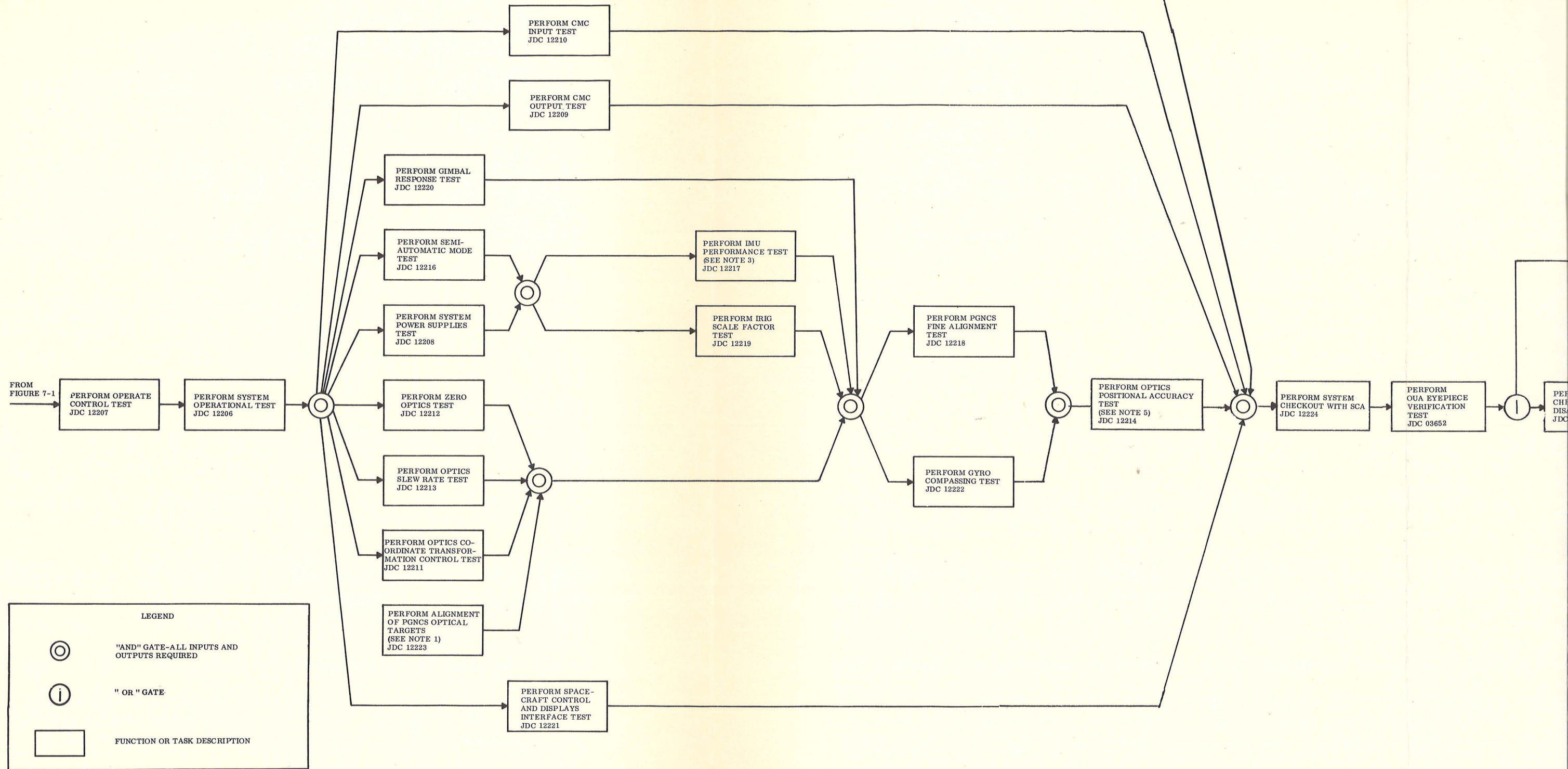
NOTE 2: IF SYSTEM CHECKOUT IS INTERRUPTED, PERFORM TURN ON AND TURN OFF PROCEDURES ACCORDING TO JDC-12204.

NOTE 3: WHEN ASSIGNED EQUIPMENT IS AVAILABLE PERFORM JDC 17109 TO REPLACE GSE WITH A/B LAMP RETAINER PANELS ON GNIC PANEL AND TO APPLY DECAL TO ESU COVER.

NOTE 4: PERFORM JDC 18054 IF MONITORING OF DSKY ENTRIES ON CTS TAPE IS DESIRED.

Figure 7-2. PGNC'S Checkout Preparation Flowgram

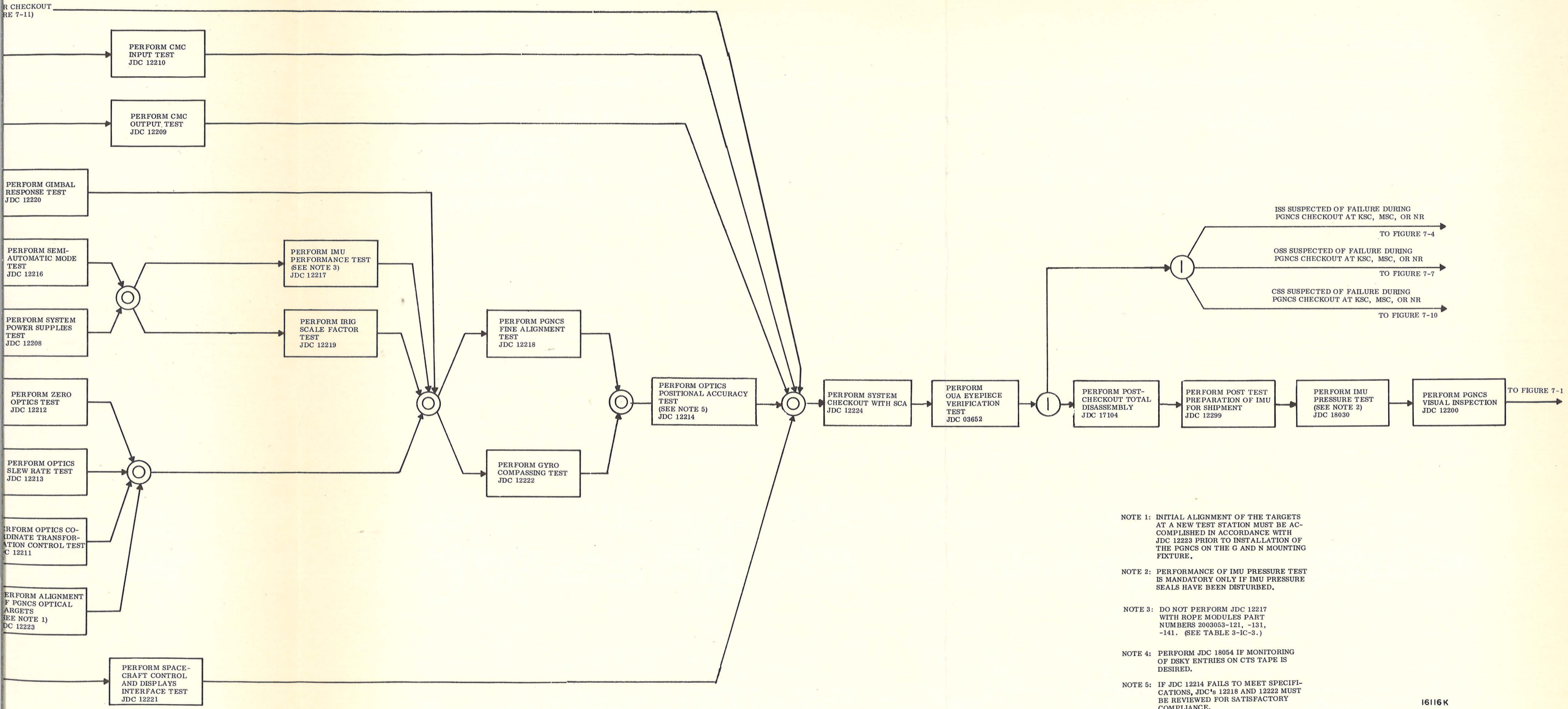
FROM SCA MASTER CHECKOUT FLOWGRAM (FIGURE 7-11)



LEGEND

- ⊙ "AND" GATE-ALL INPUTS AND OUTPUTS REQUIRED
- ⊕ "OR" GATE
- ▭ FUNCTION OR TASK DESCRIPTION

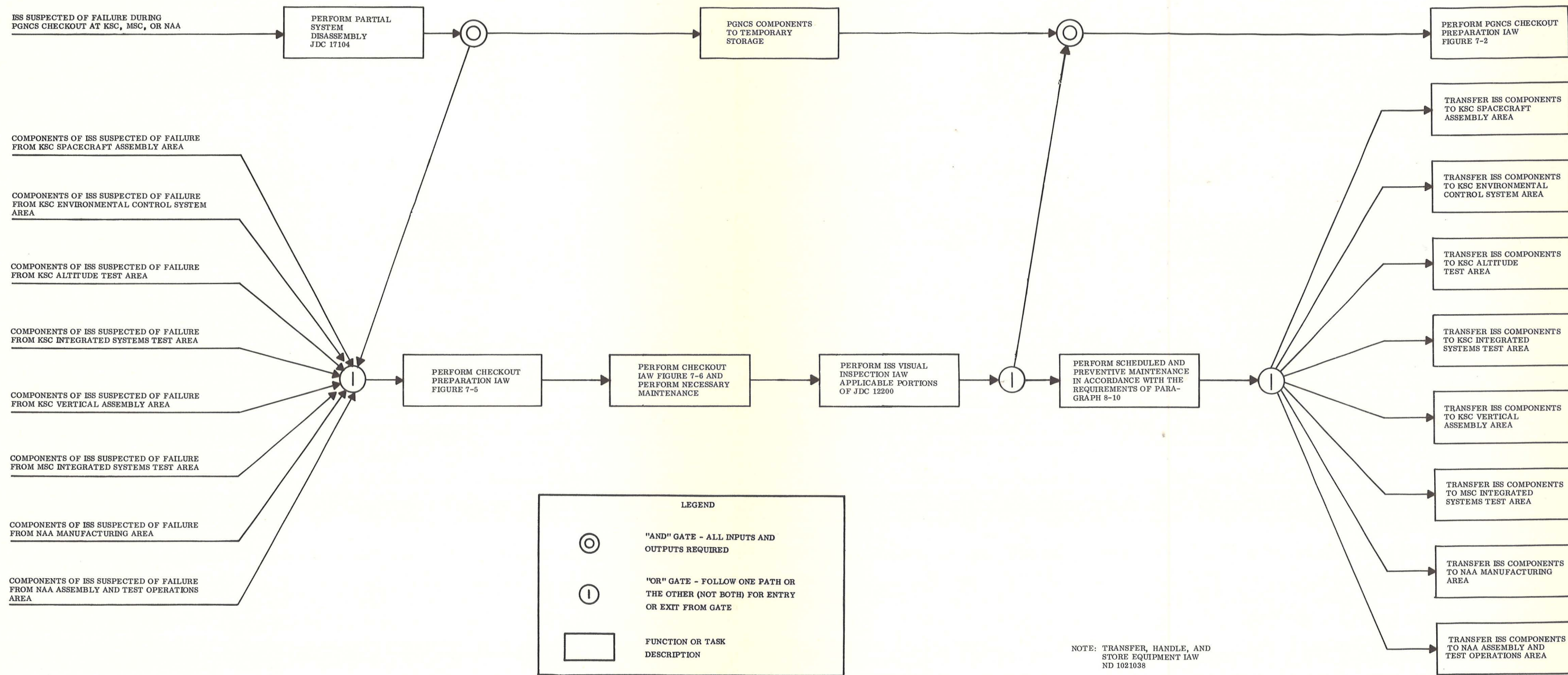
BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM



- NOTE 1: INITIAL ALIGNMENT OF THE TARGETS AT A NEW TEST STATION MUST BE ACCOMPLISHED IN ACCORDANCE WITH JDC 12223 PRIOR TO INSTALLATION OF THE PGNCS ON THE G AND N MOUNTING FIXTURE.
- NOTE 2: PERFORMANCE OF IMU PRESSURE TEST IS MANDATORY ONLY IF IMU PRESSURE SEALS HAVE BEEN DISTURBED.
- NOTE 3: DO NOT PERFORM JDC 12217 WITH ROPE MODULES PART NUMBERS 2003053-121, -131, -141. (SEE TABLE 3-IC-3.)
- NOTE 4: PERFORM JDC 18054 IF MONITORING OF DSKY ENTRIES ON CTS TAPE IS DESIRED.
- NOTE 5: IF JDC 12214 FAILS TO MEET SPECIFICATIONS, JDC's 12218 AND 12222 MUST BE REVIEWED FOR SATISFACTORY COMPLIANCE.

16116K

Figure 7-3. PGNCS Checkout Flowgram



16117D

Figure 7-4. ISS Master Checkout Flowgram

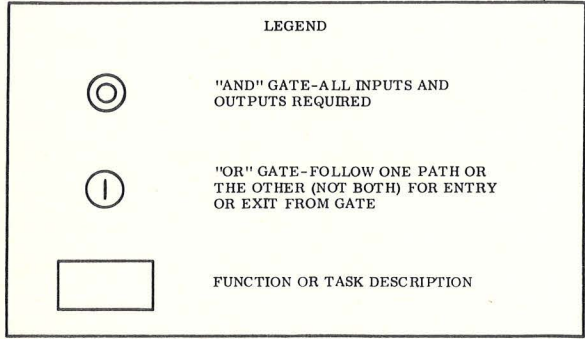
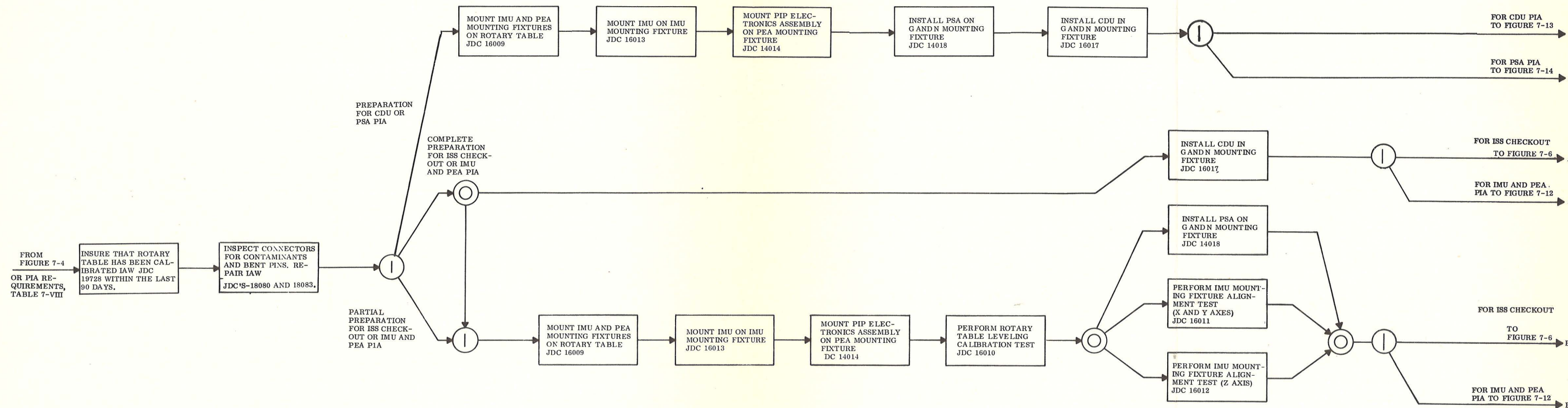
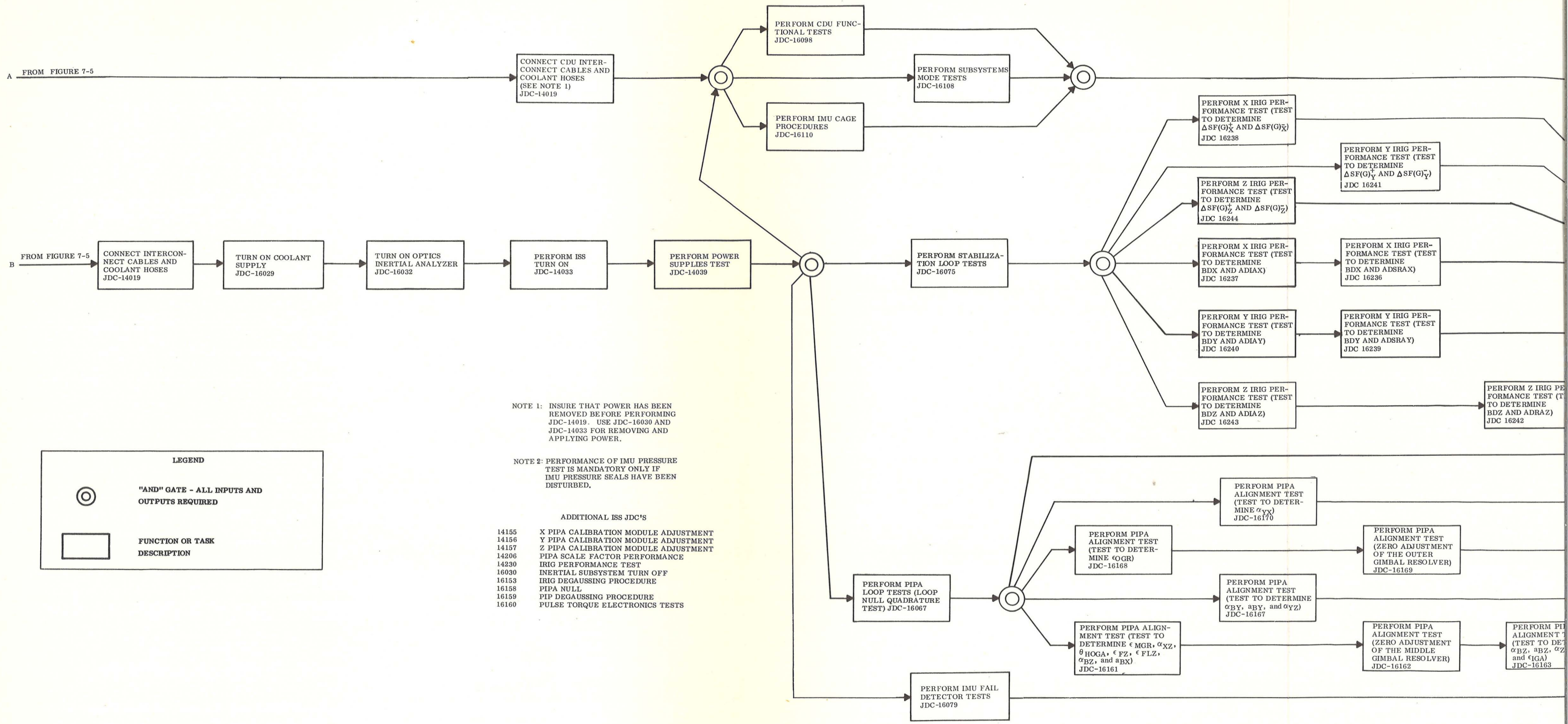


Figure 7-5. ISS Checkout Preparation Flowgram



NOTE 1: INSURE THAT POWER HAS BEEN REMOVED BEFORE PERFORMING JDC-14019. USE JDC-16030 AND JDC-14033 FOR REMOVING AND APPLYING POWER.

NOTE 2: PERFORMANCE OF IMU PRESSURE TEST IS MANDATORY ONLY IF IMU PRESSURE SEALS HAVE BEEN DISTURBED.

ADDITIONAL ISS JDC'S

- 14155 X PIPA CALIBRATION MODULE ADJUSTMENT
- 14156 Y PIPA CALIBRATION MODULE ADJUSTMENT
- 14157 Z PIPA CALIBRATION MODULE ADJUSTMENT
- 14206 PIPA SCALE FACTOR PERFORMANCE
- 14230 IRIG PERFORMANCE TEST
- 16030 INERTIAL SUBSYSTEM TURN OFF
- 16153 IRIG DEGAUSSING PROCEDURE
- 16158 PIPA NULL
- 16159 PIP DEGAUSSING PROCEDURE
- 16160 PULSE TORQUE ELECTRONICS TESTS

LEGEND

⊙ "AND" GATE - ALL INPUTS AND OUTPUTS REQUIRED

▭ FUNCTION OR TASK DESCRIPTION

PERFORM Z IRIG PERFORMANCE TEST (TEST TO DETERMINE $\Delta SF(G)_{Z}^+$ AND $\Delta SF(G)_{Z}^-$) JDC 16242

PERFORM Y IRIG PERFORMANCE TEST (TEST TO DETERMINE $\Delta SF(G)_{Y}^+$ AND $\Delta SF(G)_{Y}^-$) JDC 16241

PERFORM X IRIG PERFORMANCE TEST (TEST TO DETERMINE $\Delta SF(G)_{X}^+$ AND $\Delta SF(G)_{X}^-$) JDC 16238

PERFORM Z IRIG PERFORMANCE TEST (TEST TO DETERMINE $\Delta SF(G)_{Z}^+$ AND $\Delta SF(G)_{Z}^-$) JDC 16244

PERFORM X IRIG PERFORMANCE TEST (TEST TO DETERMINE $\Delta SF(G)_{X}^+$ AND $\Delta SF(G)_{X}^-$) JDC 16237

PERFORM X IRIG PERFORMANCE TEST (TEST TO DETERMINE $\Delta SF(G)_{X}^+$ AND $\Delta SF(G)_{X}^-$) JDC 16236

PERFORM Y IRIG PERFORMANCE TEST (TEST TO DETERMINE $\Delta SF(G)_{Y}^+$ AND $\Delta SF(G)_{Y}^-$) JDC 16240

PERFORM Y IRIG PERFORMANCE TEST (TEST TO DETERMINE $\Delta SF(G)_{Y}^+$ AND $\Delta SF(G)_{Y}^-$) JDC 16239

PERFORM Z IRIG PERFORMANCE TEST (TEST TO DETERMINE $\Delta SF(G)_{Z}^+$ AND $\Delta SF(G)_{Z}^-$) JDC 16243

PERFORM PIPA ALIGNMENT TEST (TEST TO DETERMINE α_{YZ}) JDC-16167

PERFORM PIPA ALIGNMENT TEST (ZERO ADJUSTMENT OF THE OUTER GIMBAL RESOLVER) JDC-16169

PERFORM PIPA ALIGNMENT TEST (TEST TO DETERMINE α_{OGR}) JDC-16168

PERFORM PIPA ALIGNMENT TEST (TEST TO DETERMINE ϵ_{MGR} , α_{XZ} , θ_{HOGA} , ϵ_{FLZ} , α_{BZ} , and α_{BX}) JDC-16161

PERFORM PIPA ALIGNMENT TEST (ZERO ADJUSTMENT OF THE MIDDLE GIMBAL RESOLVER) JDC-16162

PERFORM PIPA ALIGNMENT TEST (TEST TO DETERMINE α_{BZ} , α_{BZ} , α_{BZ} and ϵ_{GA}) JDC-16163

PERFORM PIPA LOOP TESTS (LOOP NULL QUADRATURE TEST) JDC-16067

PERFORM IMU FAIL DETECTOR TESTS JDC-16079

PERFORM STABILIZATION LOOP TESTS JDC-16075

PERFORM POWER SUPPLIES TEST JDC-14039

PERFORM ISS TURN ON JDC-14033

TURN ON OPTICS INERTIAL ANALYZER JDC-16032

TURN ON COOLANT SUPPLY JDC-16029

CONNECT INTERCONNECT CABLES AND COOLANT HOSES JDC-14019

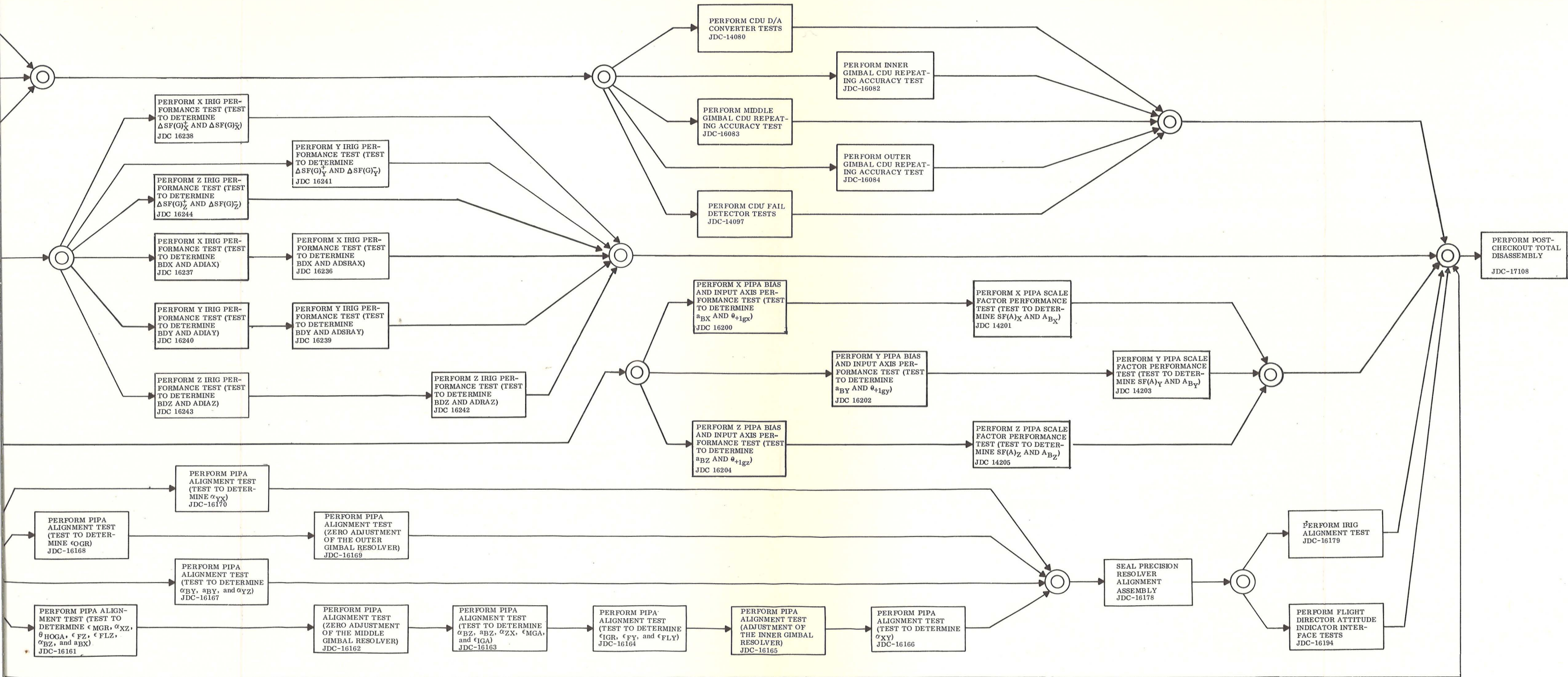
PERFORM CDU FUNCTIONAL TESTS JDC-16098

PERFORM IMU CAGE PROCEDURES JDC-16110

PERFORM SUBSYSTEMS MODE TESTS JDC-16108

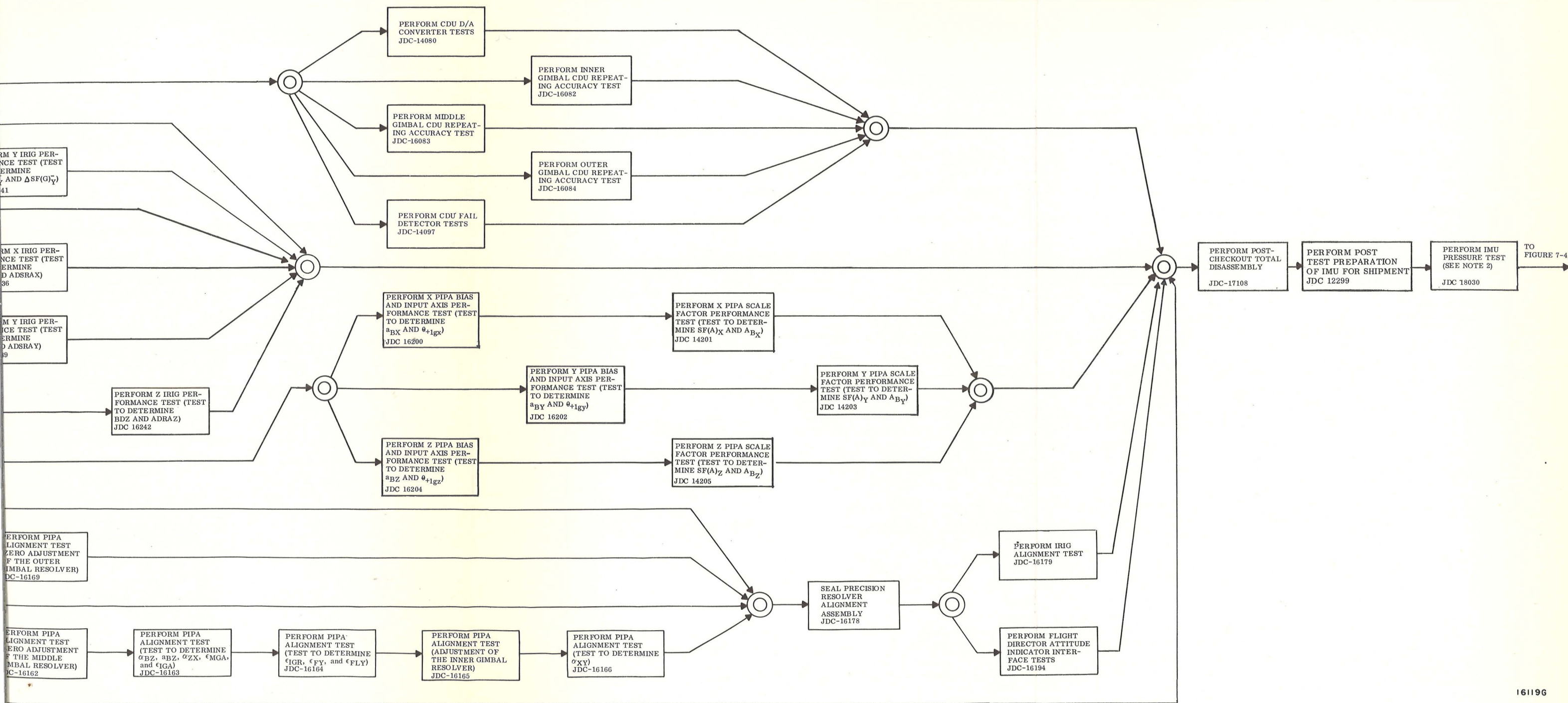
FROM FIGURE 7-5

FROM FIGURE 7-5



Fig

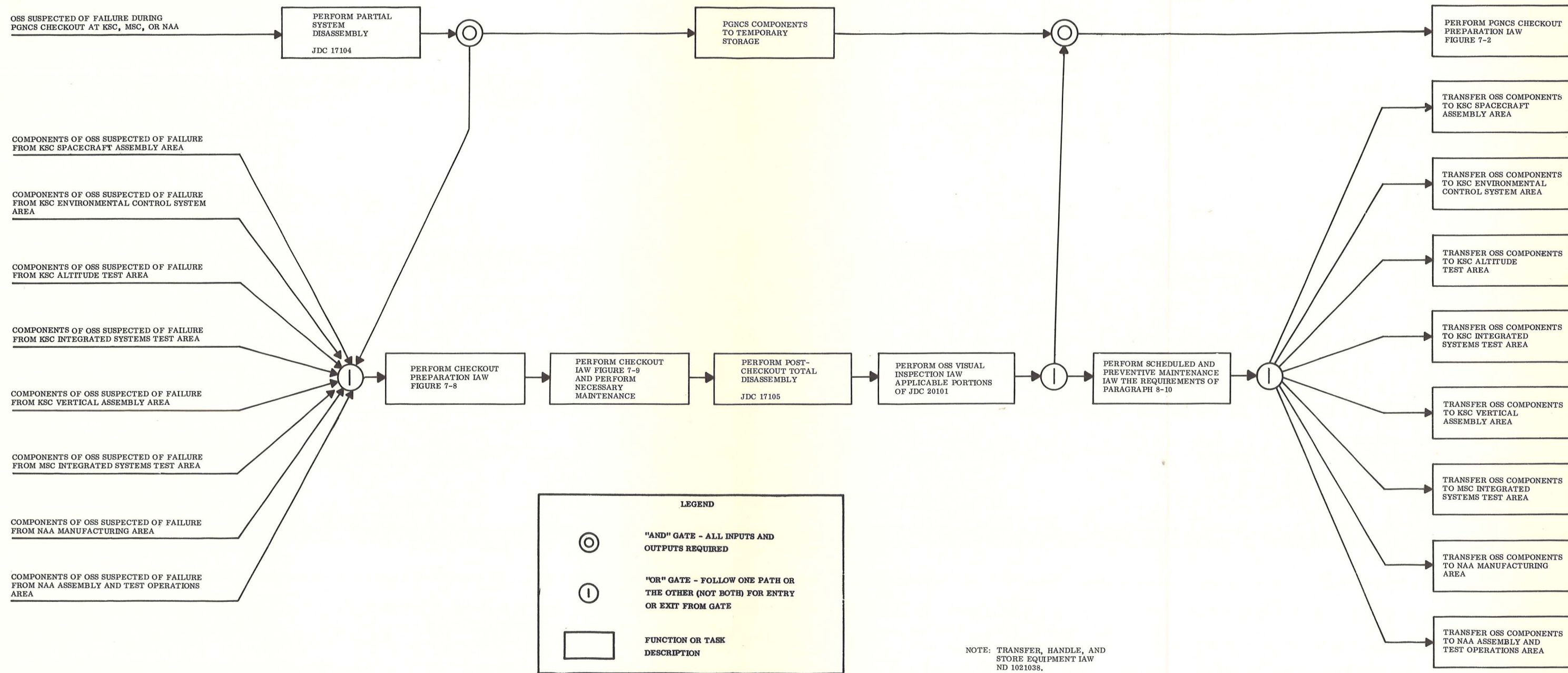
BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM



