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ABSTRACT

This document will provide the following information: A description of Mission 204A, the G&C system mission Objectives, a description of Spacecraft 012 including the G&C systems, the means for satisfying the objectives, the mission performance requirements and capabilities for the G&C systems, and the procedures for use of the systems. Detailed procedures for operating the G&C systems are documented so that they may be integrated into crew task analysis and overall operating procedures for Spacecraft 012.

LIST OF EFFECTIVE PAGES

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1 INTRODUCTION

1.1 This Guidance and Control (G&C) Data Book is intended as a planning and reference document for Block I manned flight missions. Although some sections pertain specifically to SC 012 (Mission AS-204A), most of the data included is equally applicable to SC 014.

1.2 Immediate application of the G&C data included is intended for the preparation, planning, and presentation of spacecraft capabilities and limitations at the Mission Review portion of the SC 012 CDR. Data on G&C Procedures will be used directly in the preparation of the Integrated Crew Task Analysis Documents and the Apollo Operations Handbook for SC 012. The CSME 012 evaluation will also use this data book as a basic planning document.

1.3 A revision to this document is planned to include the following:

a. Abort procedures.

b. Revisions to published procedures.

c. Other procedures determined to be required.

d. Changes to sections resulting from the Mission Review.

e. Completion of analysis presently in work.

f. Completion of descriptive sections planned or in work.

The revision will be scheduled to be released three weeks prior to the Mission Operational Readiness Review for SC 012.

2 G&C MISSION TEST OBJECTIVES

2.1 Introduction. As Mission AS 204A is the first Apollo manned flight, it is the first opportunity to test design assumptions used in Guidance and Control Subsystems designs in an integrated vehicle in a dynamic environment. While a comprehensive simulation and testing program has been undertaken (see Section 8), actual flight demonstration remains the final proof of design concepts and assumptions.

The Block I Guidance and Control capabilities have been designed as general functional capabilities, as much as possible, to allow Apollo to fly a variety of missions instead of designing to only one detailed reference mission. These general capabilities are defined in this section as the functions that should be confirmed on this flight.

2.1.1 Rate Damping.

2.1.1.1 Remarks.

2.1.1.1.1 Demonstrate Rate Damping in All Three Axes. Rate damping is included in the design of the control system to provide stabilization from external disturbing forces. Some examples of the forces that must be damped are CSM S-IVB separation, CM SM separation, roll disturbances during TVC, abort separation disturbances, those induced from any impact with a foreign body, and wind gusts. The rate damping capability is required for all vehicles and is an included functional capability of all control modes. Demonstration in any mode will prove the functioning of this system capability for all modes. Barring the occurrence of any abort during launch, the earliest demonstration of the function will occur naturally at CSM S-IVB separation in orbit with the control system in the Monitor Mode. Observation of the rate indicators on the FDAI will show whether or not the vehicle damps to the midcourse rate deadband level (nominally $\pm$ 0.2 degrees second) in all axes and how quickly this occurs.

2.1.1.1.2 Demonstrate Convergence to Minimum Impulse Limit Cycle Rates During Attitude Hold in the SCS Attitude Control Mode. Convergence of the vehicle rates to the minimum impulse rate levels is a requirement for navigation sightings. To a lesser level, this convergence applies to fuel conservation during all attitude hold periods and establishment of optimum initial conditions for SPS ignitions. The convergence will exist for all of the attitude control modes. It can best be demonstrated initially during the attitude hold period immediately following CSM S-IVB separation and the pitch maneuver (i.e., while holding attitude for SLA photography) and then confirmed during the attitude hold period prior to the first subsequent navigation sighting or IMU alignment period. The minimum impulse rate converged to will vary with vehicle inertia, RCS performance, d.c. bus voltage fluctuations, and subsystem internal tolerances. The inertial sensors on board and the TM processing of their data are not compatible with measurement of minimum rates expected. An artificial technique is used in achieving the

extremely low level rates required and is not susceptible to measurement with existing sensors. An approximate measurement of the rates experienced can be derived, however, applying RCS on-off histories and the approximately known attitude deadbands. A qualitive demonstration of the function will be available from astronaut remarks relative to vehicle rates for navigation sightings, which is the prime purpose of the function.

2.1.2 Minimum Impulse Control. Demonstrate the adequacy of the navigational sighting design basis including the optics, the attitude impulse controller, the minimum impulse control circuitry, and the RCS minimum impulse capability.

2.1.2.1. Remarks.

2.1.2.1.1 Demonstration of the on-board navigational sighting capability is necessary, as for Block II midcourse flight the on-board navigational capability is primary in some phases. SC 012 will be the first opportunity to demonstrate this combined systems capability in a dynamic environment. Orbital parameters must be determined for the orbit that the sightings are planned for to provide a comparative basis for the accuracy of the sighting. A minimum of three sightings should be scheduled. They may be taken sequentially to avoid having to turn on the G&N more than once for this requirement. Astronaut comments would be used as the basis of evaluation of the optics and the attitude impulse controller. The minimum impulse control circuitry and RCS minimum impulse capability can be coarsely determined from RCS automatic on-off histories if TM coverage exists for this period. Astronaut comments on sightings procedures and adequacy of the rate change capability of the integrated systems are also required.

2.1.3 Proportional Rate Control. Demonstrate proportional rate control utilizing the rotation control and the FDAI attitude display for (1) single axis, and (2) multi-axis maneuvers.

2.1.3.1 Remarks.

2.1.3.1.1 The rotation control and FDAI are included to provide a manual attitude change capability for the spacecraft. There are no opportunities for dynamic demonstration prior to SC 012. Two separate methods of attitude change are available (single axis or multi-axis maneuvering) and both should be demonstrated. Immediately following separation from the S-IVB, the single axis method can be demonstrated in the pitch around required for SLA photography. Following this photographic period, a multi-axis maneuver can be used in arriving at the desired passive thermal control attitude.

2.1.4 Thrust Vector Control. Demonstrate thrust vector control (TVC) performance.

2.1.4.1 Remarks.

2.1.4.1.1 Preliminary confidence in the thrust vector control capability of the control system will have been established in static firings for open loop testing and on SC 009 and 011 for dynamic closed loop operation. The manned aspects should be stressed in SC 012 as most of the manned functions are similar for Block I and Block II TVC design. See Table 2-1.

2.1.4.1.2 Manual trim of the pitch and yaw gimbals prior to each SPS firing should be compared via TM with intended trim locations. The demonstration in-flight of this function should be limited to trimming to the expected c.g. location as derived from on-board charts and the SPS fuel and oxidizer readings. It is important to establish enough data points, relating to the accuracy and readibility of the SPS gauging system, the accuracy and settability of the manual trim thumbwheels and display function, and the accuracy of predicted c.g. location and travel vs. the apparent c.g. location and travel, as all of these factors interact to limit the accuracy possible for a TVC maneuver. On Block I flights the accuracy requirements are not as critical as those relating to lunar orbit injection or transearth injection. These early flights should be used to gather data that can validate Block II design assumptions and possibly locate potential design problem areas.

2.1.4.1.3 Both the G&N delta V mode and the SCS delta V mode should be used for the SPS thrusting.

2.1.4.1.4 Monitoring of attitude (G&N mode only), attitude error, rate, gimbal position, and velocity remaining in a continuous scan pattern by the pilot must be validated in a dynamic environment. Hopefully, the emergency procedures, developed as applicable upon detection of a problem during the scan, will not be demonstrated during flight.

2.1.4.1.5 Direct on and direct off control of the SPS should be done early in the flight on one of the longer burns to demonstrate both emergency functional capabilities.

2.1.5 SCS Attitude Hold. Demonstrate SCS attitude hold capability in the propellant conservation configuration for one hour.

2.1.5.1 Remarks.

2.1.5.1.1 The SCS is designed to hold attitude in two different deadbands when a mission constraint requires it. The function of control in the minimum deadband will be demonstrated in conjunction with TVC and navigation sightings. In the wide deadband applications, minimum fuel consumption and balancing of remaining fuel between quads are required. To accomplish this, a procedure of turning off one of the roll enable switches and either the A or B dc circuit breaker for pitch, yaw, and the still enabled four roll jets is planned. In this way, a single pair of pitch, yaw, and roll jets will

remain functional. The pitch and yaw firings will use fuel from all four quads as one engine per quad remains functional. In roll, a single pair of roll jets on one quad will be firing. The roll pair on can be varied to use fuel from the fullest quad. Use of this control configuration for one hour will provide data on cumulative translational disturbances and control efficiency resulting from use of single jet rotation control in lieu of firing control couples.

2.1.5.1.2 The sole means of disabling a specific quad and retaining the use of the other three quads is through the fuel/oxidizer isolation valves for that quad. In this case, the valves will still be exercised in the pitch or yaw control lines unless all pitch or yaw jets are off electrically. The pitch and yaw jets are paired this way electrically deliberately to retain a balanced translational capability for any level of electrical inhibition (i.e., + pitch and + X and - pitch and + X are paired together). There is concern over dry operation of the RCS valves (i.e., fuel and oxidizer off but control system still operating the valve) due to the possibility of "vacuum-welding" of the metal to metal surfaces. Since the principle that would be demonstrated in the quad lost due to a failure period will be demonstrated in the normal planned wide deadband attitude hold periods, no requirement for single quad operation is seen.

2.1.6 Direct Control and Ullage.

2.1.6.1 Remarks.

2.1.6.1.1 Demonstrate Operation of Direct Attitude Control in All Three Axes. Direct rotation control and direct ullage have been included in the SCS to provide an alternate path in the event of certain possible electrical failures. Their early demonstration in the mission will validate their use in the event of the electrical failures for the remainder of this mission and for all future manned flight in Block I and Block II.

2.1.6.1.2 Demonstrate Operation of Direct Ullage. Direct ullage can be demonstrated as a part of one of the SPS thrustings in lieu of using the translation control to initiate the normal + X maneuver to settle the SPS fuel and oxidizer in their tanks. The Velocity Change Indicator will provide an additional validation of direct ullage visually over and above the slight acceleration cue also available to the pilot. The mission sequencer use of direct ullage for CSM S-IVB separation employs different circuitry upstream of the CM-SM RCS transfer switch.

2.1.7 Manual TVC. Demonstrate operation of manual TVC (MTVC).

2.1.7.1 Remarks.

2.1.7.1.1 The manual TVC mode (MTVC) has been included in Block I to provide an alternate control path to possible single point electrical failure points in the control electronics. It is only intended as an emergency means of controlling the SPS for de-orbit in the event of such electronics failure. It should be demonstrated relatively early in the SC 012 flight to validate the existence of an adequate alternate means of SPS control. It would be desirable to demonstrate the MTVC function in conjunction with an SPS burn of approximately the same duration as that for de-orbit so that approximate accuracy data on the mode may be obtained. The firing should be planned to begin in the MTVC mode to eliminate the errors and possible dynamic control problems associated with selection of MTVC from either the G&N or SCS delta V mode during an SPS burn. If possible, two MTVC's should be scheduled so that two major variables of the G&N providing an on-board attitude reference through the FDAI and the pilot flying to an external reference using the Crewman's Optical Sight or its equivalent can both be demonstrated. (If only one MTVC is possible, the external reference type should be done). See Table 2-1.

2.1.8 Attitude References. Evaluate the relative performances of the SCS and G&N attitude reference systems during launch, orbital maneuvers, and entry.

2.1.8.1 Remarks.

2.1.8.1.1 The SCS and G&N on-board attitude reference systems are both used during various mission phases for precise and coarse attitude positioning. Test data accumulation on the two systems performing in similar dynamic environments is not and will not be available prior to SC 012. A comparative basis for the performance of the two systems on both an absolute and relative basis is required. Following boost into orbit and prior to the shutdown of the G&N, G&N and SCS attitude references should be compared. Although telemetry of both reference systems is available, on-board readout and recording of the positions as shown by the two systems will provide more accurate data. The G&N inertial reference can then be checked against the stars and absolute as well as relative data derived.

2.1.8.1.1.1 Similarly for the maneuver periods prior to an SPS thrusting when the G&N is on and during entry, comparative data may be obtained. In the case of entry, the high crew workload and possible fatigue of the crew may eliminate the manual readout and recording but the telemetry or taped data should be available for this period.

2.1.9 Backup Vehicle Inertial Alignment. Demonstrate the use of the scanning telescope in conjunction with the Rotation and Attitude Impulse Controls to align the vehicle to a precise inertial attitude.

2.1.9.1 Remarks.

2.1.9.1.1 There is a question of the compatibility of both the Block I and Block II backup attitude reference systems with respect to the precise attitude orientation requirements for SPS firings, therefore an alternate backup method has been theorized, analyzed, and is now being simulated. This alternate approach has not been demonstrated in a dynamic environment, though, where the important variables of time, propellant, and final accuracy can be realistically measured. Demonstration of the adequacy of this concept will allow a significant relaxation of mission requirements for the Block I or Block II backup attitude reference as alignment of the vehicle for an SPS thrusting is the single mission constraint involving precise (i.e. less than 2 degrees) attitude orientation. In this demonstration the IMU would first be turned on and aligned. The vehicle will be deliberately moved away from the desired attitude ≈ 5 degrees per axis. Then the attitude will be re-acquired using the scanning telescope with fixed trunnion and shaft axis angles and a previously selected star pair in the field of view. The time, propellant used, and final accuracy will all be recorded following the completion of realigning the vehicle.

2.1.10 IMU Alignment. Demonstrate inflight IMU alignment with the G&N (Optics).

2.1.10.1 Remarks.

2.1.10.1.1 Demonstration of inflight IMU alignment is necessary to validate the design assumption that the IMU can be accurately re-erected after an "OFF" period or realigned after it has been on for some time as possible error build-ups have occurred. As a normal part of the flight, an IMU alignment will precede each SPS thrusting in which the G&N will be in control or be on for comparitive data purposes. For most of the mission the IMU will be in standby and require erection prior to use. In the remainder of the cases the systems may have accumulated significant drift errors requiring updating.

2.1.11 Orbital Determination. Demonstrate orbital determination with G&N Optics (scanning telescope) and computer by earth landmark tracking.

2.1.11.1 Remarks.

2.1.11.1.1 Demonstration of orbital determination during earth orbital flights is important as this is the backup to MSFN provision of navigational data for Block I flights and a prime function with respect to lunar orbital determination for Block II flights. In addition to demonstrating the function itself, analytical determination of potential accuracy, fuel required, time, and procedural adequacy can be confirmed or problem areas identified before actual Block II flights. This dynamic validation is required. MSFN and on-board orbital determination may be accomplished in parallel. This would be done after each orbit change.

2.1.12 AGC Updating. Demonstrate updating of the on-board computer from the MSFN via up-data link and voice modes.

2.1.12.1 Remarks.

2.1.12.1.1 The ground rule that MSFN will be responsible for prime navigational data for much of Block I and II missions assumes that data updating via up-data and/or voice links will be effective. Early validation of this assumption is required therefore for Block I and II. An up-data link capability will exist for SC 011 but there is no assurance, at this time, that it will be used. SC 012 is the first flight opportunity to demonstrate voice mode updating and may be the first flight application of the up-link technique. Both techniques must be done at least once.

2.1.13 Boost Monitoring. Demonstrate capability of G&N to compute attitude error for display during the fixed program portion of the boost phase for astronaut monitoring.

2.1.13.1 Remarks.

2.1.13.1.1 During the fixed program portion of the boost phase, the G&N system will display attitude error on the FDAI. These attitude errors will be monitored by the pilot to assist in making any required abort decision. Post flight comparison of G&N values versus IU values will demonstrate the adequacy of this additional abort decision aid. Following the fixed portion of the boost phase the G&N will null the attitude error indicators. The computer can no longer follow IU control with sufficient accuracy for use as an abort determining parameter. Astronaut comment plus post-flight telemetry evaluation will provide a total demonstration of this function.

2.1.14 G&N Performance. Demonstrate performance of G&N lift vector control, thrust vector control, and attitude control.

2.1.14.1 Remarks.

2.1.14.1.1 While there are significant differences between the Block I and II G&C Systems, the control philosophy is similar and so demonstration in Block I of lift vector control, thrust vector control, and attitude control will establish confidence in the Block II design basis. These functions will be demonstrated on SC 011 first but manned observations of these functions on SC 012 will provide more accurate data on the performance parameters and successive successful demonstrations on the two flights will increase the confidence in the design base. Telemetry and on-board data recording plus ground tracking during the dynamic flight phases will provide the required data base. See Table 2-1.

2.1.15 Out the Window Orientations. Verify the capability of aligning to SPS and RCS deorbit, CM-SM separation, and entry attitudes "out the window".

2.1.15.1 Remarks.

2.1.15.1.1 "Out the window" orientation should be accomplished early in the flight with the G&N and SCS ON. "Out the window" orientation for aborts has long been a design assumption but no objective data on accuracy of such orientations has been available. SC 012 will be the first opportunity to obtain such man-in-the-loop data for Apollo in a dynamic environment.

Table 2-1. TVC Control Variables

Attitude Control	Magnitude Control
A-1 G&N AUTO	B-1 G&N AUTO
A-2 SCS AUTO	B-2 SCS AUTO
A-3 MANUAL (RATE DAMPED) TO G&N BALL	B-3 DIRECT ON-OFF
A-4 MANUAL (RATE DAMPED) TO EXTERNAL REF.	
A-5 MANUAL (ACCELERATION) TO G&N BALL	
A-6 MANUAL (ACCELERATION) TO EXTERNAL REF.	

The following combinations are recommended:

**	A-1	B-1
*	A-1	B-2
*	A-1	B-3
**	A-2	B-2
	A-2	B-3
*	A-3	B-1
	A-3	B-2
	A-3	B-3
**	A-4	B-2
*	A-4	B-3

A-5 and A-6 are not recommended.

* Designates desired flight test configuration
** Designates required flight test

(Refer to objectives 2.1.4, 2.1.7, and 2.1.14.)

3 GUIDANCE AND CONTROL MISSION DATA

3.1 G&C Data. This section will include G&C data or G&C related data for the SC-012A Mission.

3.1.1 G&C Timeline. See Figure 3-1.

3.2 SCS Power Data. Power data for each of the SCS power switches are listed in Table 3-1. These data are valid for all "K" block SCS systems and so applies to SC 012, 014, 017, 020, and 008.

Table 3-1. SCS Power

	DC	AC
SCS Power Rate Gyro TVC 1 BMAG	None	
Rotation Control	None	
TVC 2	None	
FDAI Lighting	None	

3.2.1 Additional dc power is required for control mode and submode switching, RCS commands, and Direct Control functions (including SPS ON-OFF). Specific values for this power are not available.

3.3 G&N Power Data. MIT report E-1142, section 6, contains the current power requirements for G&N power by series. The series 50 power values apply to SC 012. The report is revised monthly.

3.4 CM-RCS Propellant History. Figure 3-2 shows the nominal case and Figure 3-3 shows the off nominal case for CM-RCS propellant history for an automatic G&N Entry on SC 012.

3.5 SM-RCS Propellant History.

(To be supplied).

3.6 SPS Performance Curves. Figure 3-4 shows the rise and fall curves of the SPS engine in response to G&C ON-Off commands.

3.6.1 Figure 3-5 is a curve of pitch and yaw gimbal trim angles versus SPS fuel remaining, and Figure 3-6 is a curve of Delta V capability remaining as a function of SPS fuel remaining.

3.6.2 Figure 3-7 is a curve of pound-seconds of thrust versus "on" command times for SPS minimum impulses. The nominally desired minimum impulse of 5000 ± 1000 pound seconds requires a 400 millisecond "on" command.

3.7 SPS Nominal Gimbal Position Settings and Characteristic Velocities.

3.7.1 Introduction. This section discusses the gimbal position settings and the characteristic velocities for the eight SPS firings during mission 204A.

3.7.2 General. Figure 3-8 shows the pitch and yaw gimbal angles varying linearly as functions of the SPS propellant consumed. The angular magnitudes are dependent on the position of the CSM center of gravity; they are therefore functions of the CSM weight. The nominal trim voltages were determined by applying the proper scale factor at discrete points of the pitch and yaw curves.

It is observed in Figure 3-8 that the small step indications at the 8th SPS gimbal positions are not significant when conversions to voltages are made. The increase in voltage for either pitch or yaw is in the order of 0.1 to 0.3 volts only at these steps.

3.7.2.1 Nominal SPS Pitch and Yaw Gimbal Position Settings. In Block I configurations the initial SPS engine gimbal plane does not vary in orientation. The required nominal input voltages for vertical hold during boost are:

$$E_{\theta_T} = 0.0 \text{ volts}$$

$$E_{\psi_T} = -9.24 \text{ volts}$$

3.7.2.2 Figure 3-8 delineates the position settings and input voltages at the initiation of each SPS burn maneuver. The overall voltages, corresponding to the overall range of the pitch and yaw trim angle functions, are:

$$E_{\theta_T} \text{ (range)} = 3.35 \text{ volts}$$

$$E_{\psi_T} \text{ (range)} = 6.59 \text{ volts}$$

The scale factors are:

Pitch: $K_{\delta\theta_T} = 2.22$ volts/degrees

Yaw: $K_{\delta\psi_T} = 2.22$ volts/degrees; within a range of $\psi_T = 4°$ to $+4°$ and, $K_{S\psi_T} = 2.31$ volts/degrees; within a range of $\psi_T = +4°$ to $+12°$

The error associated with any voltage magnitude is ± 5 percent.

The SPS nominal flow rate is 68.766 pounds per second.

3.7.3 Characteristic Velocities. Table 3-2 contains data that relates delta velocity sources to Gimbal Position Setting (GPS) requirements. The required delta V maneuver for an orbital change, or trajectory characteristic, is shown as a summation of the velocity obtained in the SPS burn and the small velocity magnitude imparted by the ullage maneuver.

3.7.3.1 The desired delta velocity, as a counter indication for display, includes the effects of engine tail off and the tolerance defined as counter accuracy. The counter range values reflect a range of SPS engines, in terms of "tail off impulse" classification, given by

$$I_{T.O.} = 8{,}000 \text{ to } 13{,}000 \text{ pound/second}$$

$$\pm 300 \text{ pound/second (absolute value)}$$

3.7.3.2 The difference in lower and upper counter range limits for delta V_c(counter velocity) is in the order of 6 to 8 feet per second for each of the eight SPS burns.