161196

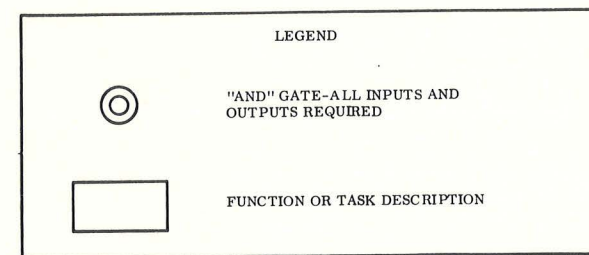
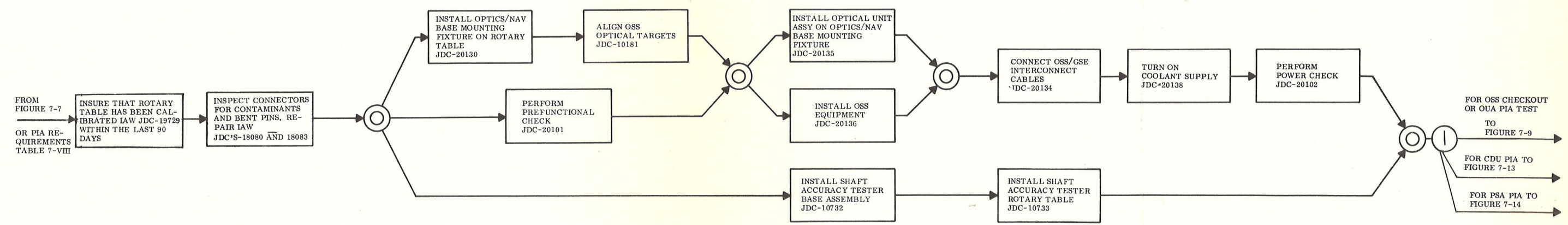
Figure 7-6. ISS Checkout Flowgram

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM



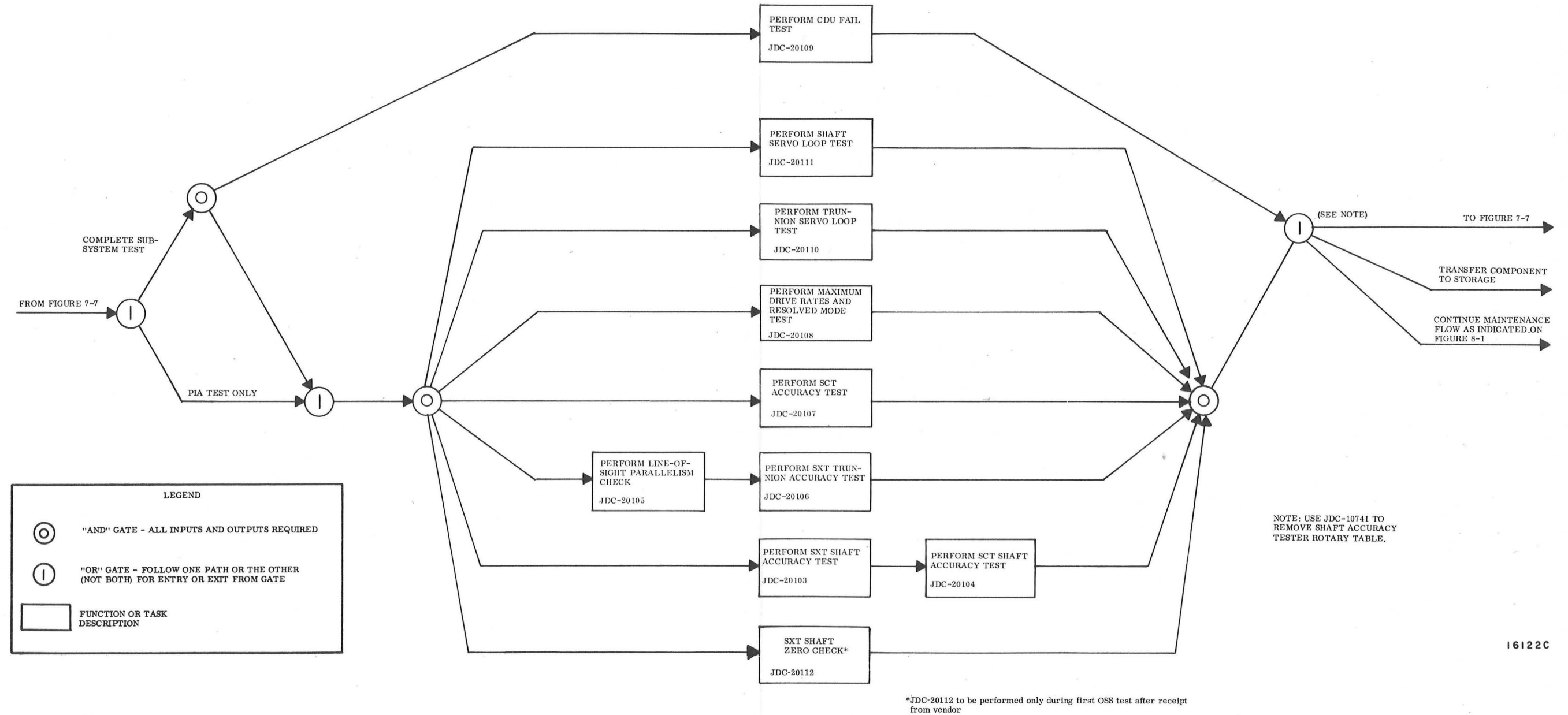
16120D

Figure 7-7. OSS Master Checkout Flowgram



16121C

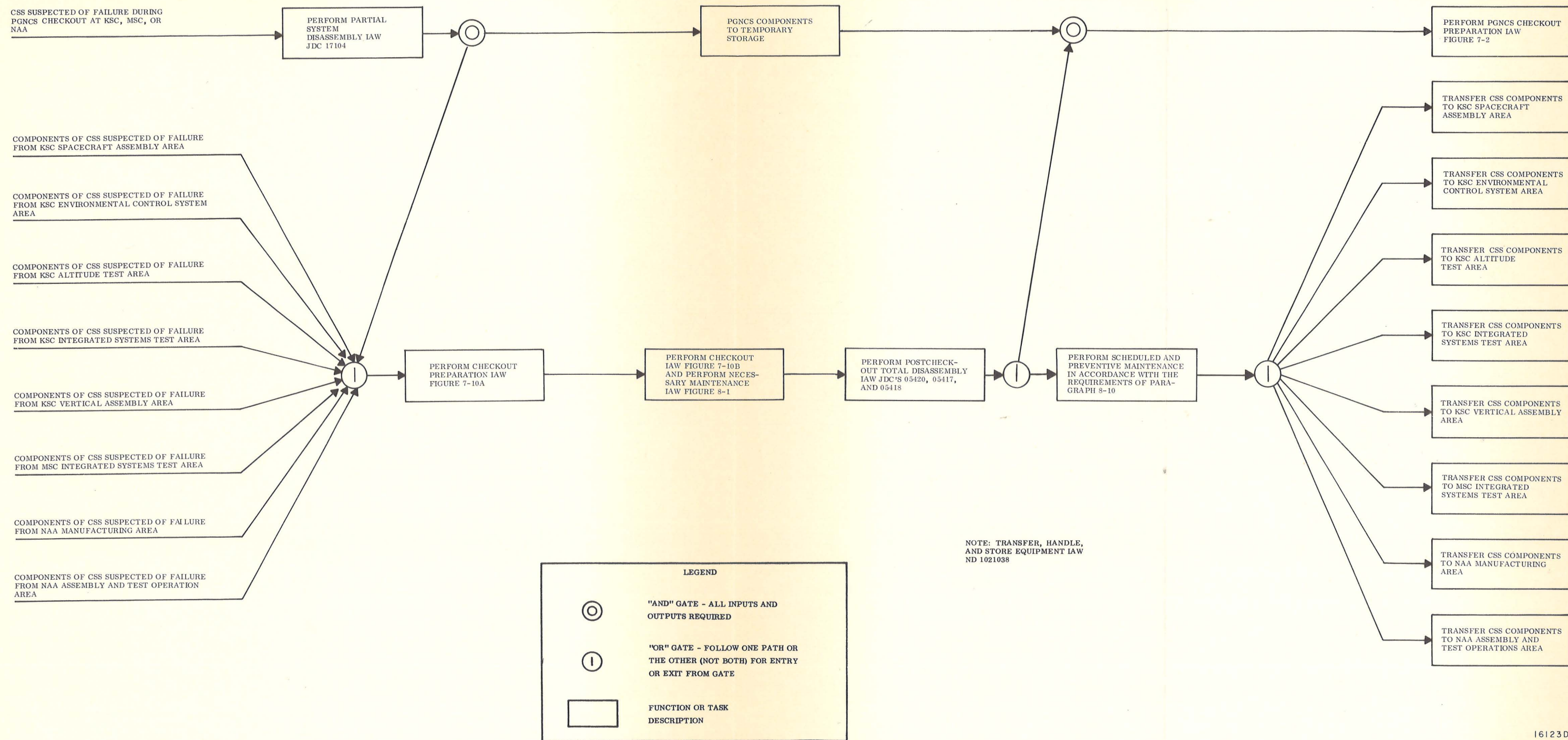
Figure 7-8. OSS Checkout Preparation Flowgram



16122C

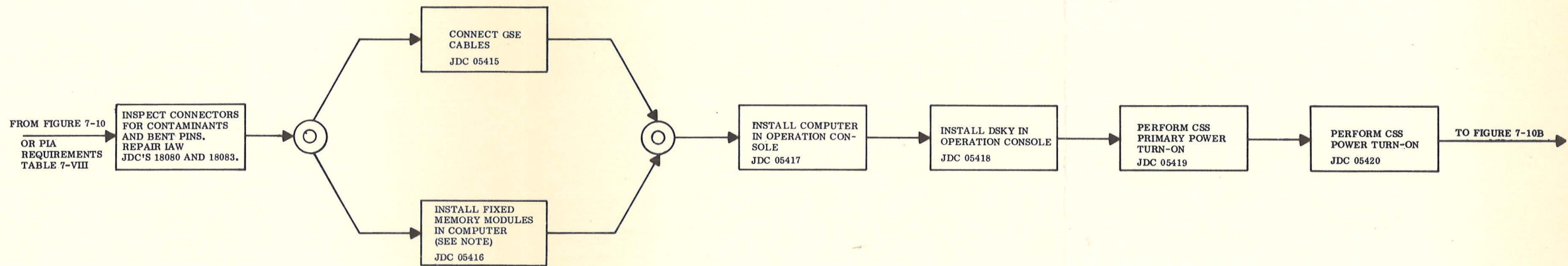
Figure 7-9. OSS Checkout Flowgram

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

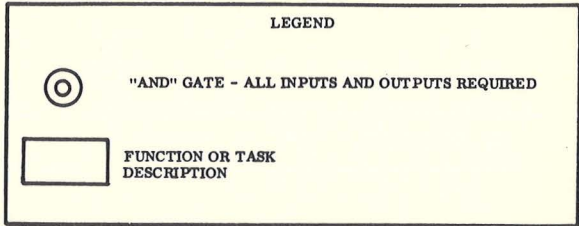


16123D

Figure 7-10. CSS Master Checkout Flowgram



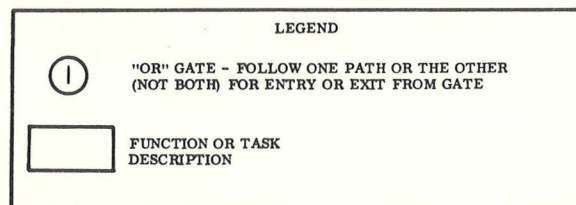
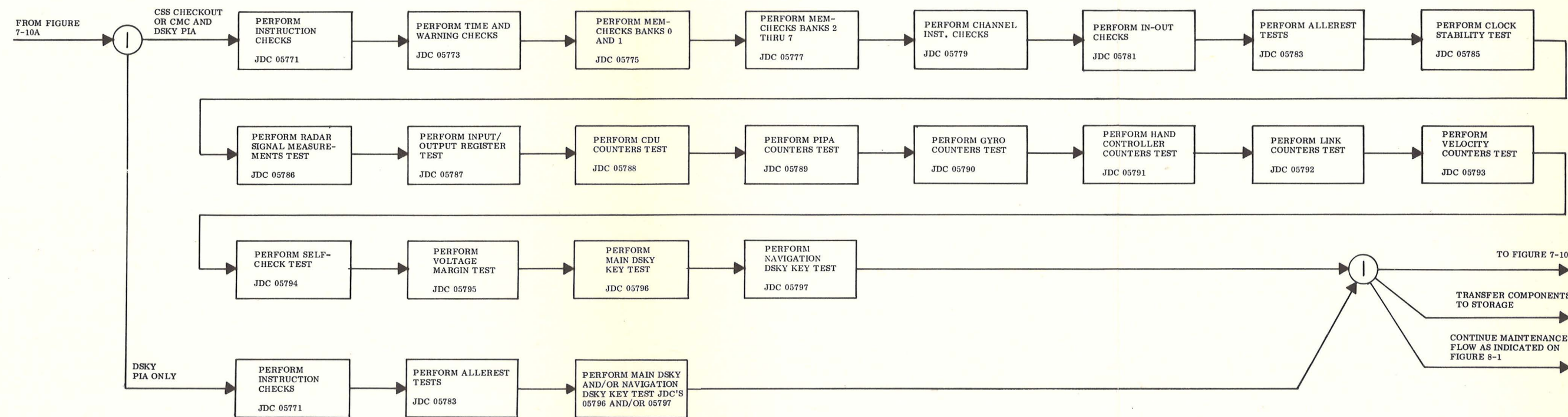
NOTE: SUNDIAL ROPE
MODULES ARE
REQUIRED FOR
COMMAND
MODULE CSS
CHECKOUT



18545B

Figure 7-10A. CSS Checkout Preparation Flowgram

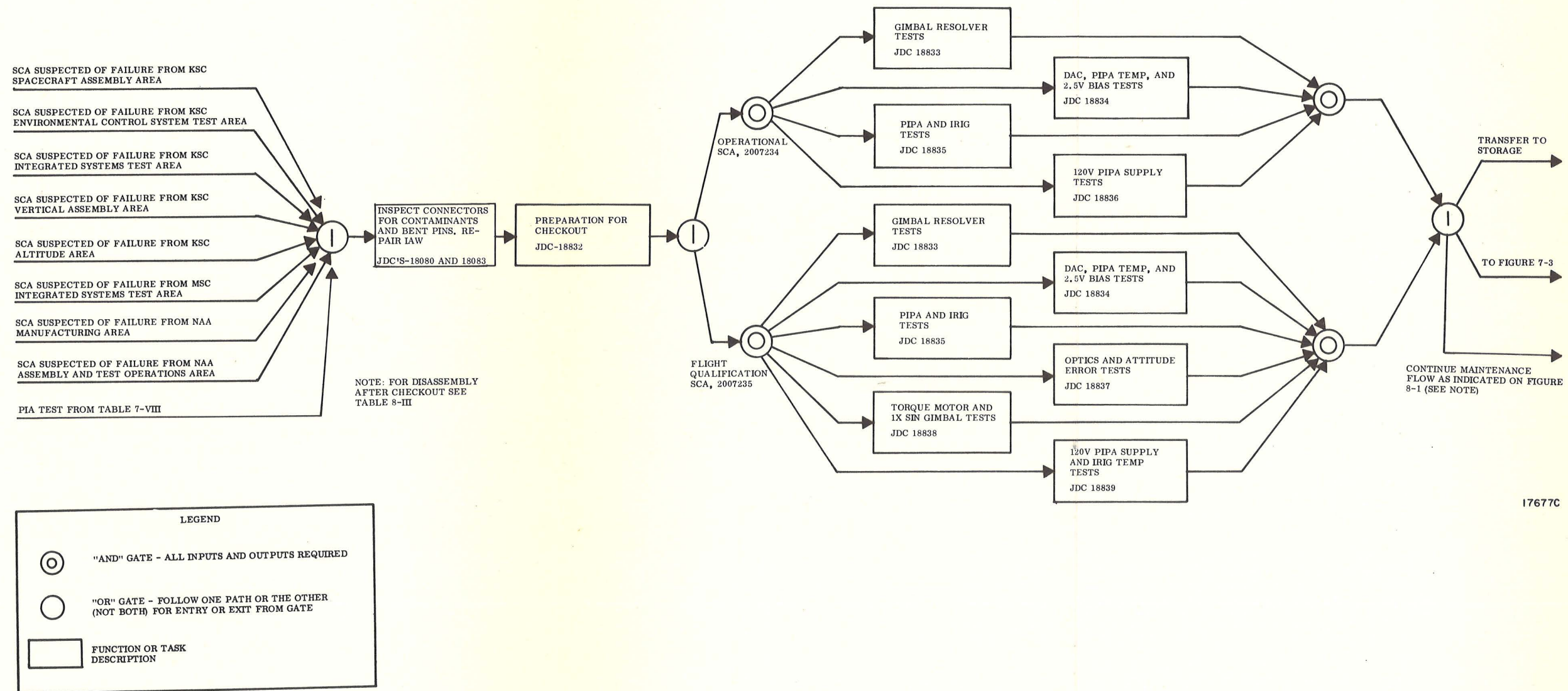
BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM



- ADDITIONAL CSS JDC'S
- JDC-05403 PERIOD MEASUREMENT
 - JDC-05406 TAPE LOAD OPERATING PROCEDURE
 - JDC-05407 TAPE VERIFY OPERATING PROCEDURE
 - JDC-05408 KEYBOARD LOAD OPERATING PROCEDURE
 - JDC-05409 READ AGC OPERATING PROCEDURE
 - JDC-05412 TRANSFER CONTROL OPERATING PROCEDURE
 - JDC-05413 PROGRAMMER AND MONITOR AND LOGIC DRAWER NO. 2 PANELS PRELIMINARY TEST SET-UP
 - JDC-05414 XY & RDC INTERFACE PANELS PRELIMINARY TEST SET-UP
 - JDC-05772 INSTRUCTION CHECKS MYLAR TAPE
 - JDC-05774 TIME AND WARNING CHECKS MYLAR TAPE
 - JDC-05776 MEMCHECK BANKS 0 & 1 TEST MYLAR TAPE
 - JDC-05778 MEMCHECK BANKS 2 THRU 7 TEST MYLAR TAPE
 - JDC-05780 CHANNEL INST. CHECKS MYLAR TAPE
 - JDC-05782 IN-OUT CHECKS MYLAR TAPE
 - JDC-05784 ALLEREST MYLAR TAPE

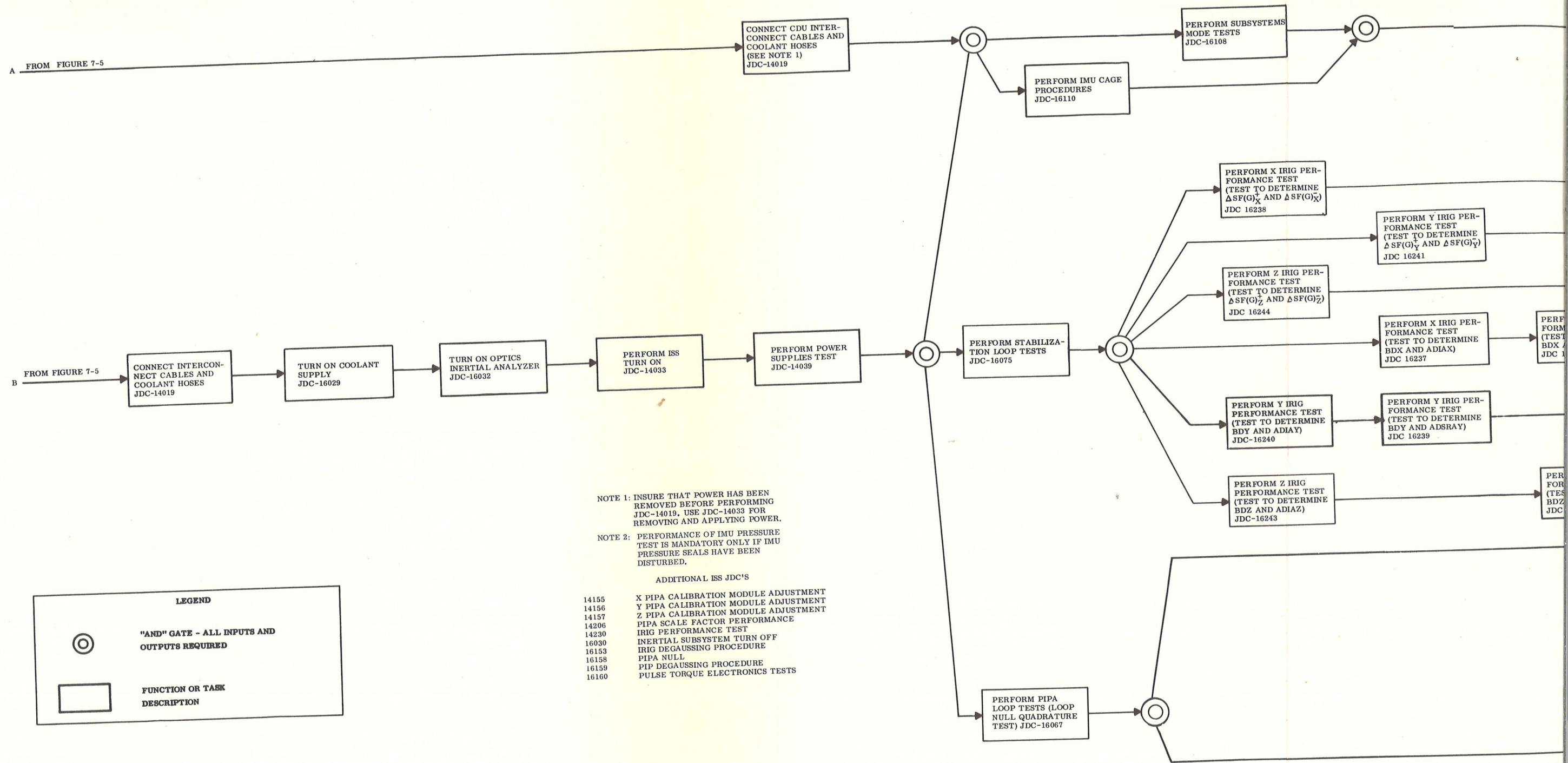
NOTE
ND 1021042 SUPPLEMENT CONTAINS PROGRAM LISTINGS OF COMPUTER FIELD VERIFICATION PROCEDURE (FVP) TAPES

Figure 7-10B. CSS Checkout Flowgram



17677C

Figure 7-11. SCA Master Checkout Flowgram



A FROM FIGURE 7-5

B FROM FIGURE 7-5

LEGEND

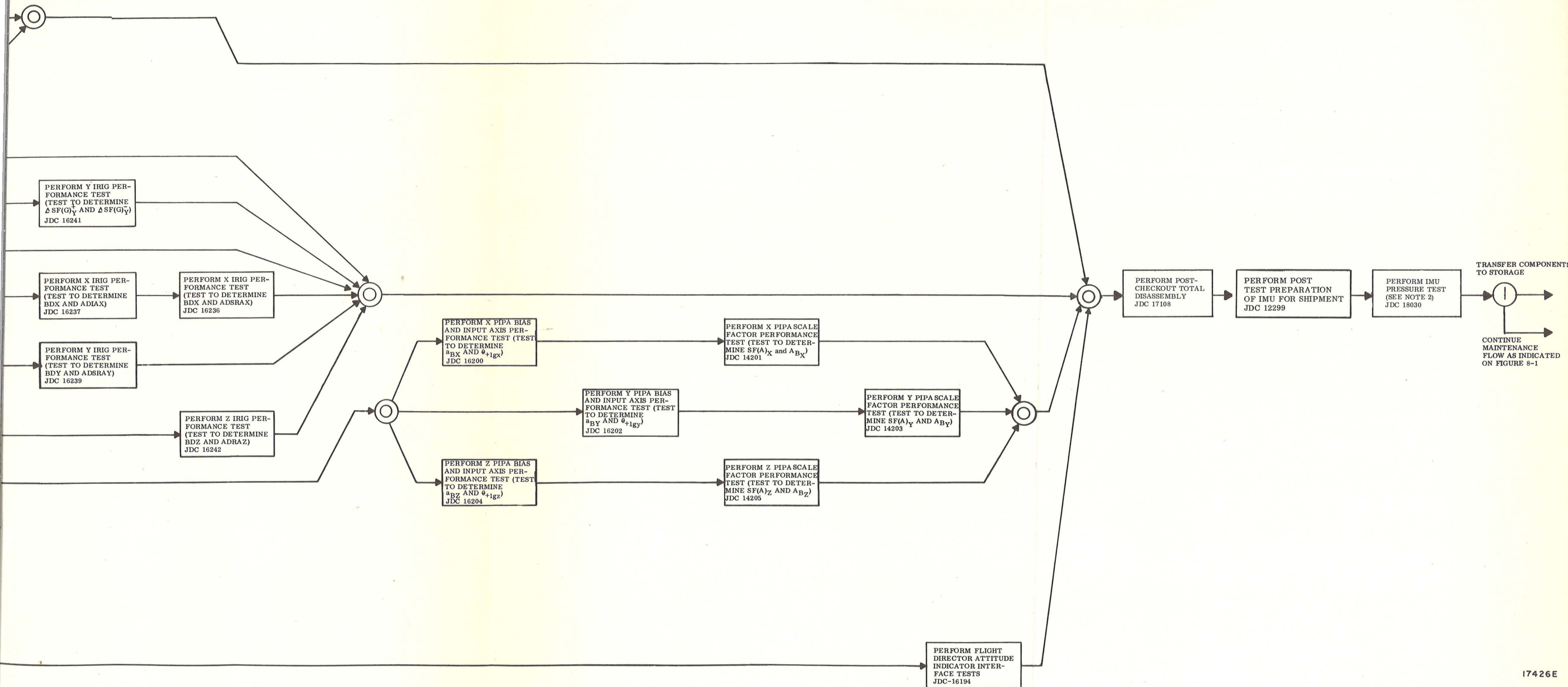
⊙ "AND" GATE - ALL INPUTS AND OUTPUTS REQUIRED

▭ FUNCTION OR TASK DESCRIPTION

NOTE 1: INSURE THAT POWER HAS BEEN REMOVED BEFORE PERFORMING JDC-14019. USE JDC-14033 FOR REMOVING AND APPLYING POWER.

NOTE 2: PERFORMANCE OF IMU PRESSURE TEST IS MANDATORY ONLY IF IMU PRESSURE SEALS HAVE BEEN DISTURBED.

- ADDITIONAL ISS JDC'S
- 14155 X PIPA CALIBRATION MODULE ADJUSTMENT
 - 14156 Y PIPA CALIBRATION MODULE ADJUSTMENT
 - 14157 Z PIPA CALIBRATION MODULE ADJUSTMENT
 - 14206 PIPA SCALE FACTOR PERFORMANCE
 - 14230 IRIG PERFORMANCE TEST
 - 16030 INERTIAL SUBSYSTEM TURN OFF
 - 16153 IRIG DEGAUSSING PROCEDURE
 - 16158 PIPA NULL
 - 16159 PIP DEGAUSSING PROCEDURE
 - 16160 PULSE TORQUE ELECTRONICS TESTS



17426E

Figure 7-12. IMU Pre-Installation Acceptance Flowgram

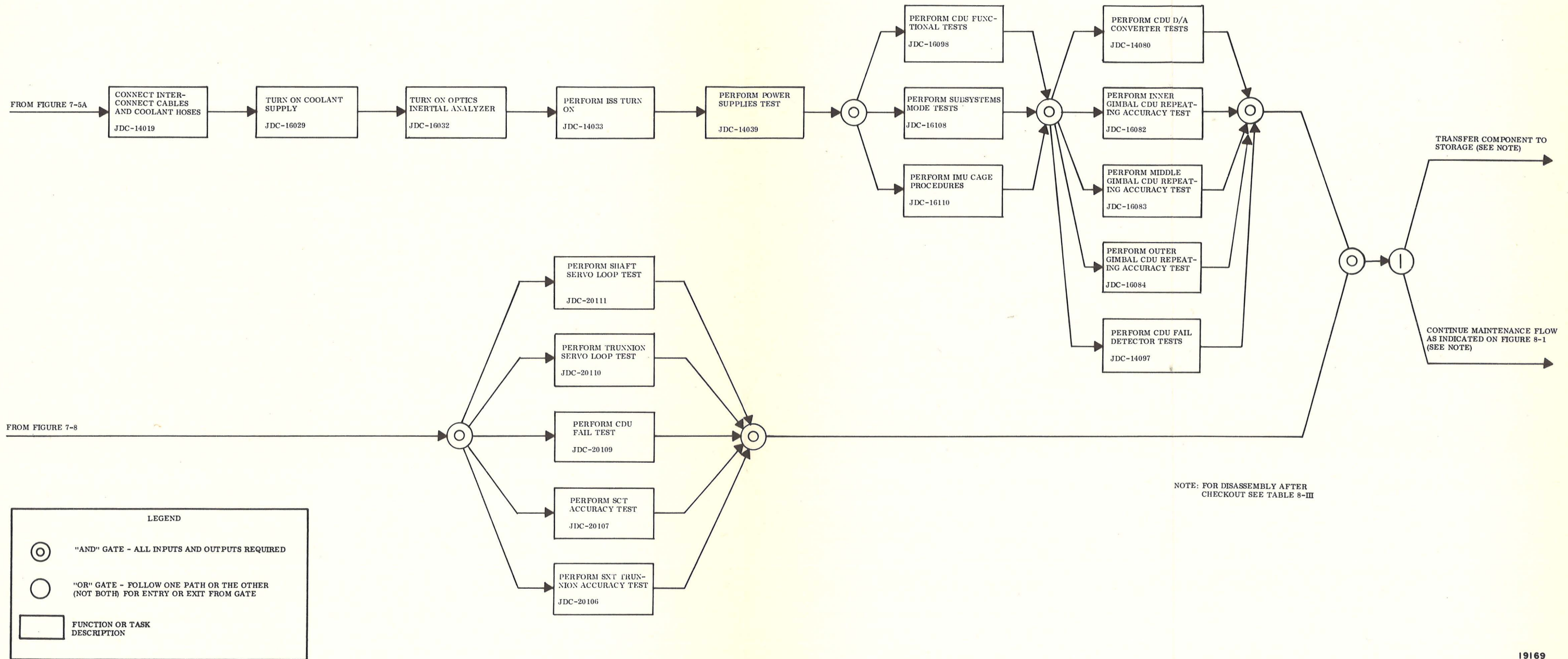
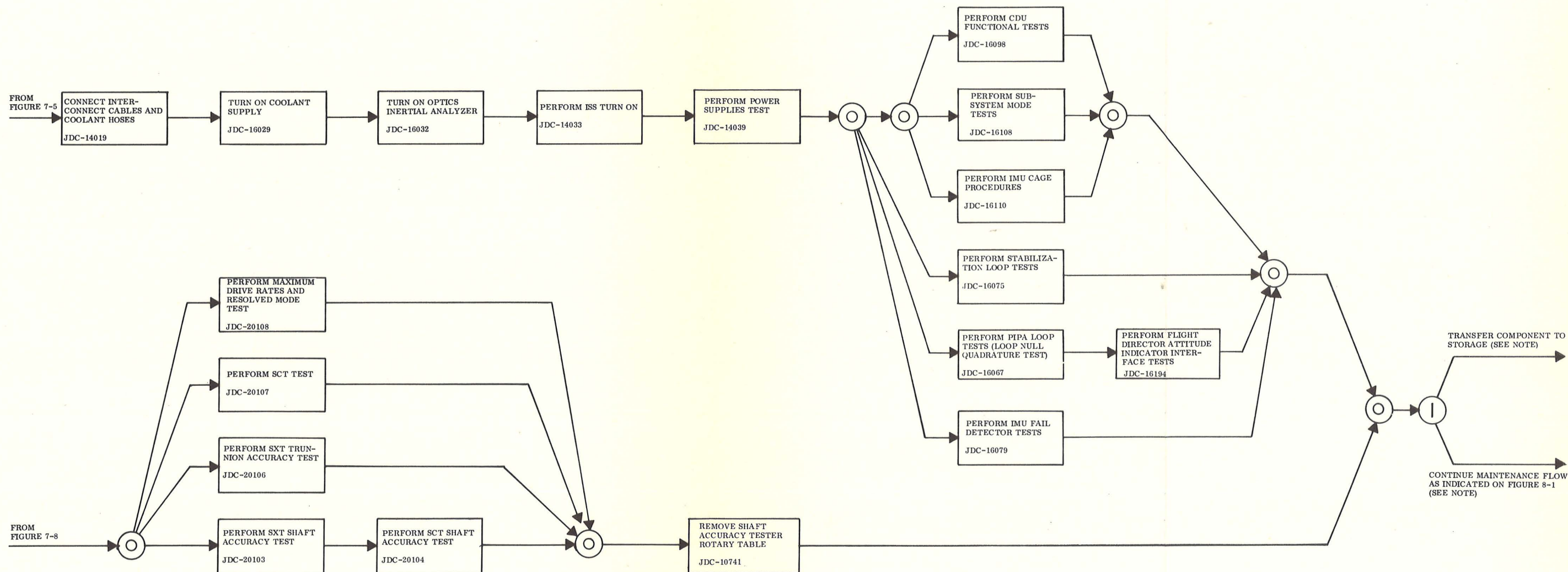
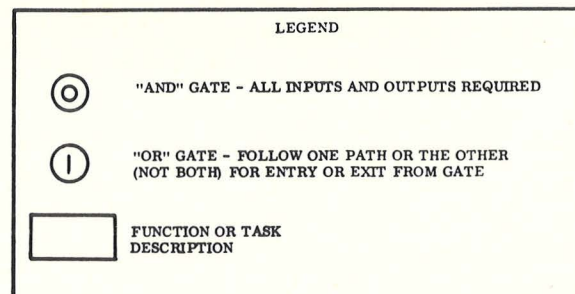


Figure 7-13. CDU Pre-Installation Acceptance Flowgram



NOTE: FOR DISASSEMBLY AFTER CHECKOUT SEE TABLE 8-III

19168

Figure 7-14. PSA Pre-Installation Acceptance Flowgram

Chapter 8

MAINTENANCE

8-1 SCOPE

This chapter provides the information necessary to use procedures prepared for malfunction isolation, pre-power assurance (PPA), removal and replacement, repair verification, and malfunction verification of the Block II PGNCS. The procedures and the information submitted in this chapter are in accordance with the maintenance concept. References to JDC's are included to provide detailed instructions for removal and replacement, PPA test, malfunction verification tests, and retest requirements. Loop diagrams and schematics are referenced to aid malfunction isolation at system or subsystem level.

8-2 MAINTENANCE CONCEPT

Figure 8-1 presents, in flow diagram format, the maintenance concept for the PGNCS. The PGNCS is maintained by the black box replacement method. (Black boxes represent major components or assemblies.) Equipment is received at field locations as a complete PGNCS or as spare black boxes.

8-3 MALFUNCTION ISOLATION

Repair of the PGNCS consists of isolating a malfunction to a black box and replacing the malfunctioned black box with a spare. If a malfunction cannot be localized to a black box during system checkout, the suspected components shall be removed and subjected to ISS, OSS, or CSS checkout. Repair of the PGNCS is limited to the replacement of the following components:

- (1) CMC and DSKY
- (2) CDU
- (2a) DSKY, main
- (2b) DSKY, nav
- (3) flight ropes
- (4) indicator control panel
- (5) IMU and PEA
- (6) nav base

- (7) OUA
- (8) interconnect harness A
- (9) interconnect harness B
- (10) interconnect harness C
- (11) interconnect harness D
- (12) interconnect harness E
- (13) interconnect harness F
- (14) interconnect harness G
- (15) interconnect harness H
- (16) PSA
- (17) signal conditioner or signal conditioner modules
- (18) test ropes
- (19) DSKY EL and IL indicators.

Malfunction isolation consists of using troubleshooting techniques to isolate a malfunction to a black box. The following aids will prove helpful in troubleshooting a block II PGNCS:

- (1) Electrical adapter cable assembly set used for signal monitoring and continuity and resistance testing in conjunction with JDC 18052.
- (2) PGNCS loop diagrams and schematics (see table 8-I).
- (3) Module schematics and flow diagrams (listed with the module location and functions, see chapter 3).
- (4) CSS logic diagrams and schematics (see table 8-II).
- (5) Engineering data.
- (6) ND 1021040, supplement B.

Malfunction isolation of PGNCS laboratory test configurations can be accomplished using the above aids, but in particular by using ND 1021040, supplement B and the electrical adapter cable assembly set.

8-3.1 ELECTRICAL ADAPTER CABLE ASSEMBLY SET. The electrical adapter cable assembly set is used to monitor signals and perform continuity tests for malfunction isolation of PGNCS black boxes. The electrical adapter cable assembly set can be used in conjunction with ND 1021040, supplement B and engineering mechanization diagrams, schematics, and interconnect diagrams listed in ND 1021043, table 8-I. JDC 18052 provides operating instructions and cable break-in information for use of the electrical adapter cable assembly set to monitor signals during PGNCS, ISS, and OSS testing, and instructions for PGNCS cable continuity testing and PGNCS component continuity and resistance testing.

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

8-3.2 ARRANGEMENT OF ND 1021040, SUPPLEMENT B. Supplement B is generally arranged by type of information (i.e., loop diagrams, monitor circuit diagrams, networks, etc.). It is not component oriented. Each type of information is grouped together and has one or more tab cards associated with it providing a skeletal index to the information.

8-3.2.1 Monitor Circuit Diagrams (MCD's). MCD's show the detailed routing of all airborne and GSE signals monitored by the OITS and associated BM-GSE. With an MCD, a monitored signal displaying an abnormal indication can be traced from its monitoring device in the OITS (such as the DVM), through the GSE selection circuitry (such as the crossbar switch), to its source in the PGNCS, ISS, OSS, or GSE. The MCD's often reference related loop diagrams for additional aid in trouble analysis.

Refer to chapter B10 in ND 1021040, supplement B for detailed instructions on MCD usage. Tables B10-I through B10-VII index specific MCD's for each test point or switch position on the OITS and associated BM-GSE. Table B10-I, for example, references a specific MCD for each position of the crossbar switch.

The MCD shows the jack and pin numbers of the airborne interface and includes additional airborne circuitry to illustrate the signal source. A malfunction can be isolated to either an airborne component or GSE equipment by monitoring the signal at the airborne interface, using the electrical adapter cable assembly set as specified in JDC 18052.

8-3.2.2 GSE Signal Selection List. The GSE signal selection list, ND 1021040, supplement B, table B10-X lists the name and test point location of all PGNCS signals which can be monitored by the OITS and associated BM-GSE during PGNCS, ISS, or OSS testing. In the event of a malfunction, table B10-X can be used to locate test points at which airborne and GSE signals related to the malfunction can be monitored. If a monitored signal displays an abnormal indication, the applicable MCD for that test point can be located by referring to the MCD index.

8-3.2.3 Loop Diagrams. The loop diagrams listed in ND 1021040, supplement B are detailed schematics of the OITS and associated BM-GSE circuitry, including the related airborne interface circuitry. The loop diagrams illustrate how various components of the OITS and BM-GSE operate together to control or test the PGNCS or ISS test configurations; these diagrams also show the power and loading circuitry used to simulate normal airborne operational environment. Associated loops and MCD's are referenced on the loop diagrams as further aids for trouble analysis. The loop diagrams depict the jack and pin numbers of the airborne interface and additional airborne circuitry to aid in understanding loop operation. A malfunction can be isolated to either an airborne component or GSE equipment by monitoring loop signals at the airborne interface, using the electrical adapter cable assembly set as specified in JDC 18052.

Refer to chapter B9 in ND 1021040, supplement B for detailed information on loop diagram usage, and table B9-II for a listing of loop diagrams associated with Block II testing. Also, chapter B6 contains a functional description of each Block II loop diagram as a further aid to understanding loop operation.

8-3.2.4 MCD and Loop Diagram Selection. Refer to table 8-IA for a general guide to the selection of MCD's and loop diagrams in the event of an abnormal indication. It is assumed that the abnormal indication has occurred during the performance of a JDC for PGNCS, ISS, or OSS testing.

8-3.2.5 Blade Blocks. Blade blocks and mating connectors are used as tie points in the OIA and GDB wire harnesses. Each blade block section mates with a correspondingly numbered and lettered connector (i.e. J109A mates with P109A). In the MCD's, the complete unit, including blade block and mating connector, is identified only by the mating connector P number. The blade blocks provide a convenient location to verify the presence of a signal. Refer to paragraph B10-14 in ND 1021040, supplement B for detailed information on the usage of blade blocks.

8-3.2.6 Network Lists. The network lists are a special version of the OIA backwall running list. Each network consists of a grouping of points (connector pins, terminal board terminals, etc.) which are electrically tied together within the OIA backwall wire harness. The networks are convenient for tracing a circuit through the backwall harness and for isolating malfunctions since they show all points at which signals can be monitored. Refer to chapter B12 in ND 1021040, supplement B for detailed information on network usage.

8-3.3 TEST POINT SIGNAL CHARACTERISTICS. Chapter 3 in ND 1021043 will be expanded to provide a tabular listing of test point characteristics. The test point signal characteristics will aid in identifying and isolating malfunctions during signal monitoring with the electrical adapter cable assembly set or using the OITS and associated BM-GSE signal monitoring capability.

8-3.4 CSS MALFUNCTION ISOLATION. Program listings of CSS test tapes have been provided as a supplement to ND 1021042 for use during testing and during malfunction isolation of CSS problems. If a malfunction occurs, analysis can proceed with the use of the program listings; loop, schematic, and logic diagrams listed in table 8-II; and computer theory of operation in chapter 4.

Table 8-IA. MCD and Loop Diagram Selection (Sheet 1 of 4)

Abnormal Indication	Reference Source	MCD or Loop Diagram Selection
<p>Abnormal indication displayed on OITS monitoring device (such as an out-of-tolerance voltage indication on DVM, PAVM, oscillograph, oscilloscope, etc.).</p> <p>Failure associated with OITS pushbutton or control (such as failure of ISS OPERATE pushbutton to light as specified in JDC).</p>	<p>Refer to MCD index, tables B10-I through B10-VII in ND 1021040, supplement B to locate applicable MCD.</p> <p>a. Select loop diagram by relating OITS pushbutton or control (nomenclature or function) with loop titles in list of Block II loops (table B9-II in ND 1021040, supplement B).</p> <p>b. Refer to panel control and indicator descriptions in chapter B2 of ND 1021040, supplement B.</p>	<p>Select MCD and associated loop diagrams referenced from MCD.</p> <p>Select loop diagrams and associated MCD's referenced from loop diagram.</p> <p>Select loop diagrams and associated MCD's referenced from loop diagram.</p>

Table 8-IA. MCD and Loop Diagram Selection (Sheet 2 of 4)

Abnormal Indication	Reference Source	MCD or Loop Diagram Selection
<p>Abnormal indication displayed on DSKY when performing JDC during system testing (such as an incorrect data display indication), or any other abnormal indication displayed during system testing.</p>	<p>c. If failure can be associated with a relay in an OITS panel, refer to relay operation charts in chapter B11 of ND 1021040, supplement B.</p> <p>a. Refer to ND 1021043 for the following information to determine area of malfunction: (such as CSS, PIPA loop, stabilization loop, etc.):</p> <ol style="list-style-type: none"> (1) JDC test descriptions listed in chapter 7. (2) System and subsystem functional analysis in chapter 2. (3) Component and module functional descriptions and test point signal characteristics in chapter 3. 	<p>Select applicable loop diagram or MCD referenced in relay operation charts.</p>

Table 8-IA. MCD and Loop Diagram Selection (Sheet 3 of 4)

Abnormal Indication	Reference Source	MCD or Loop Diagram Selection
	<p>(4) Component and module detailed theory of operation in chapter 4.</p> <p>(5) List of system mechanization drawing, schematics, and logic diagrams in tables 8-I and 8-II in chapter 8.</p> <p>b. After determining area of malfunction, refer to block II signal selection list, table B10-X, in ND 1021040, supplement B to locate test points at which airborne signals related to the malfunction can be monitored.</p> <p>c. If monitored signal(s) displays an abnormal indication, refer to MCD index, tables B10-I through B10-VII, in ND 1021040, supplement B to locate applicable MCD.</p>	<p>Select MCD's and associated loop diagrams referenced from MCD's.</p>

Table 8-IA. MCD and Loop Diagram Selection (Sheet 4 of 4)

Abnormal Indication	Reference Source	MCD or Loop Diagram Selection
Failure associated with relay in OITS panel.	Refer to relay operation charts in chapter B11 of ND 1021040, supplement B for reference to applicable loop diagrams or MCD.	Select loop diagrams or MCD.

8-4 REMOVAL AND REPLACEMENT

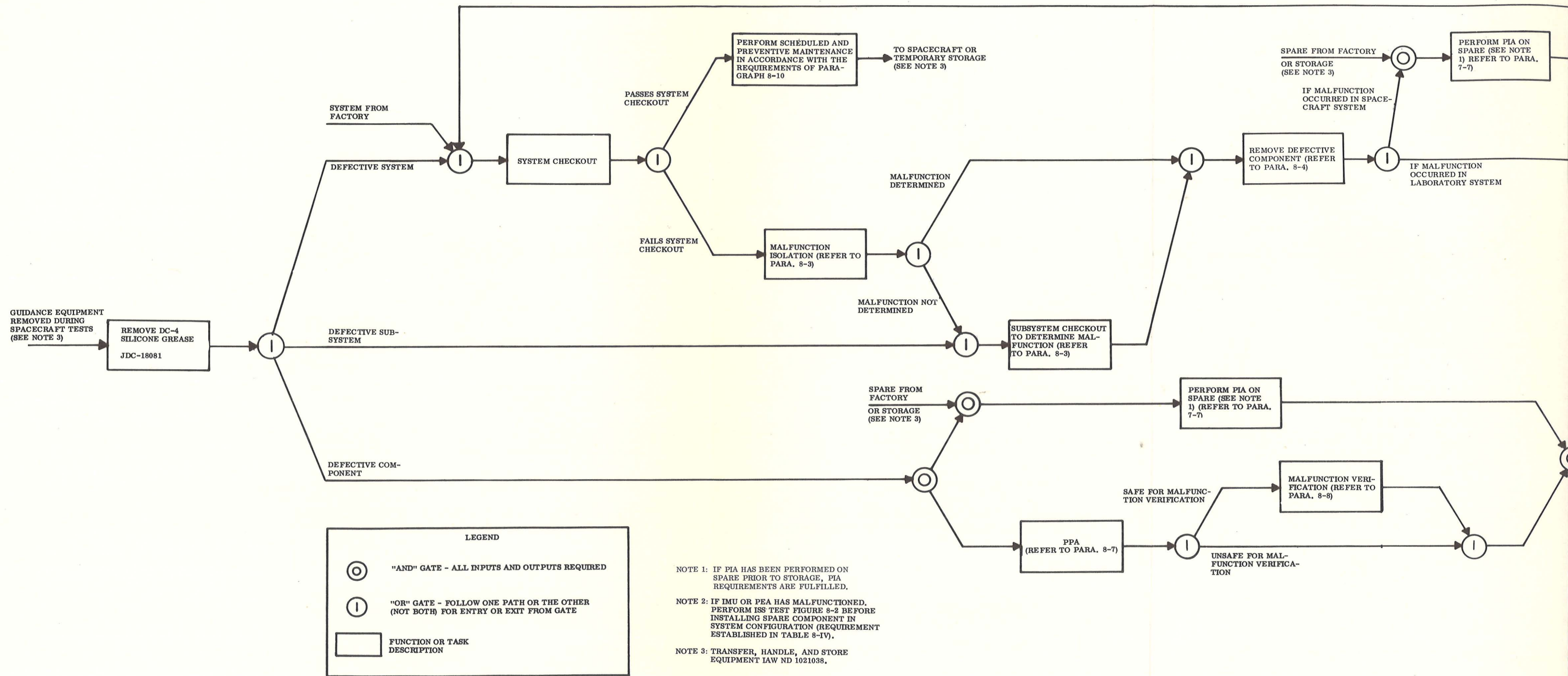
Removal and replacement JDC's for use in the laboratory are referenced in table 8-III.

8-5 REPAIR VERIFICATION

After installation of a spare into the laboratory PGNCS, a partial system check-out is performed to verify that the system is repaired. Refer to tables 8-IV and 8-IVA for the retest requirements to insure that satisfactory system performance may be attained and to verify that the malfunction has been corrected. If no malfunction occurs during repair verification, the system is considered repaired and system check-out may be resumed at the JDC where the system originally failed.

8-6 DELETED.

(See paragraph 7-7.)



LEGEND

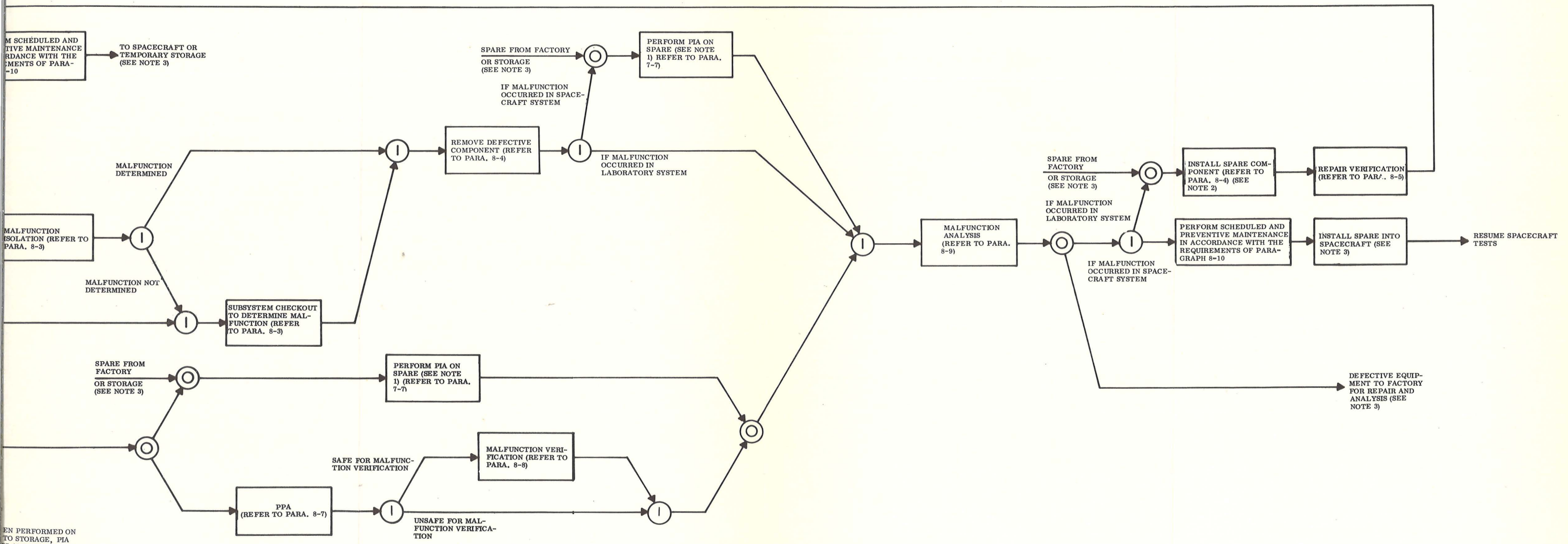
⊙ "AND" GATE - ALL INPUTS AND OUTPUTS REQUIRED

⊖ "OR" GATE - FOLLOW ONE PATH OR THE OTHER (NOT BOTH) FOR ENTRY OR EXIT FROM GATE

▭ FUNCTION OR TASK DESCRIPTION

- NOTE 1: IF PIA HAS BEEN PERFORMED ON SPARE PRIOR TO STORAGE, PIA REQUIREMENTS ARE FULFILLED.
- NOTE 2: IF IMU OR PEA HAS MALFUNCTIONED, PERFORM ISS TEST FIGURE 8-2 BEFORE INSTALLING SPARE COMPONENT IN SYSTEM CONFIGURATION (REQUIREMENT ESTABLISHED IN TABLE 8-IV).
- NOTE 3: TRANSFER, HANDLE, AND STORE EQUIPMENT IAW ND 1021038.

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM



PERFORMED ON TO STORAGE, PIA TESTS ARE FULFILLED.
 HAS MALFUNCTIONED. TEST FIGURE 8-2 BEFORE SPARE COMPONENT IN CONFIGURATION (REQUIREMENT IN TABLE 8-IV).
 HANDLE, AND STORE PER ND 1021038.

16720E

Figure 8-1. Maintenance Flowgram

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

Table 8-I. PGNCS, ISS, and OSS Loop Diagrams and Schematics

Title	Drawing Number
IMU-CDU one line mech - Block II	2015568
Optics trunnion and shaft CDU block diagram - Block II (2 line mech)	2015567
Two wire mechanization of Apollo PIPA loops	2015563
Two wire mechanization of Apollo stabilization loops	2015564
Apollo IMU temperature control system - Block II two wire mechanization	2001452
CSM 5 axis moding (2 line mech)	2015562
IMU temperature control system schematic diagram - Block II	2001463
Functional diagram optics subsystem - Block II	2015500
Zero optics mode	2015502
Shaft manual mode	2015503
Trunnion manual mode	2015504
Sextant optics resolved mode	2015505
Optical subsystem power distribution	2015506

Table 8-II. CSS Logic Diagrams and Schematics

Title	Drawing Number		
Tray A Subassembly			
	CMC 2003100	CMC 2003200	CMC 2003993
Module A1	2005059	2005259	2005259
Module A2	2005060	2005260	2005260
Module A3	2005051	2005251	2005251
Module A4	2005062	2005262	2005262
Module A5	2005061	2005261	2005261
Module A6	2005063	2005263	2005263
Module A7	2005052	2005252	2005252
Module A8	2005055	2005255	2005255

*See table 3-IB for effectivity.

Table 8-II. CSS Logic Diagrams and Schematics

Title	Drawing Number		
Tray A Subassembly (cont)			
	CMC 2003100	CMC 2003200	CMC 2003993
Module A9	2005056	2005256	2005256
Module A10	2005057	2005257	2005257
Module A11	2005058	2005258	2005258
Module A12	2005053	2005253	2005253
Module A13	2005069	2005269	2005269
Module A14	2005074	2005264	2005264
Module A15	2005065	2005265	2005265
Module A16	2005066	2005266	2005266
Module A17	2005067	2005267	2005267
Module A18	2005068	2005268	2005268
Module A19	2005070	2005270	2005270
Module A20	2005054	2005254	2005254
Module A21	2005050	2005250	2005250
Module A22	2005071	2005271	2005271
Module A23	2005072	2005272	2005272
Module A24	2005073	2005273	2005273
Interface A25, A26	2005021	2005021	2005928
Interface A27 to A29	2005020	2005928 with ECP's 501 & 505*	
Power supply module A30, A31	2005010	2005912 2005933 with ECP's 501 & 505*	2005933
		2005916	2005936
		2005945 with ECP 486*	2005971 with ECP 518*
		2005971 with ECP 518*	

*See table 3-IB for effectivity

(Sheet 2 of 4)

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

Table 8-II. CSS Logic Diagrams and Schematics

Title	Drawing Number		
Tray B Subassembly			
	CMC 2003100	CMC 2003200	CMC 2003993
Rope memory module B1 to B6 Oscillator module B7	2005003	2005003 2005930 with ECP's 501 & 505*	2005930
Alarm module B8	2005028	2005927 2005975 with ECP 719*	2005927 2005975 with ECP 719*
Erasable drive module B9, B10	2005915	2005104 2005934 with ECP's 501 & 505*	2005934
Current switch module B11	2005005	2005005 2005925 with ECP's 501 & 505*	2005925
Erasable memory module B12	2005006	2005106 2005931 with ECP 505*	2005931
Sense amplifier module B13	2005914	2005920 2005932 with ECP's 501 & 505* 2005970 with ECP 483*	2005932 2005970 with ECP 483*
Sense amplifier module B14	2005914	2005919 2005929 with ECP's 501 & 505*	2005929 2005969 with ECP's 501 & 505*
Strand select module B15	2005009	2005924 2005926 with ECP's 501 & 505*	2005926
Rope driver module B16, B17	2005913	2005100 2005942 with ECP 440 2005938 with ECP's 501 & 505*	2005938

*See table 3-IB for effectivity.

Table 8-II. CSS Logic Diagrams and Schematics

Title	Drawing Number		
DSKY			
	DSKY 2003985	DSKY 2003950	DSKY 2003994
DSKY assembly inter-connection	2005950	2005953	2005954
Indicator driver module D1 to D6	2005952	2005952	2005973
Keyboard module D8	2005903	2005903	2005939
Power supply module D7	2005904	2005921	2005937

(Sheet 4 of 4)

Table 8-III. Removal and Replacement JDC' s

JDC	Title
05416	Installation and Removal of Fixed Memory Modules and Fixed Memory Jumper Modules - Block II and LEM
05417	Computer Installation and Removal Procedure - Block II and LEM
05418	DSKY Installation and Removal Procedure - Block II and LEM
05798	DSKY E/L Installation and Removal Procedure - Block II
05799	DSKY I/L Installation and Removal Procedure - Block II
17104	Remove and Replace G and N System Components
17105	Remove and Replace Optical Subsystem Components
17108	Remove and Replace Inertial Subsystem Components
17603	Remove and Replace SCA Modules

Table 8-IV. Retest Requirements

Component Replaced	Retest JDC Number
CDU	12285
CMC	12286
Main and nav DSKY	12287
IMU and PEA	12288
Indicator control panel	12289
Interconnect harness A	12292
Interconnect harness B	12293
Interconnect harness C	12294
Interconnect harness D	12295
Interconnect harness E	12296
Interconnect harness F	12297
Interconnect harness G	12224
Interconnect harness H	12298
Nav base	12218
OUA	12290
PSA	12291
SCA*	12224

* For SCA module retest requirements, see table 8-IVA.

Table 8-IVA. Retest Requirements

SCA Module Replaced	SCA JDC's								
	12224	18832	18833	18834	18835	18836	18837	18838	18839
DAC, PIPA temp, and 2.5V bias	X	X		X					
Gimbal resolver	X	X	X						
IRIG and PIPA	X	X			X				
Optics and attitude error	X	X					X		
Torque motor and 1X sine gimbal resolver	X	X						X	
120 V PIPA supply	X	X				X			
120 V PIPA supply and IRIG temp	X	X							X

8-7 PRE-POWER ASSURANCE

PPA tests are performed on components removed from the PGNCS in the spacecraft prior to malfunction verification tests. PPA tests are performed on a suspected malfunctioning component to assure that the system or subsystem used for malfunction verification incurs no damage. PPA tests are not required if malfunction verification is performed using the spacecraft system or subsystem. Table 8-VI lists the JDC's required for PPA testing. Components not successfully passing PPA will be evaluated for final verification and/or disposition.

8-8 MALFUNCTION VERIFICATION

Prior to operation of a spare component in the spacecraft, the removed component must be verified as the malfunctioning component. Malfunction verification consists of performing the PIA tests listed in table 8-V only to the extent required to verify a malfunction. It is not necessary to perform malfunction verification on components that have failed in the laboratory. Auxiliary airborne equipment can be used to supplement test. (See paragraph 8-11.)

8-9 MALFUNCTION ANALYSIS

After a malfunction has been determined or verified, an analysis is performed to determine if the malfunction was caused by another PGNCS failure, or if the malfunction could have caused other damage to the PGNCS. If the analysis indicates other PGNCS malfunctions may exist, further malfunction isolation and malfunction verification testing is required.

The results of the malfunction analysis are returned to the factory, along with the failed component, to aid factory malfunction analysis. Factory malfunction analysis is also required for non-recurring malfunctions and non-verified malfunctions.

8-10 MAINTENANCE SCHEDULE

8-10.1 SCHEDULED MAINTENANCE. Lubricate PGNCS connector pins in accordance with JDC 18078 prior to installation of a PGNCS component into the spacecraft. Remove DC-4 silicone grease from airborne component connector contacts in accordance with JDC 18081 after removal of component from spacecraft. Lubricate and clean component header helicoil inserts and engaging hardware in accordance with JDC 18100 prior to each laboratory test setup and at the completion of all testing.

8-10.2 PREVENTIVE MAINTENANCE. Perform the following PGNCS preventive maintenance only when required:

JDC 02820, Clean optics of optical unit and ground support equipment.

JDC 18079, Lubrication of airborne harness connectors.

JDC 18080, Straightening of pin contacts.

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

- JDC 18082, Moisture proofing assembly screwheads.
- JDC 18083, Cleaning painted surfaces.
- JDC 18084, Repair painted surfaces.
- JDC 18085, Remove corrosion from magnesium surfaces.
- JDC 18086, Mercury decontamination and handling safety.
- JDC 18099, Microdot connector inspection

8-10.3 REMOVAL OF ETHYLENE GLYCOL SOLUTION LEAKS AND SPILLS. Perform the appropriate JDC's as necessary in the event of ethylene glycol solution leaks or spills.

- JDC 18087 Removal of Ethylene Glycol Solution Leaks and Spills —
General Instructions
- JDC 18088 Removal of Ethylene Glycol Solution Leaks and Spills —
Airborne Harnesses
- JDC 18090 Removal of Ethylene Glycol Solution Leaks and Spills —
CDU, CMC, LGC, PSA, PTA, and PEA
- JDC 18091 Removal of Ethylene Glycol Solution Leaks and Spills —
DSKY
- JDC 18092 Removal of Ethylene Glycol Solution Leaks and Spills — IMU
- JDC 18093 Removal of Ethylene Glycol Solution Leaks and Spills —
CCRD, and Indicator Control Panel
- JDC 18094 Removal of Ethylene Glycol Solution Leaks and Spills —
OUA and Bellows Assembly, and OUA Eyepieces
- JDC 18095 Removal of Ethylene Glycol Solution Leaks and Spills — SCA
- JDC 18096 Removal of Ethylene Glycol Solution Leaks and Spills — Nav
Base, and Eyepiece Storage Unit
- JDC 18097 Removal of Ethylene Glycol Solution Leaks and Spills — GSE
Components, and GSE Interconnect Harnesses

8-11 AUXILIARY AIRBORNE EQUIPMENT

Auxiliary airborne equipment (AAE) is defined as that equipment required to complete a system or subsystem test setup when the assigned components of the system or subsystem are not available. AAE can be composed of the following:

- (1) Qualification test equipment (QUAL TEST).
- (2) Evaluation test equipment (EVAL TEST).

- (3) Flight equipment (equipment previously flown) (FLIGHT).
- (4) Test articles (equipment specifically purchased for use as AAE).

The following conditions must be fulfilled to use AAE in a test setup:

- (1) Qualification test equipment, evaluation test equipment, and equipment previously flown must be recycled through the factory manufacturing area and meet the functional requirements of the applicable procurement specification before it is designated AAE.
- (2) Configuration of AAE must fulfill requirements of compatibility tables (chapter 3).
- (3) AAE shall be continually maintained in accordance with the functional requirements for operational airborne equipment.

Page 8-11/8-12 (figure 8-2) deleted.