Time Data		Rev No	Reference Trajectory Events	Guidance & Control Events	Guidance & Control Procedures
Duration Sec	Initiation Time Hr. Min. Sec.				
			Prelaunch	Perform Main Display Panel and Lower Equipment Bay Checkout and Configuration	10.16 Prelaunch G&C Functions
607	0:00:00		Liftoff, Boost, and Orbit Insertion	Monitor G&C Displsy	10.17 Launch G&C Functions
300	0:12:00	1		Compare G&N and SCS Attitude References	10.23 Attitude Reference Comparison
	0:17:00	1		Power Down SCS	10.1 G&C Power Down (SCS Portion Only)
600	0:19:00	1		Align IMU	10.34 IMU Alignment While Still Attached to the S-IVB
300	0:54:00	1		Demonstrate Updating of AGC Via Updata Link and Voice Modes	10.46 AGC Update
600	1:08:00			Align IMU	10.34 IMU Alignment While Still Attached to the S-IVB
360	1:25:00		S-IVB Rolls 180 degrees		

Figure 3-1. G&C Timelines

Time Data		Rev No	Reference Trajectory Events	Guidance & Control Events	Guidance & Control Procedures
Duration Sec	Initiation Time Hr. Min. Sec.				
1140	1:31:00	2		S-IVB Constrained Earth Landmark Navigation Sighting	10.31 Earth Orbit Landmark Navigation While Still Attached to the S-IVB
300	2:25:00	2		Demonstrate Updating of AGC Via Updata Link and Modes	10.46 AGC Update
360	1:50:00	2	S-IVB Rolls 180 Degrees		
600	2:40:00	2		Align IMU	10.34 IMU Alignment While Still Attached to the S-IVB
360	2:52:00		S-IVB Rolls 180 Degrees		
900	2:58:00			S-IVB Constrained Earth Landmark Navigation Sighting	10.31 Earth Orbit Landmark Navigation While Still Attached to the S-IVB
	3:13:00			Preseparation Preparation	
	3:18:00		S-IVB/CSM Separation	S-IVB/CSM Separation	10.38 CSM/S-IVB Separation and SLA Photography Orientation

Figure 3-1. G&C Timelines (cont)

Time Data		Rev No	Reference Trajectory Events	Guidance & Control Events	Guidance & Control Procedures
Duration Sec	Initiation Time Hr. Min. Sec.				
	3:18:20			Maneuver to Proper Attitude for Photographing the SLA	10.13 Att. Man to Att. Ball Ref. (Single Axis Proportional At.2 Deg/Sec
900	3:23:00		Photograph SLA	SCS Attitude Hold	10.10 SCS Attitude Hold
300	3:38:00		Post SLA Photography Orientation to Initial S-IVB-CSM Separation Attitude	Orient CSM to Initial S-IVB-CSM Separation Attitude	10:13 Attitude Maneuver to Attitude Ball Reference (Single Axis Proportional at 0.5 Deg/Sec.
900	3:45:00			Align AGCU to IMU	10.4 Precise SCS Attitude Reference Alignment to IMU Gimbal Angles
				Record SM RCS Propellant Quantity	See SM RCS Procedure
			Orient to SPS Deorbit Attitude	Orient to SPS Deorbit Attitude	10.18 S/C Attitude Maneuver to External Reference (Single Axis Proportional)
				Compare G&N and SCS Attitude References	10.23 Attitude Reference Comparison
	4:00:00			Establish Free Drift	10.2 Free Drift Establishment and Adjustment
				Record SM RCS Propellant Quantity	See SM RCS Procedure

Figure 3-1. G&C Timelines (cont)

Time Data		Rev No	Reference Trajectory Events	Guidance & Control Events	Guidance & Control Procedures
Duration Sec	Initiation Time Hr. Min. Sec.				
	4:01:00			Align AGCU to IMU	10.4 Precise SCS Attitude Reference Alignment to IMU Gimbal Angles
			Orient to SPS Deorbit Atttitude	Orient to SPS Deorbit Attitude	10.18 S/C Attitude Maneuver to an External Reference (Multi Axis Direct) 10.28
				Compare G&N and SCS Attitude References	10:23 Attitude Reference Comparison
				Record SM RCS Propellant Quantity	See SM RCS Procedure
900	4:22:00			Align IMU	CSM IMU Align
	4:37:00			Maneuver to Proper Attitude for Lunar Landmark Star Navigation Sighting	10.24 Precise S/C Orientation Using Telescope (Multi Axis Proportional .2 Deg/Sec)
	4:56:00		Lunar Landmark Star Navigation Sighting	Lunar Landmark Star Navigation Sighting	10.35 Midcourse Navigation Sighting
3600	5:10:00			SCS Attitude Hold	10.10 SCS Attitude Hold
600	6:10:00			Attitude Hold Evaluation	

Figure 3-1. G&C Timelines (cont)

Time Data		Rev No	Reference Trajectory Events	Guidance & Control Events	Guidance & Control Procedures
Duration Sec	Initiation Time Hr. Min. Sec.				
	6:20:00			Record SM RCS Propellant Quantity	See SM RCS Procedure
120	6:20:00			Power Down G&C	10.1 G&C Power Down
	23:50:00			Power Up G&N	10.9 G&C Power Up Sequence (G&N Portion)
300	23:56:00			Receive Maneuver Data Via Updata Link and Voice Modes	10.46 AGC Update
600	24:02:00			IMU Orientation Determination Program	10.44 IMU Orientation Determination
600	24:12:00			Prethrusting Orbit Change Program	10.42 Orbit Change and SPS Minimum Impulse Prethrusting
300	24:25:00			Confirm Thrusting Parameters with MSFN	10.42 Orbit Change and SPS Minimum Impulse Prethrusting
120	24:43:00			Power Up SCS	10.9 G&C Power Up Sequence (SCS Portion)
900	24:45:00			Align IMU	10.45 IMU Align
600	25:00:00			Start Thrusting Orbit Change Program	10.3 G&N Velocity Change

Figure 3-1. G&C Timelines (cont)

Time Data		Rev No	Reference Trajectory Events	Guidance & Control Events	Guidance & Control Procedures
Duration Sec	Initiation Time Hr. Min. Sec.				
15	25:11:40		Ullage	Direct Ullage	10.27 Application of Direct Ullage
35	25:11:55		Initiate 1st SPS Burn	G&N Automatic Delta V Direct On/Off Thrust	See Thrusting Procedure 10.26 Direct On/Off SPS Control Contingency (See Thrusting Procedure)
900	25:18:30			Align IMU in Local Vertical Program	10.45 IMU Align
2400	26:14:03			Series of Landmark Navigation Sightings (Targets of Opportunity)	10.36 Earth Orbit Landmark Navigation Procedure Using G&N Local Vertical Program to Establish the Proper Attitude
120	26:54:00			Establish Free Drift	10.2 Free Drift Establishment and Adjustment
300	27:56:00			Receive Maneuver Data Via Updata Link and Voice Modes	10.46 AGC Update
600	28:01:00			Prethrusting Program	10.42 Orbit Change and SPS Minimum Impulse Prethrusting

Figure 3-1. G&C Timelines (cont)

Time Data		Rev No	Reference Trajectory Events	Guidance & Control Events	Guidance & Control Procedures
Duration Sec	Initiation Time Hr. Min. Sec.				
300	28:12:00			Confirm Thrusting Parameters With MSFN	10.42 Orbit Change and SPS Minimum Impulse Prethrusting
900	28:30:00			Align IMU	10.45 IMU Align
600	28:45:00			Start Thrusting Orbit Change Program	10.3 G&N Velocity Change
15	28:54:59	19	Ullage	+ X Translation	See Thrusting Procedure
7	28:55:14	19	Initiate 2nd SPS Burn (Circularize Orbit at 130 NM)	G&N Automatic Delta V Manual On SCS Off, Thrust	See Thrusting Procedure 10.25 Manual On/SCS Off SPS Thrust Control Contingency
	29:10:00			Perform the Orientation of CSM for Earth Landmark Nav. Sighting	See - 10.36
600	29:16:00			Landmark Navigation Sightings	10.36 Earth Orbit Landmark Navigation Procedure Using G&N Local Vertical Program to Establish the Proper Attitude
120	29:26:00			Align AGCU to IMU	10.4 Precise SCS Attitude Reference Alignment to IMU Gimbal Angles

Figure 3-1. G&C Timelines (cont)

Time Data		Rev No	Reference Trajectory Events	Guidance & Control Events	Guidance & Control Procedures
Duration Sec	Initiation Time Hr. Min. Sec.				
600	29:28:00		SPS Cold Soak	Orient to SPS Cold Soak Attitude	10.12 Attitude Maneuver Attitude Set Reference (Muti Axis Prop. .2 Deg/ Sec
				Compare G&N and SCS Attitude References	10.23 Attitude Reference Comparison
120	29:38:00		Establish Spin Stablised Mode for SPS Cold Soak	Establish Spin Stablised Mode for SPS Cold Soak	10.7 Precise Wobble Mode Establishment
120	29:40:00			G&C Power Down	10.1 G&C Power Down
120	32:36:00			Power Up SCS	10.9 G&C Power Up Sequence (G&N Portion)
600	32:38:00		Update SPS Cold Soak Attitude	Update SPS Cold Soak Attitude	10.7 Precise Wobble Mode Establishment. and 10.18 SC Att. Man. to Ext. Ref.
120	32:48:00			Power Down SCS	10.1 G&C Power Down (SCS Portion)
120	35:46:00			Power Up SCS	10.9 G&C Power Up Sequence (SCS Portion)
600	35:48:00		Update SPS Cold Soak Attitude	Update SPS Cold Soak Attitude	10.7 Precise Wobble Mode Establishment. and 10.18 SC Att. Man. to Ext. Ref.
120	35:58:00			Power Down SCS	10.1 G&C Power Down (SCS Portion)

Figure 3-1. G&C Timelines (cont)

Time Data		Rev No	Reference Trajectory Events	Guidance & Control Events	Guidance & Control Procedures
Duration Sec	Initiation Time Hr. Min. Sec.				
120	38:56			Power Up SCS	10.9 G&C Power Up Sequence (SCS Portion)
600	38:58:00		Update SPS Cold Soak Attitude	Update SPS Cold Soak Attitude	10.7 Precise Wobble Mode Establishment. and 10.18 SC Att. Man. to Ext. Ref.
120	39:08:00			Power Down SCS	10.1 G&C Power Down (SCS Portion)
120	42:06:00			Power Up SCS	10.9 G&C Power Up Sequence (SCS Portion)
600	42:08:00		Update SPS Cold Soak Attitude	Update SPS Cold Soak Attitude	10.7 Precise Wobble Mode Establishment.and 10.18 SC Att. Man. to Ext. Ref.
120	42:18:00			Power Down SCS	10.1 G&C Power Down (SCS Portion)
120	45:16:00			Power Up SCS	10.9 G&C Power Up Sequence (SCS Portion)
600	45:18:00		Update SPS Cold Soak Attitude	Update SPS Cold Soak Attitude	10.7 Precise Wobble Mode Establishment. and 10.18 SC Att. Man. to Ext. Ref.
120	45:28:00			Power Down SCS	10.1 G&C Power Down (SCS Portion)
120	48:26:00			Power Up SCS	10.9 G&C Power Up Sequence (SCS Portion)

Figure 3-1. G&C Timelines (cont)

Time Data		Rev No	Reference Trajectory Events	Guidance & Control Events	Guidance & Control Procedures
Duration Sec	Initiation Time Hr. Min. Sec.				
600	48:28:00		Update SPS Cold Soak Attitude	Update SPS Cold Soak Attitude	10.7 Precise Wobble Mode Establishment
120	48:38:00			Power Down SCS	10.1 G&C Power Down (SCS Portion)
120	48:42:00			Turn On AGC	See - 10.46 AGC Update
300	48:44:00			Receive Maneuver Data Via Updata Link and Voice Modes	10.46 AGC Update
120	49:16:00			Power Up G&C	10.9 G&C Power Up Sequence
600	49:18:00			IMU Orientation Determination	10.44 IMU Orientation Determination
600	49:28:00			Prethrusting Program	10.42 Orbit Change and SPS Minimum Impulse Prethrusting
300	49:38:00			Confirm Thrusting Parameter With MSFN	See - 10:42 Orbit Change and SPS Minimum Impulse Prethrusting
900	50:00:00			Align IMU	10.45 IMU Align
600	50:15:00			SPS Monitor Program	See Thrusting Procedure
15	50:25:07		Ullage	+ X Translation	See Thrusting Procedure

Figure 3-1. G&C Timelines (cont)

Time Data		Rev No	Reference Trajectory Events	Guidance & Control Events	Guidance & Control Procedures
Duration Sec	Initiation Time Hr. Min. Sec.				
7	50:25:22		Initiate 3rd SPS Burn	MTVC With Damping To An External Reference Manual On	10.21 Manual TVC To Docking Window Reference
120	50:32:00			Power Down G&N	
600	50:36:00			Orient to SPS Solar Soak Attitude	10.13 Attitude Maneuver To Attitude Ball Reference
			Establish Spin Stabilized Mode For SPS Solar Soak	Establish Spin Stabilized Mode For SPS Solar Soak	10.7 Precise Wobble Mode Establishment
120	50:46:00			Power Down SCS	10.1 G&C Power Down (SCS Portion)
120	53:44:00			Power Up SCS	10.9 G&C Power Up Sequence (SCS Portion)
600	53:46:00		Update SPS Solar Soak Attitude	Update SPS Solar Soak Attitude	10.7 Precise Wobble Mode Establishment, and 10.18 SC Att. Man. to Ext. Ref.
120	53:56:00			Power Down SCS	10.1 G&C Power Down (SCS Portion)
120	56:54:00			Power Up SCS	10.9 G&C Power Up Sequence (SCS Portion)

Figure 3-1. G&C Timelines (cont)

Time Data		Rev No	Reference Trajectory Events	Guidance & Control Events	Guidance & Control Procedures
Duration Sect	Initiation Time Hr. Min. Sec.				
600	56:56:00		Update SPS Solar Soak Attitude	Update SPS Solar Soak Attitude	10.7 Precise Wobble Mode Establishment 10:18 S/C Attitude Maneuver To External Reference
120	57:06:00			Power Down SCS	10.1 G&C Power Down (SCS Portion)
120	60:04:00			Power Up SCS	10.9 G&C Power Up (SCS Portion)
600	60:06:00		Update SPS Solar Soak Attitude	Update SPS Solar Soak Attitude	10.7 Precise Wobble Mode Establishment, and 10.18 SC Att. Man. to Ext. Ref.
120	60:16:00			Power Down SCS	10.1 G&C Power Down (SCS Portion)
120	63:14:00			Power Up SCS	10.9 G&C Power Up Sequence (SCS Portion)
600	63:16:00		Update SPS Solar Soak Attitude	Update SPS Solar Soak Attitude	10.7 Precise Wobble Mode Establishment, and 10.18 SC Att. Man. to Ext. Ref.
120	63:26:00			Power Down SCS	10.1 G&C Power Down (SCS Portion)

Figure 3-1. G&C Timelines (cont)

Time Data		Rev No	Reference Trajectory Events	Guidance & Control Events	Guidance & Control Procedures
Duration Sec	Initiation Time Hr. Min. Sec.				
120	66:24:00			Power Up SCS	10.9 G&C Power Up Sequence (SCS Portion)
600	66:26:00		Update SPS Solar Soak Attitude	Update SPS Solar Soak Attitude	10.7 Precise Wobble Mode Establishment, and 10.18 SC Att. Man. to Ext. Ref.
120	66:36:00			Power Down SCS	10.1 G&C Power Down (SCS Portion)
120	69:34:00			Power Up SCS	10.9 G&C Power Up Sequence (SCS Portion)
600	69:36:00		Update SPS Solar Soak Attitude	Update SPS Solar Soak Attitude	10.7 Precise Wobble Mode Establishment, and 10.18 SC Att. Man. to Ext. Ref.
120	69:46:00			Power Down SCS	10.1 G&C Power Down (SCS Portion)
120	72:22:00			Turn On AGC	See - 10.46 AGC Update
300	72:24:00			Receive Maneuver Data Via Updata Link and Voice Modes	10.46 AGC Update
120	72:48:00			Power Up G&C	10.9 G&C Power Up Sequence

Figure 3-1. G&C Timelines (cont)

Time Data		Rev No	Reference Trajectory Events	Guidance & Control Events	Guidance & Control Procedures
Duration Sec	Initiation Time Hr. Min. Sec.				
600	72:50:00			IMU Orientation Determination Program	10.44 IMU Orientation Determination
600	73:08:00			Prethrusting Program	10.42 Orbit Change and SPS Minimum Impulse Prethrusting
300	73:18:00			Confirm Thrusting Parameters With MSFN	See 10:42 Orbit Change and SPS Minimum Impulse Prethrusting
900	73:30:00			Align IMU	10.45 IMU Align
600	73:55:00			SPS Monitor Program	See Thrusting Procedure
15	74:05:36	48	Ullage	+ X Translation	See Thrusting Procedure
13	74:05:51	48	Initiate 4th SPS Burns	SCS Automatic Delta V Manual On, SCS Off Thrust	10.22 SCS Velocity Change
120	74:12:00			Power Down G&C	10.1 G&C Power Down
120	75:28:00			Turn On AGC	See 10.46 AGC Update
300	75:30:00			Receive Maneuver Data Via Updata Link and Voice Modes	10.46 AGC Update
600	76:30:00			IMU Orientation Determination Program	10.44 IMU Orientation Determination

Figure 3-1. G&C Timelines (cont)

Time Data		Rev No	Reference Trajectory Event	Guidance & Control Event	Guidance & Control Procedure
Duration Sec	Initiation Time Hr. Min. Sec.				
600	76:40:00			Prethrusting Program	10.42 Orbit Change and SPS Minimum Impulse Prethrusting
300	76:50:00			Confirm Thrusting Parameters With MSFN	See 10.42 Orbit Change and SPS Minimum Impulse Prethrusting
120	77:28:00			Power Up SCS	10.1 G&C Power Up Sequence (SCS Portion)
900	77:30:00			Align IMU	10.45 IMU Align
600	77:45:00			Start Minimum Impulse Thrusting Program	10.3 G&N Velocity Change
15	77:55:05	50	Ullage	+ X Translation	See Thrusting Procedure
0.228	77:55:20	50	Initiate 5th SPS Burn	G&N Automatic Delta V G&N Minimum Impulse Thrust	See Thrusting Procedure
300	77:06:00*			Receive Maneuver Data Via Updata Link and Voice Modes	10.46 AGC Update
600	78:00:00			Prethrusting Program	10.42 Orbit Change and SPS Minimum Impulse Prethrusting
900	78:10:00			Align IMU	10.45 IMU Align

Figure 3-1. G&C Timelines (cont)

Time Data		Rev No	Reference Trajectory Events	Guidance & Control Events	Guidance & Control Procedure
Duration Sec	Initiation Time Hr. Min. Sec.				
300	78:25:00			Confirm Thrusting Parameters With MSFN	See - 10.42 Orbit Change and SPS Minimum Impulse Prethrusting
600	78:32:00			Start Minimum Impulse Thrusting Program	10.3 G&N Velocity Change
15	78:42:17	50	Ullage	+ X Translation	See Thrusting Procedure
0.228	78:42:32	50	Initiate 6th SPS Burn	G&N Automatic Delta V G&N Minimum Impulse Thrust	See Thrusting Procedure
120	78:49:00			Power Down G&N	10.1 G&C Power Down (G&N Portion)
600	78:49:00		SPS Cold Soak	Establish Spin Stabilized SPS Cold Soak	10.7 Precise Wobble Mode Establishment, and 10.18 SC Att. Man. to Ext. Ref.
120	78:59:00			Power Down SCS	10.1 G&C Power Down (SCS Portion)
120	81:51:00			Power Up SCS	10.9 G&C Power Up Sequence (SCS Portion)
600	81:59:00		Update SPS Cold Soak Attitude	Update SPS Cold Soak Attitude	10.7 Precise Wobble Mode Establishment, and 10.18 SC Att. Man. to Ext. Ref.
120	82:09:00			Power Down SCS	10.1 G&C Power Down (SCS Portion)

Figure 3-1. G&C Timelines (cont)

Time Data		Rev No	Reference Trajectory Event	Guidance & Control Events	Guidance & Control Procedure
Duration Sec	Initiation Time Hr. Min. Sec.				
120	85:07:00			Power Up SCS	10.9 G&C Power Up Sequence (SCS Portion)
600	85:09:00		Update SPS Cold Soak Attitude	Update SPS Cold Soak Attitude	10.7 Precise Wobble Mode Establishment, and 10.18 SC Att. Man. to Ext. Ref.
120	85:19:00			Power Down SCS	10.1 G&C Power Down (SCS Portion)
120	88:17:00			Power Up SCS	10.9 G&C Power Up Sequence (SCS Portion)
600	88:19:00		Update SPS Cold Soak Attitude	Update SPS Cold Soak Attitude	10.7 Precise Wobble Mode Establishment, and 10.18 SC Att. Man. to Ext Ref.
120	88:29:00			Power Down SCS	10.1 G&C Power Down (SCS Portion)
120	91:27:00			Power Up SCS	10.9 G&C Power Up Sequence (SCS Portion)
600	91:29:00		Update SPS Cold Soak Attitude	Update SPS Cold Soak Attitude	10.7 Precise Wobble Mode Establishment, and 10.18 SC Att. Man. to Ext. Ref.
120	91:39:00			Power Down SCS	10.1 G&C Power Down (SCS Portion)
120	93:14:00			Turn On AGC	10.46 AGC Update

Figure 3-1. G&C Timelines (cont)

Time Data		Rev No	Reference Trajectory Event	Guidance & Control Events	Guidance & Control Procedure
Duration Sec	Initiation Time Hr. Min. Sec.				
300	93:16:00			Receive Maneuver Data Via Update Link and Voice Modes	10.46 AGC Update
120	93:21:00			Power Up G&C	10.9 G&C Power Up
600	93:23:00			IMU Orientation Determination Program	10.44 IMU Orientation Determination
600	93:33:00			Prethrusting Program	10.42 Orbit Change and SPS Minimum Impulse Prethrusting
300	93:51:00			Confirm Thrusting Parameters With MSFN	10.42 Orbit Change and SPS Minimum Impulse Prethrusting
900	94:17:00			Align IMU	10.45 IMU Align
600	94:32:00			Start Thrusting Orbit Change Program	See Thrusting Procedures
15	94:42:36	61	Ullage	+ X Translation	See Thrusting Procedure
13.5	94:42:51	61	Initiate 7th SPS Burn	MTVC With Damping To An FDAI Reference G&N Thrust On/Off	10.20 Manual TVC To FDAI Attitude Reference
120	94:45:00			Power Down G&C	10.1 G&C Power Down
120	327:52:00			Turn On AGC	10.46 AGC Update

Figure 3-1. G&C Timelines (cont)

Time Data		Rev No	Reference Trajectory Event	Guidance & Control Event	Guidance & Control Procedure
Duration Sec	Initiation Time Hr. Min. Sec.				
300	327:54:00			Receive Maneuver Data Via Updata Link and Voice Modes	10.46 Update
120	327:59:00			Power Up G&N	10.9 G&C Power Up Sequence (G&N Portion)
600	328:01:00			IMU Orientation Determination Program	10.44 IMU Orientation Determination
600	328:11:00			Deorbit Prethrusting Program	10.43 Deorbit Prethrusting
300	328:28:00			Confirm Thrusting Program	See - 10.43 Deorbit Prethrusting
120	328:39:00			Power Up SCS	10.9 G&C Power Up Sequence (SCS Portion)
900	328:41:00			Align IMU	10.45 IMU Align
600	328:56:00			Start Deorbit Thrusting Program	10.3 G&N Velocity Change
15	329:06:14	209	Ullage	+ X Translation	See Thrusting Procedure
17	329:06:29	209	Initiate SPS Deorbit Burn	G&N Automatic Delta V G&N Thrust On/Off	See Thrusting Procedure

Figure 3-1. G&C Timelines (cont)

Time Data		Rev No	Reference Trajectory Events	Guidance & Control Events	Guidance & Control Procedures
Duration Sec	Initiation Time Hr. Min. Sec.				
40.75	329:06:46		Maneuver To CM-SM Separation Attitude	Maneuver To CM-SM Separation Attitude	10.14 CM-SM Separation Orientation and Separation Procedure
	329:07:26.75		Perform CM-SM Separation	Perform CM-SM Separation	See 10.14 CM SM Separation Orientation and Separation Procedure
	329:07:27		Maneuver To Entry Attitude	Maneuver To Entry Attitude	10.15, 0.05 g Orientation, Attitude Hold And G&N Automatic Entry
	329:14:08		400,000 Ft Entry Interface		See 10.15
	329:16:34		0.05 g	Rate Damping Only Pitch and Yaw Attitude Hold In Roll	See 10.15
	329:17:06		0.20 g	Begin Range Control Maneuvers	See 10.15
	329:23:56		25,000 Feet		

Figure 3-1. G&C Timelines (cont)

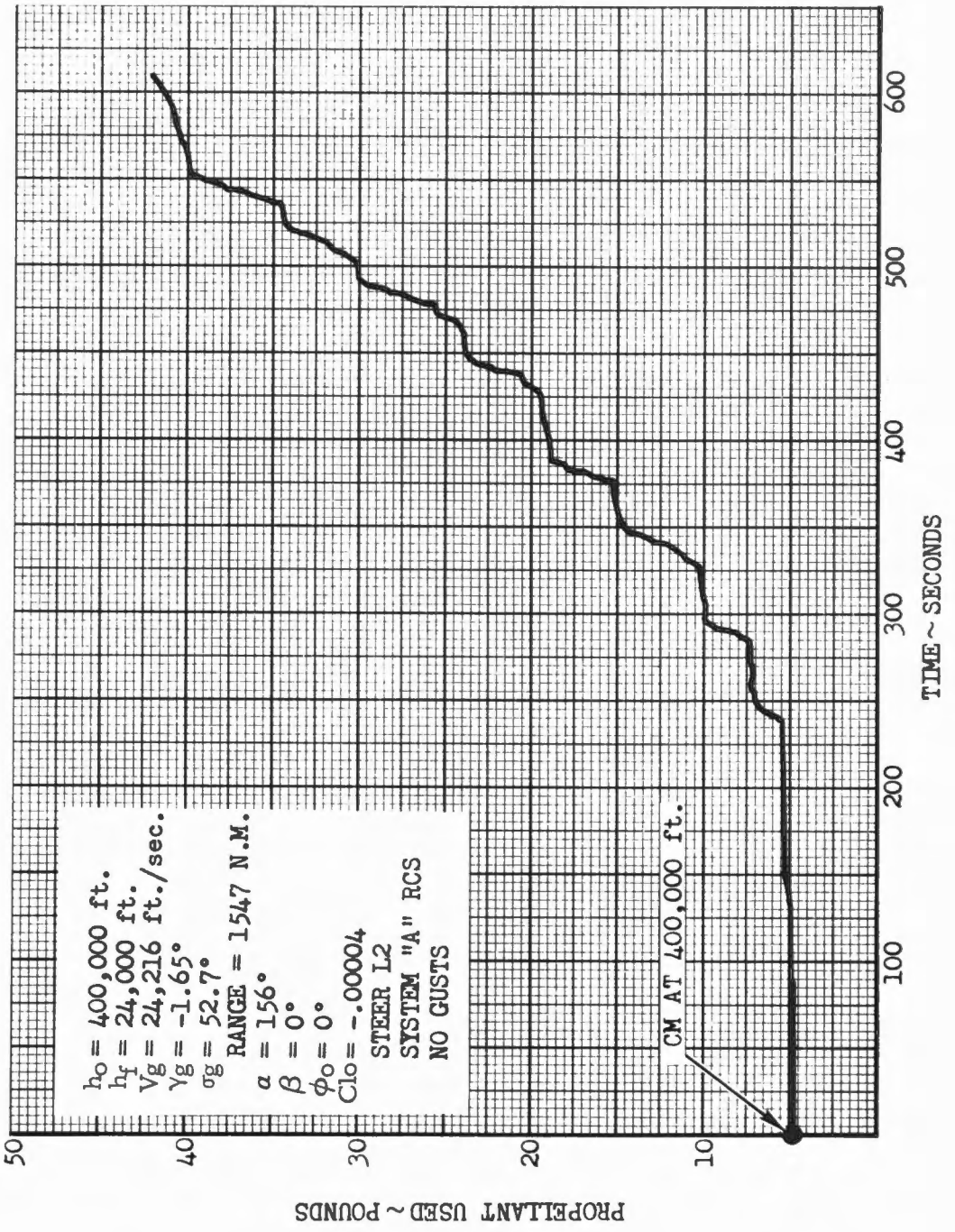

Figure 3-2. Propellant Time History SC 012 Single RCS Nominal Case

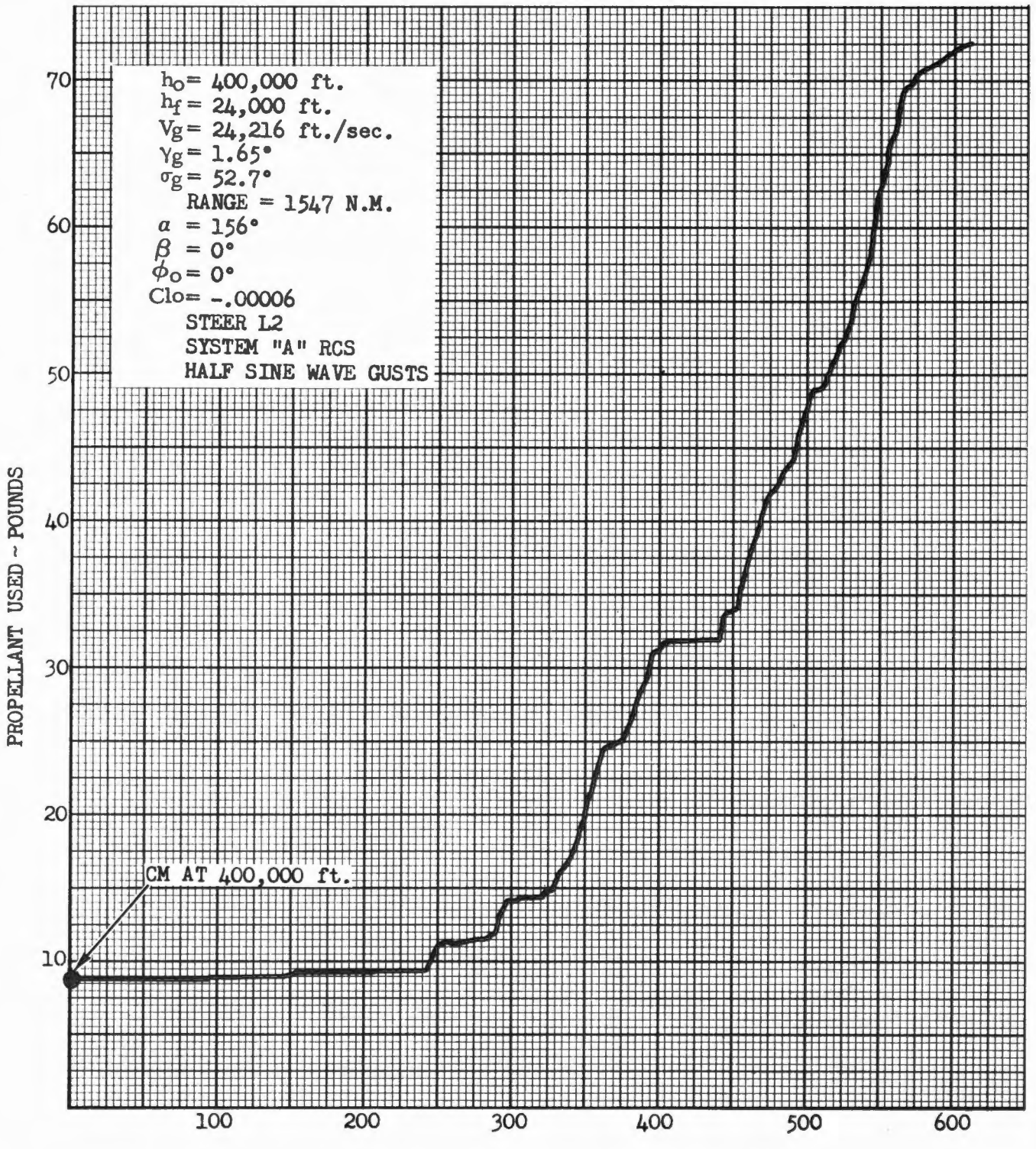

Figure 3-3. Propellant Time History SC 012 Single RCS Off-Nominal Case

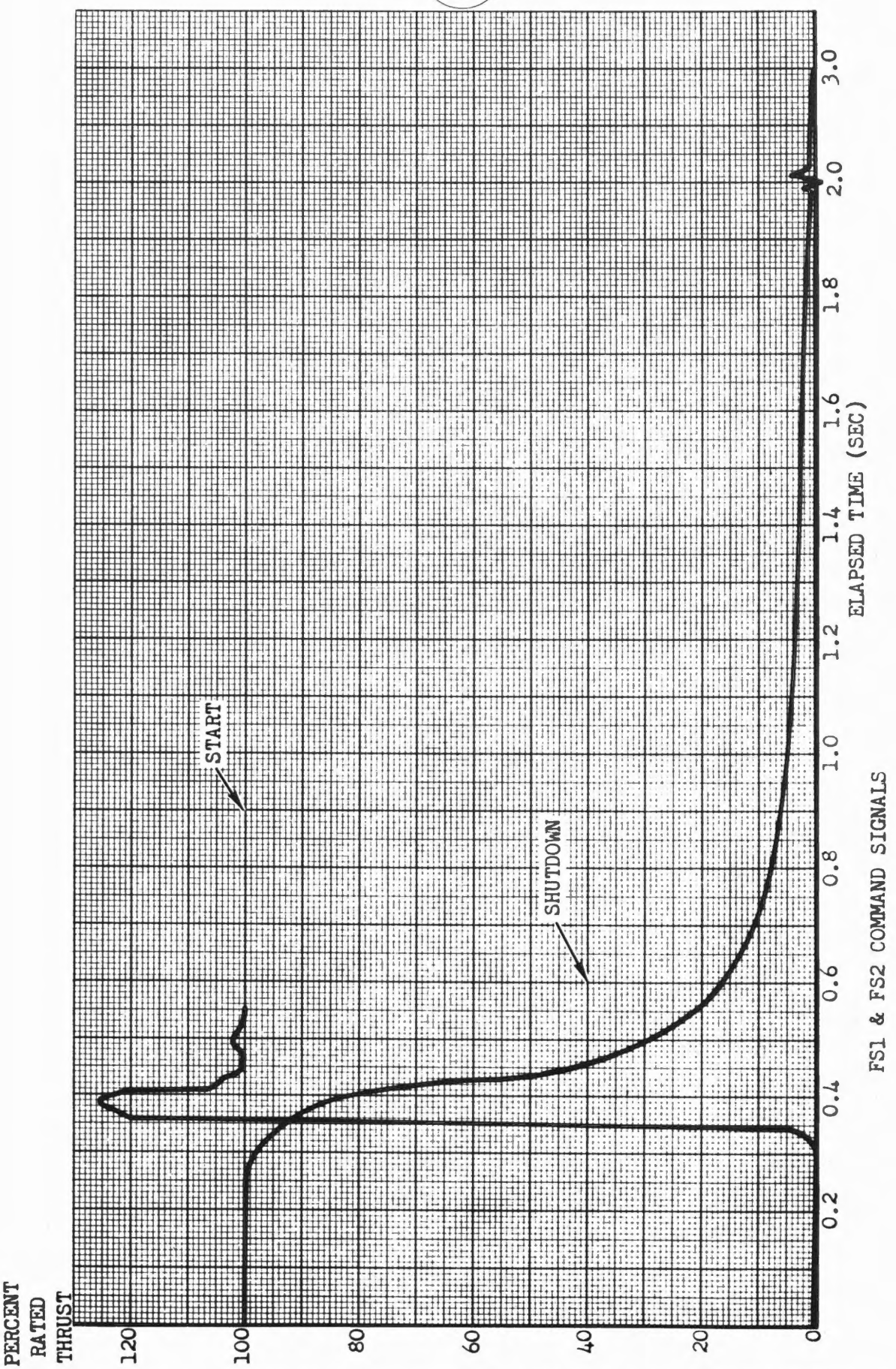

Figure 3-4. Thrust Transients SPS Engine S/N 31 Estimated Nominal.

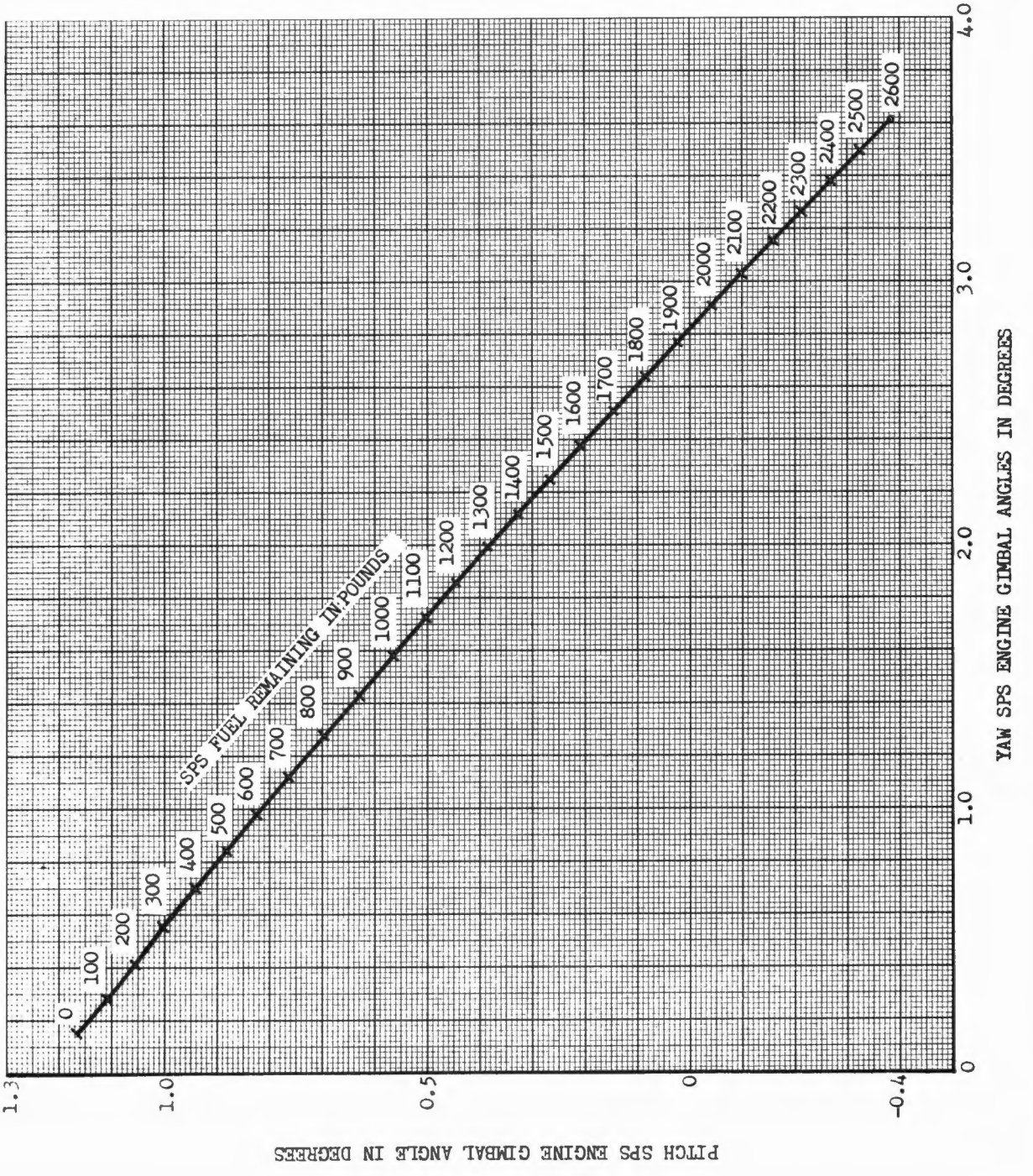

Figure 3-5. SPS Engine Gimbal Angles Versus SPS Remaining for AFRM 012.

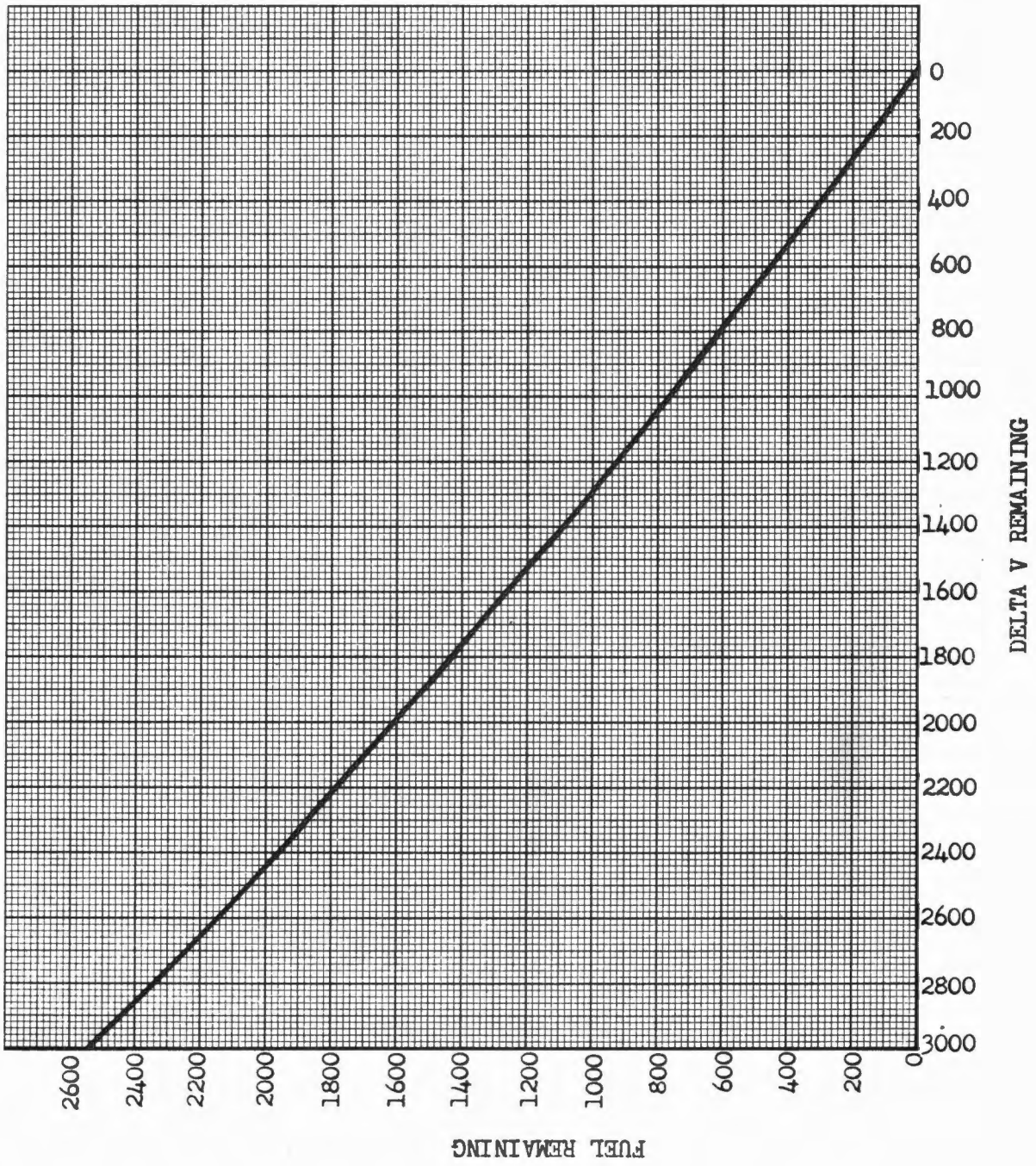

Figure 3-6. Delta V capability Remaining vs SPS Fuel Remaining.

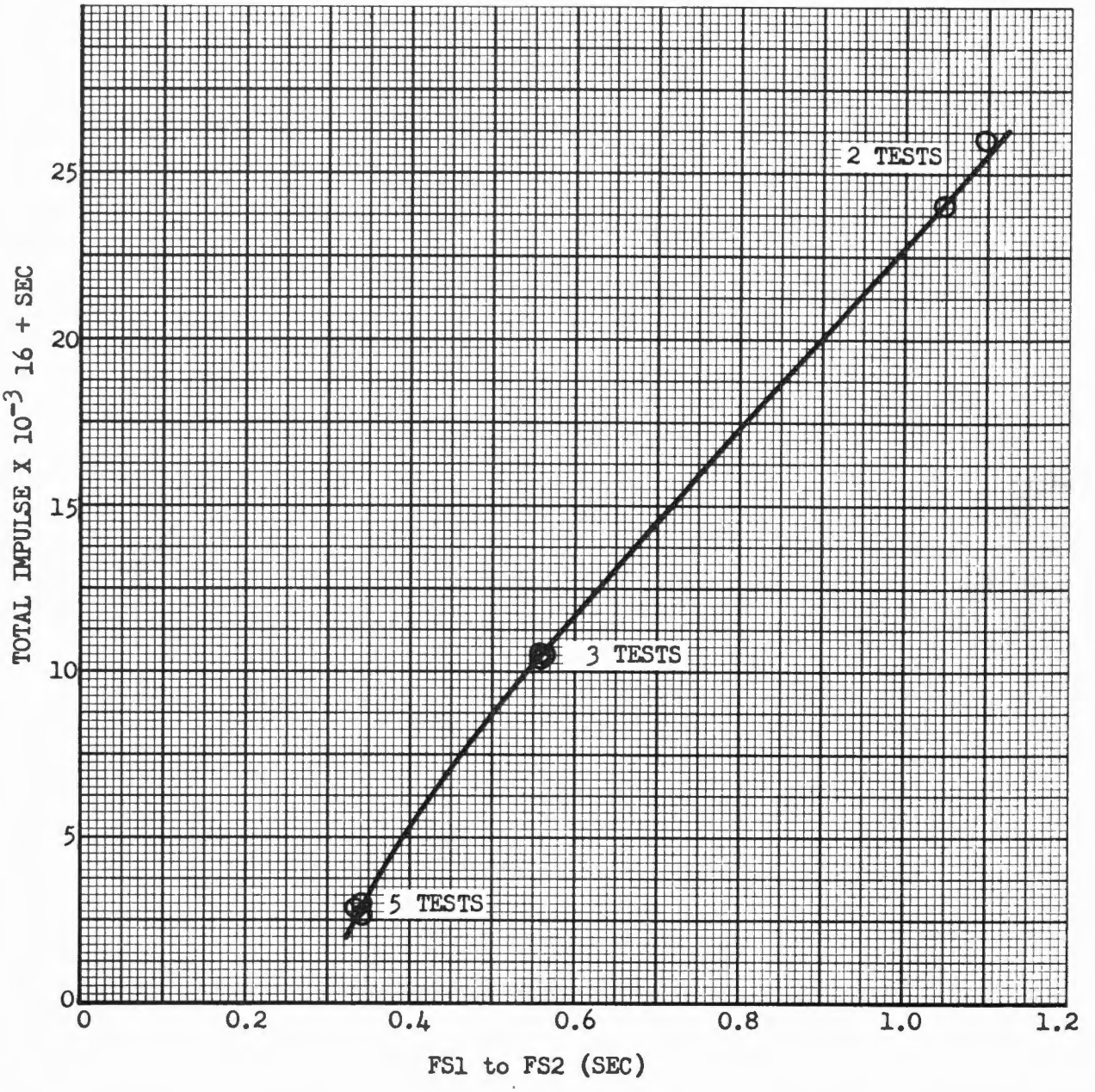

Figure 3-7. Minimum Impulse Tests AEDG Qualification Series CB and CC

MISSION 204A - S/C 012
NOMINAL SPS PITCH AND YAW GIMBAL POSITION WITH BURN TIME, AND PROPELLANT CONSUMED
(GPI POSITION AND GPS VOLTAGES ARE SHOWN)

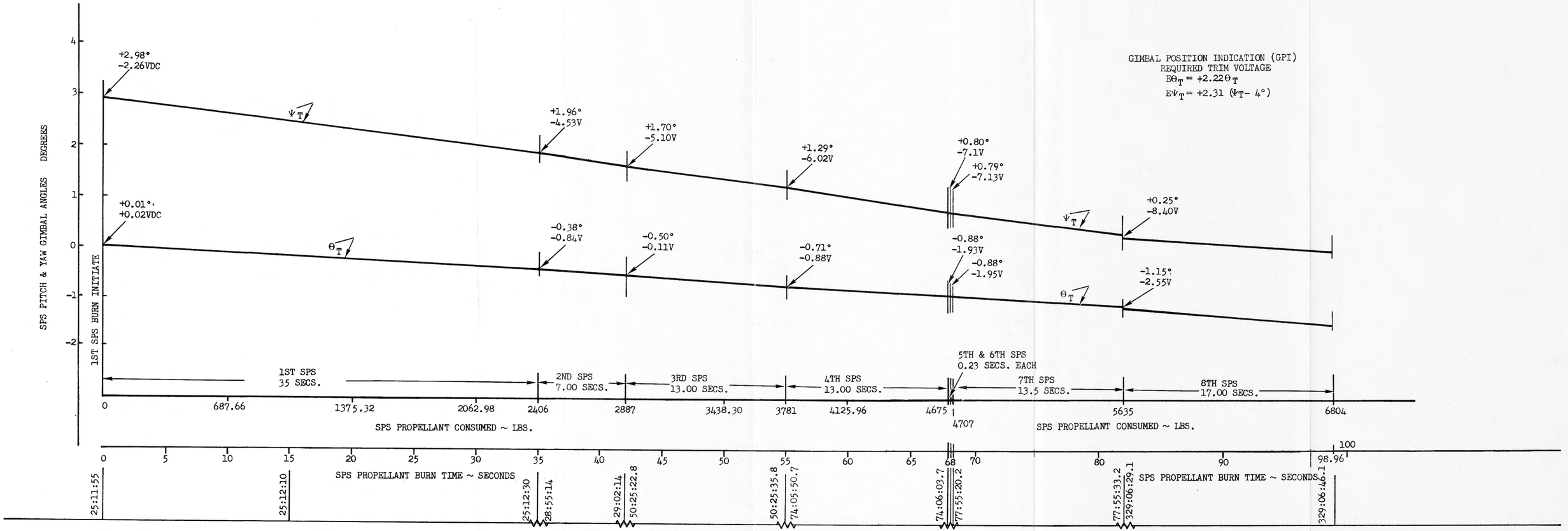

Figure 3-8. Mission 204A-SC012 Nominal SPS Pitch and Yaw Gimbal Position With Burn Time and Propellant Consumed

Table 3-2. SA 204A/012 Nominal Gimbal Position Settings and Characteristic Velocities.