Table 8-VI. List of PPA JDC's

Component	JDC Number
CDU	18271
CMC and DSKY	NA
IMU and PEA	18272
Indicator control panel	NA
Interconnect cables A through H	NA
OUA	18270
PSA	18275
SCA and SCA modules	NA

Appendix A

List of Technical Terms and Abbreviations

<u>Term</u>	<u>Definition</u>
A _{IG}	Inner gimbal angle
A _{MG}	Middle gimbal angle
A _{OG}	Outer gimbal angle
A _s	Shaft angle
A _t	Trunnion angle
a	Accelerometer
AAC	Automatic amplitude control
AAE	Auxiliary airborne equipment
ABP	Auxiliary battery pack
ACA	Attitude controller assembly
ACC	Accepted
ACCL or ACCEL	Accelerometer
ACE	Automatic checkout equipment
ACTREQ	Action request
ACTY	Activity
AD	Add

Appendix A (cont)

<u>Term</u>	<u>Definition</u>
A/D	Analog to digital
ADA	Angular differentiating accelerometer
ADC	Analog to digital converter
ADIA	Gyro drift due to acceleration along the input axis caused by an unbalance on the spin reference axis
ADSRA	Gyro drift due to acceleration along the spin reference axis caused by an unbalance on the input axis
AGC	Apollo guidance computer
AGC/CS	AGC calibration system
AGC/OC	Apollo guidance computer test set operation console
AGCU	Attitude gyro coupling unit
A-GSE	Auxiliary ground support equipment
AIICR	Apollo Integrated Inventory and Consumption Report
αB	Hypothetical rotation of the PIP case about its output axis equivalent to bias. Subscripts (X, Y, or Z) may be added to denote a specific PIP case rotation.
αX , αY , or αZ	Misalignment of PIP case about stable member axis. Subscripts (X, Y, or Z) may be added to denote a specific PIP case alignment.
APTPS	Astro sextant passive thermal protective system
ATP	Assembly test procedure
ATT	Attitude
BAL	Bank alarm
BD	Bias drift of IRIG. Subscripts (X, Y, or Z) may be added to denote a specific IRIG bias drift.
BKTF	Block transfer

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

Appendix A (cont)

<u>Term</u>	<u>Definition</u>
BLKUPL	Block uplink
BM-GSE	Bench maintenance ground support equipment
BMAG	Body mounted attitude gyro
BNK	Bank
BPLSSW	B plus switched
BPP	Battery power pack
CAGEN	Counter address generate
CCB	Configuration control board
CCS	Count, compare and skip
CDU	Coupling data unit
CES	Control electronics section
CIS	Communications and instrumentation
CG	Center of gravity
CLR	Clear
CM or C/M	Command module
CMC	Command module computer
COMP	Computer
COMP FAIL	Computer fail
CONT	Control
CS	Clear and subtract
C/S	Computer simulator
CSM	Command and Service Module
CSS	Computer subsystem

Appendix A (cont)

<u>Term</u>	<u>Definition</u>
CTRAL	Counter fail alarm
CTROR	Request to increment counter
CTS	AGC test set
CYL	Cycle left
CYR	Cycle right
D/A	Digital to analog
D and C	Display and control
DAC	Digital to analog converter
DEC	Decrease
DEMODO	Demodulator
DKEND	Downlink end
DLKHN	Downlink inhibit
DLNK	Downlink
DRB	Design review board
DSKY	Display and keyboard
DV	Divide
DVM	Digital voltmeter
ECP	Engineering change proposal
ECS	Environmental control system
E_{ig}	Inner gimbal error signal
E memory	Erasable memory
ENC	Encoder

Appendix A (cont)

<u>Term</u>	<u>Definition</u>
$E\phi_{NB}$	Roll body offset error signal
$E\phi_{sc}$	Roll body error signal
EPS	Electrical power system
$E\Psi_{NB}$	Yaw body offset error signal
$E\Psi_{sc}$	Yaw body error signal
E_{θ}	Pitch body offset error signal
ϵ_{in}	In-phase component of voltage
ϵ_q	Quadrature component voltage
ϵ_t	Total voltage
ϵ_{Fy}	Misalignment between rotary table fixed axes and gimbal case fixed axes
ϵ_{IGA}	Inner gimbal axis error
ϵ_{IGR}	Inner gimbal resolver error
ϵ_{MGA}	Middle gimbal axis error
ϵ_{MGR}	Middle gimbal resolver error
ENOFF	Engine off
ENON	Engine on
ENRST	Engine reset
ϵ_{OGR}	Outer gimbal resolver error
EPS	Electrical power system
ERR	Error

Appendix A (cont)

<u>Term</u>	<u>Definition</u>
EXC or EXCIT	Excitation
$E(X_g)$	X gyro error signal
$E(Y_g)$	Y gyro error signal
$E(Z_g)$	Z gyro error signal
FDAI	Flight director attitude indicator
FINDVAC	Find vector accumulated data
F memory	Fixed memory
FF	Flip-flop or fixed-fixed
FS	Fixed-switchable
FVP	Field verification procedure
g	Gyro
GAEC	Grumman Aircraft Engineering Corporation
$\gamma X, \gamma Y,$ or γZ	Misalignment of IRIG case about stable member corresponding axis. (First subscript denotes a specific gyro, second subscript is added to denote a specific stable member axis about which the gyro input axis is misaligned.)
G and N	Guidance and navigation
GDC	Gyro display coupler
GSE	Ground support equipment
GYRST	Gyro reset
HICOSLAM	High cosine of lambda
HISINLAM	High sine of lambda
HND PPS	Hundred pulses per second
HLOS	Horizon line of sight

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

Appendix A (cont)

<u>Term</u>	<u>Definition</u>
IA	Input axis
IAW	In accordance with
ICTC	Inertial components temperature controller
IG	Inner gimbal
IIP	Interrupt in progress
ILP	Parity inhibit
IMU	Inertial measuring unit
INC	Increase
INHINT	Inhibit interrupt
INKL	Counter increment request
IP	Interrogate pulse
IRIG	Inertial reference integrating gyro
ISS	Inertial subsystem
IU	Instrumentation unit
JDC	Job description card
JDC-DS	Job description card data sheet
K	Address or location
KEY RLSE	Key release
KRST	Key reset
KSC	Kennedy Space Center
LEM	Lunar excursion module
LINC	Load location

Appendix A (cont)

<u>Term</u>	<u>Definition</u>
LLOS	Landmark line of sight
LOCOSLAM	Low consine of lambda
LOS	Line of sight
LOSINLAM	Low sine of lambda
LSD	Least significant digit
LTRST	Light reset
MC	Memory cycle or memory control
MCT	Memory cycle time
MD	Malfunction diagram
MDA	Motor drive amplifier
Meru	Milliearth rate unit(s)
MG	Middle gimbal
MILA	Merritt Island Launch Area
MINC	Minus increment
MIT/IL	Massachusetts Institute of Technology Instrumentation Laboratory
MKTRP	Mark trap
MNHRPT	Monitor inhibit interrupt
MP	Multiply
MSA	Main summing amplifier
MSA&QR	Main summing amplifier and quadrature rejection
MSC	Manned Spacecraft Center
MSD	Most significant digit

Appendix A (cont)

<u>Term</u>	<u>Definition</u>
MSFN	Manned Space Flight Network
MSK	Mask
MSK K	Mask with data from K
MSTRT	Monitor start
N	Negative velocity pulse
N	Noun
N ₁	Sample time
N ₂	Display time
NAA	North American Aviation
Nav base	Navigation base assembly
NBD	Normal bias drift
ND	NASA document
NDX	Index
NHSYNC	Inhibit upsync
NISQ	Next instruction sequence
NLT	Not less than
NMT	Not more than
NOOP	No operation
NOVAC	No vector accumulated data
NR	North American Rockwell
NRPTAL	Interrupt has not occurred during an 80 millisecond period
OA	Output axis
OG	Outer gimbal
Rev. S	

Appendix A (cont)

<u>Term</u>	<u>Definition</u>
OIA	Optics-inertial analyzer
OINC	Display location
OITS	Optics-inertial test set
OJB	GSE junction box
OPR	Operator
OSS	Optical subsystem
OUA	Optical unit assembly
OUTCR	Out counter
OVCTR	Overflow counter
OVF	Overflow
P	Positive velocity pulse
P _I	Incrementing pulse
P&M	Program & monitor
PA	Pendulum axis
PA	Preamplifier
PAC	Program Analyzer console
PAL	Parity fail alarm
PAVM	Phase angle voltmeter
PCM	Pulse code modulated
PEA	PIPA electronics assembly
PGNCS	Primary guidance, navigation, and control system

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

Appendix A (cont)

<u>Term</u>	<u>Definition</u>
ΦH_{MGA}	Corrected reading taken from the tilt axis optigon screen with rotary axis at θH_{OGA} , outer gimbal at precision zero, and middle gimbal axis in horizontal plane
ΦH_{RA}	Corrected reading taken from the tilt axis optigon screen with rotary axis in horizontal plane
PIA	Pre-installation acceptance
PINC	Plus increment
PIP	Pulsed integrating pendulum
PIPA	Pulsed integrating pendulum accelerometer
PPA	Pre power assurance
PROG ALM	Program alarm
PSA	Power and servo assembly
PTC	Portable temperature controller
PTE	Pulse torque electronics
PTPS	Pulse torque power supply
PVR	Precision voltage reference
RCS	Reaction control system
RDA	Resolver drive amplifier
RDRST	Radar reset
REJ	Rejected
REL	Release
RELINT	Release inhibit interrupt
RIB	Retrofit instruction bulletin
RL	Read line
RLSE	Release

Appendix A (cont)

<u>Term</u>	<u>Definition</u>
RLYBIT	Relay bit
RLYWD	Relay word
RPTAL	Interrupt lock alarm
RPTLDS	Interrupt in progress longer than 10 milliseconds
RSM	Resume
RSTRT	Read start
RUPT	Interrupt
S	Total gain from rotation about an IRIG input axis to voltage output of the preamplifier, (millivolts per milliradians). Subscripts (X, Y, or Z) may be added to denote a specific IRIG total gain voltage.
SA	Servo amplifier
SAT	System assembly and test
S/C or SC	Spacecraft
SCA	Signal conditioner assembly
SCAFAL	Scaler fail alarm
SCS	Stabilization and control system
SCT	Scanning telescope
SC _x	Spacecraft roll axis
SDA	Shaft drive axis
SETEK	Set strobe
SF(A)	Scale factor of PIP. Subscripts (X, Y, or Z) may be added to denote a specific PIP scale factor.
SFTG	Scale factor of torque generator, (milliradians per pulse). Subscripts (X, Y, or Z) may be added to denote a specific IRIG torque generator scale factor.

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

Appendix A (cont)

<u>Term</u>	<u>Definition</u>
SG	Signal generator
SHANC	Shift and add increment
SHINC	Shift increment
SIDL	System Identification Data List
SJB	GSE-PSA junction box assembly
SL	Shift left
SM	Stable member or service module
SP	Switch pulse
SPS	Service propulsion system
SQG	Sequence generator
SR	Shift right
SRA	Spin reference axis
ST	State
STBY	Standby
STD2	Standard subinstruction two
S _t LOS	Star line of sight
STMIC	Standard memory inquiry cycle
SU	Subtract
SW	Switched
SXT	Sextant
TC	Transfer control
TCAL	Transfer control trap alarm

Appendix A (cont)

<u>Term</u>	<u>Definition</u>
TCSA	Start at specified address
TDA	Torque drive amplifier or trunnion drive axis
TDCR	Technical data change request
TDCR-RB	Technical data change request review board
TDRR	Technical data release or revision
TG	Tachometer-generator
THRCOM	Thrust command
θH_{IGA}	Corrected reading taken from the rotary axis optigon screen with outer and middle gimbals at precision zero, and inner gimbal axis at local vertical
θH_{OGA}	Corrected reading taken from the rotary axis optigon screen with rotary axis horizontal and outer gimbal axis horizontal and east
$\theta + I_g$	True table rotary axis angle which places PIP input axis opposite local vertical vector. Subscripts (X, Y, or Z) may be added to denote a specific PIP input axis.
$\theta - I_g$	True table rotary axis angle which places PIP input axis along local vertical vector. Subscripts (X, Y, or Z) may be added to denote a specific PIP input axis.
TLEND	Telemetry end
TLOS	Tracker line of sight
TLSTRT	Telemetry start
TM	Torque command pulse
TP	Test point or test parity
TPA	Test point adapter

Appendix A (cont)

<u>Term</u>	<u>Definition</u>
TS	Transfer to storage
ULNK	Uplink
UNF	Underflow
UPTLM	Up telemetry
V	Velocity
V	Verb
VDW	Variable deviation wedge
VTVOM	Vacuum tube voltohmmeter
WA	Write amplifier
WL	Write line
wrt	With respect to
XCH	Exchange
XFMR	Transformer
X_{sc}	Spacecraft roll axis
Y_{sc}	Spacecraft pitch axis
Z_{sc}	Spacecraft yaw axis
ZID	Inhibit strobe

Appendix B

RELATED DOCUMENTATION

This appendix explains the function and relationship of the System Identification Data List (SIDL), the Apollo Integrated Inventory and Consumption Report (AIICR), and the aperture card system to the manual.

SIDL is an official release record for documents issued to implement NASA contracts. SIDL identifies drawings, specifications, manuals and job description cards (JDC's), and other documents released to support the Block II Primary Guidance, Navigation, and Control System (PGNCS).

Manuals and JDC's are based upon the latest information available as of the publication freeze date. Manuals and JDC's are distributed after formal CCB approval. SIDL shall be consulted to determine which is the currently effective information. AC Electronics, Field Service Publications Department, will periodically revise the manuals and JDC's to the latest technical information releases.

The AIICR is a listing of all approved spare parts for the PGNCS and its associated ground support equipment (GSE).

The aperture card system is a compilation of documents in the Apollo program. Each aperture card consists of a mounted 35 MM microfilm copy of a complete document, with the exception that for manuals, only the title page, signature page, record of revisions page, and list of effective pages are included to identify the revision letter, change pages, and TDRR number.

Aperture card sets are maintained at all field sites and are used with the PGNCS manual to refer to schematics, wiring diagrams, and other drawings which are not included in the manual.

INDEX

A

	Paragraph Number
accelerometer loop	2-4.3
accelerometers	3-6.1.1.2
ambiguity logic (digital mode module)	4-4.4.8
angle counter, SCT	4-6.1.3.3
Apollo mission and program	1-2
Apollo spacecraft	1-3
astrosixtant passive thermal protective system (APTPS) assembly	3-1B
attitude control	
in-flight operation	5-8
ISS mode of operation	2-4.6.10
attitude error indication	2-4.6.7
auxiliary airborne equipment (AAE)	8-11
auxiliary functions	2-6.1.2
axes	
accelerometer	2-3.2.3
block II PGNCs	2-3
gimbal	2-3.2.4
gyro	2-3.2.2
inertial	2-3.2
optical	2-3.3
spacecraft	2-3.1
stable member	2-3.2.1

B

beam splitter	4-6.2.1.3
blade blocks	8-3.2.5

INDEX (cont)

	Paragraph Number
blower control circuit	8-3.2.5
for PGNCS part number 2015000-011	2-4.4.2
for PGNCS part number 2015000-021	2-4.4.3
buffer circuits (mode module)	
moding	4-4.9.1
phase	4-4.9.3
buffer transformer	4-4.7.7
buffer units	4-4.5.2
C	
cable assembly set, electrical adapter	8-3.1
case (gyro)	4-2.3
CDU zero (see ISS CDU discretetes)	
central processor	2-6.5
checkout	
computer subsystem	7-5.2
inertial subsystem	7-3.2
optical subsystem	7-4.2
primary guidance, navigation, and control system	7-2.2
signal conditioner assembly	7-6.2
clock and decoder logic (digital mode module)	4-4.4.2
CMC logic	4-4.6.4
coarse align enable (see ISS CDU discretetes)	
coarse align mode	2-4.6.3
coarse and fine switch logic (read counter module)	4-4.5.3
coarse select logic	4-4.6.1.1

INDEX (cont)

	Paragraph Number
coarse system module	4-4.1
command module	1-3.1
command module computer	
logic tray A	3-3.1.1
physical description	3-3.1
theory of operation	4-7
tray B	3-3.1.2
command module computer group	3-3
communications and instrumentation system (see spacecraft systems)	1-4.7
compatibility, block II	3-1A
computer mode (OSS)	2-5.5.3
computer subsystem	
checkout	7-5 and 7-5.2
functional description	2-6
preparation	7-5.1
controls and displays	1-5.2
countdown circuit (digital mode module)	4-4.4.3
counter and storage operation, basic (digital mode module)	4-4.4.1
coupling data unit	
functional analysis	2-4.5
physical description	3-2
theory of operation	4-4
CSS malfunction isolation	8-3.4

D

D/A converter output stage	4-4.8.2
D/A polarity logic	4-4.6.9

INDEX (cont)

	Paragraph Number
differential, SCT	4-6.1.3.2
digital mode module	4-4.4
digital to analog converter	4-4.8
display and control group	
indicator control panel	3-4.1
optics shroud	3-4.2
physical description	3-4
display and keyboard	
functional analysis	2-6.10
physical description	3-3.2
double dove prism and mount assembly	4-6.1.1.1
drive assemblies	
SCT	4-6.1.3
SXT	4-6.2.2
ducosyn	
IRIG magnetic suspension unit	4-2.5.3
IRIG signal generator	4-2.5.1
IRIG torque generator	4-2.5.2
ducosyns	
Apollo II IRIG	4-2.5
PIP	4-3.5
dust covers (ejectable APTPS)	3-4A
E	
earth orbit	1-2.1
electrical power system (see spacecraft systems)	
enable error counter (see ISS CDU discretetes)	

INDEX (cont)

	Paragraph Number
environmental control system (see spacecraft systems)	
entry	5-9
error angle counter and logic module	4-4.6
error counter	4-4.6.6
error counter up-down logic	4-4.6.10
eyepiece storage unit	3-5A

F

fail detect circuit	
ISS - CDU	4-4.9.4
optics - CDU	4-4.9.5
fine align electronics	2-4.2
fine align mode	2-4.6.8
flexible hose assembly	3-5
float assembly	
gyro	4-2.2
PIP	4-3.1

G

gear reduction	4-6.1.3.1
generator, 25.6 kpps (digital mode module)	4-4.4.4
GNIC panel (see indicator control panel & display and control group)	
GSE signal selection list	8-3.2.2
guidance monitor	5-3

INDEX (cont)

	Paragraph Number
gyro wheel assembly	4-2.1
gyroscopes	3-6.1.1.1
H	
housing assembly (PIP)	4-3.2
I	
I ₂ , I ₃ generators (digital mode module)	4-4.4.5
IMU cage mode	2-4.6.6
IMU turn-on	2-4.6.1
incrementing pulse selection logic (error angle counter and logic module)	4-4.6.11
indicator control panel (see display and control group)	
inertial measuring unit and PIP electronics assembly	3-6
inertial measuring unit	3-6.1
PIP electronics assembly	3-6.2
inertial reference integrating gyro Apollo II	4-2
inertial reference mode	2-4.6.9
inertial subsystem	
checkout	7-3 and 7-3.2
functional analysis	2-4
preparation	7-3.1
in-flight IMU alignment	5-5

INDEX (cont)

	Paragraph Number
input-output	2-6.7
intergimbal assembly	3-6.1.5
interrogate generator	
ISS	4-4.7.4
shaft	4-4.7.5
trunnion	4-4.7.6
interrogate module	4-4.7
involuntary instructions	2-6.2.2
IRIG (see inertial reference integrating gyro)	
ISS CDU discrettes	2-4.5.1
CDU zero	2-4.5.1.1
coarse align enable	2-4.5.1.3
enable error counter	2-4.5.1.2
S-4B takeover	2-4.5.1.4
ISS CDU zero	2-4.6.2
ISS modes of operation	2-4.6

L

ladder decoder	4-4.8.1
launch and prelaunch IMU alignment, preparation for	5-2
light transmission, SCT optics	4-6.1.2
light transmittance, SXT optics	4-6.2.1.6
loop diagrams	8-3.2.3
lunar landing	1-2.3
lunar orbit	1-2.2

INDEX (cont)

	Paragraph Number
M	
machine instructions	2-6.2
main summing amplifier and quadrature rejection module	4-4.3
maintenance	
concept	8-2
preventive	8-10.2
schedule	8-10
scheduled	8-10.1
malfunction	
analysis	8-9
isolation	8-3
verification	8-8
manual modes 2-5.5.2	
manual direct mode	2-5.5.2.4
manual resolved mode	2-5.5.2.5
slave to SXT	2-5.5.2.3
0° manual mode	2-5.5.2.1
25° manual mode	2-5.5.2.2
MCD and loop diagram selection	8-3.2.4
memory	2-6.8
midcourse correction and thrust vector control	5-7
middle gimbal	3-6.1.2
mirror and mount assembly, SXT indexing	4-6.2.1.1
mirror housing and eyepiece assembly, SXT	4-6.2.1.5
mirrors, SXT head right angle	4-6.2.1.2
mission functions	2-6.1.1

INDEX (cont)

	Paragraph Number
mix logic	
inertial coarse-fine	4-4.6.1
optics	4-4.6.2
mode module	4-4.9
modes of operation	2-5.5
moding relays	4-4.9.6
moding sync logic	
ISS	4-4.4.6
OSS	4-4.4.7
monitor circuit diagrams (MCD's)	8-3.2.1
N	
navigation	
midcourse	5-6
orbital	5-4
navigation base	3-7
navigation base, optical unit assembly and bellows installation kit	3-8
navigational measurement	
landmark	5-4.1
star-horizon	5-4.2
ND 1021040, supplement B, arrangement of	8-3.2
network lists	8-3.2.6
normalizing network	
gyro	4-2.4
PIP	4-3.4

INDEX (cont)

Paragraph
Number

O

optical base 3-9.1

optical complex

 SCT 4-6.1.1

 SXT 4-6.2.1

 SXT telescope 4-6.2.1.4

optical subsystem

 checkout 7-4 and 7-4.2

 functional analysis 2-5

 preparation 7-4.1

optical unit and bellows assembly 3-9A

optical unit assembly

 physical description 3-9

 theory of operation 4-6

optics shroud 3-4.2

outer case assembly (PIP) 4-3.3

outer gimbal 3-6.1.3

P

peripheral instructions 2-6.2.3

PGNCS interconnect harness group 3-10

PIP electronics assembly 3-6.2

 (see also 16 pulsed integrating pendulum)

power and servo assembly 3-11

INDEX (cont)

	Paragraph Number
power supplies	
functional analysis	2-6.9
theory of operation	4-5
power supply	
ISS 800 cps	4-5.3
OSS 800 cps	4-5.4
pulse torque	4-5.1
4 vdc	4-5.6
-28 vdc	4-5.2
14 vdc (interrogate module)	4-4.7.1
14 vdc (mode module)	4-4.9.2
pre-installation acceptance	8-6
pre-power assurance	8-7
primary guidance, navigation, and control system	
checkout	7-2 and 7-2.2
functional analysis	2-2
preparation	7-2.1
test descriptions	7-2.3
(see spacecraft systems)	
primary guidance, navigation, and control system interface	1-5
priority control	2-6.6
programs	2-6.1
pulse driver, 25.6 kpps	4-4.7.8
pulse selection logic, polarity	4-4.6.8
pulse sync logic,	
alternate	4-4.6.1.3
single	4-4.6.7
16 pulsed integrating pendulum	4-3

INDEX (cont)

	Paragraph Number
Q	
quadrant selector module	4-4.2
R	
rate select logic	4-4.6.5
reaction control system	
command module	1-4.4.2
service module	1-4.4.1
reaction control systems (see spacecraft systems)	
read counter	4-4.5.1
read counter module	4-4.5
reader counter up-down logic	4-4.6.3
reference generator	
ISS	4-4.7.2
optics	4-4.7.3
regular instructions	2-6.2.1
removal and replacement	8-4
repair verification	8-5
S	
scanning telescope	
functional analysis	2-5.1
physical description	3-9.3
theory of operation	4-6.1

BLOCK II PRIMARY GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

INDEX (cont)

	Paragraph Number
selected error logic	4-4.6.1.2
sequence generator	2-6.4
servo loop	
SCT shaft	2-5.3.1
SCT trunnion	2-5.3.2
SXT shaft	2-5.4.1
SXT trunnion	2-5.4.2
servo loops	
SCT	2-5.3
SXT	2-5.4
service module	1-3.2
service propulsion system (see spacecraft systems)	
sextant	
functional analysis	2-5.2
physical description	3-9.2
theory of operation	4-6.2
signal conditioner assembly	
checkout	7-6 and 7-6.2
preparation	7-6.1
theory of operation	4-8
signal conditioner modules	4-8.1
reference voltage circuits	4-8.3
2.5 volt dc bias supply	4-8.3.1
800 cps square wave generator	4-8.3.2
3200 cps isolation amplifier and multivibrator	4-8.3.3
signal conditioning circuits	4-8.2
amplifier-demodulator	4-8.2.2
blocking oscillator-rectifier-filter	4-8.2.3
chopper-amplifier-demodulator	4-8.2.1
temperature sensor amplifier	4-8.2.5
transformer-rectifier-filter	4-8.2.4
spacecraft system communications and instrumentation system	1-4.7
electrical power system	1-4.5
environmental control system	1-4.6
primary guidance, navigation, and control system	1-4.1

INDEX (cont)

	Paragraph Number
reaction control system	1-4.4
service propulsion system	1-4.3
stabilization and control system	1-4.2
stabilization and control system (see spacecraft systems)	
stabilization loop	2-4.1
stable member	3-6.1.1
stable member mounted electronics	3-6.1.1.3
supporting gimbal	3-6.1.4
systems (interface)	1-5.1
S-4B take-over	
ISS mode of operation	2-4.6.4
(see ISS CDU discrettes)	
T	
telescope	
minus 4.6-power	4-6.1.1.2
plus 4.6-power	4-6.1.1.3
temperature alarm circuit	
for PGNCS part number 2015000-011	2-4.4.4
for PGNCS part number 2015000-021	2-4.4.5
temperature control circuit	2-4.4.1
temperature control, external	2-4.4.6
temperature control system, IMU	2-4.4
test point signal characteristics	8-3.3
thrust vector control	2-4.6.5

INDEX (cont)

	Paragraph Number
timer	2-6.3
tray A, logic	3-3.1.1
tray B	3-3.1.2

U

utility functions	2-6.1.3
-------------------------	---------

Z

zero optics	2-5.5.1
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APOLLO

GUIDANCE AND NAVIGATION SYSTEM JOB DESCRIPTION CARDS

PREPARED FOR

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER

BY

DELCO ELECTRONICS
DIVISION OF GENERAL MOTORS
MILWAUKEE, WISCONSIN 53201

NASA CONTRACT NAS 9 - 497

28 JULY 1971

ATTACHMENT - IMPORTANT NOTICE

Insert this July 28, 1971 change list in front of the JDC volume index for interim reference between revisions of the indexes. The preceding revision of the JDC Index was dated July 14, 1971.

<u>JDC No.</u>	<u>Revision</u>	<u>TDCR Reference</u>
05402	B	--
12213	Z	--
12214	Y	--
12224	N	--

JDC INDEX for ND-1021038
NUMERICAL LIST OF JDC'S
REFERENCED WITHIN THIS MANUAL

This JDC index lists all JDC's which are referenced within ND-1021038. The numerical list of the JDC's and the revision letter of the latest distributed issues are listed below. SIDL lists the revision letter for the latest authorized change. This list will be revised and included with the distribution of new or revised JDC's that apply to this manual.

Remove JDC's which are listed as DELETED.

Remove any JDC which is replaced by a JDC with a later revision letter.

JDC REV

Job Title

02820 * Clean Optics of Optical Unit Assembly, Alignment Optical Telescope, and Ground Support Equipment

03081 A Purging the Optical Unit

03196 H Pack the Optical Unit for Shipment or Storage (Blk II)

03197 F Unpack Optical Unit

03234 - Package and Pack the G and N Fixture Stand

03242 - Prepare the Shaft Accuracy Tester for Use

03244 A Prepare the Alignment Mirror Assembly and Alignment Certification Fixture for Use

03247 - Prepare the Theodolite and Support Assembly for Use

03248 A Prepare the Variable Deviation Wedge for Use

03252 - Prepare the Azimuth Reference Fixture for Use

03253 A Prepare the G and N Installation Qualification Fixture for Use

03256 * Purging of AOT Angle Counter

03258 - Packing of OUA Eyepiece Assemblies

03272 A Pack Navigation Base and Optical Unit for Shipment or Storage (Blk I-100)

JDC INDEX for ND-1021038

JDC REV	Job Title
03276 A	Package and Pack Optical GSE Having Storage Cases
03277 -	Package and Pack Optical GSE
03278 A	Prepare Optical Ground Support Equipment for Use
03479 B	Prepare Empty Shipping Container for Shipment or Storage
03567 A	Pack of the Optical Unit for Storage
03621 A	Purging of the Alignment Optical Telescope
03643 E	Packing Alignment Optical Telescope
03644 D	Unpack Alignment Optical Telescope
03650 *	Maintenance and Inspection of AOT
03651 -	Unpacking and Packing the Sunshade and Radar Shield for Shipment or Storage
04723 -	Temporary Storage of AGC
04838 B	AGC Packaging and Packing - Block I (100 Series)
04839 A	Computer Subsystem Transportation - Block I (100 Series) and Block II
04840 -	Packaging and Packing CTS Tape Perforator Assembly
04841 B	Main Panel Display and Keyboard Packaging and Packing - Block I (100 Series)
04842 B	Navigation Panel Display and Keyboard Packaging and Packing - Block I (100 Series)
04843 *	Installation and Removal of DSKY's in Handling Fixtures
04845 *	Installation and Removal of AGC in Handling Fixture - Block I (100 Series)
04855 -	Packaging and Packing Main DSKY Pedestal Mount
04856 -	Packaging and Packing DSKY Handling Fixtures
04857 -	Packaging and Packing AGC Handling Fixture
04859 *	Purge and Fill Cooling Unit
04860 *	Purge and Fill Coldplate - Block I (100 Series)
04866 -	Packaging and Packing Alignment Fixture Assembly
04892 -	Preparing the CTS Tape Perforator Assembly for Use
04898 A	Packaging and Packing AGC Calibration System Drawers and Assemblies
05000 -	Packaging and Packing AGC Calibration System Loop Antenna
05002 A	Packaging and Packing AGC-OC and CTS Drawers and Assemblies

JDC INDEX for ND-1021038

JDC	REV	Job Title
05100	-	Packaging and Packing CTS Tape Reader Assembly
05101	A	Packaging and Packing AGC/GSE Interconnection Set, Subsystem
05102	A	Packaging and Packing AGC/GSE Interconnection Set G & N Test
05104	B	Packaging and Packing AGC to PSA and G & N to Spacecraft Wiring Harness
05111	B	Installation and Removal of AGC in Handling Fixture - Block II
05112	F	Packaging and Packing Display and Keyboard - Block II and LEM
05115	-	Packaging and Packing DSKY Handling Fixture - Block II
05118	-	Packaging and Packing AGC Calibration System Loop Antenna - Block II
05120	-	Packaging and Packing DSKY Mounting Stand - Block II
05121	E	Installation and Removal of AGC in Handling Fixture - Block II
05122	B	Packaging and Packing AGC - Block II
05123	-	Installation and Removal of DSKY in Handling Fixture - Block II
05441	-	Packaging and Packing of Fixed Memory Modules and Fixed Memory Jumper Modules for Storage and Shipment
17205	F	Packaging and Packing of IMU for Shipment
17206	-	Packaging and Packing of CDU Frame and Panel Assembly for Storage and Shipment
17207	A	Packaging and Packing of Optics Shroud for Storage and Shipment
17208	A	Packaging and Packing of Optics Cover for Storage and Shipment
17210	-	Packaging and Packing of CDU Frame Assembly for Storage and Shipment
17211	-	Packaging and Packing of CDU Front Panel for Storage and Shipment
17212	A	Packaging and Packing of G and N Indicator Control Panel for Storage and Shipment
17213	A	Packaging and Packing of D and C Electronics Base Assembly for Storage and Shipment
17214	A	Packaging and Packing of Modules for Storage and Shipment

JDC INDEX for ND-1021038

JDC REV	Job Title
17215 A	Packaging and Packing of Control Electronics for Storage and Shipment
17216 -	Packaging and Packing of PSA Tray Frames for Storage and Shipment
17217 -	Packaging of Optics Shroud and Cover Assembly for Storage and Shipment
17218 -	Packing of D and C Group for Shipment
17219 C	Packaging and Packing of G and N Harness and PSA End Connector for Storage and Shipment
17305 D	Unpacking Inertial Measuring Unit
17604 -	Installation and Removal of CDU Handling Fixture
18045 *	Operation of Filling and Purging Fixture
18078 *	Application of DC-4 Silicone Grease to Airborne Component Connector Contacts
18081 *	Removal of DC-4 Silicone Grease from Airborne Component Connectors
18083 *	Cleaning of Connectors and Components
18084 *	Repair of Painted Surfaces
18086 *	Mercury Decontamination and Handling Safety
19235 *	Coolant Draining and Filling Procedure
19286 D	General Packaging and Packing of Spacecraft Components and Spares
19287 A	General Packaging and Packing of Drawers and Panels of Ground Equipment Consoles and Items Intended for Immediate Use
19288 A	Packaging and Packing of Ground Support Test Equipment
19290 A	Packaging and Packing of Interconnecting Cables and Hoses
19291 A	Packaging and Packing of Current Source Monitor Panel
19292 -	Packaging and Packing of Nickel-Cadmium Battery Cells
19294 -	Packaging and Packing of GSE Junction Box
19295 -	Unpacking and Unpackaging Checklist
19296 A	Transportation of G and N Components Using G and N Transportation Cart
19301 C	Storage of IMU in Shipping Container

JDC INDEX for ND-1021038

JDC	REV	Job Title
19302	D	Packaging and Packing of Block II Interconnect Harnesses
19303	D	Packaging and Packing of LEM Interconnect Harnesses
19304	C	Packaging and Packing of Power and Servo Assembly
19702	A	Discharging of Auxiliary Battery Pack Nickel-Cadmium Battery Cells
19703	A	Discharging of Battery Power Pack Nickel-Cadmium Battery Cells
19826	*	Reassembly and Charging of Battery Power Pack or Auxiliary Battery Pack Battery Cells

*These JDC's are supplied in Job Description Card volumes and therefore are not included in this manual.

JOB PULSE COUNT

INITIAL TDRR 25824 D.S. PGS 0

SUBSYSTEM Counter-Timer (CTS)
DESCRIPTION

ASSY. 2014233-011

Operating the counter-timer to count the number of pulses during a time interval

Rev. Let.	Date	TDRR NO.	PAGES REVISED		APPROVAL		REFERENCES
			JDC	D. S.	MIT	NASA	
A	6-28-66	29858	1	-	MM	-	JDC 05420. Computer Measurements Co. Instruction Manual for Model 7893B Universal Counter-Timer.
B	6-28-71	38440	All	-	EA	-	
							IMPORTANT
							INTERVAL As required
							TOOLS AND MATERIAL

NOTE: Power is applied to the counter per JDC 05420.

PREPARATION

1. Set the switches and controls on the counter as follows:
 - a. Set the FUNCTION switch to the COUNT A position.
 - b. Set the GATE switch to the OPEN position.
 - c. Turn the DISPLAY control to the ∞ position.
 - d. Set the A INPUT VOLTS RMS switch to position 102.