Ullage Prior to SPS	Ullage RCS	SPS Burn			Gimb. Pos. Setttings				Characteristic Velocities								
					Initial Gimb. Pos. (GPI)		Initial Voltage (GPS)		Nominal			Engine Tailoff		Counter Accuracy		Counter Range	
									SPS	Ull.	Req.	Lower Limit	Upper Limit	Lower	Upper	Lower	Upper
Duration	Fuel	No.	Dur	Fuel	θ_T	ψ_T	$E\theta_T$	$E\psi_T$	ΔV_{SPS}	ΔV_{ULL}	ΔV_X	$\Delta V_{T.O.}$	$\Delta V_{T.O.}$	$\Delta V_{C.A.}$	$\Delta V_{C.A.}$	ΔV_C	ΔV_C
Secs.	Lbs.		Secs.	Lbs.	Deg.		Volts		Ft/Sec			Ft/Sec		Ft/Sec		Ft/Sec	
15.0	20.5	1	35.00	2406	0.01	2.98	0.02	-2.26	917.0	7.0	924.0	10.0	16.3	18.3	18.2	932.3	925.9
15.0	20.5	2	7.00	481	-0.38	1.96	-0.84	-4.63	187.0	7.3	194.3	10.2	16.6	3.8	3.7	187.9	181.4
15.0	20.5	3	13.00	894	-0.50	1.70	-0.84	-5.10	365.0	7.4	372.4	10.6	17.2	7.2	7.1	369.0	362.3
15.0	20.5	4	13.00	894	-0.71	1.29	-1.58	-6.02	376.1	7.6	383.7	10.6	17.2	7.5	7.3	380.6	373.8
15.0	20.5	5	0.23	16	-0.88	0.80	-1.93	-7.10	8.1	8.0	16.1	11.0	17.9	*0.10	*-0.036	7.1	0.2
15.0	20.5	6	0.23	16	-0.88	0.79	-1.95	-7.13	7.8	8.4	16.2	11.0	17.9	*0.10	*-0.034	7.2	0.3
15.0	20.5	7	13.50	928	-0.89	0.78	-1.97	-7.15	434.8	8.4	443.2	11.5	18.7	8.6	8.5	440.3	433.0
15.0	20.5	8	17.00 (98.96)	1169 (6804)	-1.15	0.22	-2.55	-8.40	577.5	8.4	585.9	12.3	20.0	11.5	11.3	585.1	577.2

* Minimum Tolerance = 2.0 F.P.S.

4 SPACECRAFT AND MISSION REFERENCE DATA

4.1 The following listed specifications and documents have been used in defining the spacecraft configuration and as a data base for the derivation of the performance values and performance limitations in this document.

a. SID 63-313 CSM Technical Specification (Block I) Revised 22 February 1965.

b. SID 64-1080 SC 012 End Item Specification (Part I) Revised 22 February 1965.

c. SID 64-1237 CSM Master End Item Specification (Block I) Revised 22 February 1965.

d. MIT R-507 G&N System Operations Plan Mission AS 204A, January 1966.

e. SID - 1006-3 Bi-monthly Weight and Balance Status Report for CSM End Item Spacecraft 012 and 014, 1 January 1966.

4.1.1 The reference documents used in developing the specific SC 012 mission requirements are listed below:

a. MSC Internal Note No. 65-FM-134, AS 204A Spacecraft 012 Reference Trajectory Volumes I, II and III dated 5 November 1965.

b. TRW 3640 - 6012 - To - 000 Mission Requirements for Apollo Spacecraft Development Mission AS 204A/AS205, dated 30 August 1965.

5 GUIDANCE AND CONTROL FUNCTIONAL DESCRIPTIONS

5.1 General Guidance and Control Descriptions.

5.1.1 Attitude Control Capabilities of Block I G&N Systems (Attitude Hold). The purpose of this section is to clarify the attitude control capabilities and limitations of the Block I G&C systems. Questions within Apollo have shown that such clarification will assist other units in mission planning and similar activities for Block I.

5.1.1.1 General. Several approaches to attitude hold capabilities have been taken into consideration during the design concept stages and now new procedural innovations are being developed in response to specific requirements (e.g., "Bar-B-Q" and "Wobble" Modes). Disregarding the source of the hold signals and the magnitude of the attitude excursions permitted, the systems can hold attitude in all three axes; hold attitude in two axes, and free drift in one axis; establish a "wobble" mode, where pitch and yaw are held approximately and a deliberate roll rate is initiated and maintained; or free drift in all three axes. In all of these cases certain electrical power, RCS fuel, and equipment operating time costs are associated with the application. In any closed system, energy management is very important, so a table showing the relative costs of the various control modes is included.

5.1.1.2 System Description. All of the control modes are basically attitude control modes with the exception of the Monitor Mode. They all include the capability of attitude maneuvers. The Monitor Mode is a rate damped, free drifting mode. The G&N and SCS Attitude Control and Delta V Modes are all similar to the extent that any of these modes can be used interchangeably (with two minor restrictions). Any use of the Attitude Impulse Controller (Minimum Impulse Control) is, for safety reasons, restricted to the G&N or SCS Attitude Control Modes. SPS thrusting (TVC) should be accomplished in the G&N or SCS Delta V Mode or their emergency backup, the Manual Thrust Vector Control Mode (MTVC). The main differences between the Entry Modes and those discussed earlier are display scaling, rate and attitude deadbands, and rate command limiting. Functionally, the modes are equivalent to their midcourse brothers. The Local Vertical Mode is an attitude control mode in which an attempt to provide an open loop torquing signal has been included to cancel out the attitude changes with respect to an earth centered frame of reference (as opposed to inertially fixed attitude hold). Due to the basic open loop nature of the mode, errors, resulting from a noncircular and/or off 100 nautical mile altitude and natural system drifts and tolerances, approaching 40 degrees per axis per orbit can occur. S&ID formally recommended to NASA/MSC that the Local Vertical Mode should not be used in flight due to the large errors probable in its application (CSM SCS Meeting No. 21, October 1964). S&ID mission planning is based on this recommendation.

5.1.1.3 Three Axes Attitude Hold. The normal attitude hold mode is that in which a space fixed three axis hold is established and maintained using either of the on-board attitude references to close the outer loop. The wide (maximum) or narrow (minimum) deadband can be selected depending upon the attitude excursion limit desired. This mode is most expensive in terms of electrical power, RCS propellant and system operating times. It should only be employed when the mission requires a specific and relatively accurate inertial attitude hold be established and maintained. Both of the on-board

attitude reference systems will require periodic updating and, depending upon the attitude tolerance of the specific mission objectives, the spacecraft attitude may require periodic correction.

5.1.1.4 Two Axes Hold-One Axis Free Drift (Bar-B-Q Mode). Thermal constraints have arisen since the control system design base establishment in which there is a desire to hold two axes space fixed while maintaining a specific rate in the third axis. While such a control mode is not specifically included in the design, the switching flexibility of the system has permitted the development of such an operational capability.

5.1.1.4.1 For this special case, the SCS Attitude Control Mode must be used. The vehicle is oriented to the desired initial attitude, and the free axis control jets are disabled by opening their respective circuit breakers after the desired rate of rotation has been established in that axis.

CAUTION: The disable switch cannot be used as this would cause all three BMAG's to cage through the AGCU.

The BMAG for that axis should now be rate caged by its Backup Rate switch, to prevent its going into and out of its attitude stops as the vehicle rotates about its axis. Equipment operating times and electrical power required will be the same as for the three axes attitude hold mode although slight RCS propellant savings will occur in the rotating axis. Again, unless the attitude constraints require very accurate control, this control application should be avoided. The BMAG's for the two held axes will have some drift and periodic updating will be required.

5.1.1.5 Wobble Mode. An application in which two axes are established in an attitude hold as a side-effect of spinning up the vehicle about the third axis is theoretically possible and being investigated at this time. Its benefits are that the control system may be turned off after the mode is established and significant savings result in all three areas of concern (i.e., equipment operating time, RCS propellant, and electrical power). The limitation to the application of this mode is that it is roughly three times less precise than previously discussed modes (half angle of 14 degrees vs. 5 degrees nominal in both cases). The rate of decay for this mode has not yet been calculated. No time can be specified on frequency of re-establishment of the mode until additional analyses and simulations have been completed. (See later sections for preliminary analytical results).

5.1.1.6 Free Drift. Where no specific attitude is required, a free drifting mode can be established in which the equipment is off and no RCS propellant is required in establishing the condition. This is the least expensive mode of control and should be used whenever possible. Present thermal constraints and mission objective requirements make it unlikely that this mode will be applied very often.

5.1.1.7 Summary. Specific procedures, for establishing the various attitude control modes described, are included separately.

5.1.1.7.1 The most accurate and most expensive method of attitude hold is the establishment of a three axis attitude hold in either the maximum or minimum deadband. In all applications, the minimum deadband uses more RCS propellant and slightly more electrical power than the maximum deadband.

5.1.1.7.2 A method that is approximately as accurate as three axis attitude hold, but that does allow for some RCS propellant savings and satisfies the thermal objective of holding two axes while rotating about the third is the "Bar-B-Q Mode."

5.1.1.7.3 A less accurate, but considerably more economical, method of two axes controlled-one axis rotating hold is the "Wobble Mode."

5.1.1.7.4 The most economical method in terms of the three parameters considered is Free Drift, but this mode can only be applied where no specific attitude constraint exists.

5.1.1.7.5 All methods of attitude control, except Free Drift, require periodic updating of the attitude reference and may require periodic vehicle maneuvering.

5.1.1.7.6 The G&N would not be used for the Bar-B-Q, or Wobble modes. To establish the mode the SCS would also have to be on, and a considerable increase in electrical power would be required. Also, the available operating time for the G&N subsystem is considerably less than for the SCS. Finally, the SCS BMAG's are better suited to body axis control by axis for these applications than the G&N IMU. See Table 5-1 for a comparison of the attitude hold modes.

5.1.2 SC 012 Application of Spin-Stabilized Inertial Attitude Hold Capability. Some of the experiments tentatively planned for the SC 012 mission require holding specific inertial attitudes for relatively long periods of time (12 to 20 hours). An active attitude hold with the SCS RCS for these time periods is undesirable in terms of other mission objectives. The SM/RCS propellant consumed would seriously limit the orbital dwell period, and a specifically identified objective for SC 012 is to remain in orbit as long as possible. Due to the NASA directed deletion of on-board spares and the inflight test and maintenance concepts that Block I equipment is designed to, the reliability goal for the SCS is on the order of 14 hours of operation without a failure. Obviously, two 12 hour attitude hold periods more than use up the safe operating time of the SCS and so some alternative method of performing the experiments must be found or the experiments should be dropped.

A spin-stabilized inertial attitude hold mode is being investigated for Block II passive thermal control applications. This mode is based on the classical mechanics case discussed by Goldstein, ("Classical Mechanics", Addison-Wesley Publishing Co., 1965, Reading, Massachusetts (pp. 156-163)). Certain assumptions are made in exploring the application of this technique to Block I orbital flihgt and they and the limitations to the "wobble" mode will be covered in the following section.

MODE		ATTITUDE ACCURACY	EQUIPMENT TIME	RCS FUEL	ELECTRICAL POWER
3 AXIS HOLD	G & N	± 5 3 AXES	GREATEST	GREATEST	GREATEST
	SCS	± 5 3 AXES	HIGH	GREATEST	HIGH
BAR-B-Q	SCS ONLY	± 5 2 AXES ± 180 1 AXIS	HIGH	HIGH	HIGH
WOBBLE	SCS ONLY	± 20 2 AXES ± 180 1 AXIS	MINIMUM	MINIMUM	MINIMUM
FREE DRIFT	MON-ITOR	± 180 3 AXES	HIGH	NONE	HIGH
FREE DRIFT	NONE	± 180 3 AXES	NONE	NONE	NONE

Table 5-1. Comparison of Attitude Hold Methods

5.1.2.1 Discussion. Several assumptions will be required to apply the principles of Goldstein's classic case to the Apollo CSM. As will be shown in the discussion, the assumptions and limitations are not extreme and, in other studies, where actual values have been used, no significant changes to the general solution were found. Two unknowns do limit the application of the "wobble" made in orbital flight, but their magnitude and impact are unknown at this time. Both the gravity gradient and atmospheric drag effects and their possible effects on this mode will be covered later.

5.1.2.1.1 The first assumption required is that the body considered is a rigid body with two axes symmetrical. For the lightest earth orbital CSM inertias, the current I_{yy} and I_{zz} values are just above and below 35,000 slug feet^2. This study will use the median between the two values. A value of 12,000 slug-feet^2 will be used for I_{xx}.

5.1.2.1.2 The principal X axis (Xp) of the vehicle has been calculated as approximately 1.8 degrees offset from the vehicle X axis (X_B). Although the transforms are available, the differences between body rates and rates about the principal axes are so slight that the rates will be assumed to be equal. The actual offset of the principal axis is into the +Y and -Z directions at a ratio of roughly 1 - 3, see Figure 5-1.

5.1.2.2 General Case. Residual body rates in all axes can be reduced to roughly .01 degrees/second. Imparting a roll rate to the vehicle will not increase these rates in pitch and yaw to more than .02 degrees/second and, in fact, may reduce these rates to zero.

5.1.2.2.1 The pitch and yaw rates may have any value between $\pm$ .10 degrees/second at the start of the roll rate, and any value between $\pm$ .02 degrees/second after imparting a .5 degree/second roll rate. The SCS would now be shut off.

5.1.2.2.2 The vehicle principal axes angular momentums will now add vectorially (as illustrated in Figure 5-2) to produce a vector offset from the principal X axis by the angle α. The magnitude of α will be determined by the magnitudes of the pitch ($\omega\theta$), yaw ($\omega\psi$) and roll ($\omega\psi$) rates and the moments of inertia for the three axes. The direction of α in the Y-Z plane will be determined by the vector sum of $\omega\theta$ and $\omega\psi$. Since for the general case we have allowed $\omega\theta$ and $\omega\psi$ to have any sense, the inertial axis (X_T) about which the vehicle will rotate may be offset in any direction from Xp. The formula for determining α is given below:

$$\alpha = \tan^{-1}\sqrt{\frac{|\omega_\theta I_{yy}|^2 + |\omega\psi I_{zz}|^2}{I_{xx}\,\omega\phi}} \qquad (1)$$

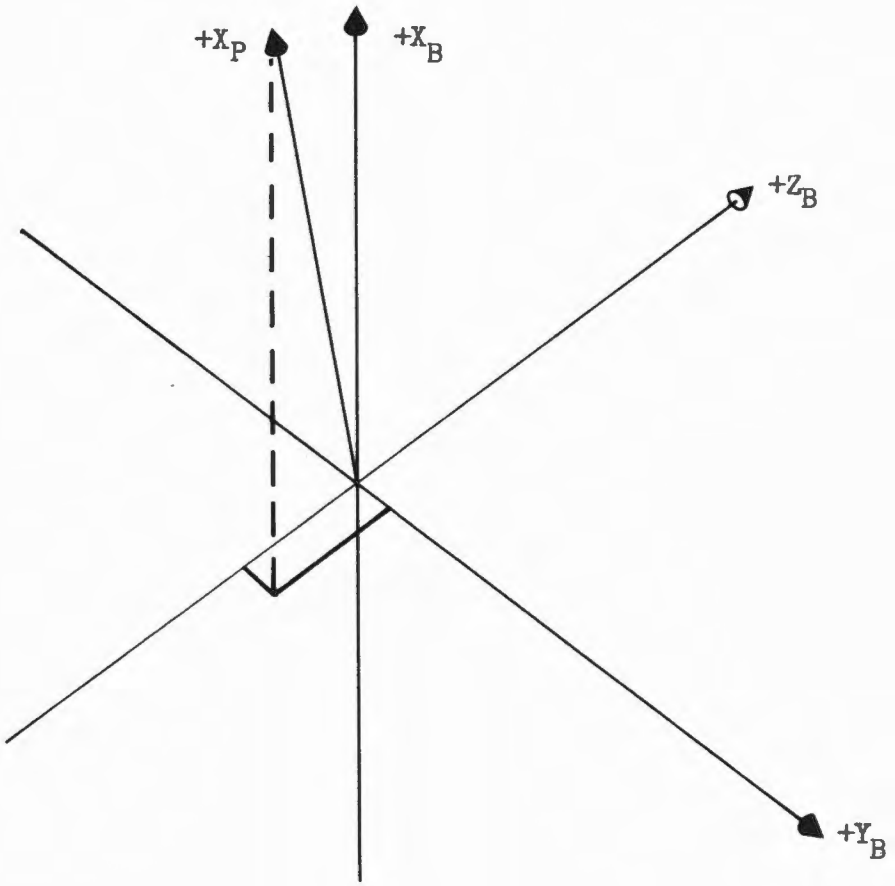

Figure 5-1. Principal X Axis Offset

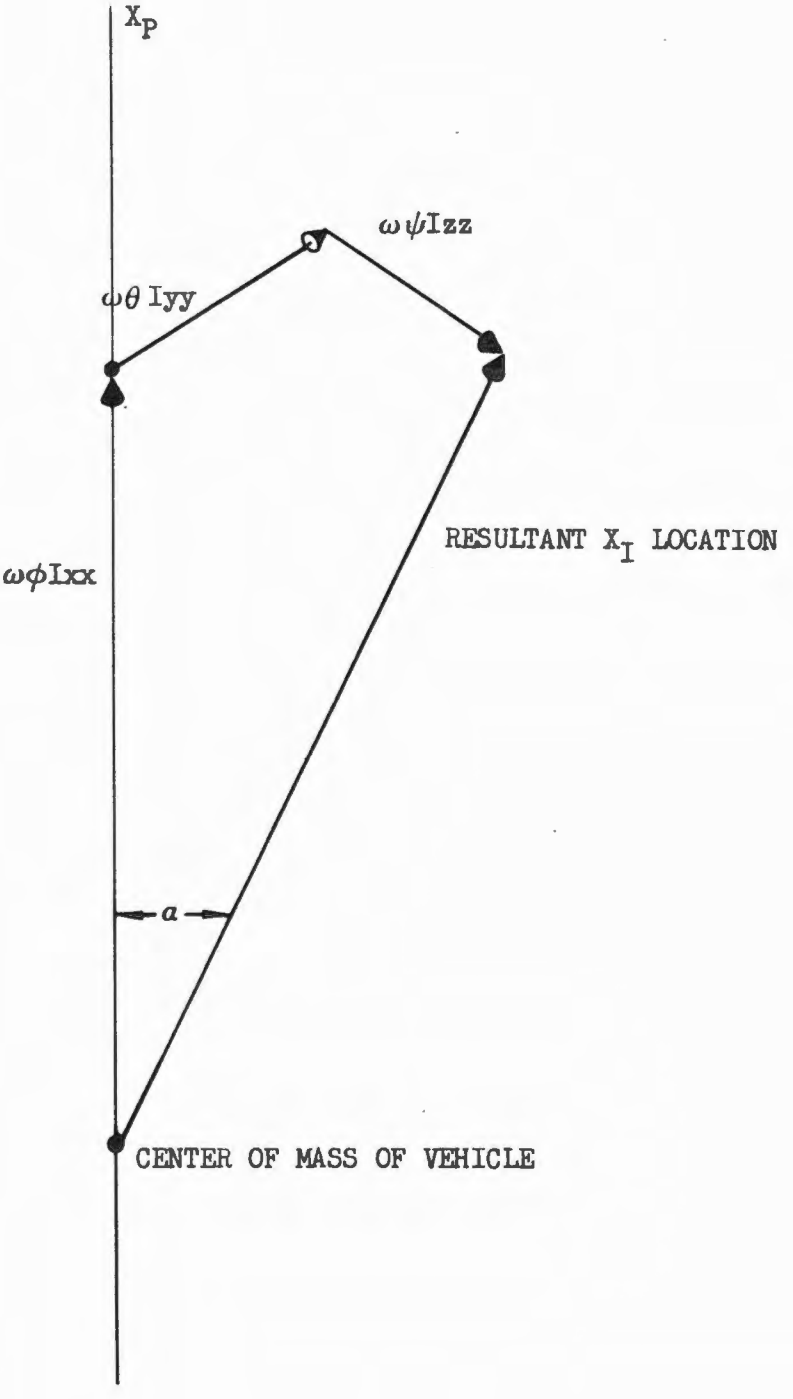

Figure 5-2. Angular Monentum Vector

Remembering the assumption $I_{yy} = I_{zz} = I_1$, equation (1) simplifies to:

$$\alpha = \tan^{-1} \frac{I_1}{I_{xx}\omega\phi} \sqrt{|\omega_\theta|^2 + |\omega\psi|^2} \qquad (2)$$

As the inertials are a constant of any given time, equation (2) shows that increasing $\omega\phi$ or decreasing $\omega\theta$ or $\omega\psi$ will cause α to decrease and vice versa. The smaller α becomes the more precisely we will know our inertial axis of rotation location.

Assuming $\omega_\theta = \omega\psi = \omega\Delta$ then

$$\sqrt{|\omega_\theta|^2 + |\omega\psi|^2} = \sqrt{2}\ \omega\Delta \qquad (3)$$

Equation (2) can now be simplified to

$$\tan\alpha = \frac{I_1}{I_{xx}}\ \sqrt{2}\ \left|\frac{1}{\omega\phi}\right| \omega\Delta \qquad (4)$$

Solving equation (4) for the maximum value of $\omega\Delta$ results in $\alpha \approx 9.3$ degrees.

The inertial axis (X_I), about which the principal axis (Xp) will rotate, is therefore, constrained to lie within a pyramid about the Xp axis such that the half angle of the inscribed cone is 9.3 degrees (see Figure 5-3).