PROCEDURE

2. Observe the positions of the CHANNEL T and CHANNEL S switches on the COMPUTER TEST SET X-Y INTERFACE panel. (These switches must be returned to the

observed positions in a later step of this JDC.)

3. Perform only part "a" or part "b" of this step.

- a. If the FREQ + PHASE switch on the COMPUTER TEST SET X-Y INTERFACE panel is set to FRS S▶T, set the CHANNEL S switches to position 112.
- b. If the FREQ + PHASE switch on the COMPUTER TEST SET X-Y INTERFACE panel is set to FRT T▶S, set the CHANNEL T switches to position 112.

4. On the FREQUENCY COUNTER, set the A SLOPE switch to +.

5. On the FREQUENCY COUNTER, select the A INPUT VOLTS RMS position where A TRIGGER LEVEL can be properly

VERIFICATION WITH SIDL REQUIRED BEFORE USE

DATE 1 FEB 66

adjusted. (This is usually 26.)

6. On the FREQUENCY COUNTER, set the A TRIGGER LEVEL control to the center of the counting range.

7. On the COMPUTER TEST SET X-Y INTERFACE panel, return the CHANNEL S and CHANNEL T switches to the positions observed in step 2 of this JDC.

8. On the FREQUENCY COUNTER, depress the RESET pushbutton.

JOB OPTICS SLEW RATE TEST

JDC 12213 REV. Z PAGE 1 OF 10
 INITIAL TDRR 29882 D.S. PGS 5

SUBSYSTEM G AND N SYSTEM

ASSY.

DESCRIPTION The test demonstrates slewing performance of the optics servo loops.

Rev Let.	Date	TDRR NO.	PAGES REVISED		APPROVAL		REFERENCES
			JDC	D. S.	MIT	NASA	
A	7-28-66	30305	2-5	3, 4	EA JS	WS JS	PS-2015000
B	11-10-66	31891	1, 6	-	EA JS	-	
C	11-15-66	31942	1, 6	-	EA JS	-	IMPORTANT Avoid slewing of SXT shaft and trunnion axes into their mechanical stops.
D	1-12-67	32621	1, 4	-	EA JS	-	
E	2-2-67	32883	All	2	EA JS	-	INTERVAL
F	3-2-67	33103	-	2	EA JS	-	
G	5-4-67	33719	-	3	EA JS	-	TOOLS AND MATERIAL
H	6-6-67	33910	4	-	EA JS	-	
J	9-6-67	34560	1	-	EA JS	-	TOOLS AND MATERIAL
K	9-22-67	34704	4, 5, 6	2, 3, 4	EA JS	-	
L	10-5-67	34806			EA JS	-	TOOLS AND MATERIAL
M	12-7-67	35208	7, 8	4, 5	EA JS	-	
N	1-16-68	35450	5	2, 3	EA JS	-	TOOLS AND MATERIAL
P	2-29-68	35771	4, 5, 6	-	EA JS	-	
R	4-29-68	36124	1, 2, 5, 6	2, 3	EA JS	-	TOOLS AND MATERIAL
S	7-11-68	36514	1, 8	-	EA JS	-	
T	9-12-68	36819	1, 8	-	EA JS	-	TOOLS AND MATERIAL
U	10-21-68	36930	6	5	EA JS	-	
V	3-11-69	37404	5	2	EA JS	-	TOOLS AND MATERIAL
W	5-26-70	38124	1, 8, 9, 10	4, 5	EA JS	-	
Y	3-26-71	38393	7, 8, 9	4	EA JS	-	TOOLS AND MATERIAL
Z	7-28-71	38437	1, 7, 10,	-	EA JS	-	

NOTE: 1. Use extreme care when tilting G&N Mounting Fixture to insure that components do not strike locking handles.
 2. The G&N Mounting Fixture shall be set at the 90.0° position. Care must be taken to prevent gimbal lock (see JDC 12215).
 3. Oscillograph Amplifier sensitivities stated herein are nominal and may be

adjusted at the discretion of the operator.

INITIALIZATION

1. Perform JDC 12215 to establish a Master Initialization condition.
2. Press to light OPTICS POWER ON pushbutton on Test Control panel.

NOTE: Step 2A applies only if Restart Monitor module (2898989) is installed.

2A. Perform the following DSKY operations:

- a. VERB 21 NOUN 10 ENTR

VERIFICATION WITH SIDL REQUIRED BEFORE USE

DATE 30 JUN 66

SUBSYSTEM G AND N SYSTEM

ASSY

b. 00077 ENTR

c. 00000 ENTR

NOTE: Step 3 applies
to Indicator Control
panel 2021290 only.

3. Set switches on Indicator Control
panel as follows:

- a. OPTICS ZERO to OFF
- b. OPTICS TEL TRUN to SLAVE TO SXT
- c. OPTICS COUPLING to DIRECT
- d. OPTICS MODE to MAN
- e. OPTICS SPEED to HI

NOTE: Step 3A applies to
all Indicator Control panels
except 2021290.

3A. Set switches on Indicator Control
panel as follows:

- a. OPTICS MODE to MAN
 - b. OPTICS CONTROLLER SPEED to HI
 - c. OPTICS CONTROLLER COUPLING to
DIRECT
 - d. OPTICS TRACKER to OFF
 - e. OPTICS TELESCOPE TRUNNION to
SLAVE TO SXT
4. Insure CH4 AC, CH5 AC, CH6 AC,
800 ~ 0 PH REFERENCE, and OPT 800 ~ TO
PH GEN pushbuttons on Oscillograph Signal
Selector panel are lighted.

5. Insure SCT TRUN, SXT SHAFT, and
SXT TRUN switches on PSA Test Point
Adapter are set to 1:1.

HIGH SPEED SLEW RATE

6. Set CHANNEL 2 switch on Oscillograph
Signal Selector panel to 12 and CHANNEL 5

switch to 11 to monitor the following signals:

a. SXT Trunnion MDA Tach Mon. on
CHANNEL 2

b. SCT Trunnion MDA Tach Mon. on
CHANNEL 5

7. Set SCOPE "A" INPUT switch on
Primary Signal Selector panel to SIG 2 and
CROSSBAR CONTROL to 14 to monitor the
SXT Trunnion MDA Output Mon. on Oscil-
loscope.

8. Press CHART SPEEDS 5 pushbutton on
Oscillograph Control panel. Set CHANNEL 2
sensitivity on the Oscillograph Amplifier
panel to 500 MV/MM and CHANNEL 5 sensi-
tivity to 200 MV/MM.

NOTE: Step 9 applies to
Indicator Control
panel
2021290 only.

9. Set OPTICS ZERO switch on Indicator
Control panel to ZERO. After 20 seconds,
set OPTICS ZERO switch to OFF.

NOTE: Step 9A applies to
all Indicator Control
panels except 2021290.

9A. Set OPTICS MODE switch on Indicator
Control panel to ZERO. After 20 seconds,
set OPTICS MODE switch to MAN.

10. Start Oscillograph by setting CHART
DRIVE switch on Oscillograph Control panel
to MM/SEC.

11. Measure and record the steady state
peak to peak voltage indicated on the Oscil-
loscope while holding the Optics Hand Con-
troller to the upper limit not longer than 5

SUBSYSTEM G AND N SYSTEM

ASSY

seconds. Release the Optics Hand Controller and set CHART DRIVE switch to OFF. Set all sensitivities on Oscillograph Amplifier panel to OFF and record maximum steady state indications of CHANNELS 2 and 5.

12. Set CHANNEL 1 switch on Oscillograph Signal Selector panel to 13 to monitor the SCT Shaft MDA Tach Mon. signal on CHANNEL 1.

13. Set CHANNEL 1 sensitivity on Oscillograph Amplifier panel to 500 MV/MM.

14. Set SCOPE "A" INPUT switch on Primary Signal Selector panel to SIG 1 and CROSSBAR CONTROL to 14 to monitor the SXT Shaft MDA Output Mon. on Oscilloscope.

14A. Using the Optics Hand Controller, position the SXT Trunnion between 0° and 10° as indicated by the Trunnion TPAC.

NOTE: Step 15 applies to Indicator Control panel 2021290 only.

15. Set OPTICS ZERO switch on Indicator Control panel to ZERO. After 20 seconds, set OPTICS ZERO switch to OFF.

NOTE: Step 15A applies to all Indicator Control panels except 2021290.

15A. Set OPTICS MODE switch on Indicator Control panel to ZERO. After 20 seconds, set OPTICS MODE switch to MAN.

16. Start the Oscillograph by setting CHART DRIVE switch on Oscillograph Control panel to MM/SEC.

17. Measure and record the steady state peak to peak voltage indicated on the Oscilloscope while holding the Optics Hand Controller to the right limit not longer than 10 seconds. Release the Optics Hand Controller and set CHART DRIVE switch to OFF. Set all sensitivities on Oscillograph Amplifier panel to OFF and record the maximum steady state indications of CHANNEL 1.

18. Set the CHANNEL 1 switch on the Oscillograph Signal Selector panel to 12 to monitor the SXT Shaft MDA Tach Mon. voltage on CHANNEL 1.

19. Set CHANNEL 1 sensitivity to 500 mv/mm on the Oscillograph Amplifier panel.

20. Start the Oscillograph by setting the CHART DRIVE switch on the Oscillograph Control panel to MM/SEC.

21. Hold Optics Hand Controller to the left limit not longer than 10 seconds. Release Optics Hand Controller.

22. Stop Oscillograph and record maximum steady state indication on CHANNEL 1.

MEDIUM SPEED SLEW RATE

23. Set VOLTMETER INPUT PAVM switch on Primary Signal Selector panel to SIG 1 and CROSSBAR CONTROL to 05. Set PAVM FUNCTION selector to 0° to monitor in-phase voltage of the SCT Trunnion MDA Tach Mon.

NOTE: Step 24 applies to Indicator Control panel 2021290 only.

SUBSYSTEM G AND N SYSTEM

ASSY

24. Set OPTICS ZERO switch on Indicator Control panel to ZERO. After 20 seconds, set OPTICS ZERO switch to OFF. Set OPTICS SPEED switch to MED.

NOTE: Step 24A applies to all Indicator Control panels except 2021290.

24A. Set OPTICS MODE switch on Indicator Control panel to ZERO. After 20 seconds, set OPTICS MODE switch to MAN. Set OPTICS CONTROLLER SPEED switch to MED.

25. Measure and record the voltage indicated on the PAVM while holding the Optics Hand Controller to the upper limit not longer than 20 seconds. Release the Optics hand controller.

26. Set CHANNEL 5 switch to 11 on Oscillograph Signal Selector panel to monitor the SCT Trunnion MDA TACH Mon.

27. Set VOLTMETER INPUT PAVM switch on Primary Signal Selector panel SIG 2 and CROSSBAR CONTROL to 09 to monitor the SXT Trunnion MDA TACH Mon.

28. Set CHANNEL 5 sensitivity to 10 MV/MM on Oscillograph Amplifier panel. Press CHART SPEEDS 20 pushbutton on the Oscillograph Control Panel and set CHART DRIVE switch to MM/SEC.

29. Measure and record the voltage indicated on the PAVM while holding the Optics Hand Controller to the lower limit not longer than 20 seconds. Release the Optics Hand Controller and set CHART DRIVE switch to OFF. Set all sensitivities on Oscillograph

Amplifier panel to OFF and record steady state indication of CHANNEL 5 per Figure 1. Record maximum width of any pulses at 1/2 positive peak or 1/2 negative peak points on CHANNEL 5 per Figure 1. If no pulses occur, write none on the data sheet.

30. Deleted.

31. Set VOLTMETER INPUT PAVM switch on Primary Signal Selector panel to SIG 2 and CROSSBAR CONTROL to 04 to monitor the SCT Shaft MDA Tach Mon.

NOTE: Step 32 applies to Indicator Control panel 2021290 only.

32. Set OPTICS ZERO switch on Indicator Control panel to ZERO. After 20 seconds, set OPTICS ZERO switch to OFF.

NOTE: Step 32A applies to all Indicator Control panels except 2021290.

32A. Set OPTICS MODE switch on Indicator Control panel to ZERO. After 20 seconds, set OPTICS MODE switch to MAN.

33. Measure and record the voltage indicated on the PAVM while holding the Optics Hand Controller to the right limit not longer than 20 seconds. Release the Optics Hand Controller.

34. Set CHANNEL 1 switch to 13 on Oscillograph Signal Selector panel to monitor the SCT Shaft MDA TACH Mon.

35. Set VOLTMETER INPUT PAVM switch on Primary Signal Selector panel to SIG 2 and CROSSBAR CONTROL to 07 to monitor the SXT Shaft MDA Tach Mon.

SUBSYSTEM G AND N SYSTEM

ASSY

36. Set CHANNEL 1 sensitivity to 20 MV/MM on Oscillograph Amplifier panel and set CHART DRIVE switch to MM/SEC.

37. Measure and record the voltage indicated on the PAVM while holding the Optics Hand Controller to the left limit not longer than 20 seconds. Release the Optics Hand Controller and set CHART DRIVE switch to OFF. Set all sensitivities on Oscillograph Amplifier panel to OFF and record steady state indication of CHANNEL 1 per Figure 1. Record maximum width of any pulses at 1/2 positive peak or 1/2 negative peak points on CHANNEL 1 per Figure 1. If no pulses occur, write none on the data sheet.

LOW SPEED SLEW RATE

38. Set VOLTMETER INPUT PAVM switch on Primary Signal Selector panel to SIG 2 and CROSSBAR CONTROL to 06 to monitor the CDU Trunnion Fine Error.

39. Set the DEGREES dial on the PAVM to 50.

NOTE: Step 40 applies to Indicator Control panel 2021290 only.

40. Set OPTICS ZERO switch on Indicator Control panel to ZERO. After 20 seconds, set OPTICS ZERO switch to OFF. Set OPTICS SPEED switch to LO.

NOTE: Step 40A applies to all Indicator Control panels except 2021290.

40A. Set OPTICS MODE switch on Indicator Control panel to ZERO. After 20 seconds, set OPTICS MODE switch to MAN. Set

OPTICS CONTROLLER SPEED switch to LO.

41. Measure and record the steady state voltage and sign indicated on the PAVM while holding Optics Hand Controller to the upper limit.

41A. Measure and record the steady state voltage and sign indicated on the PAVM while holding Optics Hand Controller to the lower limit.

41B. Release Optics Hand Controller. Add the absolute value recorded in step 41 to the absolute value recorded in step 41A. Record the result.

42. Set the DEGREES dial on the PAVM to 0.

43. Set VOLTMETER INPUT PAVM switch to SIG 1 and CROSSBAR CONTROL to 05 to monitor the SCT Trunnion MDA Tach Mon.

44. Set the CHANNEL 2 switch to 12 and the CHANNEL 5 switch to 11 on the Oscillograph Signal Selector panel to monitor:

- a. SXT Trun MDA Tach Mon. on CHANNEL 2
- b. SCT Trun MDA Tach Mon. on CHANNEL 5

45. Set CHANNEL 2 sensitivity to 10 MV/MM and CHANNEL 5 sensitivity to 5 MV/MM on Oscillograph Amplifier panel and set CHART DRIVE switch to MM/SEC.

46. Measure and record the steady state voltage indicated on the PAVM while holding the Optics Hand Controller to the upper limit until the SXT Trunnion reaches 85° LOS as indicated by the Trunnion TPAC. Release the Optics Hand Controller.

SUBSYSTEM G AND N SYSTEM

ASSY

47. Set CHART DRIVE switch on Oscillograph Control panel to OFF. Set all sensitivities on Oscillograph Amplifier to OFF. Record steady state indication of CHANNELS 2 and 5 per Figure 1. Record maximum width of any pulses at 1/2 positive peak or 1/2 negative peak points on CHANNELS 2 and 5 per Figure 1.

47A. Measure and record the steady state voltage indicated on PAVM while holding Optics Hand Controller to lower limit. Release Optics Hand Controller.

47B. Add the absolute value recorded in step 46 to the absolute value recorded in step 47A and divide by two. Record results as average value of SCT Trun MDA Tach Mon.

48. Set CHANNEL 1 switch on Oscillograph Signal Selector panel to 12 to monitor SXT Shaft MDA Tach Mon. signal on CHANNEL 1.

49. Set VOLTMETER INPUT PAVM switch on Primary Signal Selector panel to SIG 2 and CROSSBAR CONTROL to 05 to monitor the CDU Shaft Fine Error.

50. Using the Optics Hand Controller with the OPTICS SPEED switch set to HI, position the SXT Trunnion between 0° and 10° as indicated by the Trunnion TPAC.

NOTE: Step 51 applies to Indicator Control panel 2021290 only.

51. Set OPTICS ZERO switch on Indicator Control panel to ZERO. After 20 seconds, set OPTICS ZERO switch to OFF.

NOTE: Step 51A applies to all Indicator Control panels except 2021290.

51A. Set OPTICS MODE switch on Indicator Control panel to ZERO. After 20 seconds, set OPTICS MODE switch to MAN.

52. Connect the PSA TPA #2 output TB3-32 (RED) HI and TB3-28 (BLK) LO to the Buffered Probe input J7 HI and J8 LO.

53. On the AUX INPUT PANEL, connect the Buffered Probe output to the Channel 3 AC input, to monitor the SCT Shaft MDA TACH Mon. signal on CHANNEL 3. Set the CHANNEL 3 switch on the AUX INPUT PANEL to OSS 800 cps. Set CHANNEL 3 switch on Oscillograph Signal Selector panel to 15.

54. Set CHANNEL 1 sensitivity to 10 MV/MM and CHANNEL 3 sensitivity to 5 MV/MM on Oscillograph Amplifier panel.

55. Holding the Optics Hand Controller to the left with the OPTICS SPEED switch set to HI, position the SXT Shaft to $(-180^{\circ} \pm 1^{\circ})$ indicated by the Shaft TPAC. Return the OPTICS SPEED SWITCH to LO.

56. Start the Oscillograph by setting CHART DRIVE switch on Oscillograph Control panel to MM/SEC.

57. Measure and record the steady state voltage indicated on the PAVM while holding the Optics Hand Controller to right limit. Continue holding Optics Hand Controller to right limit until SXT Shaft reaches $+180^{\circ}$ as indicated by the Shaft TPAC.

DATE 30 JUN 66

SUBSYSTEM G AND N SYSTEM

ASSY

58. Release the Optics Hand Controller and set CHART DRIVE switch to OFF.

59. Set all sensitivities on Oscillograph Amplifier panel to OFF and record steady state indications of CHANNEL 1 and CHANNEL 3 per Figure 1. Record the maximum width of any pulses at 1/2 positive peak or 1/2 negative peak points of CHANNEL 1 and CHANNEL 3 per Figure 1.

NOTE: Step 60 applies to Indicator Control panel 2021290 only.

60. Set OPTICS ZERO switch on Indicator Control panel to ZERO. Wait 20 seconds before proceeding.

NOTE: Step 60A applies to all Indicator Control panels except 2021290.

60A. Set OPTICS MODE switch on Indicator Control panel to ZERO. Wait 20 seconds before proceeding.

61. Set CROSSBAR CONTROL on Primary Signal Selector panel to the following positions and measure the quadrature voltage indicated on the PAVM.

Signal	CROSSBAR CONTROL
a. SCT Trun MDA P/A Mon.	103
b. SXT Shaft MDA P/A Mon.	203
c. SXT Trun MDA P/A Mon.	106
d. SCT Shaft MDA P/A Mon.	210

NOTE: Step 62 applies to Indicator Control panel 2021290 only.

62. Set OPTICS ZERO switch on Indicator Control panel to OFF. Set OPTICS SPEED switch to LO.

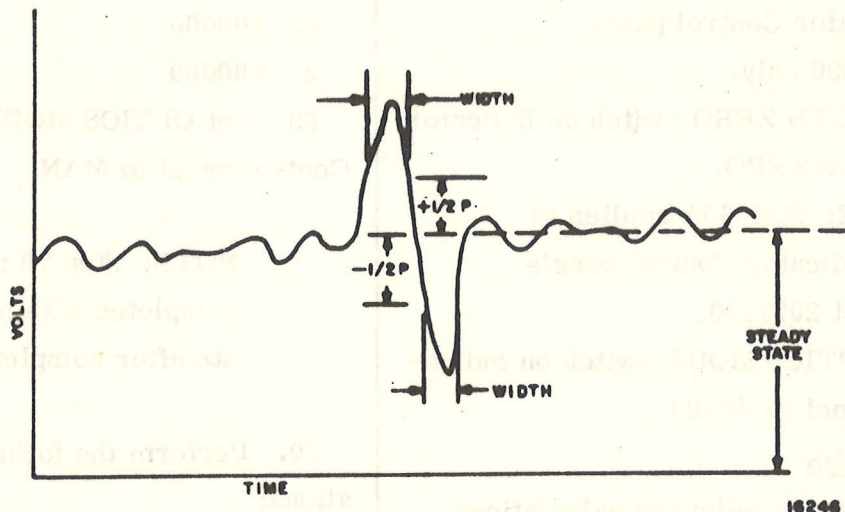


Figure 1. Signal Characteristics Diagram

SUBSYSTEM G AND N SYSTEM

ASSY

NOTE: Step 62A applies to all Indicator Control panels except 2021290.

62A. Set OPTICS MODE switch on Indicator Control panel to MAN. Set OPTICS CONTROLLER SPEED switch to LO.

63. Press MARK pushbutton. Observe DSKY displays VERB 06 NOUN 56 and data in the following form:

- a. Row 1 = ±XXX.XX (Shaft angle in degrees)
- b. Row 2 = ±XX.XXX (Trunnion angle in degrees)
- c. Row 3 = XXX.XX (Time in seconds)

Record Row 1, Row 2, and Row 3 indications.

64. Approximately 60 seconds after first mark, press MARK pushbutton again and record new Row 1, Row 2, and Row 3 indications.

NOTE: Step 65 applies to Indicator Control panel 2021290 only.

65. Set OPTICS ZERO switch on Indicator Control panel to ZERO.

NOTE: Step 65A applies to all Indicator Control panels except 2021290.

65A. Set OPTICS MODE switch on Indicator Control panel to ZERO.

CALCULATIONS

66. Perform the following calculations for hand controller drift rates:

- a. Δ Shaft angle = step 64.a - step 63.a
- b. Δ Trunnion angle = step 64.b - step 63.b

NOTE: If step 64.c is less than step 63.c, add 163.84 seconds to step 64.c.

c. Δ Time = step 64.c - step 63.c

d. Shaft drift rate = $\frac{\Delta \text{ Shaft angle}}{\Delta \text{ Time}}$

e. Trunnion drift rate = $\frac{\Delta \text{ Trunnion angle}}{\Delta \text{ Time}}$

NOTE: Steps 67 through 83 apply only if the Indicator Control panel has ECP 792 installed.

COMPUTER AIDED OPTICS TRACKING

67. Set OPTICS ZERO switch on Indicator Control panel to OFF.

68. Set OPTICS MODE switch on Indicator Control panel to CMC and perform the following DSKY operations:

- a. VERB 41 NOUN 55 ENTR
- b. +00000 ENTR
- c. +00000 ENTR

69. Set OPTICS MODE switch on Indicator Control panel to MAN.

NOTE: Step 70 must be completed within one minute after completing step 69.

70. Perform the following DSKY operations:

- a. VERB 21 NOUN 10 ENTR
- b. 00012 ENTR
- c. 00002 ENTR
- d. VERB 16 NOUN 55 ENTR

DATE 30 JUN 66

SUBSYSTEM G AND N SYSTEM

ASSY

NOTE: In step 71, display may cycle one ECDU bit ($R1 = \pm 000.01^\circ$; $R1 = \pm 00.003^\circ$). Record display for larger positive or negative incremental difference from 00000.

71. When DSKY display settles out, record the contents of Row 1 and Row 2.

72. Perform the following DSKY operations:

- a. VERB 24 NOUN 01 ENTR
- b. 00053 ENTR
- c. 00360 ENTR
- d. 00360 ENTR
- e. VERB 21 NOUN 10 ENTR
- f. 00012 ENTR
- g. 00002 ENTR ENTR
- h. 00014 ENTR
- i. 06000 ENTR
- j. Press KEY RELEASE

73. When DSKY display settles out, record the contents of Row 1 and Row 2.

74. Perform the following calculations:

- a. Shaft = Row 1, step 73 minus Row 1, step 71.
- b. Trunnion = Row 2, step 73 minus Row 2, step 71.

75. Set OPTICS SPEED switch on Indicator Control panel to MED.

76. Set OPTICS COUPLING switch on Indicator Control panel to DIRECT.

77. Hold the Optics Hand Controller to the right limit and record the contents of Row 1 on the DSKY. Release the Optics Hand Controller.

78. Hold the Optics Hand Controller to the left limit and record the contents of Row 1 on the DSKY. Release the Optics Hand Controller.

79. Perform the following calculations:

- a. Increasing Shaft Δ angle = Row 1, step 77 minus Row 1, step 73.
- b. Decreasing Shaft Δ angle = Row 1, step 78 minus Row 1, step 73.

80. Hold the Optics Hand Controller to the upper limit and record the contents of Row 2 on the DSKY. Release the Optics Hand Controller.

81. Hold the Optics Hand Controller to the lower limit and record the contents of Row 2 on the DSKY. Release the Optics Hand Controller.

82. Perform the following calculations:

- a. Increasing Trunnion Δ angle = Row 2, step 80 minus Row 2, step 73.
- b. Decreasing Trunnion Δ angle = Row 2, step 81 minus Row 2, step 73.

83. Perform the following DSKY operations:

- a. VERB 21 NOUN 10 ENTR
- b. 00012 ENTR
- c. 00002 ENTR

NOTE: Step 84 applies only when Restart Monitor module (2898989) is installed.

84. Perform the following DSKY operations:

- a. VERB 01 NOUN 10 ENTR
- b. 00077 ENTR
- c. The contents of Row 1 shall be 00000.

SUBSYSTEM G AND N SYSTEM

ASSY

85. Press to extinguish OPTICS POWER ON pushbutton on the Test Control panel.

CAUTION: Use extreme care when tilting G&N Mounting Fixture to insure that components do not strike locking handles.

86. Return the G&N Mounting Fixture to the 32.5° position.

NOTE: Step 87 applies only if Restart Monitor module (2898989) is installed.

87. Perform the following DSKY operations:

- a. VERB 21 NOUN 10 ENTR
- b. 00077 ENTR
- c. 00000 ENTR

APOLLO G&N
EQUIPMENT TEST
DATA SHEET 1 OF 5

NO. <u>12213</u> ^{JDC}
REV. <u>Z</u>
INITIAL TDRR <u>29882</u>

JOB OPTICS SLEW RATE TEST

ASSEMBLY UNDER TEST	TEST HISTORY
TITLE _____	DATE _____
SER. NO. _____ DWG _____ REV. _____	START _____ END _____ SITE / LOCATION _____
	TIME _____
	START _____ END _____ TOTAL ELAPSED _____

MAJOR GROUND SUPPORT EQUIPMENT		
NAME _____	SER. NO. _____	CAL DATE _____
NAME _____	SER. NO. _____	CAL DATE _____

CONDUCTED BY _____	APPROVED BY _____
NAME/AFFILIATION	NAME/AFFILIATION

JDC ITEM NO.	PARAMETER	UNITS	MIN VALUE	RECORDED VALUE	MAX VALUE	REJ	ACC
11	SXT TRN MDA OUTPUT MON (OSC)	V p-p	13		23		
	SXT TRN MDA TACH MON (CH 2)	V rms	2.0		4.6		
	SCT TRN MDA TACH MON (CH 5)	V rms	0.5		1.2		
17	SXT SHAFT MDA OUTPUT MON (OSC)	V p-p	13		23		
	SCT SHAFT MDA TACH MON (CH 1)	V rms	2.0		4.6		
22	SXT SHAFT MDA TACH MON	V rms	2.0		4.6		
25	SCT TRUN MDA TACH MON	V rms	0.05		0.12		
29	SXT TRN MDA TACH MON	V rms	0.20		0.46		

DATE 30 JUN 66

APOLLO G&N
EQUIPMENT TEST
DATA SHEET 2 OF 5

JDC	
NO.	12213
REV.	Z

JOB OPTICS SLEW RATE TEST

JDC ITEM NO.	PARAMETER	UNITS	MIN VALUE	RECORDED VALUE	MAX VALUE	REJ	ACC
29 (cont)	SCT TRN MDA TACH MON PULSE WIDTH	m. sec.			200		
	SCT TRUN MDA TACH MON	V rms	0.05		0.12		
33	SCT SHAFT MDA TACH MON	V rms	0.20		0.46		
37	SXT SHAFT MDA TACH MON	V rms	0.20		0.46		
	SCT SHAFT MDA TACH MON	V rms	0.20		0.46		
	SCT SHAFT MDA TACH PULSE WIDTH	M. sec.			200		
41	TRN CDU FINE ERROR	V rms					
41A	TRN CDU FINE ERROR	V rms					
41B	TRN CDU FINE ERROR (41+41A)	V rms	0.02		0.15		
46	SCT TRUN MDA TACH MON	V rms					
47	SCT TRUN MDA TACH MON	V rms					
	SCT TRUN MDA TACH MON PULSE WIDTH	m. sec.			250		
	SXT TRUN MDA TACH MON	V rms	0.020		0.046		

DATE 30 JUN 66

APOLLO G&N
EQUIPMENT TEST
DATA SHEET 3 OF 5

JDC
NO. <u>12213</u>
REV. <u>Z</u>

JOB OPTICS SLEW RATE TEST

JDC ITEM NO.	PARAMETER	UNITS	MIN VALUE	RECORDED VALUE	MAX VALUE	REJ	ACC
47 (cont)	SXT TRUN MDA TACH MON PULSE WIDTH	m. sec.			250		
47A	SCT TRUN MDA TACH MON	V rms					
47B	SCT TRUN MDA TACH MON (AV- ERAGE VALUE)	V rms	0.005		0.013		
57	SHAFT CDU FINE ERROR	V rms	0.02		0.1		
59	SXT SHAFT MDA TACH MON (CHANNEL 1)	V rms	0.020		0.046		
	SXT SHAFT MDA TACH MON PULSE WIDTH	m. sec.			250		
59	SCT SHAFT MDA TACH MON (CHANNEL 3)	V rms	0.020		0.046		
	SCT SHAFT MDA TACH MON PULSE WIDTH	m. sec.			250		
61	SCT TRUN P/A QUADRATURE VOLTAGE	V rms			0.8		
	SXT SHAFT P/A QUADRATURE VOLTAGE	V rms			0.8		
	SXT TRUN P/A QUADRATURE VOLTAGE	V rms			0.8		

DATE 30 JUN 66

APOLLO G&N
EQUIPMENT TEST
DATA SHEET 4 OF 5

JDC	NO. <u>12213</u>
REV. <u>Z</u>	

JOB OPTICS SLEW RATE TEST

JDC ITEM NO.	PARAMETER	UNITS	MIN VALUE	RECORDED VALUE	MAX VALUE	REJ	ACC
61 (cont)	SCT SHAFT P/A QUADRATURE VOLTAGE	V rms			0.8		
63.a	Shaft angle	deg		() _ _ . _ _			
63.b	Trunnion angle	deg		() _ _ . _ _			
63.c	Time	sec		_ _ . _ _			
64.a	Shaft angle	deg		() _ _ . _ _			
64.b	Trunnion angle	deg		() _ _ . _ _			
64.c	Time	sec		_ _ . _ _			
66.a	Δ Shaft angle	deg					
66.b	Δ Trunnion angle	deg					
66.c	Δ Time	sec					
66.d	Shaft drift rate	deg/ sec	-0.0333		+0.0333		
66.e	Trunnion drift rate	deg/ sec	-0.0167		+0.0167		
71	Row 1, Shaft Angle	deg		() _ _ _ _			
71	Row 2, Trunnion Angle	deg		() _ _ _ _			
73	Row 1, Shaft Angle	deg		() _ _ _ _			
73	Row 2, Trunnion Angle	deg		() _ _ _ _			
74.a	Shaft Commanded Angle	deg	9.65		11.65		
74.b	Trunnion Commanded Angle	deg	2.40		2.92		
77	Inc. Shaft Angle	deg		() _ _ _ _			
78	Dec. Shaft Angle	deg		() _ _ _ _			
79.a	Inc. Shaft Δ Angle	deg	1.14		2.12		

DATE 30 JUN 66

APOLLO G&N
EQUIPMENT TEST
DATA SHEET 5 OF 5

JDC	
NO.	12213
REV.	Z

JOB OPTICS SLEW RATE TEST

JDC ITEM NO.	PARAMETER	UNITS	MIN VALUE	RECORDED VALUE	MAX VALUE	REJ	ACC
79.b	Dec. Shaft Δ Angle	deg	1.14		2.12		
80	Inc. Trunnion Angle	deg		() _____			
81	Dec. Trunnion Angle	deg		() _____			
82.a	Inc. Trunnion Δ Angle	deg	0.28		0.52		
82.b	Dec. Trunnion Δ Angle	deg	0.28		0.52		

JDC ITEM NO.	CALCULATIONS
66.a	Δ Shaft angle = step 64.a - step 63.a Δ Shaft angle =
66.b	Δ Trunnion angle - step 64.b - step 63.b Δ Trunnion angle =
66.c*	Δ Time = step 64.c - step 63.c Δ Time =
66.d	Shaft drift rate = $\frac{\Delta \text{ Shaft angle}}{\Delta \text{ Time}}$ Shaft drift rate =
66.e	Trunnion drift rate = $\frac{\Delta \text{ Trunnion angle}}{\Delta \text{ Time}}$ Trunnion drift rate =

* If step 64.c is less than step 63.c, add 163.84 seconds to step 64.c.