5.1.2.2.3 Assuming that the X_B axis has been pointed in the direction of the desired inertial attitude hold, the vehicle will simultaneously be rotating the X_B axis about the Xp axis and the Xp axis about the X_I. Figure 5-4 shows the path constraints of these motions in the Y-Z plane. The actual attitude history with respect to inertial space will depend upon the values of the periods of revolution of X_B and Xp about X_I. For this general case, we have assumed $\omega\phi_B \approx \omega\phi_p = 0.5$ degree/second. This results in 5 revolutions/hour of X_B about Xp. The rate for Xp about X_I can be calculated from equation (5) to be $\approx$ 3.3 revolutions/hour.

$$\omega\phi_I = \frac{I_1 - I_{xx}}{I_1}\ \omega\phi_p \qquad (5)$$

Figure 5-5 illustrates the means of calculating the maximum travel of the X_B axis from the initial point of alignment. Assuming that X_B on the left is the initial inertial attitude desired as we said earlier, it will be 1.8 degrees from Xp. Imparting an $\omega\phi$ of .5 degree/second will start the vehicle rotating about X_I at the angle α which was calculated to be 9.3 degrees maximum. The angle (β) between the desired X_B orientation and the actual worst case travel of X_B can be seen to be:

$$\beta = 2\alpha + 2\left|\angle X_p - \angle X_B\right| \approx 22^\circ \qquad (6)$$

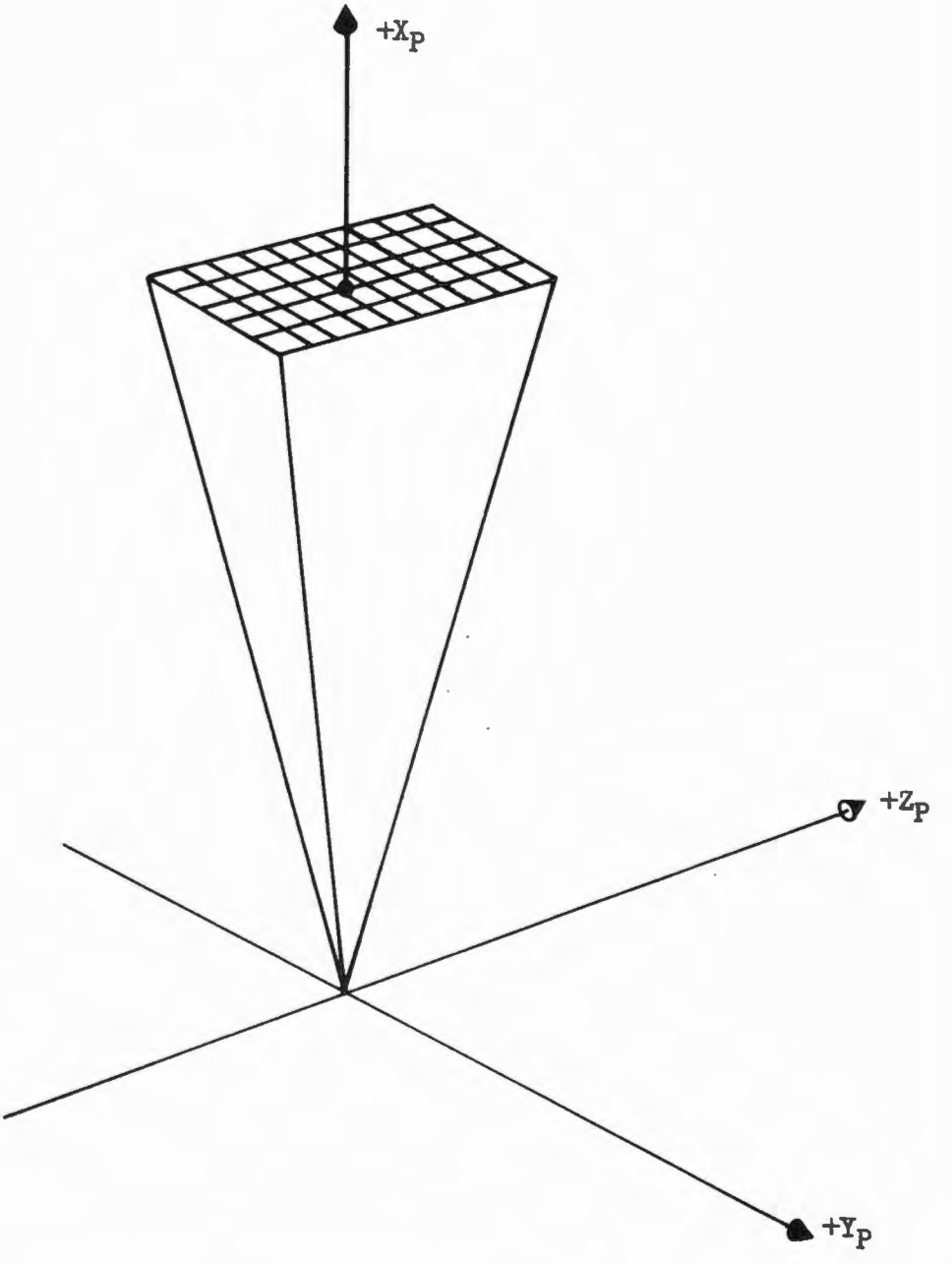

Figure 5-3. Value of Possible Angular Momentum Vector Locations

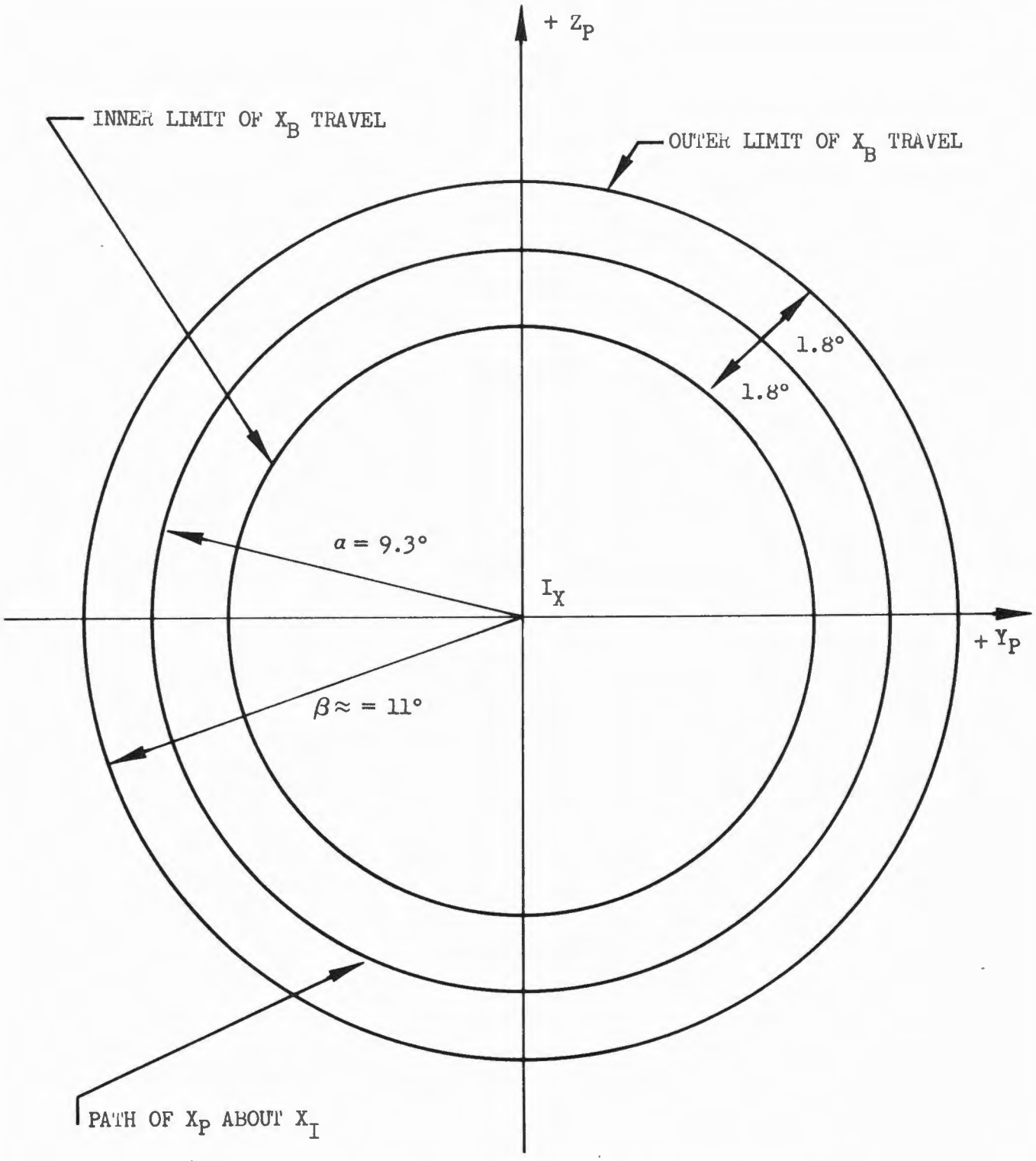

Figure 5-4. Y-Z Plane Paths of X Body Axis

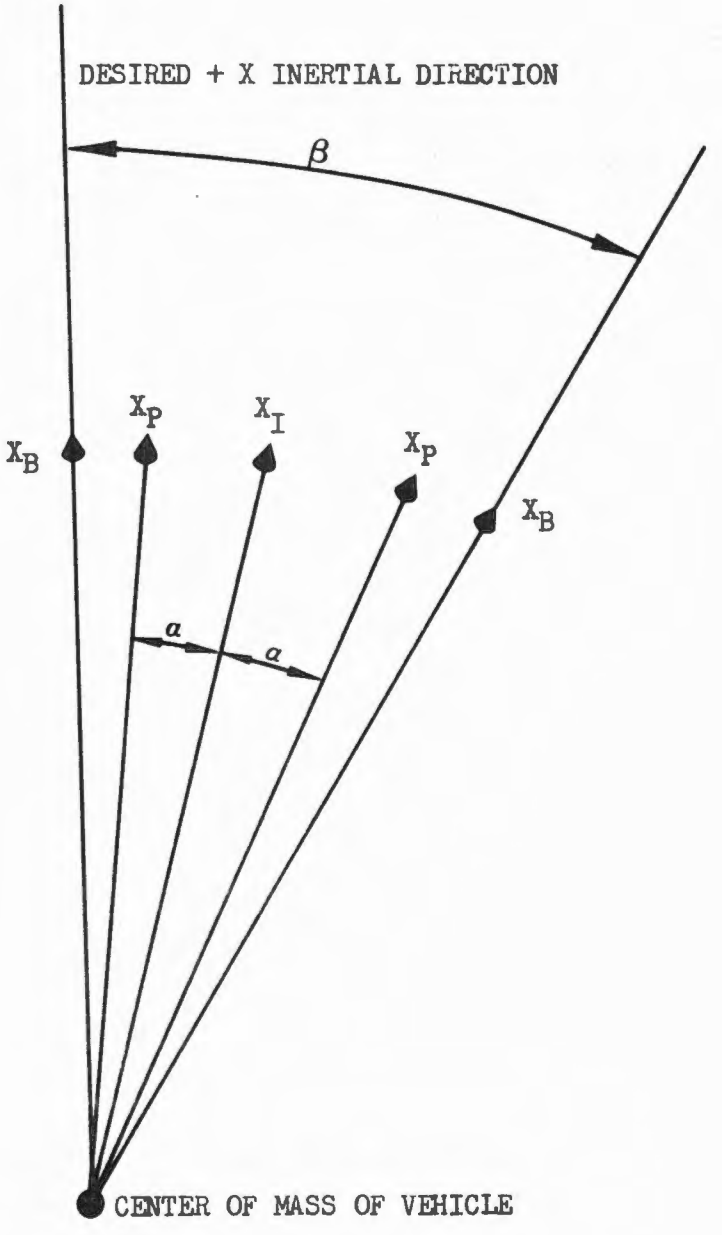

Figure 5-5. X-Y Plane Illustration of Angular Offsets

5.1.2.3 Special Case. For some experiments, a more precise spin-stabilized attitude hold may be desirable. For these cases an additional procedure has been prepared and is included as 10.7 Precise Wobble Mode Establishment.

5.1.2.3.1 If the sense of $\omega\theta$ and $\omega\psi$ are known, the general case location of X_I will be constrained to be in a single quadrent as shown in Figure 5-6. The sense of $\omega\theta$ and $\omega\psi$ can be determined by observing the direction of motion of the pitch and yaw attitude error indicators. By picking specific senses for $\omega\theta$ and $\omega\psi$, a specific quadrent for the location of X_I can be established. A negative (moving down) pitch indicator motion and a negative (moving left) yaw indicator will limit the location of X_I to the +Y -Z quadrent. This is the quadrent that also contains Xp.

5.1.2.3.2 If the phasing of $\omega\theta$ to $\omega\psi$ is not correct, or if their magnitude is too low to be sure of their sense, the minimum impulse control at the G&N station can be used to adjust for these problems.

5.1.2.3.3 In place of $\omega\theta$ and $\omega\psi$ ranging from plus to minus .02 degree/second, they can now be restricted to having some positive value less than .02 degree/second. A lower limit can also be set as, unless this value exists, positive motion of the attitude error indicators could not be observed. The upper limit of .02 degree/second will cause 1.2 degrees of travel of the indicators in a minute. Any rate slower than .6 degree in a minute will be difficult to determine, so the lower rate limit will be set at .01 degree/second. Imposition of these rate boundries will limit the location of X_I even further as is shown in Figure 5-7.

5.1.2.3.4 If the area through which X_I must pass (shaded area of Figure 5-7) can be superimposed about the desired inertial X_B orientation the value of β can be substantially reduced. The choice of the +Y, -Z quadrent for location of X_I was deliberate. The offset location of X_I from Figure 5-7 is shown in a view of the X_B-Z_B plane in Figure 5-8 to clarify this discussion. The center of the area of possible locations of X_I can be seen to be a fixed value away from the X_B axis.

5.1.2.3.5 If the X_B axis is initially aligned away from the desired inertial hold axis in the ($+Z_B$, $-Y_B$) quadrent the area of possible locations will now be superimposed over the desired inertial hold attitude (see Figure 5-9).

The maximum value for β in this special case can be found using equation (7) (see Figure 5-10).

$$\beta_{MAX} = \alpha_{MAX} + \left(\angle X_p - \angle X_B\right) + \tfrac{1}{2}\left(\alpha_{MAX} - \alpha_{MIN}\right) \qquad (7)$$

All values for equation (7) are known except for α MIN. α MIN is calculated using equation (4) and the minimum assumed limit of .01 degree/second to be 4.6 degrees. Equation (7) can now be solved and β_{max} is equal to 13.4 degrees.

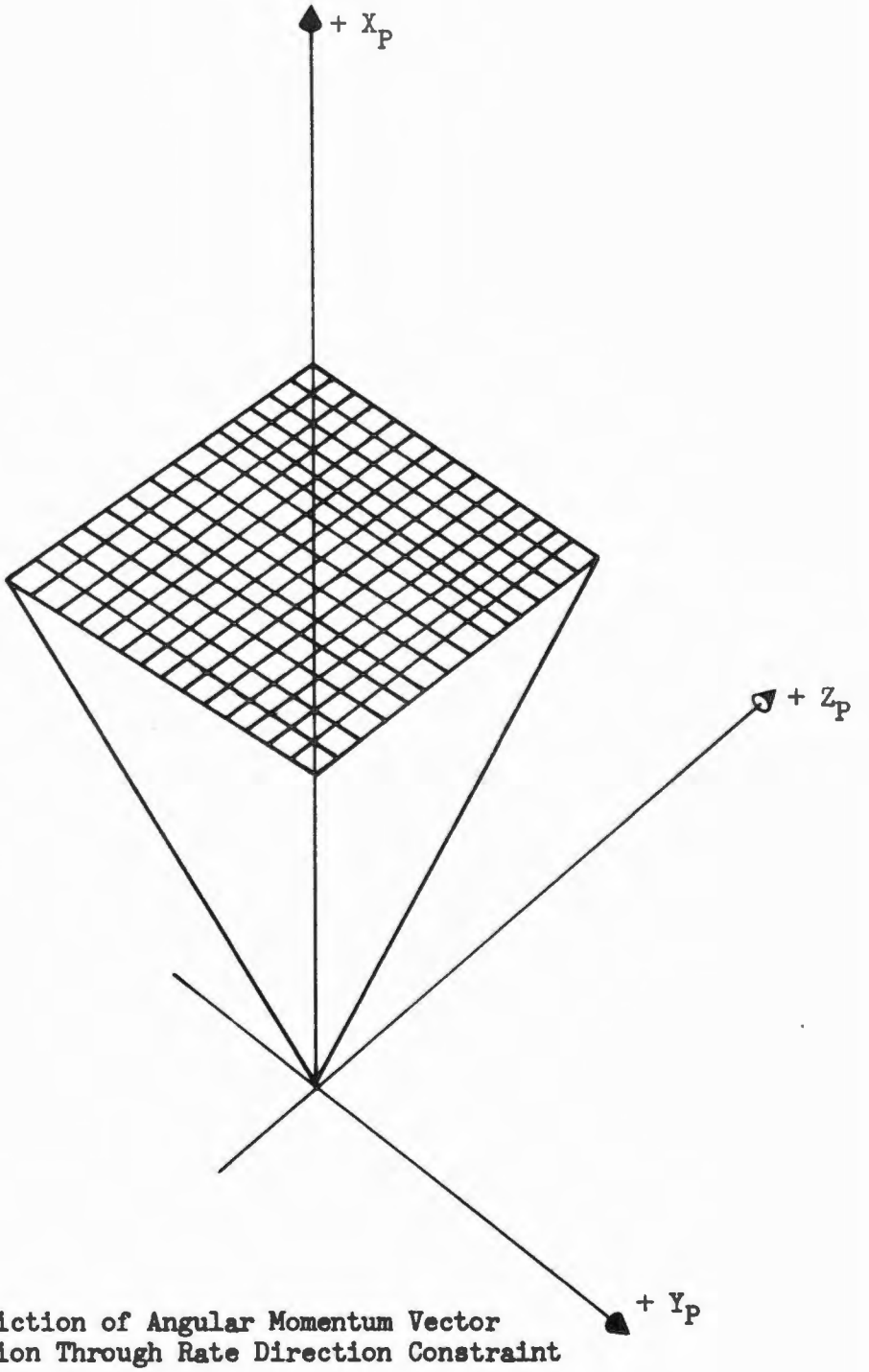

Figure 5-6. Restriction of Angular Momentum Vector Location Through Rate Direction Constraint