DATE 30 JUN 66

JOB OPTICS POSITIONAL ACCURACY TEST

JDC 12214 REV. Y PAGE 1 OF 9
 INITIAL TDRR 29882 D.S. PGS 11

SUBSYSTEM G & N SYSTEM

ASSY.

DESCRIPTION SXT LOS parallelism and SXT St LOS positional accuracy are checked in this test.

Rev. Let.	Date	TDRR NO.	PAGES REVISED		APPROVAL		REFERENCES
			JDC	D.S.	MIT	NASA	
A	7-28-66	30306	2, 4, 5	2, 3, 5	EA	WS	PS 2015000 JDC 19128
B	9-1-66	30925	5	-	JP	-	
C	9-15-66	31055	1, 2, 5, 6	2, 9, 10	EA	-	IMPORTANT See below.
D	11-10-66	31892	1, 3, 4, 5	-	EA	-	
E	1-19-67	32692	1, 2, 3, 5	1, 2, 11	EA	-	
F	2-2-67	32884	1, 2, 3, 4, 5	-	EA	-	INTERVAL
G	3-2-67	33107	-	2	EA	-	
H	5-4-67	33720	-	11	EA	-	
J	7-27-67	34237	1	-	EA	-	TOOLS AND MATERIAL Variable Deviation Wedge SCT Resolution Card
K	9-6-67	34560	1	-	EA	-	
L	9-28-67	34741	1, 2, 3, 6, 7, 8	1, 9	EA	-	
M	10-26-67	34934	3	7	EA	-	
N	3-19-68	35891	1, 3	1-8, 11	EA	-	
P	5-2-68	36154	1, 2, 5, 8	-	EA	-	
R	10-21-68	36929	1	-	EA	-	
S	12-10-68	37113	2, 3, 8, 9	All	EA	-	
T	12-27-68	37153	2	-	EA	-	
U	1-28-69	37272	-	1, 9	EA	-	
V	3-11-69	37405	2	-	EA	-	
W	5-26-70	38125	1, 8	-	EA	-	
Y	6-28-71	38438	2, 9	-	EA	-	

IMPORTANT: 1. Insure that JDC 19128 has been performed within the last six months.
 2. Avoid slewing of SXT shaft and trunnion axes into their mechanical stops.
 3. If a Fresh Start (VERB 36 ENTR) is performed at any time during performance of this JDC, set OPTICS ZERO switch (Indicator Control panel 2021290) to OFF and then to ON and wait 18 seconds before proceeding; or set OPTICS MODE switch (all Indicator Control panels except 2021290) to MAN and then to ZERO and wait 18 seconds before proceeding.

CAUTION: Use extreme care when tilting G&N Mounting Fixture to insure that components do not strike cradle locking handles.

NOTE: 1. Perform JDC 12215 to establish a Master Initialization condition. Place the G & N Mounting Fixture in the 0.0° position immediately after the IMU is coarse aligned to zero

VERIFICATION WITH SIDL REQUIRED BEFORE USE

DATE 30 JUN 66

SUBSYSTEM G & N SYSTEM

ASSY

degree. 2. Step 1 applies to Indicator Control panel 2021290 only Step 1A applies to all Indicator Control panels except 2021290.

1. Press OPTICS POWER ON pushbutton on Test Control panel. OPTICS POWER ON pushbutton shall light. Insure that OPTICS TEL TRUN switch on Indicator Control panel is set to SLAVE TO SXT and the OPTICS ZERO switch is set to OFF. Press RSET pushbutton on DSKY and ALARM RESET pushbutton on Programmer and Monitor panel of CTS to reset alarms which may occur.

1A. Press OPTICS POWER ON pushbutton on Test Control panel. OPTICS POWER ON pushbutton shall light. Insure that OPTICS TELESCOPE TRUNNION switch on Indicator Control panel is set to SLAVE TO SXT and that OPTICS TRACKER switch is set to OFF. Press RSET pushbutton on DSKY and ALARM RESET pushbutton on Programmer and Monitor panel of CTS to reset alarms which may occur.

NOTE: Step 1B applies only if Restart Monitor module (2898989) is installed.

1B. Perform the following DSKY operations:

- a. VERB 21 NOUN 10 ENTR
- b. 00077 ENTR
- c. 00000 ENTR

NOTE: Step 2 applies to Indicator Control panel 2021290 only. Step 2A applies to all Indicator Control panels except 2021290.

2. Set OPTICS COUPLING switch to DIRECT and set OPTICS SPEFD switch to HI.

2A. Set OPTICS CONTROLLER COUPLING switch to DIRECT and set OPTICS CONTROLLER SPEED switch to HI.

3. Place OPTICS MODE switch on the Indicator Control panel to MAN.

NOTE: Step 4 applies to Indicator Control panel 2021290 only. Step 4A applies to all Indicator Control panels except 2021290.

4. Set OPTICS ZERO switch on Indicator Control panel to ZERO. After 20 seconds, return OPTICS ZERO switch to OFF.

4A. Set OPTICS MODE switch on Indicator Control panel to ZERO. After 20 seconds, return OPTICS MODE switch to MAN.

5. through 7. Deleted

8. Cover the SXT StLOS. Sight through the SXT LLOS and adjust the G&N Mounting Fixture until the dot of target number 1 is horizontally adjacent to the double vertical lines of the SXT reticle.

SUBSYSTEM G & N SYSTEM

ASSY

9. Place the Variable Deviation Wedge (VDW) in front of target number 1 using the VDW base which allows deviation to be measured in the horizontal plane (setting knobpoints right). Set the VDW dial to zero.

NOTE: Step 10 applies to Indicator Control panel 2021290 only. Step 10A applies to all Indicator Control panels except 2021290.

10. Set OPTICS MODE switch to CMC and perform the following DSKY operations:

- a. VERB 41 NOUN 55 ENTR
- b. +27000 ENTR
- c. +45000 ENTR

Wait until optics stop driving before proceeding.

10A. Set OPTICS MODE switch on Indicator Control panel to CGC and perform the following DSKY operations:

- a. VERB 41 NOUN 55 ENTR
- b. +27000 ENTR
- c. +45000 ENTR

Wait until optics stop driving before proceeding.

11. Sight through the SXT LLOS and move the VDW laterally until the target number 1 reticle is seen clearly. Adjust the VDW dial until the central vertical reticle line of SXT is coincident with dot and vertical reticle line of target number 1. Record the VDW dial reading on line (g. 1). Complete line (g. 2). Uncover the SXT StLOS.

12. Complete lines (h), (i), (j), and (k) on the Data Sheet.

13. Place the VDW in front of target number 3 and cover target number 1.

14. Set the VDW to the value recorded on line (k).

NOTE: Step 15 applies to Indicator Control panel 2021290 only. Step 15A applies to all Indicator Control panels except 2021290.

15. Set OPTICS MODE switch on Indicator Control panel to MAN and set OPTICS SPEED switch to LO.

15A. Set OPTICS MODE switch on Indicator Control panel to MAN and set OPTICS CONTROLLER SPEED switch to LO.

16. Manipulate the Optics Hand Controller vertically to position the SXT StLOS until the central dot on reticle of target number 3 approaches the vertical crosshair on the SXT reticle. At the instant of coincidence, press MARK pushbutton.

NOTE: VERB 06, NOUN 56 shall appear on the CMC DSKY indicating optical CDU and time displays.

17. Record the DSKY Row 2 indication on line (1) of the Data Sheet. Repeat step 16 two more times, recording the DSKY Row 2 indication for each MARK.

SUBSYSTEM

G & N SYSTEM

ASSY

18. Observe the three bit counts of line (1) of the Data Sheet. If two of the three counts are equal, record this count in line (m). If all three counts are different, record the count which falls between the smallest and the largest on line (m).

19. Complete lines (n) and (o) of the Data Sheet.

20. Set the VDW to the value recorded on line (o).

21. Manipulate the Optics Hand Controller vertically to position the SXT StLOS until the central dot on the reticle of target number 3 approaches the vertical crosshair on the SXT reticle. Press the MARK pushbutton at the instant of coincidence.

22. Record the DSKY Row 2 indication on line (p) of the Data Sheet. Repeat step 21 two more times, recording the DSKY Row 2 indication for each MARK.

23. Observe the three bit counts of line (p). If two of the three counts are equal, record this count on line (q). If all three counts are different, record the count which falls between the smallest and the largest on line (q).

24. Complete lines (r), (s), (t) and (u).

25. Set the VDW to the value recorded on line (u).

26. Manipulate the Optics Hand Controller vertically to position the SXT StLOS until the central dot on the reticle of target number 3 is approaching the vertical crosshair on the SXT reticle. Press the MARK

pushbutton at the instant of coincidence.

27. Record the DSKY Row 2 indication on line (v). Repeat step 26 two more times, recording the DSKY Row 2 indication for each MARK.

28. Observe the three bit counts of line (v). If two of the three counts are equal, record this count on line (w). If all three counts are different, record the count which falls between the smallest and the largest on line (w).

29. Complete lines (x), (y), (z) and (aa).

30. Set the VDW to the value recorded on line (aa).

31. Manipulate the Optics Hand Controller vertically to position the SXT StLOS until the central dot on the reticle of target number 3 is approaching the vertical crosshair on the SXT reticle. Press the MARK pushbutton at the instant of coincidence.

32. Record the DSKY Row 2 indication on line (ab). Repeat step 31 two more times, recording the DSKY Row 2 indication for each MARK.

33. Observe the three bit counts of line (ab). If two of the three counts are equal, record this count on line (ac). If all three counts are different, record the count which falls between the smallest and the largest on line (ac).

34. Complete lines (ad), (ae), (af) and (ag).

35. Set the VDW to the value recorded on line (ag).

SUBSYSTEM G & N SYSTEM

ASSY

36. Manipulate the Optics Hand Controller vertically to position the SXT StLOS until the central dot on the reticle of target number 3 is approaching the vertical crosshair on the SXT reticle. Press the MARK pushbutton at the instant of coincidence.

37. Record the DSKY Row 2 indication on line (ah). Repeat step 36 two more times, recording the DSKY Row 2 indication for each MARK.

38. Observe the three bit counts on line (ah). If two of the three counts are equal, record this count on line (ai). If all three counts are different, record the count which falls between the smallest and the largest on line (ai).

39. Complete lines (aj), (ak), (al) and (am).

40. Set the VDW to the value recorded on line (am).

41. Manipulate the Optics Hand Controller vertically to position the SXT StLOS until the central dot on the reticle of target number 3 is approaching the vertical crosshair on the SXT reticle. Press the MARK pushbutton at the instant of coincidence.

42. Record the DSKY Row 2 indication on line (an). Repeat step 41 two more times, recording the DSKY Row 2 indication for each MARK.

43. Observe the three bit counts on line (an). If two of the three counts are equal, record this count on line (ao). If all three counts are different, record the count which

falls between the smallest and the largest on line (ao).

44. Complete lines (ap), (aq), (ar) and (as).

45. Set the VDW to the value recorded on line (as).

46. Manipulate the Optics Hand Controller vertically to position the SXT StLOS until the central dot on the reticle of target number 3 is approaching the vertical crosshair on the SXT reticle. Press the MARK pushbutton at the instant of coincidence.

47. Record the DSKY Row 2 indication on line (at). Repeat step 46 two more times, recording the DSKY Row 2 indication for each MARK.

48. Observe the three bit counts on line (at). If two of the three counts are equal, record this count on line (au). If all three counts are different, record the count which falls between the smallest and the largest on line (au).

49. Complete lines (av) and (aw).

49A. Using Optics Hand Controller, position the SXT Trunnion between 0° and 10° as indicated by the Trunnion TPAC.

NOTE: Step 50 applies to Indicator Control panel 2021290 only. Step 50A applies to all Indicator Control panels except 2021290.

50. Set OPTICS ZERO switch on Indicator Control panel to ZERO. After approximately 20 seconds, set OPTICS ZERO switch to OFF.

DATE 30 JUN 66

SUBSYSTEM G & N SYSTEM

ASSY

50A. Set OPTICS MODE switch on Indicator Control panel to ZERO. After approximately 20 seconds, set OPTICS MODE switch to MAN.

NOTE: Step 51 applies to Indicator Control panel 2021290 only. Step 51A applies to all Indicator Control panels except 2021290

51. Set OPTICS SPEED switch to HI and, using Optics Hand Controller, drive SXT until Shaft TPAC indicates approximately +27000. Return OPTICS SPEED switch to LO and manipulate Optics Hand Controller to fine position and hold SXT so Shaft TPAC indicates +27000.

51A. Set OPTICS CONTROLLER SPEED switch to HI and, using Optics Hand Controller, drive SXT until Shaft TPAC indicates approximately +27000. Return OPTICS CONTROLLER SPEED switch to LO and manipulate Optics Hand Controller to fine position and hold SXT so Shaft TPAC indicates +27000.

52. Insure that the horizontal reticle line of the SCT is coincident with the horizontal reticle line of target number 2 by adjusting the G & N Mounting Fixture cradle.

NOTE: Step 53 applies to Indicator Control panel 2021290 only. Step 53A applies to all Indicator Control panels except 2021290.

53. Set OPTICS ZERO switch on Indicator Control panel to ZERO. After approximately 20 seconds, set OPTICS ZERO switch to OFF. Set OPTICS TEL TRUN switch to 25° . The target number 2 reticle pattern shall appear to intersect the number 0 on the SCT vertical reticle line.

53A. Set OPTICS MODE switch on Indicator Control panel to ZERO. After approximately 20 seconds, set OPTICS MODE switch to MAN. Set OPTICS TELESCOPE TRUNNION switch to 25° . The target number 2 reticle pattern shall appear to intersect the number 0 on the SCT vertical reticle line.

NOTE: Step 54 applies to Indicator Control panel 2021290 only. Step 54A applies to all Indicator Control panels except 2021290.

54. Set OPTICS TEL TRUN switch to 0° . The target number 2 reticle pattern shall appear to intersect the center of the SCT reticle pattern.

54A. Set OPTICS TELESCOPE TRUNNION switch to 0° . The target number 2 reticle pattern shall appear to intersect the center of the SCT reticle pattern.

NOTE: Step 55 applies to Indicator Control panel 2021290 only. Step 55A applies to all Indicator Control panels except 2021290.

SUBSYSTEM G & N SYSTEM

ASSY

55. Set OPTICS TEL TRUN switch to SLAVE TO SXT.

55A. Set OPTICS TELESCOPE TRUNNION switch to SLAVE TO SXT.

NOTE: Step 56 applies to Indicator Control panel 2021290. Step 56A applies to all Indicator Control panels except 2021290.

56. Set OPTICS ZERO switch to ZERO. After approximately 20 seconds, set OPTICS ZERO switch to OFF.

56A. Set OPTICS MODE switch to ZERO. After approximately 20 seconds, set OPTICS MODE switch to MAN.

NOTE: Step 57 applies to Indicator Control panel 2021290 only. Step 57A applies to all Indicator Control panels except 2021290.

57. Set OPTICS SPEED switch to HI and, using Optics Hand Controller, drive SXT until Shaft TPAC indicates approximately +27000. Set OPTICS SPEED switch to LO and manipulate Optics Hand Controller to fine position and hold SXT so that Shaft TPAC indicates +27000.

57A. Set OPTICS CONTROLLER SPEED switch to HI and, using Optics Hand Controller, drive SXT until Shaft TPAC indicates approximately +27000. Set OPTICS CONTROLLER SPEED switch to LO and manipulate Optics Hand Controller to fine

position and hold SXT so that Shaft TPAC indicates +27000.

58. Insure the horizontal reticle line of the SCT is coincident with horizontal reticle line of target number 2 by adjusting the G & N Mounting Fixture cradle.

59. Sight through the SXT StLOS and, using the Optics Hand Controller, position the approximate center of the SXT StLOS reticle pattern to the number 10 resolution pattern of target number 1.

60. Sight through StLOS and LLOS and observe the number 10 and surrounding lines of target number 1 reticle. The number 10 and surrounding lines shall be clear and distinct. Record indication.

61. Position the SCT resolution card approximately 10 feet from the SCT trunnion axis.

62. Sight through the SCT LOS and, using the Optics Hand Controller, position the approximate center of the SCT LOS reticle pattern to the 3 min. resolution pattern of the resolution card.

63. Sight through the SCT and observe the number and surrounding lines on the resolution card. The number and surrounding lines shall be clear and distinct. Record indication.

64. Using Optics Hand Controller, position the SXT Trunnion between 0° and 10° as indicated by the Trunnion TPAC.

SUBSYSTEM G & N SYSTEM

ASSY

NOTE: Step 65 applies to Indicator Control panel 2021290 only. Step 65A applies to all Indicator Control panels except 2021290.

65. Set OPTICS ZERO switch to ZERO. After one minute, perform following DSKY operations:

- a. VERB 06 NOUN 55 ENTR
- b. Record Row 1 (Shaft Angle) and Row 2 (Trunnion LOS Angle) indications on lines (a) and (b) of the Data Sheet.

65A. Set OPTICS MODE switch to ZERO. After one minute, perform the following DSKY operations:

- a. VERB 06 NOUN 55 ENTR
- b. Record Row 1 (Shaft Angle) and Row 2 (Trunnion LOS Angle) indications on lines (a) and (b) of the Data Sheet.

66. Place the VDW in front of target number 1 using the VDW base which allows deviation to be measured in the vertical plane (setting knob points upward). Set VDW dial to zero.

67. Cover the SXT StLOS. Sight through the SXT LLOS and adjust the G & N Mounting Fixture until the horizontal reticle line of the SXT is coincident with the dot and horizontal reticle line of target number 1.

NOTE: If coincidence cannot be achieved in step 67 by adjusting the G & N Mounting Fixture, target number 1 may be

adjusted in azimuth as necessary to achieve coincidence.

68. Sight through the SXT LLOS and move the VDW laterally until target number 1 reticle is seen clearly. Adjust the VDW dial until the central horizontal reticle line of SXT is coincident with dot and horizontal reticle line of target number 1. Record the VDW reading on line (c). Uncover the SXT StLOS.

NOTE: If the value obtained for line (g) in step 69 is not within tolerance, perform the alternate procedure given in steps 72 through 80 to verify that an out-of-tolerance condition exists.

69. Cover the SXT LLOS. Sight through the SXT StLOS and adjust the VDW dial until the central horizontal reticle line of SXT is coincident with the dot and horizontal reticle line of target number 1. Record the VDW reading on line (e). Complete lines (d), (f), and (g). Uncover SXT LLOS.

NOTE: Step 70 applies to Indicator Control panel 2021290 only. Step 70A applies to all Indicator Control panels except 2021290.

70. Set OPTICS ZERO switch on Indicator Control panel to OFF.

SUBSYSTEM G & N SYSTEM

ASSY

70A. Set OPTICS MODE switch on Indicator Control panel to MAN.

70B. Perform the following DSKY operations:

- a. VERB 01 NOUN 10 ENTR
- b. 00077 ENTR
- c. The contents of Row 1 shall be 00000.

71. Press OPTICS POWER ON pushbutton on Test Control panel. OPTICS POWER ON pushbutton shall go out.

71A. Perform the following DSKY operations:

- a. VERB 21 NOUN 10 ENTR
- b. 00077 ENTR
- c. 00000 ENTR

ALTERNATE SXT LOS PARALLELISM PROCEDURE

72. Place the theodolite in a line coincident with the SXT LLOS and cover the SXT StLOS.

73. Level theodolite base to the plate spirit level and level the altitude spirit level. Adjust the telescope focus to infinity. Set telescope to approximately 90°. Install the portable light assembly and adapter in the SXT eyepiece assembly. While observing the theodolite image, adjust the G & N Mounting Fixture until the SXT reticle is superimposed on the theodolite horizontal filar.

74. Align the theodolite horizontal filar to the SXT reticle and record the vertical angle.

75. Reverse and plunge the theodolite telescope and repeat step 74.

76. Repeat steps 74 and 75 for seven additional pairs of readings. After each time that step 75 is completed, drive the theodolite elevation off prior to realigning to the SXT reticle.

77. Place the theodolite in a line coincident with the SXT StLOS and cover the SXT LLOS.

78. Repeat step 73.

79. Repeat steps 74, 75, and 76.

80. Complete calculations for SXT StLOS to LLOS parallelism error.

DATE 30 JUN 66

APOLLO G&N
EQUIPMENT TEST
DATA SHEET 1 OF 11

JDC NO. <u>12214</u> REV <u>Y</u> INITIAL TDRR <u>29882</u>
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JOB OPTICS POSITIONAL ACCURACY TEST

ASSEMBLY UNDER TEST			TEST HISTORY		
TITLE _____	DATE _____	START _____	END _____	SITE / LOCATION _____	
SER. NO. _____	DWG _____	REV. _____	TIME _____	START _____	END _____
			TOTAL ELAPSED _____		

MAJOR GROUND SUPPORT EQUIPMENT		
NAME _____	SER. NO. _____	CAL DATE _____
NAME _____	SER. NO. _____	CAL DATE _____

CONDUCTED BY _____	APPROVED BY _____
NAME/AFFILIATION _____	NAME/AFFILIATION _____

JDC ITEM NO.	PARAMETER	UNITS	MIN VALUE	RECORDED VALUE	MAX VALUE	REJ	ACC
11	VDW Reading of WLLOS*	deg min		_____			
	Convert line (g. 1) to sec using Calibration chart*	sec		() _____			
12	Transfer target calibration angle	deg		_____			
	ϕ_3 from JDC 12223	min		_____			
	Item C. 1 to nearest whole second	sec		_____			
	Calculate: $45^\circ -$ line (h) to nearest second	sec		() _____			
	Calculate: Line (i) + line (g. 2)	sec		() _____			
	Convert line (j) to VDW reading using calibration chart**	deg min		_____			

*VDW reading decreasing from 360° indicates (+) angle (seconds).
 VDW reading increasing from 0° indicates (-) angle (seconds).
 **If line (j) is -, add calibration chart indication to $0^\circ 0'$.
 If line (j) is +, subtract calibration chart indication from $359^\circ 60'$.

DATE 30 JUN 66

APOLLO G&N
EQUIPMENT TEST
DATA SHEET 2 OF 11

JDC
NO. 12214
REV. Y

JOB OPTICS POSITIONAL ACCURACY TEST

JDC ITEM NO.	PARAMETER	UNITS	MIN VALUE	RECORDED VALUE	MAX VALUE	REJ	ACC
17	Record CMC NAV DSKY Row 2 display * 45°	Row 2 deg bits		----- _____			
		Row 2 deg bits		----- _____			
		Row 2 deg bits		----- _____			
18	Select bit count 45°	bits	16382	_____	16386		
19	Calculate: Line (j) + 90 sec	sec		() _____			
	Convert Line (n) to VDW reading using calibration chart**	deg min		_____ _____			
22	Record CMC NAV DSKY Row 2 Display *45° (+90")	Row 2 deg bits		----- _____			
		Row 2 deg bits		----- _____			
		Row 2 deg bits		----- _____			

(l)

(m)

(n)

(o)

(p)

*Multiply CMC DSKY Row 2 x 364.09 to convert to bits.
**If line (n) is -, add calibration chart indication to 0°0'.
If line (n) is +, subtract calibration chart indication from 359°60'.

DATE 30 JUN 66

APOLLO G&N
EQUIPMENT TEST
DATA SHEET 3 OF 11

JDC
NO. <u>12214</u>
REV. <u>Y</u>

JOB OPTICS POSITIONAL ACCURACY TEST

JDC ITEM NO.	PARAMETER	UNITS	MIN VALUE	RECORDED VALUE	MAX VALUE	REJ	ACC	
23	Select bit count 45° (+90")	bits						(q)
24	Calculate: Line (m) +00009 bits	bits		() _____				(r)
	Calculate: Line (q) - Line (r) G & N Accuracy Bits 45° (+90")	bits	-2	() _____	+2			(s)
	Calculate: Line (j) +30 sec	sec		() _____				(t)
	Convert Line (t) to VDW reading using calibration chart**	deg min		_____ _____				(u)
27	Record CMC NAV	Row 2						(v)
	DSKY Row 2 display * 45° (+30")	deg bits		_____._____ _____				
		Row 2 deg bits		_____._____ _____				
		Row 2 deg bits		_____._____ _____				

*Multiply CMC DSKY Row 2 x 364.09 to convert to bits.
**If line (t) is -, add calibration chart indication to 0°0'.
If line (t) is +, subtract calibration chart indication from 359°60'.

DATE 30 JUN 66

APOLLO G&N
EQUIPMENT TEST
DATA SHEET 4 OF 11

JDC	NO. <u>12214</u>
REV. <u>Y</u>	

JOB OPTICS POSITIONAL ACCURACY TEST

JDC ITEM NO.	PARAMETER	UNITS	MIN VALUE	RECORDED VALUE	MAX VALUE	REJ	ACC
28	Select bit count 45° (+30")	bits		_____			
29	Calculate: Line (m) +00003 bits	bits		() _____			
	Calculate: Line (w) - Line (x) G & N Accuracy BITS 45° (+30")	bits	-2	() _____	+2		
	Calculate: Line (j) -60 sec	sec		() _____			
	Convert Line (z) to VDW reading using calibration chart**	deg min		_____ _____			
32	Record CMC NAV DSKY Row 2 display * 45° (+60")	Row 2		_____			
		deg		_____			
		bits		_____			
		Row 2		_____			
		deg		_____			
		bits		_____			
33	Select bit count 45° (+60")	bits		_____			

(w)

(x)

(y)

(z)

(aa)

(ab)

(ac)

*Multiply CMC DSKY Row 2 x 364.09 to convert to bits.
**If line (z) is -, add calibration chart indication to 0°0'.
If line (z) is +, subtract calibration chart indication from 359°60'.

DATE 30 JUN 66

APOLLO G&N
EQUIPMENT TEST
DATA SHEET 5 OF 11

JDC
NO. <u>12214</u>
REV. <u>Y</u>

JOB OPTICS POSITIONAL ACCURACY TEST

JDC ITEM NO.	PARAMETER	UNITS	MIN VALUE	RECORDED VALUE	MAX VALUE	REJ	ACC	
34	Calculate: Line (m) + 00006 bits	bits		() _____				(ad)
	Calculate: Line (ac) - Line (ad) G & N Accuracy BITS 45° (+60")	bits	-2	() _____	+2			(ae)
	Calculate: Line (j) - 30 sec	sec		() _____				(af)
	Convert Line (af) to VDW reading using calibration chart**	deg min		_____ _____				(ag)
37	Record CMC NAV DSKY Row 2 display * 45° (-30")	Row 2 deg bits		_____._____ _____				(ah)
		Row 2 deg bits		_____._____ _____				
		Row 2 deg bits		_____._____ _____				
38	Select bit count 45° (-30")	bits		_____				(ai)

*Multiply CMC DSKY Row 2 x 364.09 to convert to bits.

**If line (af) is -, add calibration chart indication to 0°0'.

If line (af) is +, subtract calibration chart indication from 359°60'.

DATE 30 JUN 66

APOLLO G&N
EQUIPMENT TEST
DATA SHEET 6 OF 11

JDC	NO. <u>12214</u>
REV. <u>Y</u>	

JOB OPTICS POSITIONAL ACCURACY TEST

JDC ITEM NO.	PARAMETER	UNITS	MIN VALUE	RECORDED VALUE	MAX VALUE	REJ	ACC
39	Calculate: Line (m) -00003 bits	bits		() _____			
	Calculate: Line (ai) - Line (aj) G & N Accuracy BITS 45° (-30")	bits	-2	() _____	+2		
	Calculate: Line (j) -90 sec	sec		() _____			
	Convert Line (al) to VDW reading using calibration chart**	deg min		_____ _____			
42	Record CMC NAV DSKY Row 2 display * 45° (-90")	Row 2 deg bits		_____ _____			
		Row 2 deg bits		_____ _____			
		Row 2 deg bits		_____ _____			

*Multiply CMC DSKY Row 2 x 364.09 to convert to bits.
 **If line (al) is -, add calibration chart indication to 0°0'.
 If line (al) is +, subtract calibration chart indication from 359°60'. DATE 30 JUN 66

APOLLO G&N
EQUIPMENT TEST
DATA SHEET 7 OF 11

JDC
NO. <u>12214</u>
REV. <u>Y</u>

JOB OPTICS POSITIONAL ACCURACY TEST

JDC ITEM NO.	PARAMETER	UNITS	MIN VALUE	RECORDED VALUE	MAX VALUE	REJ	ACC	
43	Select bit count 45° (-90")	bits		_____				(ao)
44	Calculate: Line (m) -00009 bits	bits		() _____				(ap)
	Calculate: Line (ao) - Line (ap) G & N Accuracy BITS 45° (-90")	bits	-2	() _____	+2			(aq)
	Calculate: Line (j) -60 sec	sec		() _____				(ar)
	Convert Line (ar) to VDW reading using calibration chart**	deg min		_____ _____				(as)
47	Record CMC NAV	Row 2		_____				(at)
	DSKY Row 2 display *	deg bits		_____._____ _____				
	45° (-60")	Row 2 deg bits		_____._____ _____				
		Row 2 deg bits		_____._____ _____				

*Multiply CMC DSKY Row 2 x 364.09 to convert to bits.

**If line (ar) is -, add calibration chart indication to 0°0'.

If line (ar) is +, subtract calibration chart indication from 359°60'.

DATE 30 JUN 66

APOLLO G&N
EQUIPMENT TEST
DATA SHEET 8 OF 11

JDC
NO. 12214
REV. Y

JOB OPTICS POSITIONAL ACCURACY TEST

JDC ITEM NO.	PARAMETER	UNITS	MIN VALUE	RECORDED VALUE	MAX VALUE	REJ	ACC
48	Select bit count 45° (-60')	bits		_____			
49	Calculate: Line (m) -00006 bits	bits		() _____			
	Calculate: Line (au) - Line (av) G & N Accuracy BITS 45° (-60")	bits	-2	() _____	+2		
53 or 53A	SCT (Offset 25°)			Reacted as Specified			
54 or 54A	SCT Comparison (Offset 0°)			Reacted as Specified			
60	Image resolution		clear and distinct				
63	Image resolution		clear and distinct				
65 or 65A	DSKY Row 2 display (Trunnion angle)	deg	-00007	() _____	+00006		
	DKSY Row 1 display (Shaft angle)	deg	-00003	() _____	+00002		
68	VDW Reading of WLLOS*	deg min		_____ _____			

*VDW reading decreasing from 360° indicates (+) angle (seconds)
VDW reading increasing from 0° indicates (-) angle (seconds)

DATE 30 JUN 66

APOLLO G&N
EQUIPMENT TEST
DATA SHEET 9 OF 11

JDC	
NO.	<u>12214</u>
REV.	<u>Y</u>

JOB OPTICS POSITIONAL ACCURACY TEST

JDC ITEM NO.	PARAMETER	UNITS	MIN VALUE	RECORDED VALUE	MAX VALUE	REJ	ACC
69	Convert line (c) to sec using Calibration chart*	sec		() _____			
	VDW Reading of WSTLOS*	deg min		_____ _____			
	Convert line (e) to sec using calibration chart*	sec		() _____			
	Calculate: Line (f) - Line (d) - Vertical Error from JDC 19128, step B.19. StLOS-LLOS parallelism	sec	-10	() _____	+10		

(d)
(e)
(f)
(g)

*VDW reading decreasing from 360° indicates (+) angle (seconds)
VDW reading increasing from 0° indicates (-) angle (seconds)

DATE 30 JUN 66

APOLLO G&N
EQUIPMENT TEST
DATA SHEET 10 OF 11

JDC	
NO.	12214
REV.	Y

JOB OPTICS POSITIONAL ACCURACY TEST

JDC ITEM NO.	RECORDED VALUES		
74, 75	$\Delta 1 - \underline{90^{\circ} \quad 00' \quad 00.0''}$	$\Delta 2 - \underline{270^{\circ} \quad 00' \quad 00.0''}$	$\Delta 3 - \underline{270^{\circ} \quad 00' \quad 00.0''}$
	$\Delta 4 - \underline{90^{\circ} \quad 00' \quad 00.0''}$	$\Delta 5 - \underline{90^{\circ} \quad 00' \quad 00.0''}$	$\Delta 6 - \underline{270^{\circ} \quad 00' \quad 00.0''}$
	$\Delta 7 - \underline{270^{\circ} \quad 00' \quad 00.0''}$	$\Delta 8 - \underline{90^{\circ} \quad 00' \quad 00.0''}$	$\Delta 9 - \underline{90^{\circ} \quad 00' \quad 00.0''}$
	$\Delta 10 - \underline{270^{\circ} \quad 00' \quad 00.0''}$	$\Delta 11 - \underline{270^{\circ} \quad 00' \quad 00.0''}$	$\Delta 12 - \underline{90^{\circ} \quad 00' \quad 00.0''}$
	$\Delta 13 - \underline{90^{\circ} \quad 00' \quad 00.0''}$	$\Delta 14 - \underline{270^{\circ} \quad 00' \quad 00.0''}$	$\Delta 15 - \underline{270^{\circ} \quad 00' \quad 00.0''}$
	$\Delta 16 - \underline{90^{\circ} \quad 00' \quad 00.0''}$		
	$\frac{\Sigma \Delta}{16} = \underline{\hspace{2cm}}$		

APOLLO G&N
EQUIPMENT TEST
DATA SHEET 11 OF 11

JDC NO. <u>12214</u> REV. <u>Y</u>
--

JOB OPTICS POSITIONAL ACCURACY TEST

JDC ITEM NO.	RECORDED VALUES			
79	$\Delta 1 - \begin{matrix} \circ & ' & '' \\ 90^\circ & 00' & 00.0'' \end{matrix}$	$\Delta 2 - \begin{matrix} 270^\circ & 00' & 00.0'' \\ \circ & ' & '' \end{matrix}$	$\Delta 3 - \begin{matrix} 270^\circ & 00' & 00.0'' \\ \circ & ' & '' \end{matrix}$	
	$\Delta 4 - \begin{matrix} \circ & ' & '' \\ 90^\circ & 00' & 00.0'' \end{matrix}$	$\Delta 5 - \begin{matrix} \circ & ' & '' \\ 90^\circ & 00' & 00.0'' \end{matrix}$	$\Delta 6 - \begin{matrix} 270^\circ & 00' & 00.0'' \\ \circ & ' & '' \end{matrix}$	
	$\Delta 7 - \begin{matrix} 270^\circ & 00' & 00.0'' \\ \circ & ' & '' \end{matrix}$	$\Delta 8 - \begin{matrix} \circ & ' & '' \\ 90^\circ & 00' & 00.0'' \end{matrix}$	$\Delta 9 - \begin{matrix} \circ & ' & '' \\ 90^\circ & 00' & 00.0'' \end{matrix}$	
	$\Delta 10 - \begin{matrix} 270^\circ & 00' & 00.0'' \\ \circ & ' & '' \end{matrix}$	$\Delta 11 - \begin{matrix} 270^\circ & 00' & 00.0'' \\ \circ & ' & '' \end{matrix}$	$\Delta 12 - \begin{matrix} \circ & ' & '' \\ 90^\circ & 00' & 00.0'' \end{matrix}$	
	$\Delta 13 - \begin{matrix} \circ & ' & '' \\ 90^\circ & 00' & 00.0'' \end{matrix}$	$\Delta 14 - \begin{matrix} 270^\circ & 00' & 00.0'' \\ \circ & ' & '' \end{matrix}$	$\Delta 15 - \begin{matrix} 270^\circ & 00' & 00.0'' \\ \circ & ' & '' \end{matrix}$	
	$\Delta 16 - \begin{matrix} \circ & ' & '' \\ 90^\circ & 00' & 00'' \end{matrix}$			
	80	$\Sigma \Delta (72) =$		
		$\Sigma \Delta (67, 68) =$	- _____	StLOS/LLOS Parallelism
	Tolerance: -10 minimum, +10 maximum			

DATE 30 JUN 66

**BLOCK II SIGNAL CONDITIONER
JOB FUNCTIONAL CHECKOUT**

JDC 12224 REV. N PAGE 1 OF 15
INITIAL T.D.R.R. 32758 D.S. PGS 9

SUBSYSTEM G & N SYSTEM

ASSY.

DESCRIPTION This JDC provides a functional checkout procedure for the Signal Conditioner Assembly. Functional operation is evaluated by checking Signal Conditioner Assembly input and output data for proper correlation. Procedural methods are incorporated to cause signal generation in normally nulled loops where possible in a G & N test configuration for maximum checkout capability.

Rev. Let.	Date	TDRR NO.	PAGES REVISED		APPROVAL		REFERENCES
			JDC	D. S.	MIT	NASA	
A	8-10-67	34330	All	All	EA	-	PS 2015000 JDC 12204
B	9-6-67	34560	1	-	EA	-	
C	9-22-67	34705	1, 2, 4	2	EA	-	IMPORTANT
D	10-12-67	34827	2, 4, 6, 7, 8	-	EA	-	See below
E	11-9-67	35020	1-9	1-3, 5, 7	EA	-	
F	1-16-68	35449	7	-	EA	-	INTERVAL
G	4-5-68	36040	4, 5	3, 7	EA	-	
H	4-29-68	36123	1, 4, 8	5	EA	-	TOOLS AND MATERIAL
J	6-17-68	36351	1, 4, 5	3	EA	-	Decade Inductance, General Radio
K	12-27-68	37152	All	All	EA	-	1490F or equivalent
L	3-11-69	37410	1	-	EA	-	
M	5-26-70	38134	1, 15	-	EA	-	
N	6-28-71	38439	2	-	EA	-	

IMPORTANT: 1. Avoid slewing of SXT shaft and trunnion axes into their mechanical stops.

2. Insure that cable W226 is removed and connector assembly (2003099) or Restart Monitor module (2898989) is connected to CGC test connector before proceeding with this JDC. NOTE: The items marked with an asterisk (*) are applicable only for SCA P/N 2007035 and are to be omitted for SCA P/N 2007234.

NOTE: Do not command zero optics from a trunnion angle greater than 10°.

A. PREPARATION

1. Perform JDC 12204 to downmode to OIA PILOT POWER mode.
2. Position SCA in cutout above DSKY on right side of cradle front panel assembly with SCA connectors facing bracket assembly, P/N 2900919, and attach with six captive screws. Torque screws finger tight.
3. Position SCA Deutsch connectors J1, J2, and J3 in bracket assembly (observe placarding on bracket assembly for connector locations) and attach with hex nuts

VERIFICATION WITH SIDL REQUIRED BEFORE USE

DATE 26 JAN 67

SUBSYSTEM G & N SYSTEM

ASSY

supplied with each connector. Torque hex nuts finger tight.

CAUTION: Extreme care must be exercised when mating connectors to prevent pin and jack damage.

4. Connect GNF harness connectors P7, P8, and P9 to SCA connectors J2, J1, and J3, respectively.

5. Perform JDC 12204 to advance system to ISS Operate mode.

6. Set CROSSBAR CONTROL on Primary Signal Selector panel to 173.

7. Adjust G&N POWER ADJUST control on Test Control panel until Digital Voltmeter (DVM) indicates 28.8 (± 0.25) vdc.

8. Press to light OPTICS POWER ON pushbutton on Test Control panel.

NOTE: Step 8A applies only when Restart Monitor module (2898989) is installed.

8A. Perform the following DSKY operations:

- a. VERB 21 NOUN 10 ENTR
- b. 00077 ENTR
- c. 00000 ENTR

9. Perform following switch settings on applicable Indicator Control panel:

a. On Indicator Control panel 2021290 only set -

(1) OPTICS ZERO to OFF then to ZERO

(2) OPTICS TEL TRUN to SLAVE TO SXT

(3) OPTICS COUPLING to DIRECT

(4) OPTICS MODE to MAN

(5) OPTICS SPEED to LO

b. On all Indicator Control panels except 2021290 set -

(1) OPTICS MODE to MAN then to ZERO

(2) OPTICS CONTROLLER SPEED to LO

(3) OPTICS CONTROLLER COUPLING to DIRECT

(4) OPTICS TRACKER to OFF

(5) OPTICS TELESCOPE TRUNNION to SLAVE TO SXT

B. PROCEDURE

28 VDC STANDBY AND OPERATE

1. Connect SCA GSE Distribution Box (GDB) stepper switch to DVM by setting CROSSBAR CONTROL on Primary Signal Selector panel to 271.

NOTE: To position Test Selector panel, perform following operations:

a. Press SIGNAL

CONDITIONER LEVEL 1

ENABLE pushbutton if

first digit of Test Se-

lector panel position is

1, or press SIGNAL

CONDITIONER LEVEL 2

ENABLE pushbutton if

first digit is 2.

b. Press PUSH TO

ADVANCE pushbutton

until display indicates last

SUBSYSTEM G & N SYSTEM

ASSY

17. Set CHART DRIVE switch on Oscillograph Control panel to OFF. Record Z PIPA loop closure test results as satisfactory if loop closure indication on channel 8 (SCA output) corresponds to loop closure indication on channel 4 (SCA input).

18. Set Test Selector panel to 118 to monitor Y PIPA G/S in-phase output on channels 5 and 8.

19. Set CHART DRIVE switch on Oscillograph Control panel to MM/SEC.

NOTE: Ignore all lamp indications which occur during performance of step 20.

20. Enter VERB 35 into DSKY and press ENTR pushbutton.

21. Observe channel 8 for indication of PIPA loop opening for approximately 30 seconds and then closing.

22. Set CHART DRIVE switch on Oscillograph Control panel to OFF. Record Y PIPA loop closure test results as satisfactory if loop closure indication on channel 8 (SCA output) corresponds to loop closure indication on channel 5 (SCA input).

23. Set Test Selector panel to 119 to monitor X PIPA G/S in-phase output on channels 6 and 8.

24. Set CHART DRIVE switch on Oscillograph Control panel to MM/SEC.

NOTE: Ignore all lamp indications which occur during performance of step 25.

25. Enter VERB 35 into DSKY and press ENTR pushbutton.

26. Observe channel 8 for indication of PIPA loop opening for approximately 30 seconds and then closing.

27. Set CHART DRIVE switch on Oscillograph Control panel to OFF. Record X PIPA loop closure test results as satisfactory if loop closure indication on Channel 8 (SCA output) corresponds to loop closure indication on channel 6 (SCA input).

28. Perform following DSKY operations:

a. VERB 41 NOUN 20 ENTR

b. Observe:

VERB 21 NOUN 22 Flashing

c. +00000 ENTR

d. Observe:

VERB 22 NOUN 22 Flashing

e. -22500 ENTR

f. Observe:

VERB 23 NOUN 22 Flashing

g. -03500 ENTR

29. Repeat steps 13 through 27 and then set all Oscillograph Amplifier sensitivities to OFF.

POWER SUPPLY AND TEMPERATURE

30. Set CROSSBAR CONTROL on Primary Signal Selector panel to 259 and measure and record 120 vdc PIPA supply voltage on DVM. (SCA input.)

31. Set CROSSBAR CONTROL to 271.

32. Set Test Selector panel to 103 and measure and record 120 vdc PIPA supply voltage on DVM. (SCA output.)

DATE _____

BLOCK II SIGNAL CONDITIONER
FUNCTIONAL CHECKOUT

JOB

JDC 12224 REV N PAGE 5 OF 15

SUBSYSTEM G & N SYSTEM

ASSY

33. Set Test Selector panel to 104 and measure and record 2.5 vdc TM bias voltage on DVM.
34. Set CROSSBAR CONTROL on Primary Signal Selector panel to 123 and measure and record 28 volt 3200 cps supply voltage on DVM. (SCA input.)
35. Set CROSSBAR CONTROL to 271.
36. Set Test Selector panel to 106 and measure and record 28 volt 3200 cps supply voltage on DVM. (SCA output.)
37. Set CROSSBAR CONTROL on Primary Signal Selector panel to 121 and measure and record IMU 28 volt 800 cps 1% supply voltage on DVM. (SCA input.)
38. Set CROSSBAR CONTROL to 271.
39. Set Test Selector panel to 113 and measure and record IMU 28 volt 800 cps 1% supply voltage on DVM. (SCA output.)
- *40. Set CROSSBAR CONTROL on Primary Signal Selector panel to 101 and measure and record optics 28 volt 800 cps 1% supply voltage on DVM. (SCA input.)
- *41. Set CROSSBAR CONTROL to 271.
- *42. Set Test Selector panel to 128 and measure and record optics 28 volt 800 cps 1% supply voltage on DVM. (SCA output.)
43. Set CROSSBAR CONTROL on Primary Signal Selector panel to 255 and measure and record PIPA temperature on DVM. (SCA input.)
44. Set CROSSBAR CONTROL to 271.
45. Set Test Selector panel to 201 and

measure and record PIPA temperature on DVM. (SCA output.)

*46. Set CROSSBAR CONTROL on Primary Signal Selector panel to 156 and measure and record IRIG temperature on DVM. (SCA input.)

*47. Set CROSSBAR CONTROL to 271.

*48. Set Test Selector panel to 202 and measure and record IRIG temperature on DVM. (SCA output.)

NOTE: SCM TEST

TMC INHIBIT lamp

on Temperature

Monitor Control

panel will light when-

ever PIPA or IRIG

temperature monitor

is selected (steps 43

through 48). Ignore

lamp indication.

*49. Set CROSSBAR CONTROL on Primary Signal Selector panel to 299.

*50. Connect PSA TPA direct probes to TB4-21 (high) and TB5-22 (low) and measure and record IMU heater current on DVM. (SCA input.)

*51. Set CROSSBAR CONTROL on Primary Signal Selector panel to 271.

*52. Set Test Selector panel to 150 and measure and record IMU heater current on DVM. (SCA output.)

*53. Set CROSSBAR CONTROL on Primary Signal Selector panel to 299.

DATE _____

SUBSYSTEM G & N SYSTEM

ASSY

NOTE: An indication may or may not be present during performance of steps 54 and 56 depending upon blower cycling.

*54. Connect PSA TPA direct probes to TB4-20 (high) and TB5-33 (low) and measure and record IMU blower current on DVM. (SCA input.)

*55. Set CROSSBAR CONTROL on Primary Signal Selector panel to 271.

*56. Set Test Selector panel to 151 and measure and record IMU blower current on DVM. (SCA output.)

IG, MG, AND OG SERVO ERRORS

57. Perform following DSKY operations:

- a. VERB 36 ENTR
- b. VERB 41 NOUN 20 ENTR
- c. Observe:
 VERB 21 NOUN 22 Flashing
- d. +00000 ENTR
- e. Observe:
 VERB 22 NOUN 22 Flashing
- f. +00000 ENTR
- g. Observe:
 VERB 23 NOUN 22 Flashing
- h. +00000 ENTR

58. Set switches on Signal Generator as follows:

- RANGE to X 0.1
- FREQUENCY meter to 2
- FUNCTION to SQUARE
- DC BALANCE to mid position
- AMPLITUDE TO 70

59. Perform following DSKY operations:

- a. VERB 42 ENTR
- b. VERB 33 ENTR

60. Set FUNCTION control on PAVM to 0° and FREQUENCY control to 3200 ~.

61. Press to light GIMBAL SERVO TEST pushbutton on Test Selector panel.

62. Set CROSSBAR CONTROL on Primary Signal Selector panel to 135 to monitor IG servo error on PAVM.

63. Connect decade inductance to PSA TPA test points TB5-32 (high) and TB5-40 (low).

64. Set GIMBAL SERVO TEST switch on Test Selector panel to 1.

65. Set Test Selector panel to 137.

66. Press to light TEST START pushbutton.

67. Set SCOPE "A" INPUT SIGNAL switch on Primary Signal Selector panel to SIG 1 and SCOPE "A" INPUT REFERENCE switch to 3.

68. Monitor lissajous pattern on Oscilloscope and adjust decade inductance until lissajous pattern indicates minimum phase shift.

69. Measure and record both right and left maximum meter deflection of PAVM. Add the absolute values and record result as maximum meter spread. (SCA input.)

70. Set CROSSBAR CONTROL on Primary Signal Selector panel to 271 and measure and record both high and low

SUBSYSTEM G & N SYSTEM

ASSY

voltage indications on DVM. Subtract low voltage from high voltage and record result as maximum meter spread. (SCA output.)

71. Press TEST STOP pushbutton on Test Selector panel. TEST START pushbutton shall go out.

72. Calculate IG servo error SCA output to IG servo error SCA input as follows.

Record result:

IG servo error =

$$\frac{\text{Step 70, max meter spread}}{\text{Step 69, max meter spread}} = 0.91 (\pm 15\%)$$

73. Set CROSSBAR CONTROL on Primary Signal Selector panel to 134 to monitor MG servo error on PAVM.

74. Connect decade inductance to PSA TPA test points TB5-41 (high) and TB5-40 (low).

75. Set GIMBAL SERVO TEST switch on Test Selector panel to 2.

76. Set Test Selector panel to 138.

77. Press to light TEST START pushbutton.

78. Monitor lissajous pattern on Oscilloscope and adjust decade inductance until lissajous pattern indicates minimum phase shift.

79. Measure and record both right and left maximum meter deflection of PAVM. Add the absolute values and record result as maximum meter spread. (SCA input.)

80. Set CROSSBAR CONTROL on Primary Signal Selector panel to 271 and measure and record both high and low voltage indications on DVM. Subtract low voltage from high voltage and record result as maximum meter spread. (SCA output.)

81. Press TEST STOP pushbutton on Test Selector panel. TEST START pushbutton shall go out.

82. Calculate MG servo error SCA output to MG servo error SCA input as follows.

Record result:

MG servo error =

$$\frac{\text{Step 80, max meter spread}}{\text{Step 79, max meter spread}} = 0.91 (\pm 15\%)$$

83. Set CROSSBAR CONTROL on Primary Signal Selector panel to 133 to monitor OG servo error on PAVM.

84. Connect decade inductance to PSA TPA test points TB5-31 (high) and TB5-40 (low).

85. Set GIMBAL SERVO TEST switch on Test Selector panel to 3.

86. Set Test Selector panel to 139.

87. Press to light TEST START pushbutton.

88. Monitor lissajous pattern on Oscilloscope and adjust decade inductance until lissajous pattern indicates minimum phase shift.

SUBSYSTEM G & N SYSTEM

ASSY

89. Measure and record both right and left maximum meter deflection of PAVM. Add the absolute values and record result as maximum meter spread. (SCA input.)

90. Set CROSSBAR CONTROL on Primary Signal Selector panel to 271 and measure and record both high and low voltage indications on DVM. Subtract low voltage from high voltage and record result as maximum meter spread. (SCA output.)

91. Press TEST STOP pushbutton on Test Selector panel. TEST START pushbutton shall go out.

92. Calculate OG servo error SCA output to OG servo error SCA input as follows.

Record result:

OG servo error =

$$\frac{\text{Step 90, max meter spread}}{\text{Step 89, max meter spread}} = 0.91 (\pm 15\%)$$

93. Press to extinguish GIMBAL SERVO TEST pushbutton on Test Selector panel. IG, MG, AND OG TORQUE MOTOR CURRENTS

*94. Insure that AMPLITUDE control on Signal Generator is set to 0.

*95. Connect jumper between PROBES OUTPUT DIRECT jacks and CH6DC IN jacks on Auxiliary Input panel.

*96. Set OSCILLOGRAPH SELECTOR CHANNEL 6 switch on Oscillograph Signal Selector panel to 15.

*97. Insure that CH6DC indicator is lighted.

*98. Zero Oscillograph channel 6 and set sensitivity to 0.1 V/CM. Set sensitivity of channel 8 to 1 V/CM and zero adjust channel 8 trace as near center as possible with a 2.5 vdc bias input.

*99. Set FREQUENCY meter on Signal Generator to 1 and RANGE switch to X1.

*100. Set CHART DRIVE switch on Oscillograph Control panel to MM/SEC.

*101. Set CROSSBAR CONTROL on Primary Signal Selector panel to 176 to monitor Signal Generator output on Oscilloscope.

*102. Press to light GIMBAL SERVO TEST pushbutton on Test Selector panel.

*103. Connect PSA TPA direct probes to TB2-31 (high) and TB1-49 (low) to monitor IG torque motor current on channel 6. (SCA input.)

*104. Set Test Selector panel to 132 and GIMBAL SERVO TEST switch to 1 to monitor IG torque motor current on channel 8. (SCA output.)

*105. Press to light TEST START pushbutton.

*106. Increase Signal Generator AMPLITUDE control until Oscilloscope indicates 2 volts peak-to-peak. Maintain Signal Generator AMPLITUDE control setting for approximately 10 seconds, then set AMPLITUDE control to 0.

*107. Press TEST STOP pushbutton on Test Selector panel. TEST START pushbutton shall go out.

DATE 26 JAN 67

SUBSYSTEM G & N SYSTEM

ASSY

*108. Set CHART DRIVE switch on Oscillograph Control panel to CM/HR. Measure and record peak-to-peak SCA input signal monitored on channel 6 and peak-to-peak SCA output signal monitored on channel 8.

*109. Set CHART DRIVE switch on Oscillograph Control panel to MM/SEC.

*110. Connect PSA TPA direct probes to TB2-32 (high) and TB1-49 (low) to monitor MG torque motor current on channel 6. (SCA input.)

*111. Press to light TEST START pushbutton.

*112. Increase Signal Generator AMPLITUDE control until Oscilloscope indicates 1 volt peak-to-peak. Maintain Signal Generator AMPLITUDE control setting for approximately 10 seconds, then set AMPLITUDE control to 0.

*113. Press TEST STOP pushbutton on Test Selector panel. TEST START pushbutton shall go out.

*114. Set CHART DRIVE switch on Oscillograph Control panel to CM/HR. Measure and record peak-to-peak SCA input signal monitored on channel 6 and peak-to-peak SCA output signal monitored on channel 8.

*115. Set CHART DRIVE switch on Oscillograph Control panel to MM/SEC.

*116. Connect PSA TPA direct probes to TB1-45 (high) and TB1-49 (low) to monitor OG torque motor current on channel 6. (SCA input.)

*117. Press to light TEST START pushbutton.

*118. Increase Signal Generator AMPLITUDE control until Oscilloscope indicates 1 volt peak-to-peak. Maintain Signal Generator AMPLITUDE control setting for approximately 10 seconds, then set AMPLITUDE control to 0.

*119. Press TEST STOP pushbutton on Test Selector panel. TEST START pushbutton shall go out.

*120. Set CHART DRIVE switch on Oscillograph Control panel to CM/HR. Measure and record peak-to-peak SCA input signal monitored on channel 6 and peak-to-peak SCA output signal monitored on channel 8.

*121. Set GIMBAL SERVO TEST switch on Test Selector panel to OFF. Set CHART DRIVE switch on Oscillograph Control panel to OFF and set sensitivities on Oscillograph Amplifiers to OFF.

1X RESOLVER SIN AND COS

122. Perform following DSKY operations:

- a. VERB 41 NOUN 20 ENTR
- b. Observe:
VERB 21 NOUN 22 Flashing
- c. +04500 ENTR
- d. Observe:
VERB 22 NOUN 22 Flashing
- e. +04500 ENTR
- f. Observe:
VERB 23 NOUN 22 Flashing
- g. +04500 ENTR

SUBSYSTEM G & N SYSTEM

ASSY

123. Set CROSSBAR CONTROL on Primary Signal Selector panel to 243 and measure and record IG 1X resolver cos voltage indicated on DVM. (SCA input.)

124. Set CROSSBAR CONTROL on Primary Signal Selector panel to 271 and set Test Selector panel to 120. Measure and record IG 1X resolver cos voltage indicated on DVM. (SCA output.)

125. Calculate SCA output IG 1X resolver cos to SCA input IG 1X resolver cos as follows. Record result:

IG 1X resolver cos =

$$\frac{8.1 \text{ (Step 124 - Step 33)}}{\text{Step 123}} = 1 (\pm 10\%)$$

Step 123

126. Set Test Selector panel to 121 and measure and record MG 1X resolver cos voltage indicated on DVM. (SCA output.)

127. Set CROSSBAR CONTROL on Primary Signal Selector panel to 242 and measure and record MG 1X resolver cos voltage indicated on DVM. (SCA input.)

128. Calculate SCA output MG 1X resolver cos to SCA input MG 1X resolver cos as follows. Record result:

MG 1X resolver cos =

$$\frac{8.1 \text{ (Step 126 - Step 33)}}{\text{Step 127}} = 1 (\pm 10\%)$$

Step 127

129. Set CROSSBAR CONTROL on Primary Signal Selector panel to 241 and measure and record OG 1X resolver cos voltage indicated on DVM. (SCA input.)

130. Set CROSSBAR CONTROL on Primary Signal Selector panel to 271 and set Test Selector panel to 122. Measure and record OG 1X resolver cos voltage indicated on DVM. (SCA output.)

131. Calculate SCA output OG 1X resolver cos to SCA input OG 1X resolver cos as follows. Record result:

OG 1X resolver cos =

$$\frac{8.1 \text{ (Step 130 - Step 33)}}{\text{Step 129}} = 1 (\pm 10\%)$$

Step 129

132. Set Test Selector panel to 123 and measure and record IG 1X resolver sin voltage indicated on DVM. (SCA output.)

133. Set CROSSBAR CONTROL on Primary Signal Selector panel to 144 and measure and record IG 1X resolver sin voltage indicated on DVM. (SCA input.)

134. Calculate SCA output IG 1X resolver sin to SCA input IG 1X resolver sin as follows. Record result:

IG 1X resolver sin =

$$\frac{8.1 \text{ (Step 132 - Step 33)}}{\text{Step 133}} = 1 (\pm 10\%)$$

Step 133

135. Set CROSSBAR CONTROL on Primary Signal Selector panel to 143 and measure and record MG 1X resolver sin voltage indicated on DVM. (SCA input.)

136. Set CROSSBAR CONTROL on Primary Signal Selector panel to 271 and set Test Selector panel to 124. Measure and record MG 1X resolver sin voltage indicated on DVM. (SCA output.)

BLOCK II SIGNAL CONDITIONER
FUNCTIONAL CHECKOUT

JOB

JDC 12224 REV N PAGE 11 OF 15

SUBSYSTEM G & N SYSTEM

ASSY

137. Calculate SCA output MG 1X resolver sin to SCA input MG 1X resolver sin as follows. Record result:

$$\frac{\text{MG 1X resolver sin} = 8.1 \text{ (Step 136 - Step 33)}}{\text{Step 135}} = 1 (\pm 10\%)$$

138. Set Test Selector panel to 125 and measure and record OG 1X resolver sin voltage indicated on DVM. (SCA output.)

139. Set CROSSBAR CONTROL on Primary Signal Selector panel to 142 and measure and record OG 1X resolver sin voltage indicated on DVM (SCA input.)

140. Calculate SCA output OG 1X resolver sin to SCA input OG 1X resolver sin as follows. Record result:

$$\frac{\text{OG 1X resolver sin} = 8.1 \text{ (Step 138 - Step 33)}}{\text{Step 139}} = 1 (\pm 10\%)$$

141. Perform following DSKY operations:

- a. VERB 41 NOUN 20 ENTR
- b. Observe:
VERB 21 NOUN 22 Flashing
- c. +00000 ENTR
- d. Observe:
VERB 22 NOUN 22 Flashing
- e. +00000 ENTR
- f. Observe:
VERB 23 NOUN 22 Flashing
- g. +00000 ENTR

SHAFT AND TRUNNION CDU FINE ERROR

*142. Enter VERB 06 NOUN 55 into DSKY and press ENTR pushbutton.

*143. Set CROSSBAR CONTROL on Primary Signal Selector panel to 271.

*144. Set Test Selector panel to 146 to connect SCA shaft CDU fine error output to DVM.

*145. Connect jumper between PROBES OUTPUT BUFFERED jacks and PAVM IN jacks on Auxiliary Input panel.

*146. Set PAVM switch on Primary Signal Selector panel to AUX.

*147. Connect PSA TPA buffered probes to TB3-23 (high) and TB3-34 (low) to connect SCA shaft CDU fine error input to PAVM.

*148. Set OPTICS ZERO switch on Indicator Control panel (Indicator Control panel 2021290 only) to OFF and set OPTICS MODE switch to MAN.

*149. Perform following DSKY operations:

- a. VERB 21 NOUN 10 ENTR
- b. 00012 ENTR
- c. 00011 ENTR

*150. Position Optics Hand Controller on Indicator Control panel to the left until PAVM indicates 1.0 vac in-phase. Record SCA output indicated on DVM.

*151. Set OPTICS ZERO switch on Indicator Control panel 2021290 to ZERO. On all Indicator Control panels except 2021290, set OPTICS MODE switch to ZERO.

*152. Enter VERB 06 NOUN 55 into DSKY and press ENTR pushbutton.

*153. Set Test Selector panel to 147 to connect SCA trunnion CDU fine error output to DVM.

DATE 26 JAN 67

BLOCK II SIGNAL CONDITIONER
FUNCTIONAL CHECKOUT

JOB

JDC 12224 REV N PAGE 12 OF 15

SUBSYSTEM G & N SYSTEM

ASSY

*154. Connect PSA TPA buffered probes to TB3-22 (high) and TB3-34 (low) to connect SCA trunnion CDU fine error input to PAVM.

*155. Set OPTICS ZERO switch on Indicator Control panel (Indicator Control panel 2021290 only) to OFF and set OPTICS MODE switch to MAN.

*156. Perform following DSKY operations:

- a. VERB 21 NOUN 10 ENTR
- b. 00012 ENTR
- c. 00011 ENTR

*157. Position Optics Hand Controller on Indicator Control panel to a down position until PAVM indicates 0.64 vac in-phase. Record SCA output indicated on DVM.

*158. Perform following DSKY operations:

- a. VERB 36 ENTR
- b. VERB 21 NOUN 10 ENTR
- c. 00012 ENTR
- d. 00200 ENTR
- e. VERB 21 NOUN 10 ENTR
- f. 00012 ENTR
- g. 00202 ENTR
- h. VERB 21 NOUN 01 ENTR
- i. 00053 ENTR
- j. 40000 ENTR
- k. VERB 21 NOUN 01 ENTR
- l. 00054 ENTR
- m. 40000 ENTR
- n. VERB 21 NOUN 10 ENTR
- o. 00014 ENTR
- p. 06000 ENTR

*159. Set Test Selector panel to 126 and measure and record SCA trunnion CDU DAC output indicated on DVM.

*160. Set Test Selector panel to 127 and measure and record SCA shaft CDU DAC output indicated on DVM.

*161. Perform following DSKY operations:

- a. VERB 36 ENTR
- b. VERB 21 NOUN 10 ENTR
- c. 00012 ENTR
- d. 00200 ENTR
- e. VERB 21 NOUN 10 ENTR
- f. 00012 ENTR
- g. 00202 ENTR
- h. VERB 21 NOUN 01 ENTR
- i. 00053 ENTR
- j. 37777 ENTR
- k. VERB 21 NOUN 01 ENTR
- l. 00054 ENTR
- m. 37777 ENTR
- n. VERB 21 NOUN 10 ENTR
- o. 00014 ENTR
- p. 06000 ENTR

*162. Set Test Selector panel to 126 and measure and record SCA trunnion CDU DAC output indicated on DVM.

*163. Set Test Selector panel to 127 and measure and record SCA shaft CDU DAC output indicated on DVM.

SXT AND SCT SHAFT AND TRUNNION TACH
OUTPUTS

*164. Set Test Selector panel to 129.

DATE 26 JAN 67

BLOCK II SIGNAL CONDITIONER
FUNCTIONAL CHECKOUT

JOB

JDC 12224 REV N PAGE 13 OF 15

SUBSYSTEM G & N SYSTEM

ASSY

*165. Connect following signals to Oscillograph by setting switches on Oscillograph Signal Selector panel to positions indicated:

<u>Switch</u>	<u>Signal</u>
CHANNEL 1 to 12	SXT shaft tach monitor
CHANNEL 8 to 4	SCA GDB stepper switch

*166. Zero Oscillograph channel 1 and set sensitivity to 20 MV/MM. Set sensitivity of channel 8 to 1 V/CM and zero adjust channel 8 for a centered trace with a 2.5 vdc bias input.

*167. Press CHART SPEEDS 5 pushbutton on Oscillograph Control panel and set CHART DRIVE switch to MM/SEC.

*168. Set OPTICS SPEED switch on Indicator Control panel to MED. Set OPTICS ZERO switch (Indicator Control panel 2021290 only) to OFF and set OPTICS MODE switch to MAN.

*169. Hold Optics Hand Controller to left limit not longer than 20 seconds.

*170. Set CHART DRIVE switch on Oscillograph Control panel to OFF. Record SCA SXT shaft tach input and output signals monitored on channels 1 and 8.

*171. Set Test Selector panel to 148 to connect SCA SCT shaft tach output to Oscillograph channel 8.

*172. Set CHANNEL 1 switch on Oscillograph Signal Selector panel to 13 to connect SCA SCT shaft tach input to channel 1.

*173. Zero Oscillograph channel 1 and set sensitivity to 200 MV/MM. Set sensitivity of channel 8 to 1 V/CM and zero adjust channel 8 for a centered trace with a 2.5 vdc bias input.

*174. Set CHART DRIVE switch on Oscillograph Control panel to MM/SEC.

*175. Set OPTICS SPEED switch on Indicator Control panel to HI.

*176. Hold Optics Hand Controller to right limit for approximately 20 seconds.

*177. Set CHART DRIVE switch on Oscillograph Control panel to OFF. Record SCA SCT shaft tach input and output signals monitored on channels 1 and 8.

*178. Set Test Selector panel to 130 to connect SCA SXT trunnion tach output to Oscillograph channel 8.

*179. Set CHANNEL 2 switch on Oscillograph Signal Selector panel to 12 to connect SCA SXT trunnion tach input to Oscillograph channel 2.

*180. Zero Oscillograph channel 2 and set sensitivity to 20 MV/MM. Set sensitivity of channel 8 to 1 V/CM and zero adjust channel 8 for a centered trace with a 2.5 vdc bias input.