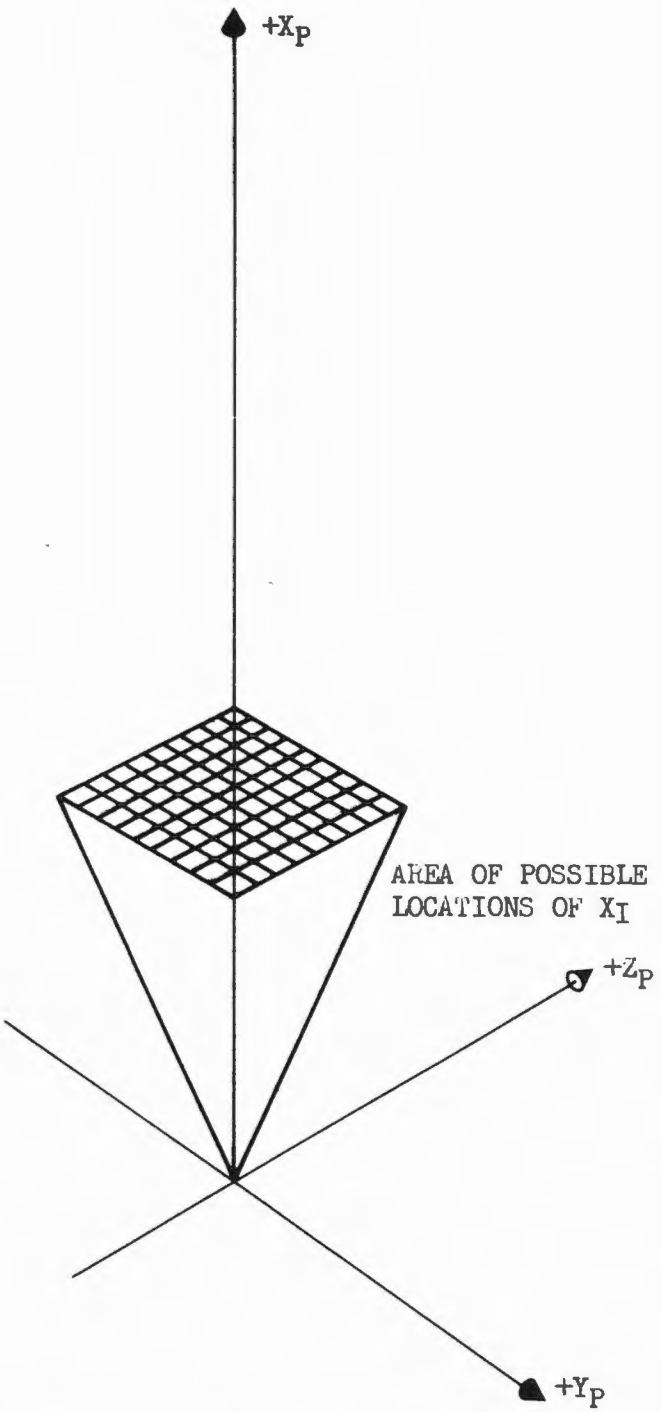

Figure 5-7. Further Restriction Through Rate Magnitude Selection

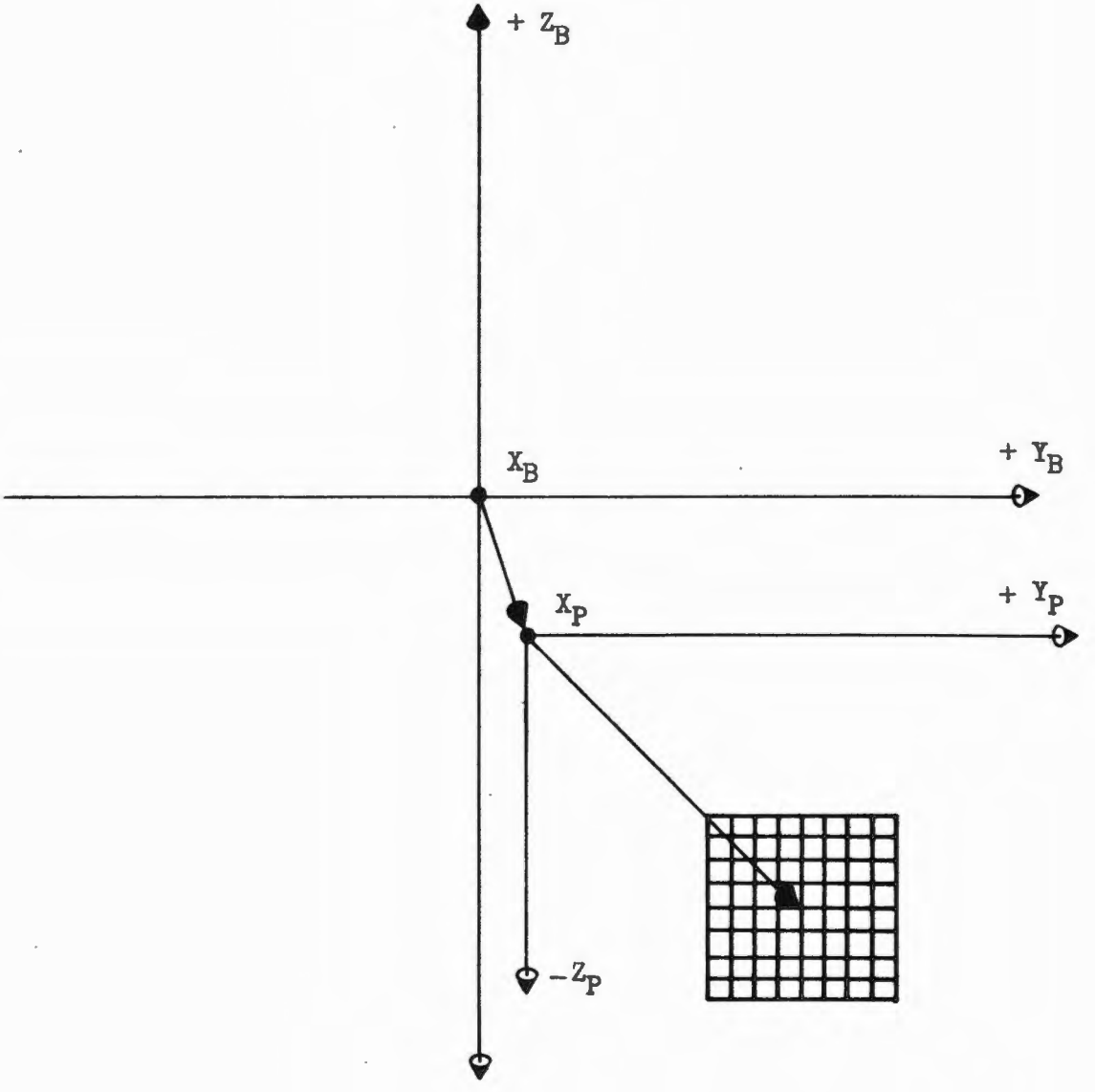

Figure 5-8. Y-Z Plane Plot of Restricted Location

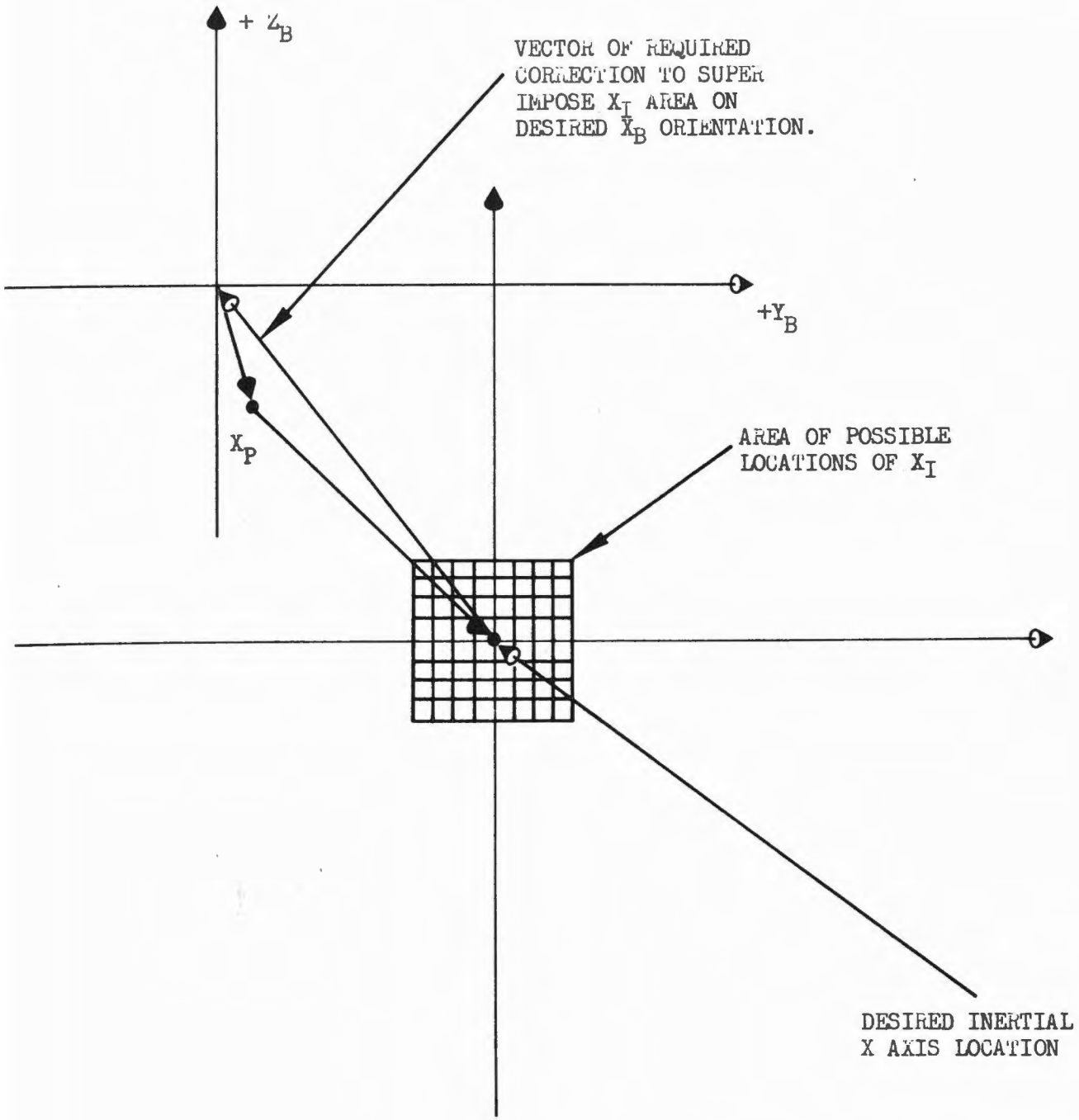

Figure 5-9. Optimization of Angular Momentum Vector Location Uncertainty

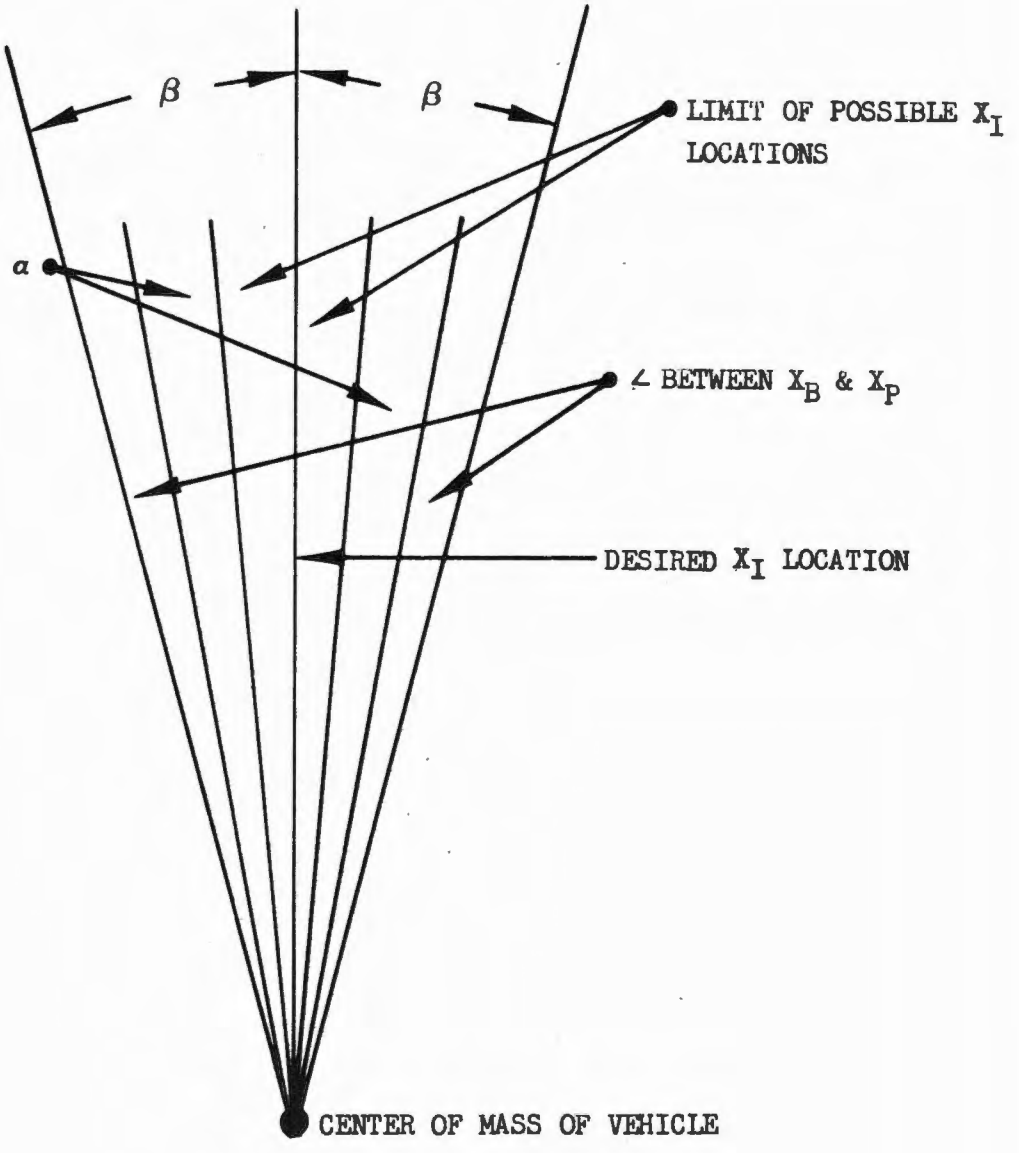

Figure 5-10. X-Y Plane Illustration of Reduction in Angular Momentum Vector Uncertainty

The specific offset from the desired X_B pointing direction required can be determined by taking the reciprocal of the vector sum of the X_B - Xp offset and the Xp - X_I nominal offset. X_I nominal will lie along a line through the Xp point that is at 45 degrees from the +Y and -Z axes. The magnitude of the nominal X_I offset is determined by determining the median between α MAX and α MIN which is $\approx$ 7 degrees. The vector resolution results in a required offset of $\approx$ 8 degrees at $\approx$ 30 degrees from the +Z axis toward the -Y axis.

Imparting $\omega\phi$ will cause the area of possible locations of X_I to rotate in the same direction as the imparted rate. The value of this shift can be found by combining the standard angular equations of motion of

$$\omega_F = \omega_o + \alpha t \tag{8}$$

and

$$\theta = \omega_o t + \tfrac{1}{2}\alpha t^2 \tag{9}$$

and assuming $\omega_0 = 0$ results in

$$\theta = \frac{(\omega_F)^2}{2\alpha} \tag{10}$$

Using the .5 degree/second rate assumed and $\alpha\phi$ of 13.1 degrees/second^2, $\theta\phi$ is $\approx$ 0.01 degree. $\theta\phi$ is insignificant and will not be considered.

5.1.2.3.6 For the specific problem, where the sun is too near the desired +X orientation for either the general or special case, procedure, 10.24 outlines the steps required to orient the vehicle using the telescope, and minimum impulse control. Since a specific attitude is established using the telescope, assume that the special case compensation has been included in the star field orientation data to provide the more accurate attitude hold.

5.1.2.4 Limitations. In orbit, the atmosphere will produce an effective drag on the SC that will attempt to "streamline" the vehicle into the orbital path. For any inertial attitude held the disturbances to the attitude from this effect will be a function of the atmospheric density, the vehicle profile, and the instantaneous difference angles existing between the vehicle attitude and the "streamlined" attitude. The exact magnitude of these disturbances is not known for this case but the general prediction that their effect will be to cause an increasing α due to perturbations to the $\omega\theta$ and $\omega\psi$ values can be made. As higher $\omega\phi$ rates are used this sensitivity decreases so the higher the $\omega\phi$, the more stable the "wobble" mode.

5.1.2.4.1 The gravity gradient effect tends to align the vehicle X axis parallel to the local vertical with the +X axis either up or down. Again the exact magnitude of the disturbances is not known, but they will be proportional to the angle between the X axis and the local vertical (which will change continually in orbit).

5.1.2.4.2 While the atmospheric effect tends to streamline and slow down the CSM, the gravity gradient effect tends to bring the X axis parallel to the local vertical. The two effects will therefore fight each other and their relative effect will vary with vehicle attitude with respect to the local vertical.

5.1.2.5 Conclusions.

a. Where no specific attitude need be held, a three axis free drift with the SCS off is most efficient in terms of power, SM RCS fuel, and SCS reliability.

b. Where a specific inertial attitude must be held for 1 hour (BMAG warmup time) or longer and the attitude accuracy requirements are between 22 degrees and 45 degrees the wobble mode can be used without offsetting the X_B axis as shown in Figure 5-9.

c. When the accuracy requirement of (2) above lies between 14 degrees and 22 degrees, the method of alignment, including the compensation shown in Figure 5-9, should be applied.

d. If the attitude accuracy is less than 14 degrees, then the SCS attitude control mode must be used. The only cases where this seems desirable are for navigation sightings and Delta V maneuvers.

e. The effects of gravity gradient and atmospheric drag effects on this mode must be calculated to determine their impact.

5.1.2.6 Summary. A spin-stabilized inertial attitude hold (wobble) mode can be established in earth orbit. This mode is applicable for periods of 1 hour and longer and where the attitude accuracy requirement is equal to or greater than $\pm$ 14 degrees. Its use will permit turning off the SCS system and conserving both electrical power and SM RCS propellant.

The stability of this mode will depend upon the impact of atmospheric drag and the gravity gradient effects, which have not been calculated yet for this application.

Increasing the roll rate (ω_ϕ) directly decreases the "wobble" angle and increases the stability of the "wobble" mode. As the only recognized penalty to higher roll rates is the SM RCS propellant required to impart and remove them, higher roll rates than those used in this study (0.5 degrees/second) can be considered for actual flight applications.

5.1.3 Proposed Alternate Method to Present Thermal Control Approach. This section contains a proposed alternate method of satisfying the thermal constraints of the SPS engine for both the free drift mission periods and the attitude hold periods for the hot and cold soak test firings of the SPS. It is based on data contained in Figure 5-11. The effort was initiated by the preliminary analysis results received showing that the wobble (spin stabilized) mode will not be useful as proposed to date. A means of satisfying SPS thermal constraints, minimizing SM RCS propellant consumption, conserving electrical power, and reducing SCS operating time is therefore proposed.

5.1.3.1 Problem Statement. The present attitude timeline for SC 012 includes long attitude hold periods for SPS cold and heat soak prior to SPS burns. These times are given as fixed numbers of hours in some cases preceded or followed by an equally expensive hold period to provide assurance that the SPS equipment is not exceeding its lower temperature limits of 40 degrees F. The hold periods are expensive in terms of three critical consumables for the mission (i.e., electrical power, SM RCS propellant, and SCS operating time) and any reduction in these attitude hold periods will have a direct relationship to increasing mission duration. Mission duration is very important with respect to SC 012 performance for establishment of lunar flight feasibility. A joint study of means of reducing the hold times has been completed by G&C Systems and SPS Analysis. The jointly developed method will result in significant savings in SM RCS propellant, electrical power, and SCS operating times. The basic principle of this method can also be applied with only slight procedural variation to provide a check against exceeding the lower temperature limits of the SPS during periods of true free drift.

5.1.3.1.1 Studies by the SPS group have established heating and cooling rates for the SPS area based upon the relationship between the sun and the - X axis of the vehicle. A telemetry point in the SPS is available to indicate current temperature. Periods of MSFN telemetry coverage are available from the trajectory data and the time of SPS burns and free drift are similarly. available. The SPS has an upper temperature stable limit of 95 degrees - 100 degrees F.

5.1.3.1.2 The analytically derived heating and cooling rates versus solar attitude are presented in Figure 5-11. More complete data on temperature change characteristics in the SPS region is available from SPS Analysis.

5.1.3.1.3 A sampling method can be derived which will meet the hardware constraints and still allow a considerable reduction of mission planning constraints. An example of each application follows:

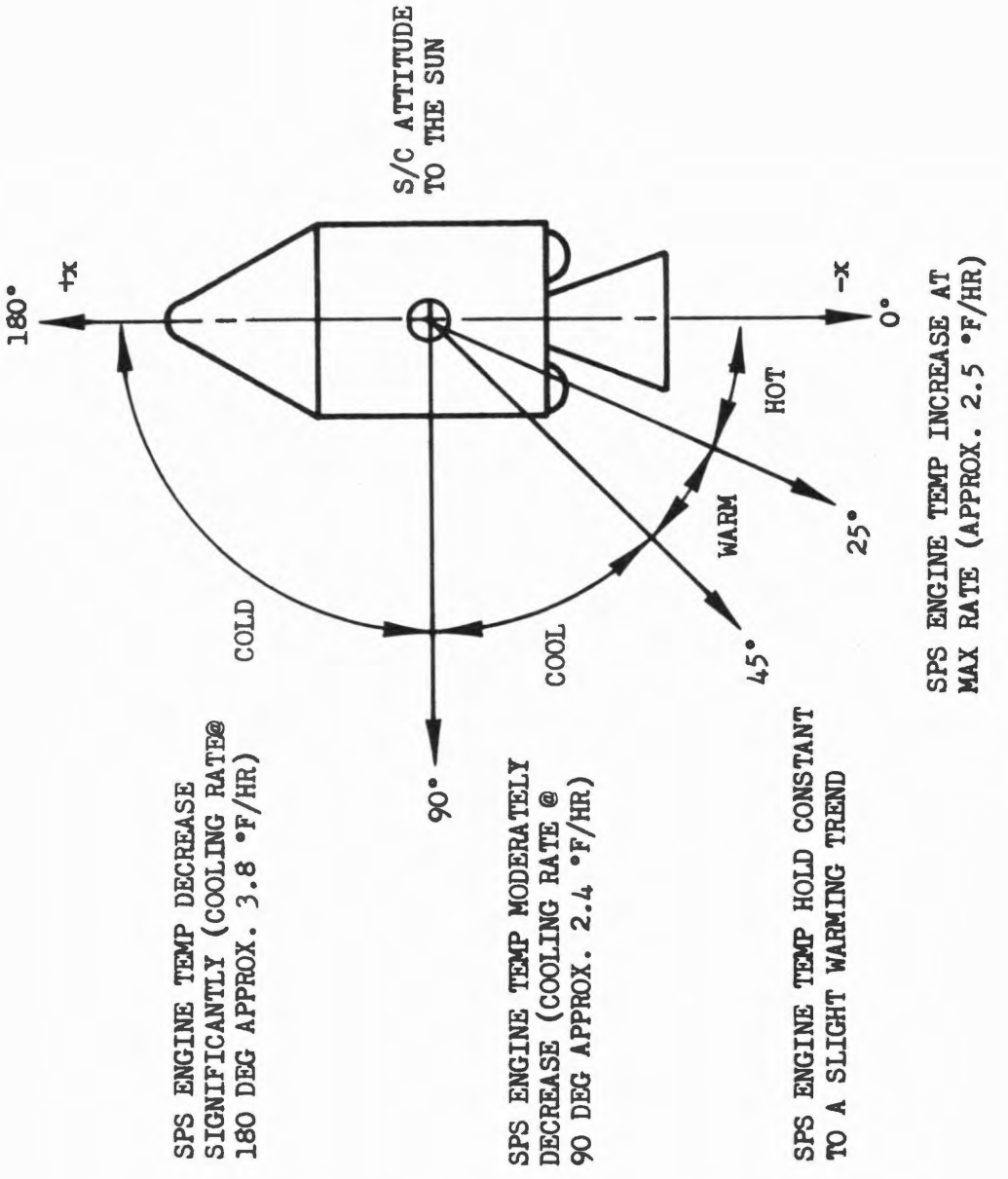

Figure 5-11. SPS ENGINE THERMAL RESPONSE

5.1.3.2 General Case (Free Drift). First the general case will be covered, then the application for cold and heat soak will be discussed. Each time a MSFN telemetry contact is available, the SPS temperature should be checked. The astronaut should then identify visually the relationship between the SPS nozzle (- X axis) and the sun and the direction of drift of the vehicle. Examination of Figure 5-11 will show that for any attitude an approximate heating or cooling rate can be resolved. From the direction of drift, the probable change to the heating or cooling rate can be predicted. If necessary, the random drift rate can be modified simply to adjust the temperature trend appropriately. Several examples are given of sample evaluations for clarification.

Example 1: Temperature: 78 degrees F, attitude: - X 120 degrees from sun, drift trend: - X moving away from sun.

Conclusions: Temperature is acceptable, presently vehicle is in an SPS heating attitude, and drift is toward cooling. The temperature limit will not be reached for

$$\frac{78°F - 40°F}{3.8°F \text{ (max. cooling rate)}} = \frac{38}{3.8} = 10$$

A minimum of 10 hours

Example 2: Temperature: 58 degrees, attitude: - X 130 degrees from sun, drift trend: - X toward sun.

Conclusions: Temperature is acceptable, presently vehicle is in SPS cooling attitude, trend is toward warming area but will be cooling for some time so temperature should be watched carefully.

The temperature limit will not be reached for $\left(\frac{58 - 40}{3.8} = \frac{18}{3.8} = 4.7\right)$ a minimum of 4.7 hours.

Example 3: Temperature: 51 degrees, attitude: - X 150 degrees from sun drift trend: - X away from sun

Conclusions: Temperature is getting too low, presently vehicle is in cooling attitude and will be getting cooler, may reach or exceed 40 degree F before drifting back to the warming region. The temperature limit may be reached in

$$\left(\frac{51 - 40}{3.8} = \frac{11}{3.8} = 2.9\right)$$

a minimum 2.9 hours. To avoid a requirement for rapid maneuver and attitude hold at the optimum heating attitude if the cooling rate and trend continues the drift should be adjusted at this time.

5.1.3.3 Drift Adjustment. A detailed procedure is included in the G&C procedures section to cover G&C functions required in adjusting the spacecraft drift pattern. Functionally, the pilot will set up single jet firings, turn on the SCS in the SCS Attitude Control mode leaving the inertial sensors open, and then move to the lower equipment bay. At the lower equipment bay, the astronaut will enable the Attitude Impulse Control and then adjust the vehicle drift pattern to head toward the sun with the - X axis. Pitch or yaw or a combination of a pitch and a yaw minimum impulse should be used to stop the drift toward a - X axis 180 degrees from the sun condition and start the - X axis back toward the sun.

NOTE: Regardless of how carefully temperature, attitude, and drift rates are monitored, the design is biased to the cold side to such an extent that, after extended drift periods, presently unscheduled heat soaks will be required to bring the temperatures in the SPS area up to safe levels. Tests are being scheduled on AFRM 008 to verify to some extent the analytically derived thermal trend data being prepared by Engine Analysis.

5.1.3.4 Heat and Cold Soaks - General. In the SC 012 mission there are two cold soak periods called out before the third and seventh burns and a hot soak called out before the fourth burn. The objective is to cool or heat the SPS area to $\approx$ 40 degrees F or $\approx$ 100 degrees and then fire the SPS thereby demonstrating performance near the upper and lower design limits. The maximum temperature, as mentioned earlier, can be considered to be 100 degrees F. The minimum temperature is 40 degrees F. The maximum temperature difference to be heated or cooled would be 60 degrees F. The maximum cooling rate of 3.8 degrees F per hour divided into the maximum temperature differential shows that, a maximum of $\approx$ 15 hours before the cold soak burns the convergent sampling method should be initiated. The maximum heating rate can similarly be used to develop a maximum time required to heat the SPS area to the 100 degrees F region; 60 degrees F divided by 2.5 degrees per hour shows that, if the SPS area were at 40 degrees F, $\approx$ 20 hours of a heating attitude hold would be required to reach the 100 degrees F level.

5.1.3.4.1 For planning purposes, ten minutes should be allowed to configure the required equipment and establish the attitude hold for heating or cooling. Twenty minutes will be required for the IMU alignment and pre-thrusting preparations following the thermal control soak periods.

5.1.3.4.2 As a normal routine part of MSFN telemetry contacts, the SPS area temperature will be checked. A series of converging refinements of the actual hold duration required should be initiated a minimum of 16.5 hours (for cold soak) and 24.5 hours (for heat soak) prior to the firing time. Since the procedure would be the same for heat or cold soak, except for the direction of temperature control, a single case using the cold soak values will be used as an example.

5.1.3.5 Cold Soak - Example. The first step is to examine the mission timeline for MSFN telemetry contacts preceding the 16.5 hour maximum cooling time. For this example, two contacts will be assumed to be available. The first will be at - 19.3 hours from the firing time and the second will be at - 17.2 hours.

5.1.3.5.1 At the 19.3 contact the following conditions are observed by the MSFN station and the astronaut: (1) An SPS area temperature of 68 degrees F, (2) an angle of 100 degrees between the - X axis and the sun, and (3) the - X axis is moving away from the sun. This data provides the basis for the first refinement to the 16.5 hours commencement time.

5.1.3.5.2 The temperature difference is (68 degrees F - 40 degrees F) 28 degrees. Dividing that value by the 3.8 degrees F per hour cooling rate for cold soak yields a requirement for 7.3 hours of cold soak hold. When the 0.5 hour constant for other functions is added the first refinement results in a reduction in required hold time of 8.7 hours. In addition, the present position and drift direction are both in the proper direction.

5.1.3.5.3 Repeating this process at the 17.2 hour point, the new data set is: (1) a temperature of 64 degrees F, (2) an angle of 120 degrees between the - X axis and the sun, and (3) - X axis again moving away from the sun. The temperature difference of 24 degrees yields a start time now of 6.8 hours ahead of the cold soak burn and again both the present attitude and the drift trend are in the correct direction, no adjustments are required.

5.1.3.5.4 Moving forward to the MSFN telemetry contact immediately before the last refinement, the refinement process should continue for each intervening MSFN telemetry contact, assume that the latest start time is 6.5 hours and that the contact closest to this time is 7.3 hours. The temperature, attitude, and drift trend should be measured and evaluated as before. This last iteration establishes the actual time for cold soak attitude hold establishment. A temperature of $\approx$ 40 degrees F will be achieved for the test objective. In this case, hours of attitude hold have been avoided. The attendant savings in SM RCS propellant, electrical power, and SCS operating time will be directly reflected in increased mission life. Remembering that there are three such firings scheduled (two cold, one hot), an appreciable extension to mission life can be expected.

time lost due to this blind spot is approximately six seconds. This would reduce the maximum tracking time for a landmark in the Landmark Definition Limit, and passing through the blind spot to≈48 seconds. Due to this fact, landmarks which will not pass through the blind spot should be selected. Landmarks within 16 NM of the orbital plane should not be used because they would pass through the blind spot.

5.1.4.2.2 The tracking time in the Landmark Definition Limit is decreased as the LOS to landmark angle from the orbital plane increases. Assuming 20 seconds is the minimum time needed to perform a sighting, the maximum angle from the orbital plane would be approximately 40 degrees.