*181. Set CHART DRIVE switch on Oscillograph Control panel to MM/SEC.

*182. Set OPTICS SPEED switch on Indicator Control panel to MED.

*183. Hold Optics Hand Controller to upper limit not longer than 10 seconds.

DATE 26 JAN 67

BLOCK II SIGNAL CONDITIONER
FUNCTIONAL CHECKOUT

JOB

JDC 12224 REV N PAGE 14 OF 15

SUBSYSTEM G & N SYSTEM

ASSY

*184. Set CHART DRIVE switch on Oscillograph Control panel to OFF. Record SCA SXT trunnion tach input and output signals monitored on channels 2 and 8.

*185. Set Test Selector panel to 149 to connect SCA SCT trunnion tach output to Oscillograph channel 8.

*186. Set CHANNEL 5 switch on Oscillograph Signal Selector panel to 11 to connect SCA SCT trunnion tach input to Oscillograph channel 5.

*187. Insure that CH5AC indicator on Oscillograph Signal Selector panel is lighted.

*188. Zero Oscillograph channel 5 and set sensitivity to 50 MV/MM. Set sensitivity of channel 8 to 1 V/CM and zero adjust channel 8 for a centered trace with a 2.5 vdc bias input.

*189. Set CHART DRIVE switch on Oscillograph Control panel to MM/SEC.

*190. Set OPTICS SPEED switch on Indicator Control panel to HI.

*191. Hold Optics Hand Controller to lower limit for approximately 10 seconds.

*192. Set CHART DRIVE switch on Oscillograph Control panel to OFF. Set sensitivities on Oscillograph Amplifiers to OFF. Record SCA SCT trunnion tach input and output signals monitored on channels 5 and 8.

YAW, PITCH, AND ROLL ATTITUDE

ERRORS

*193. Perform following DSKY operations:

a. VERB 41 NOUN 20 ENTR

b. Observe:

VERB 21 NOUN 22 Flashing

c. +00000 ENTR

d. Observe:

VERB 22 NOUN 22 Flashing

e. +00000 ENTR

f. Observe:

VERB 23 NOUN 22 Flashing

g. +00000 ENTR

h. VERB 21 NOUN 10 ENTR

i. 00012 ENTR

j. 00060 ENTR

NOTE: ISS warning lamp on Indicator Control panel may light during performance of step 194. Ignore lamp indication.

*194. Perform following DSKY operations:

a. VERB 43 ENTR

b. Observe:

VERB 21 NOUN 22 Flashing

c. +01600 ENTR

d. Observe:

VERB 22 NOUN 22 Flashing

e. +01600 ENTR

f. Observe:

VERB 23 NOUN 22 Flashing

g. +01600 ENTR

*195. Connect jumper between PROBES OUTPUT DIRECT jacks and PAVM IN jacks on Auxiliary Input panel. Set PAVM switch on Primary Signal Selector panel to AUX.

DATE 26 JAN 67

*196. Connect PSA TPA direct probes to TB4-44 (high) and TB4-48 (low) and measure and record SCA yaw attitude error input indicated on PAVM.

*197. Set Test Selector panel to 114 and measure and record SCA yaw attitude error output indicated on DVM.

*198. Calculate SCA yaw attitude error output to SCA yaw attitude error input as follows. Record result:

Yaw attitude error =
$$\frac{2.44 \text{ (Step 197 - Step 33)}}{\text{Step 196}} = 1 (\pm 10\%)$$

*199. Connect PSA TPA direct probes to TB4-45 (high) and TB4-49 (low) and measure and record SCA pitch attitude error input indicated on PAVM.

*200. Set Test Selector panel to 115 and measure and record SCA pitch attitude error output indicated on DVM.

*201. Calculate SCA pitch attitude error output to SCA pitch attitude error input as follows. Record result:

Pitch attitude error =
$$\frac{2.44 \text{ (Step 200 - Step 33)}}{\text{Step 199}} = 1 (\pm 10\%)$$

*202. Connect PSA TPA direct probes to TB4-43 (high) and TB4-47 (low) and measure and record SCA roll attitude error input indicated on PAVM.

*203. Set Test Selector panel to 116 and measure and record SCA roll attitude error output indicated on DVM.

*204. Calculate SCA roll attitude error output to SCA roll attitude error input as follows. Record result:

Roll attitude error =
$$\frac{2.44 \text{ (Step 203 - Step 33)}}{\text{Step 202}} = 1 (\pm 10\%)$$

Step 202

NOTE: Step 205 applies only when Restart Monitor module (2898989) is installed.

205. Perform the following DSKY operations:

- a. VERB 01 NOUN 10 ENTR
- b. 00077 ENTR
- c. The contents of Row 1 shall be 00000.

206. Perform JDC 12204 to turn off G & N system.

APOLLO G&N
EQUIPMENT TEST
DATA SHEET 1 OF 9

NO. <u>12224</u> ^{JDC}
REV <u>N</u>
INITIAL TDRR <u>32758</u>

JOB BLOCK II SIGNAL CONDITIONER FUNCTIONAL CHECKOUT

<u>ASSEMBLY UNDER TEST</u>			<u>TEST HISTORY</u>		
TITLE _____	DATE _____	START _____	END _____	SITE / LOCATION _____	
SER. NO. _____	DWG _____	REV. _____	TIME _____	START _____	END _____
			TOTAL ELAPSED _____		

<u>MAJOR GROUND SUPPORT EQUIPMENT</u>					
NAME _____	SER. NO. _____	CAL DATE _____			
NAME _____	SER. NO. _____	CAL DATE _____			

CONDUCTED BY _____	APPROVED BY _____
NAME/AFFILIATION _____	NAME/AFFILIATION _____

JDC ITEM NO.	PARAMETER	UNITS	MIN VALUE	RECORDED VALUE	MAX VALUE	REJ	ACC
2	28 vdc CGC operate	vdc	3.9		4.9		
3	28 vdc IMU standby	vdc	3.9		4.9		
4	28 vdc optics operate	vdc	3.9		4.9		
7	Lamp operation						
	CMC warning voltage	vdc	3.9		4.9		
17	Z PIPA loop closure						
22	Y PIPA loop closure						
27	X PIPA loop closure						

DATE 26 JAN 67

APOLLO G&N
EQUIPMENT TEST
DATA SHEET 2 OF 9

JDC NO. <u>12224</u> REV. <u>N</u>
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JOB BLOCK II SIGNAL CONDITIONER FUNCTIONAL CHECKOUT

JDC ITEM NO.	PARAMETER	UNITS	MIN VALUE	RECORDED VALUE	MAX VALUE	REJ	ACC
29(17)	Z PIPA loop closure						
29(22)	Y PIPA loop closure						
29(27)	X PIPA loop closure						
30	120 vdc PIPA supply	vdc					
32	120 vdc PIPA supply	vdc	2.3		4.7		
33	2.5 vdc TM bias	vdc	2.45		2.55		
34	3200 cps 28 volts	vac					
36	3200 cps 28 volts	vdc	4.2		4.8		
37	800 cps 28 volts 1% IMU	vac					
39	800 cps 28 volts 1% IMU	vdc	4.2		4.8		
40	800 cps 28 volts 1% optics	vac					
42	800 cps 28 volts 1% optics	vdc	4.2		4.8		
43	PIPA temperature	vdc					

DATE 26 JAN 67

APOLLO G&N
EQUIPMENT TEST
DATA SHEET 3 OF 9

JDC NO. <u>12224</u> REV. <u>N</u>
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JOB BLOCK II SIGNAL CONDITIONER FUNCTIONAL CHECKOUT

JDC ITEM NO.	PARAMETER	UNITS	MIN VALUE	RECORDED VALUE	MAX VALUE	REJ	ACC
45	PIPA temperature	vdc	2.0		3.5		
46	IRIG temperature	vdc					
48	IRIG temperature	vdc	2.37		3.75		
50	IMU heater current	vdc					
52	IMU heater current	vdc	3.9		4.8		
54	IMU blower current	vdc					
56	IMU blower current	vdc	4.0		4.6		
69	Maximum right	vac					
	Maximum left	vac					
	Maximum meter spread	vac					
70	High voltage	vdc					
	Low voltage	vdc					
	Maximum meter spread	vdc					
72	IG servo error		0.7735		1.0465		
79	Maximum right	vac					
	Maximum left	vac					
	Maximum meter spread	vac					
80	High voltage	vdc					

DATE 26 JAN 67

APOLLO G&N
EQUIPMENT TEST
DATA SHEET 4 OF 9

JDC NO. <u>12224</u> REV. <u>N</u>
--

JOB BLOCK II SIGNAL CONDITIONER FUNCTIONAL CHECKOUT

JDC ITEM NO.	PARAMETER	UNITS	MIN VALUE	RECORDED VALUE	MAX VALUE	REJ	ACC
80 (cont)	Low voltage	vdc					
	Maximum meter spread	vdc					
82	MG servo error		0.7735		1.0465		
89	Maximum right	vac					
	Maximum left	vac					
	Maximum meter spread	vac					
90	High voltage	vdc					
	Low voltage	vdc					
	Maximum meter spread	vdc					
92	OG servo error		0.7735		1.0465		
108	IG torque motor current (channel 6)	Δv					
	IG torque motor current (channel 8)	Δv	channel 6 x 4		channel 6 x 6		
114	MG torque motor current (channel 6)	Δv					
	MG torque motor current (channel 8)	Δv	channel 6 x 4		channel 6 x 6		
120	OG torque motor current (channel 6)	Δv					

DATE 26 JAN 67

APOLLO G&N
EQUIPMENT TEST
DATA SHEET 5 OF 9

JDC
NO. <u>12224</u>
REV. <u>N</u>

JOB BLOCK II SIGNAL CONDITIONER FUNCTIONAL CHECKOUT

JDC ITEM NO.	PARAMETER	UNITS	MIN VALUE	RECORDED VALUE	MAX VALUE	REJ	ACC
120 (cont)	OG torque motor current (channel 8)	Δv	channel 6 x 1.8		channel 6 x 3.8		
123	IG 1X resolver cos	vac					
124	IG 1X resolver cos	vdc					
125	IG 1X resolver cos		0.90		1.10		
126	MG 1X resolver cos	vdc					
127	MG 1X resolver cos	vac					
128	MG 1X resolver cos		0.90		1.10		
129	OG 1X resolver cos	vac					
130	OG 1X resolver cos	vdc					
131	OG 1X resolver cos		0.90		1.10		
132	IG 1X resolver sin	vdc					
133	IG 1X resolver sin	vac					
134	IG 1X resolver sin		0.90		1.10		
135	MG 1X resolver sin	vac					
136	MG 1X resolver sin	vdc					
137	MG 1X resolver sin		0.90		1.10		

DATE 26 JAN 67

APOLLO G&N
EQUIPMENT TEST
DATA SHEET 6 OF 9

JDC	
NO.	<u>12224</u>
REV.	<u>N</u>

JOB BLOCK II SIGNAL CONDITIONER FUNCTIONAL CHECKOUT

JDC ITEM NO.	PARAMETER	UNITS	MIN VALUE	RECORDED VALUE	MAX VALUE	REJ	ACC
138	OG 1X resolver sin	vdc					
139	OG 1X resolver sin	vac					
140	OG 1X resolver sin		0.90		1.10		
150	Shaft CDU fine error	vdc	4.35		4.81		
157	Trunnion CDU fine error	vdc	4.35		4.81		
159	Trunnion CDU DAC output	vdc	4.00		5.00		
160	Shaft CDU DAC output	vdc	4.00		5.00		
162	Trunnion CDU DAC output	vdc	0.00		1.00		
163	Shaft CDU DAC output	vdc	0.00		1.00		
170	SCA input (channel 1)	Δv					
	SCA output (channel 8)	Δv	channel 1 x 4.0		channel 1 x 6.0		
177	SCA input (channel 1)	Δv					
	SCA output (channel 8)	Δv	channel 1 x 0.4		channel 1 x 0.6		

DATE 26 JAN 67

APOLLO G&N
EQUIPMENT TEST
DATA SHEET 7 OF 9

JDC	
NO.	12224
REV.	N

JOB BLOCK II SIGNAL CONDITIONER FUNCTIONAL CHECKOUT

JDC ITEM NO.	PARAMETER	UNITS	MIN VALUE	RECORDED VALUE	MAX VALUE	REJ	ACC
184	SCA input (channel 2)	Δv					
	SCA output (channel 8)	Δv	channel 2 x 4.0		channel 2 x 6.0		
192	SCA input (channel 5)	Δv					
	SCA output (channel 8)	Δv	channel 5 x 0.4		channel 5 x 0.6		
196	Yaw attitude error	vac					
197	Yaw attitude error	vdc					
198	Yaw attitude error		0.90		1.10		
199	Pitch attitude error	vac					
200	Pitch attitude error	vdc					
201	Pitch attitude error		0.90		1.10		
202	Roll attitude error	vac					
203	Roll attitude error	vdc					
204	Roll attitude error		0.90		1.10		

DATE 26 JAN 67

APOLLO G&N
EQUIPMENT TEST
DATA SHEET 8 OF 9

JDC NO. <u>12224</u> REV. <u>N</u>
--

JOB BLOCK II SIGNAL CONDITIONER FUNCTIONAL CHECKOUT

JDC ITEM NO.	CALCULATIONS
72	IG servo error = $\frac{\text{Step 70, max meter spread}}{\text{Step 69, max meter spread}} = 0.91 (\pm 15\%)$
82	MG servo error = $\frac{\text{Step 80, max meter spread}}{\text{Step 79, max meter spread}} = 0.91 (\pm 15\%)$
92	OG servo error = $\frac{\text{Step 90, max meter spread}}{\text{Step 89, max meter spread}} = 0.91 (\pm 15\%)$
125	IG 1X resolver cos = $\frac{8.1 \times (\text{Step 124} - \text{Step 33})}{\text{Step 123}} = 1 (\pm 10\%)$
128	MG 1X resolver cos = $\frac{8.1 \times (\text{Step 126} - \text{Step 33})}{\text{Step 127}} = 1 (\pm 10\%)$
131	OG 1X resolver cos = $\frac{8.1 \times (\text{Step 130} - \text{Step 33})}{\text{Step 129}} = 1 (\pm 10\%)$
134	IG 1X resolver sin = $\frac{8.1 \times (\text{Step 132} - \text{Step 33})}{\text{Step 133}} = 1 (\pm 10\%)$

DATE 26 JAN 67

APOLLO G&N
EQUIPMENT TEST
DATA SHEET 9 OF 9

JDC
NO. <u>12224</u>
REV. <u>N</u>

JOB BLOCK II SIGNAL CONDITIONER FUNCTIONAL CHECKOUT

JDC ITEM NO.	CALCULATIONS
137	MG 1X resolver sin = $\frac{8.1 \times (\text{Step } 136 - \text{Step } 33)}{\text{Step } 135} = 1 (\pm 10\%)$
140	OG 1X resolver sin = $\frac{8.1 \times (\text{Step } 138 - \text{Step } 33)}{\text{Step } 139} = 1 (\pm 10\%)$
198	Yaw attitude error = $\frac{2.44 \times (\text{Step } 197 - \text{Step } 33)}{\text{Step } 196} = 1 (\pm 10\%)$
201	Pitch attitude error = $\frac{2.44 \times (\text{Step } 200 - \text{Step } 33)}{\text{Step } 199} = 1 (\pm 10\%)$
204	Roll attitude error = $\frac{2.44 \times (\text{Step } 203 - \text{Step } 33)}{\text{Step } 202} = 1 (\pm 10\%)$

DATE 26 JAN 67

**SUBSYSTEM
 DESCRIPTION**

ASSY.

Procedure to package and pack block II interconnect harnesses. Packaging procedure is to level B and packing procedure is to level C.

Rev. Let.	Date	TDRR NO.	PAGES REVISED		APPROVAL		REFERENCES
			JDC	D. S.	MIT	NASA	
A	3-16-67	33211	2	-	EA	-	ND 1002214 MIL-P-116
B	3-17-67	33241	2	-	EA	-	ND 1021038, Chapter 1
C	6-12-68	36336	2	-	EA	-	IMPORTANT
D	8-20-71	38462	1, 2, 3, 4, 5	-	EA	-	
							INTERVAL
							TOOLS AND MATERIAL
							See table of materials.

TABLE OF MATERIALS

QUANTITY	MATERIAL	DIMENSIONS	SPECIFICATIONS
As required	Polyethylene bags or sheet wrap	As required	L-P-378, Type II, Grade C
As required	Fiberboard sheet	As required	PPP-F-320, Type CF, Variety DW, Grade B
39	Connector covers (See connector cover list.)		
As required	Reinforced gummed tape	3" wide	PPP-T-45, Type II
1 (for each harness)	Packing container of 275 pound corrugated fiberboard	As required	PPP-B-636, Type CF, Class Domestic
As required	Lint-free cloth		
As required	Polystyrene spaghetti or equivalent		MIL-C-26861

VERIFICATION WITH SIDL REQUIRED BEFORE USE

DATE 11 AUG 1966

SUBSYSTEM

ASSY

TABLE OF MATERIALS (Continued)

QUANTITY	MATERIAL	DIMENSIONS	SPECIFICATIONS
1	Plywood box	As required	PP-B-601
As Required	Strapping, steel, flat	As required	QQ-S-781
1	Packing container of 600-pound triple-wall corrugated fiberboard	As required	PPP-636, Type CF, Class Domestic
As required	1/4-inch, 2-pound density, flexible polyester	As required	MIL-P-26514, Type I, Class 2
As required	Material, Transparent, flexible Cellular, Plastic film, 3/16-inch cushioning thickness. Cell height 3/16 ($\pm 1/16$) inch, Cell diameter 3/8 ($\pm 1/16$) inch.	As required	MIL-C-81013, Type I
As required	Material, Transparent, flexible, Cellular, Plastic film, 1/2-inch cushioning thickness. Cell height 1/2 ($\pm 3/32$) inch. Cell diameter 1-1/4 ($\pm 1/16$) inch.	As required	MIL-C-81013, Type II
1	Moisture-vapor proof pouch	As required	MIL-B-117, Type I, Class E

DATE _____

SUBSYSTEM

ASSY

CONNECTOR COVER LIST

CONNECTOR DESIGNATION	CONNECTOR COVER PART NUMBER
56P1	MS3180-14
56P2	MS3180-16
56P3	MS3180-18
56P4	MS3180-18
56P5	MS3180-18
56P6	MS3180-18
56P7	MS3180-16
56P8	MS3180-16
56P9	*6900060
56P10	*6900059
56P12	MS3180-18
56P13	MS3182A-27
56P14	MS3180-8
56P15	1897432-002
56P16	1897432-002
56P17	*2900929
56P18	*2900930
56P19	*2900932
56P20	MS3180-18
56P21	MS3180-16
56P22	MS3180-18
56P23	MS3182A-19
56P24	MS3180-18
56P25	MS3180-18
56P26	*2900930
56P27	*2900931
56P28	*2900931
56P29	*2900932
56P30	2900920
56P31	2900920
56P32	MS3180-18
56J1	MS3181-14
56J2	MS3181-16
56J3	MS3181-18
56J4	MS3181-18
56J5	MS3181-18
56J6	MS3181-8
56J7	MS3181-8
56J8	MS3181-8
	*Torque connector screws to 5 ± 2 in-lbs when attaching connector covers.

A. PREPARATION

1. Remove dust and dirt by wiping harnesses with a clean, lint-free cloth.
2. Check that connectors and harness cables are dry and free of corrosion and foreign matter.
3. Insure that records and tags required by local administrative procedures are complete and up-to-date.
4. Obtain required packaging and packing materials from storage or local procurement.

B. PROCEDURE

1. Refer to connector cover list to place appropriate covers on connectors. Wrap all connectors in accordance with figure 1 and tape with three inch reinforced gummed tape.

CAUTION: Do not coil or bend harnesses while handling or packaging.

2. Place each harness in a polyethylene bag carefully maintaining original shape, exhaust air, and carefully seal bag with either three inch reinforced gummed tape or impulse sealer. Place harness clamps and associated hardware in polyethylene bag and tape to harness bag.

PACKAGING AND PACKING OF BLOCK II
INTERCONNECT HARNESSSES

JOB

JDC 19302 REV D PAGE 4 OF 5

SUBSYSTEM

ASSY

3. Mark and label each moisture-vapor-proof pouch as follows:

- a. NASA drawing number and revision letter
- b. Short form nomenclature
- c. Quantity
- d. Level and date of packaging
- e. Supplier
- f. Serial number
- g. Contract number
- h. Reinspection date.

4. Place each harness and associated hardware, prepared in steps B.1 and B.2, into moisture-vaporproof pouches.

5. Heat seal moisture-vaporproof pouches.

6. Obtain fiberboard packing containers of sufficient size to contain each harness without coiling and to allow at least two inches for cushioning material between harness and container.

7. Place approximately two inches of cushioning material on bottom of carton.

8. Carefully place wrapped harness into fiberboard carton.

9. Place cushioning material around harness so that cushioning material supports harness in its original shape. Insure that harness is adequately surrounded by cushioning to prevent movement in carton.

10. Seal top and bottom seams of carton with three-inch reinforced gummed tape.

NOTE: Each harness may be packed as one item (steps 11 thru 14 and step

16), or packed together (steps 15 and 16) for shipment. Perform either steps 11 thru 14 and step 16, or 15 and 16 as applicable.

11. Place polystyrene cushioning or spaghetti on bottom of fiberboard packing container.

12. Place packaged item into fiberboard packing container.

13. Place polystyrene cushioning or spaghetti on top, sides, and ends of packaged item.

14. Close fiberboard packing container. Secure top and bottom center seams of fiberboard container with gummed reinforced tape.

15. Construct plywood shipping container of sufficient size to contain eight packaged harnesses. Place packages into shipping container, fill voids with folded fiberboard sheet or other dunnage to obtain a rattle-free pack. Secure top of container and strap container with flat steel strapping.

16. Mark outer packing container for shipment as follows:

- a. Level of packing
- b. Appropriate destination levels
- c. Shipping control numbers.

DATE _____

PACKAGING AND PACKING OF BLOCK II
INTERCONNECT HARNESSSES

JOB

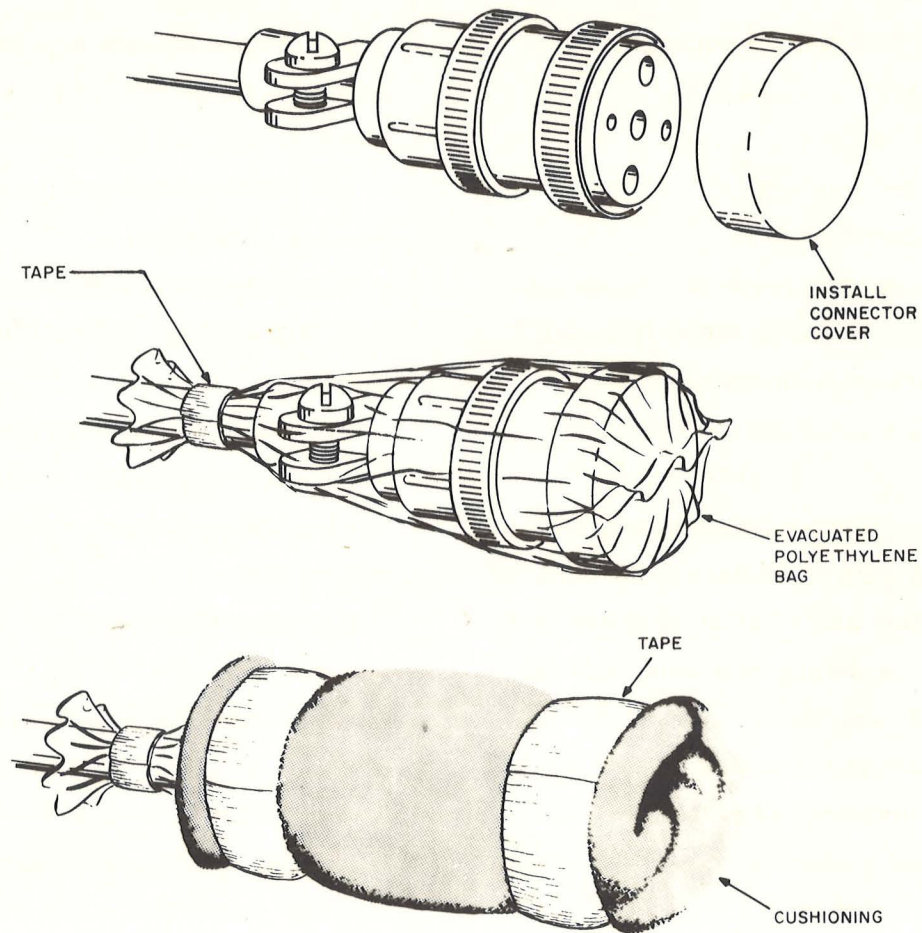
JDC 19302

REV D

PAGE 5 OF 5

SUBSYSTEM

ASSY



15080C

Figure 1. Connector Wrapping

DATE _____

JOB PACKAGING AND PACKING OF LEM
INTERCONNECT HARNESSSES

JDC 19303 REV. D PAGE 1 OF 5
INITIAL TDRR 30640 D.S. PGS

SUBSYSTEM
DESCRIPTION

ASSY.

Procedure to package and pack LEM interconnect harnesses. Packaging procedure is to level B and packing procedure is to level C.

Rev. Let.	Date	TDRR NO.	PAGES REVISED		APPROVAL		REFERENCES
			JDC	D. S.	MIL	NASA	
A	3-16-67	33210	2	-	EA <i>4/5</i>	-	ND 1002214 ND 1021038, Chapter 1
B	3-17-67	33242	2	-	EA <i>4/5</i>	-	
C	4-26-68	36135	2	-	EA <i>AD</i>	-	IMPORTANT
D	8-20-71	38463	1, 2, 3, 4, 5	-	EA <i>AS</i>	-	
							INTERVAL
							TOOLS AND MATERIAL See table of materials.

TABLE OF MATERIALS

QUANTITY	MATERIAL	DIMENSIONS	SPECIFICATIONS
As required	Polyethylene bags or sheet wrap	As required	L-P-378, Type II, Grade C
As required	Fiberboard sheet	As required	PPP-F-320, Type CF, Variety DW, Grade B
As required	Lint free cloth		
22	Connector covers (See connector cover list.)		
As required	Reinforced gummed tape	3" wide	PPP-T-45, Type II
As required	Polystyrene spaghetti or equivalent		MIL-C-26861
As required	Wrapping paper, neutral		
2	Packing container of 600 pound triple-wall corrugated fiberboard	As required	PPP-636, Type CF, Class Domestic

VERIFICATION WITH SIDL REQUIRED BEFORE USE

DATE 11 AUG 1966

SUBSYSTEM

ASSY

TABLE OF MATERIALS (Continued)

QUANTITY	MATERIAL	DIMENSIONS	SPECIFICATIONS
As required	1/4-inch, 2-pound density, flexible polyester	As required	MIL-P-26514, Type I, Class 2
As required	Material, transparent, flexible, Cellular, Plastic film, 3/16-inch cushioning thickness. Cell height 3/16 ($\pm 1/16$) inch, cell diameter 3/8 ($\pm 1/16$) inch.	As required	MIL-C-81013, Type I
As required	Material, transparent, flexible, Cellular, Plastic film, 1/2-inch cushioning thickness. Cell height 1/2 ($\pm 3/32$) inch, cell diameter 1-1/4 ($\pm 1/16$) inch.	As required	MIL-C-81013, Type II
1	Moisture-vaporproof pouch	As required	MIL-B-117, Type I, Class E

DATE _____

SUBSYSTEM

ASSY

CONNECTOR COVER LIST

CONNECTOR DESIGNATION	CONNECTOR COVER PART NUMBER
56P1	*6900062
56P2	*6900061
56P3	*6900060
56P4	*6900059
56P5	MS3180-18
56P6	MS3180-18
56P7	MS3180-18
56P8	MS3180-20
56P9	MS3180-16
56P10	MS3180-18
56P11	MS3180-24
56P12	MS3180-18
56P13	MS3180-18
56P14	MS3180-18
56P15	MS3180-14
56P16	MS3180-18
56P17	MS3180-24
56P18	MS3180-18
56P19	*6900063
56P20	1897432-002
56P21	1897432-002
56J1	MS3181-10
	*Torque connector screws to 5 ± 2 in-lbs when attaching connector covers.

A. PREPARATION

1. Remove dust and dirt by wiping harnesses with a clean, lint-free cloth.
2. Check that connectors and harness cables are dry and free of corrosion and foreign matter.
3. Insure that records and tags required by local administrative procedures are complete and up-to-date.
4. Obtain required packaging and packing materials from storage or local procurement.

B. PROCEDURE

NOTE: Wrap sharp corners of TB2 of LEM "B" harness using folded polyethylene sheeting.

1. Refer to connector cover list to place appropriate covers on connectors and prepare all connectors, and TB2 of LEM "B" harness in accordance with figure 1.

CAUTION: Do not coil or bend harnesses while handling or packaging.

2. Place each harness in a polyethylene bag, exhaust air, and carefully seal bag with either three-inch reinforced gummed tape or impulse sealer.

SUBSYSTEM

ASSY

3. Mark and label each moisture-vapor-proof pouch as follows:

- a. NASA drawing number and revision letter
- b. Short form nomenclature
- c. Quantity
- d. Level and date of packaging
- e. Supplier
- f. Serial number
- g. Contract number
- h. Reinspection date.

4. Place each harness and associated hardware, prepared in steps B.1 and B.2, into moisture-vaporproof pouches.

5. Heat seal moisture-vaporproof pouches.

6. Obtain fiberboard packing containers of sufficient size to contain each harness without coiling and to allow at least two inches for cushioning material between harness and container.

7. Place approximately two inches of cushioning material on bottom of carton.

8. Carefully place wrapped harness into fiberboard carton.

9. Place cushioning material around harness so that cushioning material supports harness in its original shape. Insure that harness is adequately surrounded by cushioning to prevent movement in carton.

10. Seal top and bottom seams of carton with three-inch reinforced gummed tape.

11. Place polystyrene cushioning or spaghetti on bottom of outer packing container.

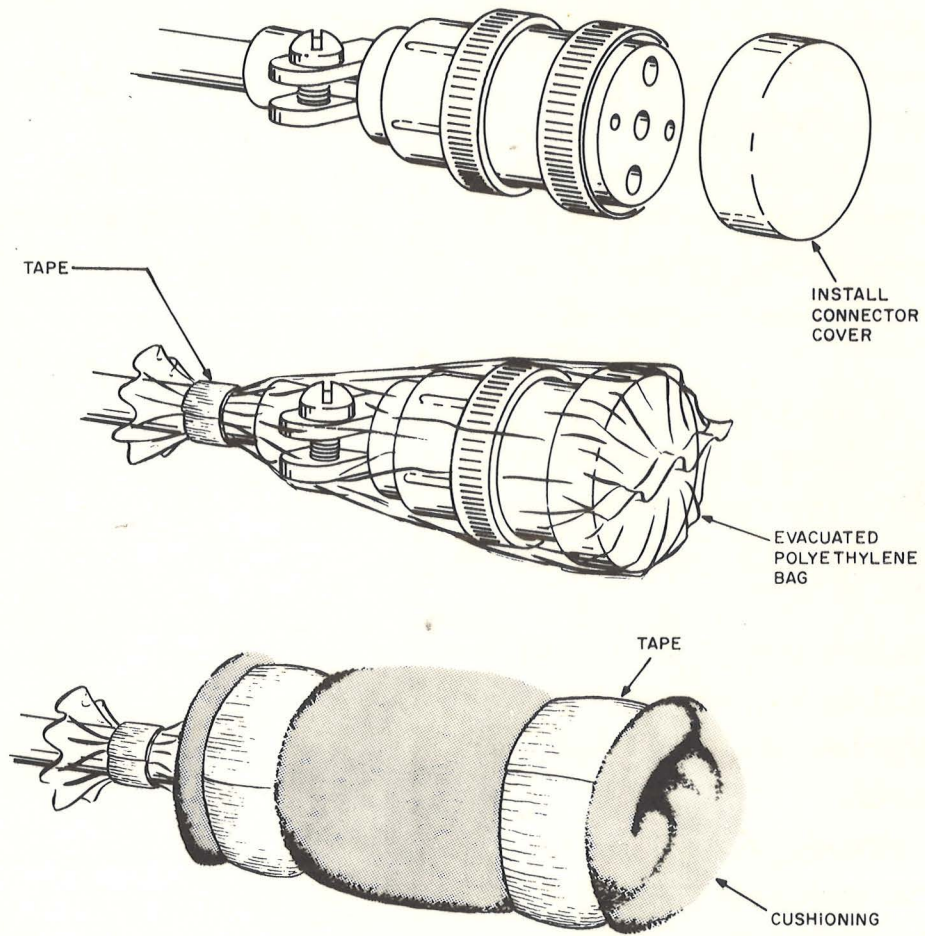
12. Place packaged item into outer packing container.

13. Place polystyrene cushioning or spaghetti on top, sides, and ends of packaged item.

14. Close outer packing container and secure top and bottom center seams of fiberboard cartons with gummed reinforced tape.

15. Mark outer packing container for shipment as follows:

- a. Level of packing
- b. Appropriate destination labels
- c. Shipping control numbers.



15080C

Figure 1. Connector Wrapping

DATE _____