5.1.4.3 Landmark Definition Limit. Once the landmark has been recognized, the operator must know when the landmark is defined enough to MARK. It is presently accepted that the landmark will have sufficient definition when the angle between the line of sight to the landmark and the vehicle's local vertical is less than 45 degrees. The operator must determine from the view in the optics when the target falls within this Landmark Definition Limit. This can be done when the reticle is in the position given for the Landmark Recognition Limit. With the Earth's horizon just tangent to the top of the telescope's field of view, the angle from the local vertical to the "M" line is 46 degrees 20 minutes. This is 1 degree 20 minutes from the accepted limit. A landmark will move into the accepted limit one second after the "M" line is reached.

5.1.4.4 Summary. With the reticle in the reference position, shaft angle zero, and the Earth's horizon just tangent to the top of the telescope's field of view, the following may be determined:

a. Due to time consideration, the landmark must be recognized before it passes the "M" line. (Landmark Recognition Limit.)

b. The landmark will be in the correct band under the CSM if it will cross the "M" line before it passes from the telescope's field of view.

c. The Landmark Definition Limit is entered when the "M" line is crossed by the landmark. The operator should move the reticle laterally to place the crosshairs on the target before the "M" line is reached by the landmark. In some cases this may not be possible, due to late recognition of the landmark.

5.2 SCS Functional Descriptions.

5.2.1 SCS Power Distribution and Switching. This section will discuss the SCS power distribution and switching. The design philosophy, operational applications, failure effects, and operational limitations of SCS power distribution will be discussed in this section.

5.2.1.1 General. The ac and dc power on the spacecraft is available from redundant buses. The buses may or may not be connected to independant sources of power. In either case, the ultimate sources of energy are the fuel cells and/or batteries. A simplified block diagram of the power sources is included as Figure 5-13. If a more detailed insight is required in this area, the reader is referred to the Electrical Power Systems design area and their reference documents.

5.2.1.2 Power Distribution Philosophy. In the fall of 1964, as a part of the MTVC design change, a complete relayout of the SCS power switching and power distribution was undertaken. The objective of this effort was the correction of the existing single point failures possible in the TVC paths and as much as possible in the other control loops. Most normal automatic and manual functions were distributed to a common group and as much as possible in the other control loops. Most normal automatic and manual functions were distributed to a common group of power switches, called group 1 switches and circuit breakers. Backup or emergency control paths were assigned to the alternate set of circuit breakers and power switches, called group 2 switches.

5.2.1.2.1 Automatic reaction control system coils have been divided functionally and equally between the two dc buses as shown in Figure 5-14. Direct dc power was similarly divided between the two 1. rotation controls, 2. SPS engine on-off control paths, and 3. direct ullage switch contacts (see Figure 5-15). Power (dc) for the translation controls was taken from the two normal dc bus circuit breakers (A dc bus to Translation Control No. 1 and B dc bus to Translation Control No. 2). Control panel power is similarly taken from the normal dc circuit breakers. In this case, the power is tied together through isolation diodes and then distributed to the control mode and submode switches.

5.2.1.3 Power Distribution Details.

5.2.1.3.1 Power Switches. The SCS power switches for each controlled function are connected so that power can either be off, have ac taken from ac bus 1 and dc taken from dc bus A, or have ac taken from ac bus 2 and dc taken from dc bus B. Some of the six power switches are less complex than others. DC is not always used. The Rotation control switch controls only phase A. ac. Figure 5-16 shows the details of the power switching.

5.1.4 Obtaining Information From the Telescope's Field of View When Manual Tracking is Performed. During Earth Orbit - Landmark sightings, certain information must be obtained by looking through the telescope. Due to the short time available to perform an Earth Orbit Landmark sighting, it is not advisable to obtain the required information in any other manner. The information that must be obtained by looking through the telescope is as follows:

a. Landmark Recognition Limit. The point at which the landmark must be recognized, so that sufficient time remains to acquire, track, and accurately obtain MARKS before the landmark passes from the field of view of the telescope.

b. Distance From Orbital Plane. Distance landmark is from orbital plane. This distance must be determined when the landmark is first recognized.

c. Landmark Definition Limit. The point at which the landmark definition is fine enough to allow accurate MARKS.

The above information can be obtained by the operator from looking through the telescope with the aid of the reticle's "R" and "M" lines.

5.1.4.1 Landmark Recognition Limit. A landmark must be recognized a given distance in front of the vehicle. This distance is dictated by the time it takes the operator to acquire, track and accurately obtain two MARKS before the landmark passes from the field of view of the telescope. For a given landmark, this distance will establish a point on the path the landmark will follow. This point is the Landmark Recognition Limit. The point will fall on a line which is the recognition limit for all landmarks. The reticle's "M" line can be superimposed on this line by driving the optics in trunnion until the earth's horizon is just tangent to the top of the telescope's field of view, (see Figure 5-12). The landmark should be recognized before it passes the "M" line in the above position. If the landmark is recognized after it has passed the "M" line there may not be sufficient time remaining to acquire, track and obtain two accurate MARKS before the landmark passes from the field of view of the telescope.

5.1.4.2 Distance from Orbital Plane. After the landmark is recognized, the operator must determine if the landmark will pass inside of the Landmark Definition Limit. The band width on each side of the orbit plane is eighty-five nautical miles. With the reticle in the same position as for the Landmark Recognition Limit, the landmark position can be easily determined. If the landmark will cross the "M" line before it passes from the telescope's field of view, it will fall within the proper band, (see Figure 5-12). The operator should determine the above when the landmark is recognized. Waiting for the landmark to cross the "M" line would only be wasting time. Once it is determined the landmark will pass within the required band, the operator should center the landmark on the crosshairs of the telescope.

5.1.4.2.1 It is known that the telescope has a blind spot or area where the telescope is unable to keep up with motion of the landmark. Tracking

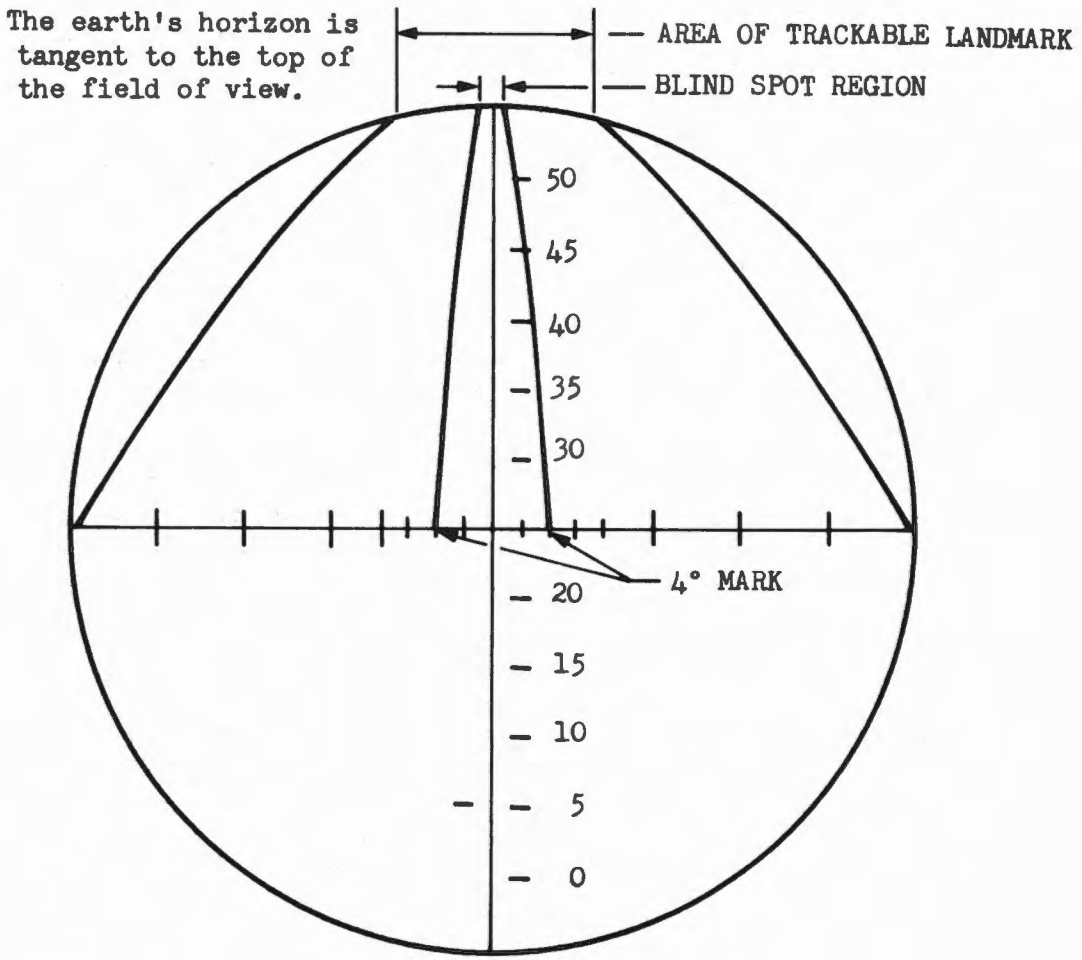

Figure 5-12. Telescope Field of View for Landmark Recognition Limit and Distance from Orbital Plane.

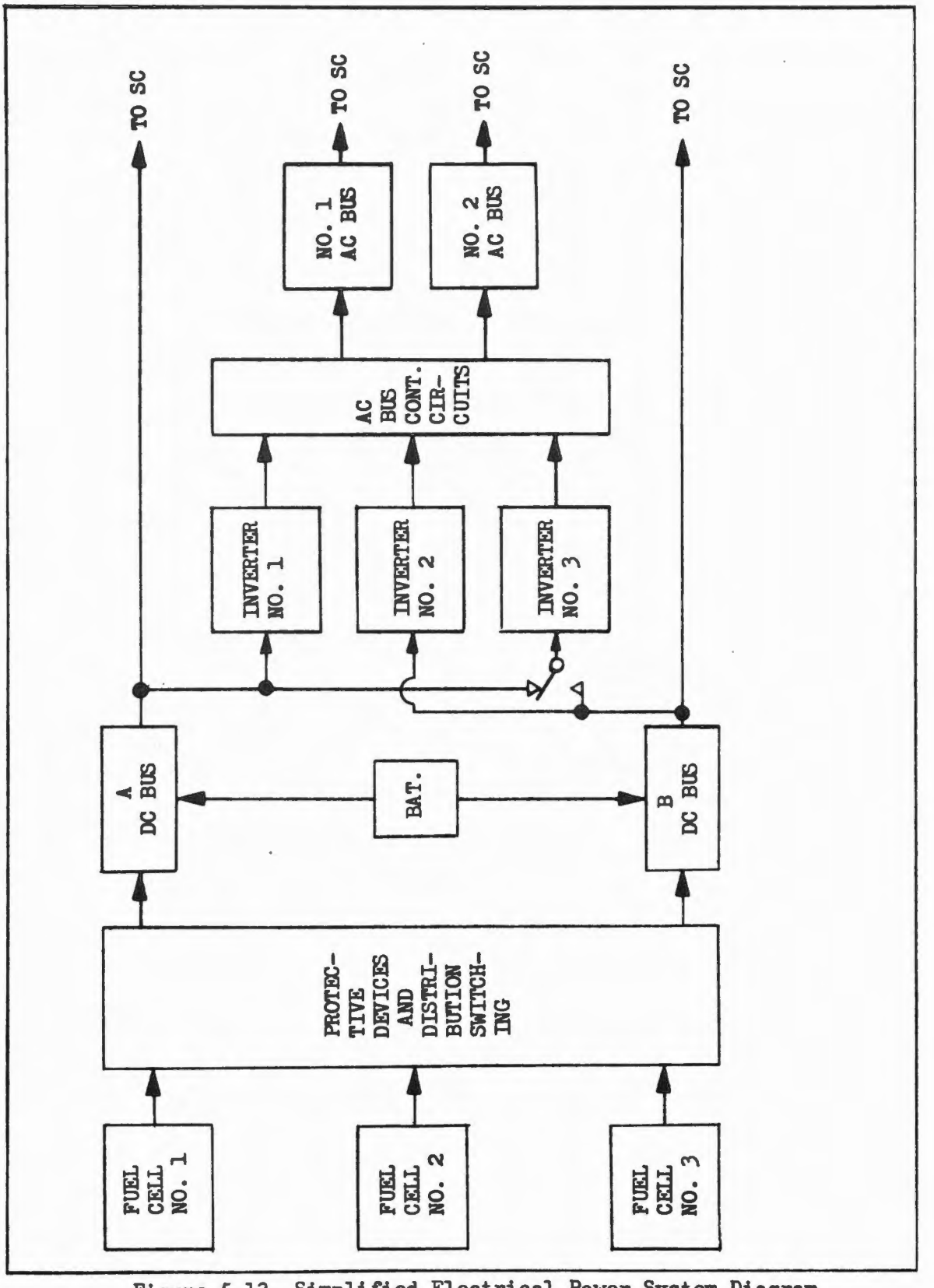

Figure 5-13. Simplified Electrical Power System Diagram

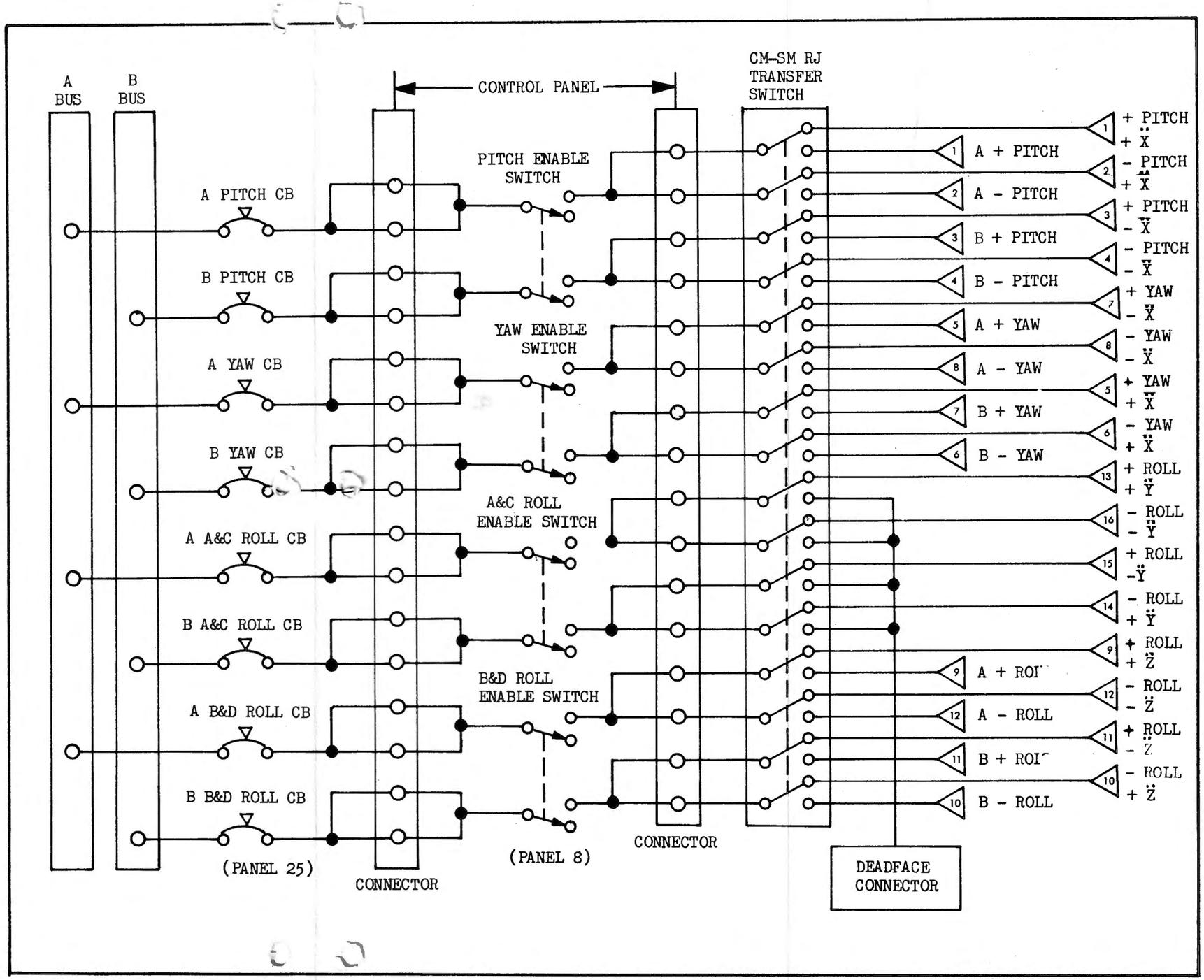

Figure 5-14. DC Power Distribution to Automatic RCS Coils

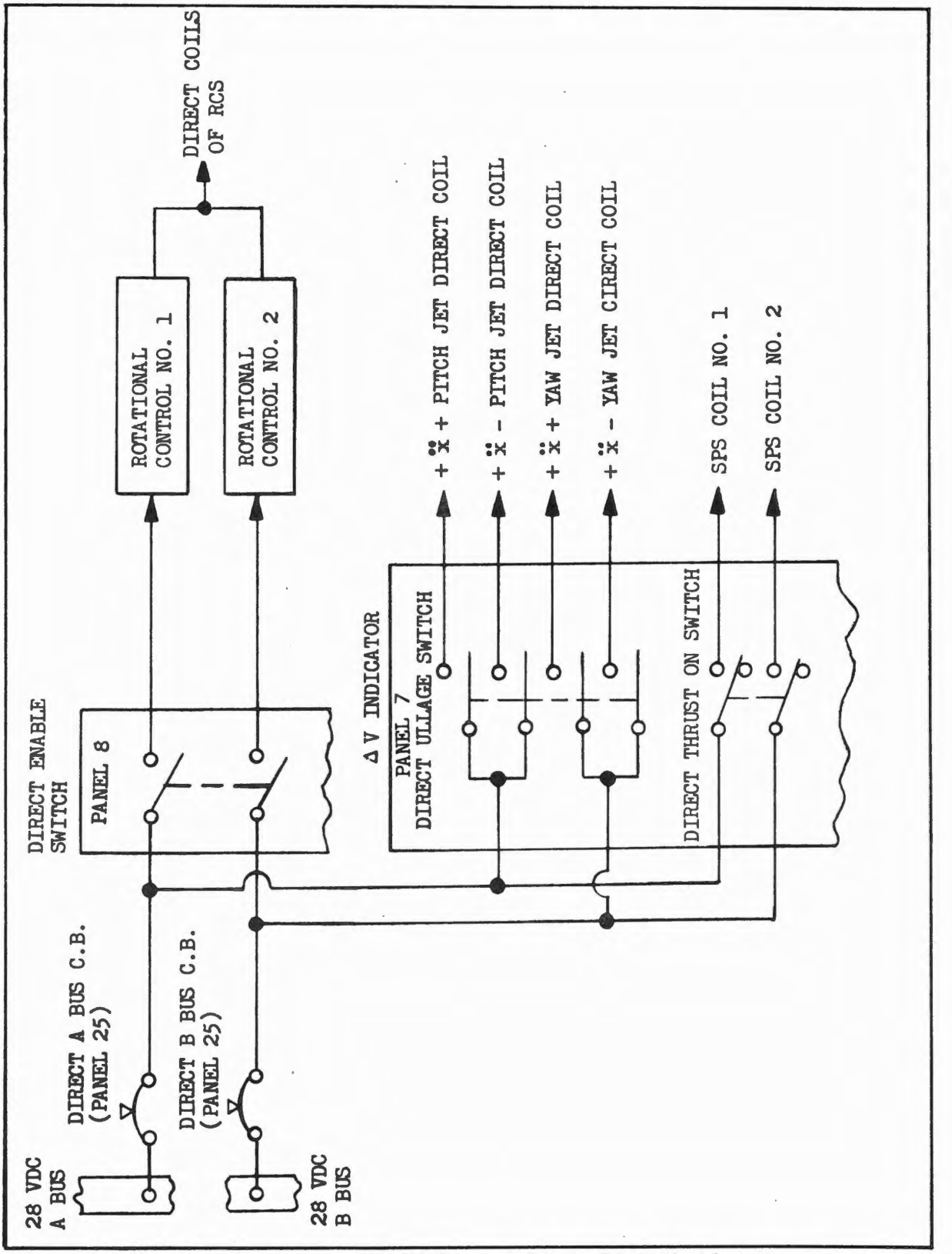

Figure 5-15. DC Direct Power Distribution

3

5-33, 5-34

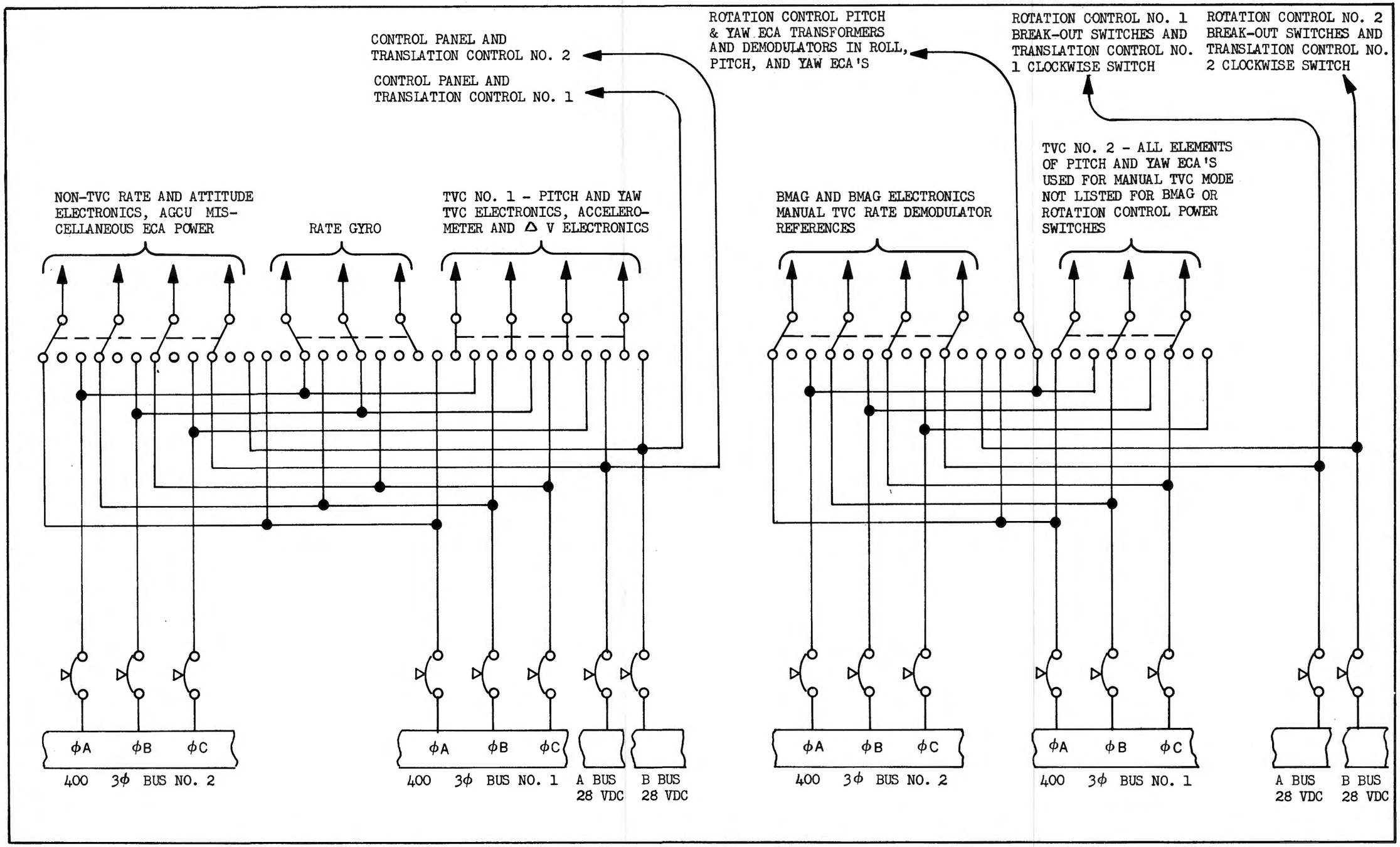

Figure 5-16. SCS Power Switching

CAUTION: Care must be exercised in setting up the electrical power distribution to assure that the same dc bus/inverter/ac bus relationships (Figure 1) are being established that has been used for the SCS power switches. If for example A bus dc power was used to excite inverter No. 3 and then inverter No. 3 were placed on ac bus No. 2, a failure of Bus A would cause loss of both primary (group 1 AC and dc power) and emergency (group 2 ac power) circuits. A single failure would loose both control paths.

5.2.1.3.2 Automatic vs MTVC Control Power. The normal mode for velocity corrections is the G&N delta V mode. The gimbal control loops for the SPS engine normally use the Servo No. 1 paths in both pitch and yaw. The SCS pitch and yaw TVC electronics and the rate gyros are also a part of the normal control mode.

5.2.1.3.2.1 The emergency SPS engine control path consists of the MTVC electronics, the direct on and direct off control of the SPS, and in the preferred mode the BMAG's in a rate mode of operation. The MTVC electronics in pitch and yaw consists of some added demodulators, summing amplifiers, power supplies and the No. 2 servo amplifier control loops as shown in Figure 5-17.

5.2.1.3.2.2 The SPS direct on off dc power is taken in parallel from the A and B dc Direct circuit breakers to the two independent control paths as shown in Figure 5-15.

5.2.1.3.2.3 The MTVC pitch and yaw electronics are connected to the TVC No. 2 power switch, which is a group 2 switch. All other TVC electronics, the accelerometer, and delta V Indicator power are connected to the TVC No. 1 power switch which is a group 1 switch.

5.2.1.3.2.4 Rotation control excitation is taken from the group 2 ac bus. Phase A only is taken to the pitch and yaw ECA's from the power switch and applied to the primary of two step down transformers. The transformer in pitch is used to excite the three proportional control transducers in Rotation Control No. 1 and the transformer in yaw is used to excite Rotation Control No. 2. The phase A ac is also used in the pitch, yaw, and roll ECA's as a demodulator reference for the Rotation Control outputs. This signal flow is shown in Figure 5-18. The outputs are used for either rate or acceleration control inputs in the MTVC mode and for proportional rate control in all other modes.

5.2.1.3.3 Sensor Control. In the mission timeline the two gyro packages within the SCS must be active. The Rate Gyros are a part of normal TVC control and the BMAG's are a part of the MTVC loops, as mentioned earlier. The Rate Gyro and BMAG power switches are independant. The Rate Gyros use group 1 power and the BMAG's use group 2 power. Refer back to Figure 5-16 for switching details.

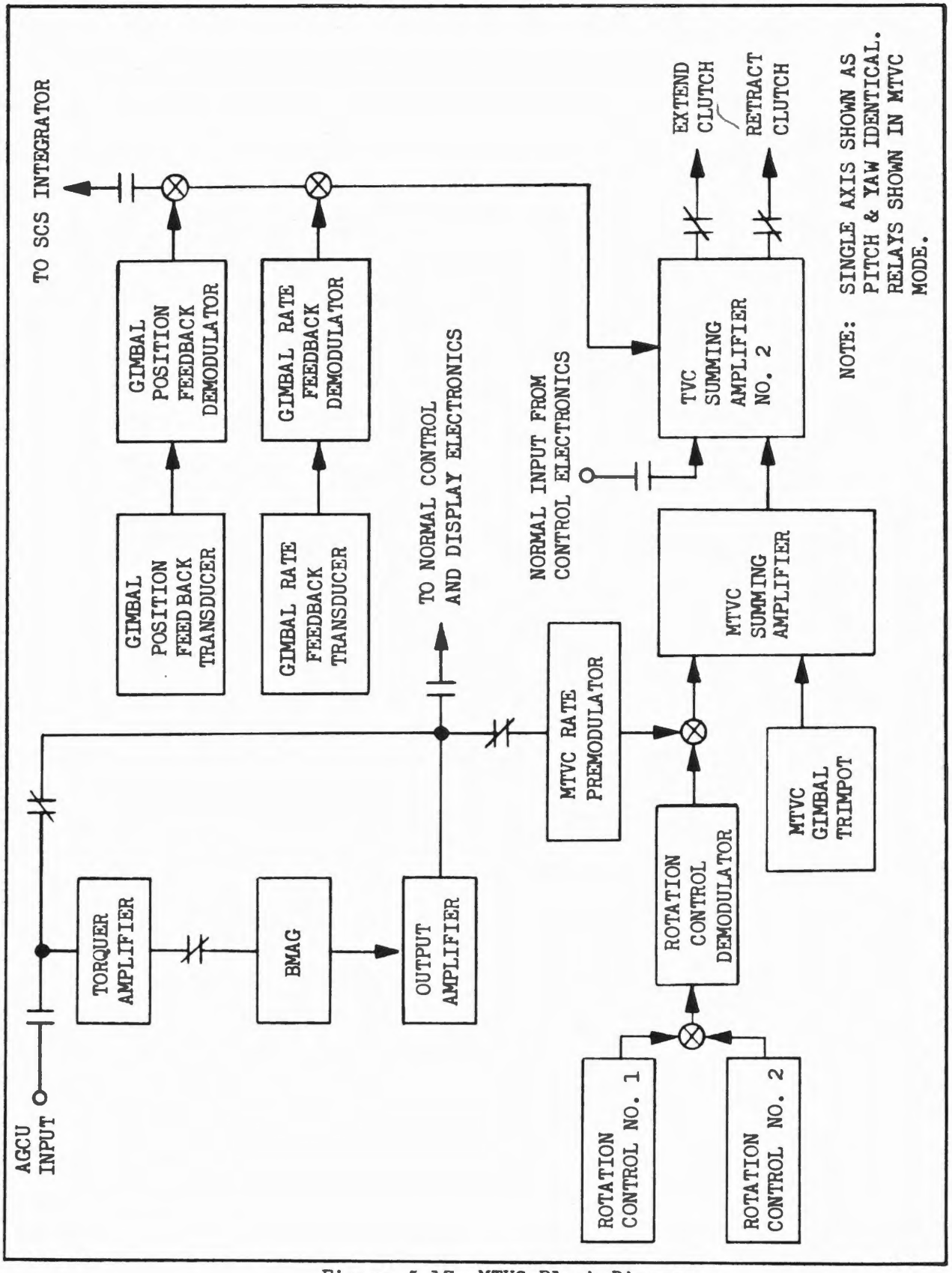

Figure 5-17. MTVC Block Diagram

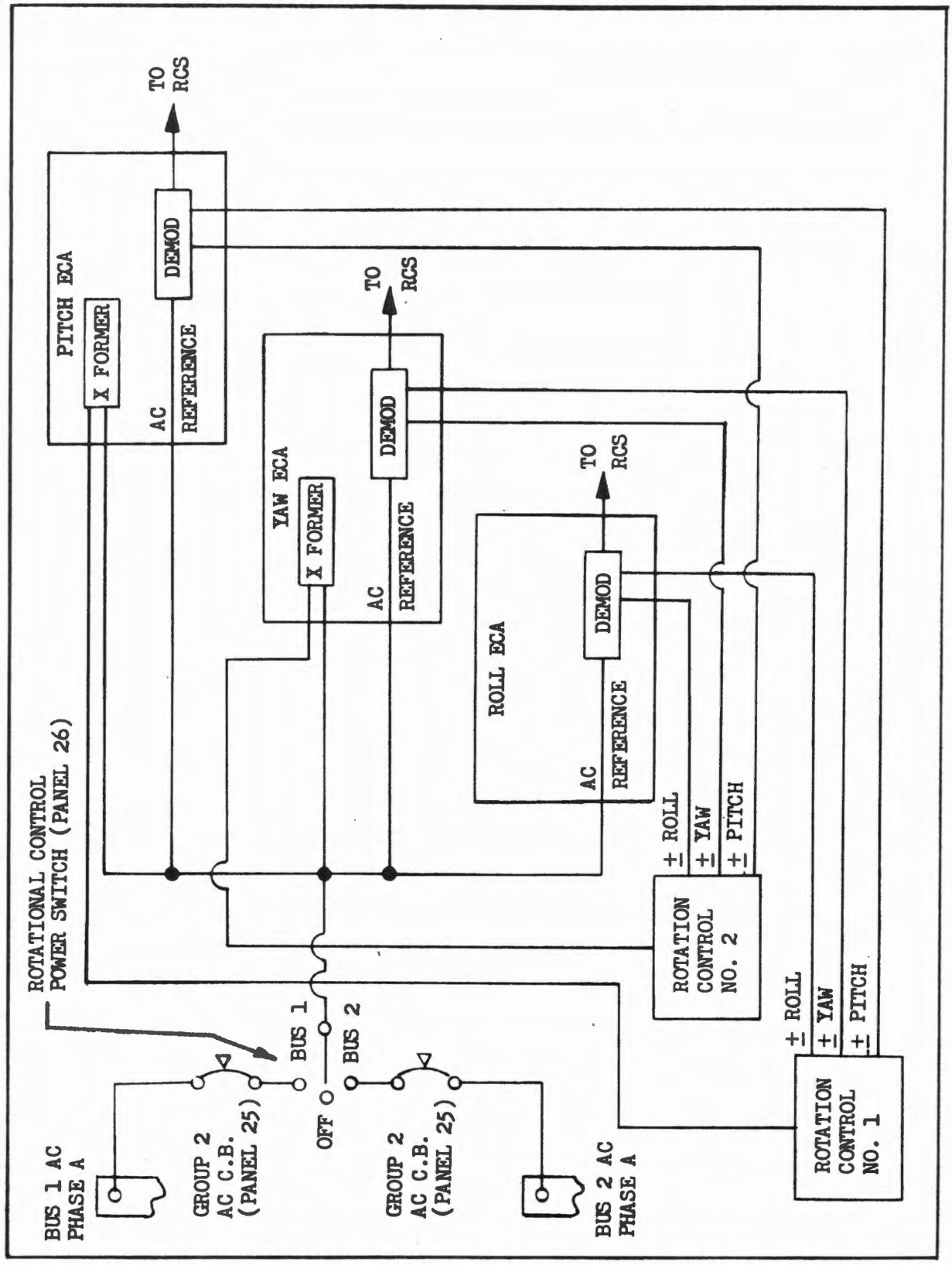

Figure 5-18. Proportional Control Power Distribution

5.2.1.4 Power Failure Considerations.

5.2.1.4.1 Bus Failures. As shown in Figure 5-16, the power switches of either group may be connected to either pair of ac and dc power. Figure 5-13 also shows that ac and dc power sources may be interchanged between the bus sets or tied together in almost any combination. Where time is not critical this switching flexibility will permit retention of all control functions in spite of temporary bus or power source problems. The control of the spacecraft involves several time and/or environmental critical periods when such switching flexibility is not adequate. Specifically entry and TVC periods have been identified as being time critical.

5.2.1.4.1.1 TVC normal and emergency control have been specifically grouped on two independant sets of circuit breakers for this reason. The group 1 switches will be set up on the bus 1 ac and A bus dc position and the group 2 switches will be at the bus 2 ac and B bus dc position. Two inverters must be on and should be connected independantly to the two ac buses both for TVC and during entry. Failure of the ac bus suppling the group 2 switches has no impact on TVC control. Failure of the ac bus suppling the group 1 switches will cause loss of TVC control. This is an immediately recognizable failure. The corrective action is to switch to the MTVC mode and complete the delta V. AC bus failure in entry has similar impacts to failures during TVC. During entry, the power switches would be set the same as for a TVC, except that TVC No. 1 and 2 would be off. Again, ac bus 1 failure would be immediately recognizable. All control and display functions would stop. Vehicle control would have to be maintained with direct rotation until the power switches can be switched to the other bus. Some erratic control will be present as the control system comes back on the line, but this will disappear quickly. The Rate Gyro and then the SCS Power switches should be changed to the other bus pair in that order. A bus 2 ac failure would be more difficult to pick up, assuming no previous failures. Proportional control authority loss in all three axes would occur. In a G&N Manual Entry, roll proportional control would be lost. This could be recovered by switching the Rotation Control power switch. The backup attitude reference in the SCS will be lost by this power failure. If time and environment permits, it may be realigned to the G&N data after switching the BMAG power switch back on again. The latter should be done in any case to restore BMAG availability as a backup rate source.

NOTE: Again, for both the Entry and any TVC phase, two inverters must be on and connected separately to the two ac buses.

5.2.1.4.1.2 It is critical that one of the Rotation Controls work for Entry. The direct power (Figure 5-15) for the two controls is provided independently. Most of the path for proportional control is separate also. The single common point for all three axes is the Rotation Control ac power switch (Figure 5-18). The common point by control channel is the demodulator or downstream electronics. The alternate path for either of these problems is direct control.

5.2.1.4.1.3 Failure of a dc bus, such that the bus is lost for the remainder of the mission, can be corrected by selecting the other bus. One half of the automatic RCS control will be lost with the permanent failure of either dc bus. Direct control and the other half of the automatic RCS control will remain functional. One translation and rotation control pair will loose their dc power which applied breakout signals; translation commands; direct control; and MTVC selection. The other pair will be unaffected. Direct power will be lost to 1/2 of the direct ullage jets, one of the SPS engine on-off circuits, and (as just mentioned) one of the rotation controls. Control mode selection will not be affected since its supply is redundant. See Figure 5-14 and 5-15.

5.2.1.4.2 SCS Power Failures. Two different failure conditions will be considered on the SCS side of the circuit breakers, shorts and opens.

5.2.1.4.3 Direct Power. Direct power is connected as shown in Figure 5-15. By inspection, an open at any point will cause loss of all functions beyond that point. As the two independent paths exist a limited operational degradation occurs for any open failure.

5.2.1.4.3.1 A short on either path will open the circuit breaker for that path rendering the path nonfunctional. In this case, an SPS on-off coil, one rotation control, and two of the direct ullage jets will no longer have dc power available. If time permits, the circuit breaker can be reset to see if the problem was transient. If not, the redundant path permits a safe return.

5.2.1.4.4 Automatic RCS Power. Automatic RCS 28 vdc power is distributed as shown in Figure 5-14. An open at any point will preclude firing any of the RCS downstream of that point through the automatic circuitry.

5.2.1.4.4.1 A short at any jet on the return side will cause that jet to fire continuously. A short at any point upstream of the high side of the RCS coils will cause the related circuit breaker to open. Two automatic control jets are lost functionally, if this occurs.

5.2.1.4.5 Control Panel. A detailed schematic for the Control Panel will be included in this data book. Inspection of the schematic will show that most open circuits will only cause loss of control functions beyond that point in that path. A short will cause both isolation diodes or circuit breakers to open and will loose all normal mode and submode switching control.

5.2.1.4.6 SCS Power Switches. Any open in the power path following any of the power switches will cause loss of all functions downstream of that point. Any short will cause the appropriate circuit breaker to open. All switches on that circuit breaker should be turned off. Then one at a time they can be turned back on after resetting the circuit breaker. The failed circuit can be isolated in this way and left off. The functions related to the circuit including the failure will also be lost. Refer to Figure 5-16 for a gross indication of functions lost. Precise determination of the functions lost will require extensive analyses of the SCS Schematic and SCS Wiring diagram for this vehicle.

5.2.1.5 Power Control Selection vs Mission Phase. Table 5-2 is a table of the correct positions of the SCS power switches and circuit breakers for the various mission phases identified to date.

Table 5-2. Power Control Position by Mission Phase

Control	Launch	S-IVB Control	S-IVB Separation	Monitor	Attitude Hold 15 Min.	Attitude Manuver	TVC	Free Drift or Wobble	Bar-B-Q Mode	CM-SM Separation	Entry	
											Separation to 25000 Feet	25000 Feet to Impact
SCS Power	AC 1	OFF	AC 1	ON 1 or 2	AC 1	AC 1	AC 1	OFF	AC 1	AC 1	AC 1	OFF
Rate Gyros	AC 1	AC 1	AC 1	AC 1	AC 1	AC 1	AC 1	AC 1	AC 1	AC 1	AC 1	OFF
TVC No. 1	AC 1	OFF	OFF	OFF	OFF	OFF	AC 1	OFF	OFF	OFF	OFF	OFF
BMAG's	AC 2	AC 2	AC 2	AC 2	AC 2	AC 2	AC 2	AC 2	AC 2	AC 2	AC 2	OFF
Rotation Control	AC 2	AC 2	AC 2	AC 2	AC 2	AC 2	AC 2	AC 2	AC 2	AC 2	AC 2	OFF
TVC No. 2	AC 2	OFF	OFF	OFF	OFF	OFF	AC 2	OFF	OFF	OFF	OFF	OFF
Direct RCS	ON	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF	ON	ON	OFF
Pitch Enable	ON	OFF	ON	ON	ON	ON	ON	OFF	ON	ON	ON	OFF**
Yaw Enable	ON	OFF	ON	ON	ON	ON	ON	OFF	ON	ON	ON	OFF**
B&D Roll Enable	ON	OFF	ON	*	*	*	ON	OFF	ON	ON	ON	OFF**
A&C Roll Enable	ON	OFF	ON	*	*	*	OFF	OFF	OFF	OFF	OFF	OFF
Pitch A Breaker	CLOSED	CLOSED	CLOSED	CLOSED	*	CLOSED	CLOSED	CLOSED	*	CLOSED	CLOSED	CLOSED
Pitch B Breaker	CLOSED	CLOSED	CLOSED	CLOSED	*	CLOSED	CLOSED	CLOSED	*	OPEN	OPEN	OPEN
Yaw A Breaker	CLOSED	CLOSED	CLOSED	CLOSED	*	CLOSED	CLOSED	CLOSED	*	CLOSED	CLOSED	CLOSED
Yaw B Breaker	CLOSED	CLOSED	CLOSED	CLOSED	*	CLOSED	CLOSED	CLOSED	*	OPEN	OPEN	OPEN
B&D Roll A Breaker	CLOSED	CLOSED	CLOSED	CLOSED	*	CLOSED	CLOSED	CLOSED	OPEN	CLOSED	CLOSED	CLOSED
B&D Roll B Breaker	CLOSED	CLOSED	CLOSED	CLOSED	*	CLOSED	CLOSED	CLOSED	OPEN	OPEN	OPEN	OPEN
A&C Roll A Breaker	CLOSED	CLOSED	CLOSED	CLOSED	*	CLOSED	CLOSED	CLOSED	CLOSED	OPEN	OPEN	OPEN
A&C Roll B Breaker	CLOSED	CLOSED	CLOSED	CLOSED	*	CLOSED	CLOSED	CLOSED	CLOSED	OPEN	OPEN	OPEN

* One is "ON" or "CLOSED" the other is "OFF" or "OPEN" by pairs (Example: A&C or B&D Roll Enable)

** Turned Off Sequentially: First Pitch, then Yaw, then B&D Roll to Back-Up Mission Sequencer RCS Inhibit

5.2.2 SPS Thrust ON/OFF Control Circuit. This section will discuss the mechanization within the SCS, the three methods of turning on and off the SPS engine, the design philosophy, and the operational considerations. The failure effects and corrections will also be covered.

5.2.2.1 Background and Philosophy. In the original design two methods were included for initiating the SPS engine thrust, (G&N Auto and SCS Manual); four methods were included for terminating the SPS engine thrust, (G&N Auto, SCS Auto, Clockwise Translation Control Switches, and the THRUST OFF switch on the Delta V display). An extensive failure mode analysis of the SCS thrust control circuitry disclosed both "failure-firing and "failure-to-fire" design problems. The thrust control circuitry was too far along the design path for revisions so changes were made to the interfacing circuitry to provide three initiating control paths for the SPS, (G&N Auto, SCS Manual, and Direct ON), and three terminating control paths for the SPS (G&N Auto, SCS Auto, and Direct OFF (thrust off) switch position on the Delta V display).

5.2.2.1.1 Attempts to simplify the G&N Auto On Circuitry during the early design phases were unsuccessful. A means of retaining the steering signals from the G&N and the G&N displays for a velocity change, (as a "workaround" to this possible failure) were included in the design.

5.2.2.2 G&N Automatic Control. When the computer requires ignition of the SPS engine, a 102.4 kc signal is transmitted to the SCS on the thrust control interface line. Thrust OFF, is indicated by the removal of this signal. Reference (ICD MH01-01238-216, Engine ON-OFF Signals to SCS MIT-NAA, Block I, Series 100, E0210748, dated 3 March 1965) covers the details of this G&N/SCS interface.

5.2.2.2.1 Within the SCS, the pulse train is detected and converted into a dc logic signal. The signal is then "added" with both the presence of the G&N Delta V mode signal and either a normal + X ullage or the direct ullage signal, see Figure 5-19. Satisfaction of these conditions result in an "on" condition for both switching amplifiers and an "on" output to the THRUST ON light behind the THRUST ON pushbutton of the Delta V indicator, (see Figure 5-20). In their "on" condition the switching amplifiers provide a ground for the SPS coils. Removal of the pulse train or the G&N Delta V mode signal will return the switching amplifiers to the "off" condition. Ullage is normally manually terminated one second after thrust "on". A latching circuit on the ullage logic is provided to satisfy this logic section. In addition to the SPS engine "on" and thrust "on" pushbutton illumination functions, the thrust "on" signal is used to inhibit the pitch and yaw RCS automatic control paths, and to close the inputs of attitude and rate error signals to the TVC servo amplifiers, thereby providing gimbal control of the pitch and yaw axes, (see Figure 5-21). The gimbal control path includes the time delay on the removal of "thrust on" to retain gimbal control during the significant portion of the thrust decay period. The RCS inhibit is delayed "on" to insure ullage during the thrust buildup period.

5.2.2.2.2 For the G&N Auto control circuitry to control SPS "on/off", one more condition must be satisfied within the SCS. The thrust control switch must be in normal position, (see Figure 5-22).

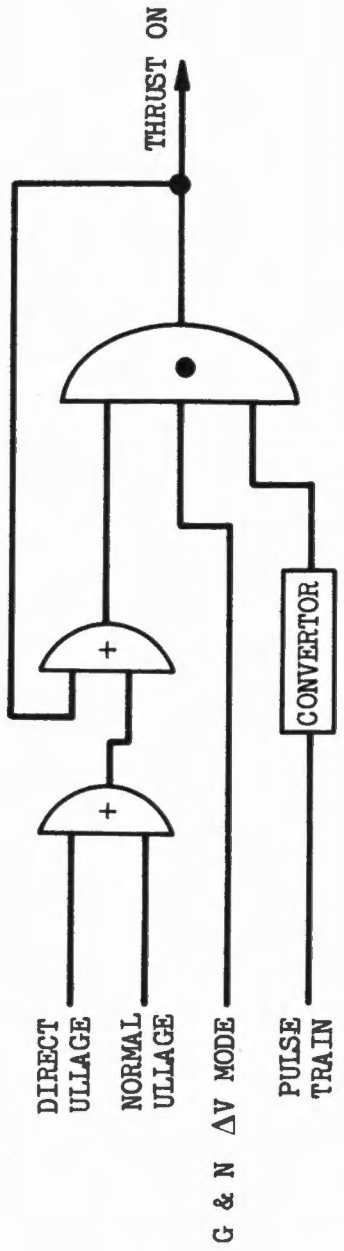

Figure 5-19. G&N Thrust On Logic

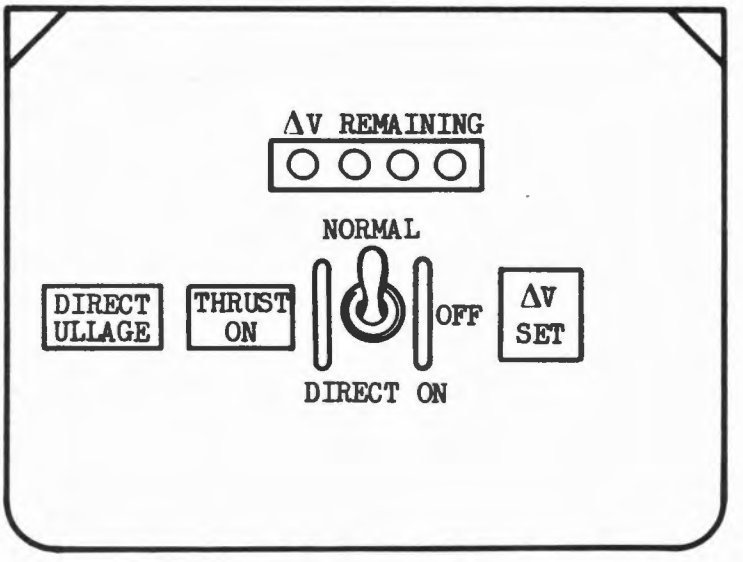

Figure 5-20. Delta V Indicator

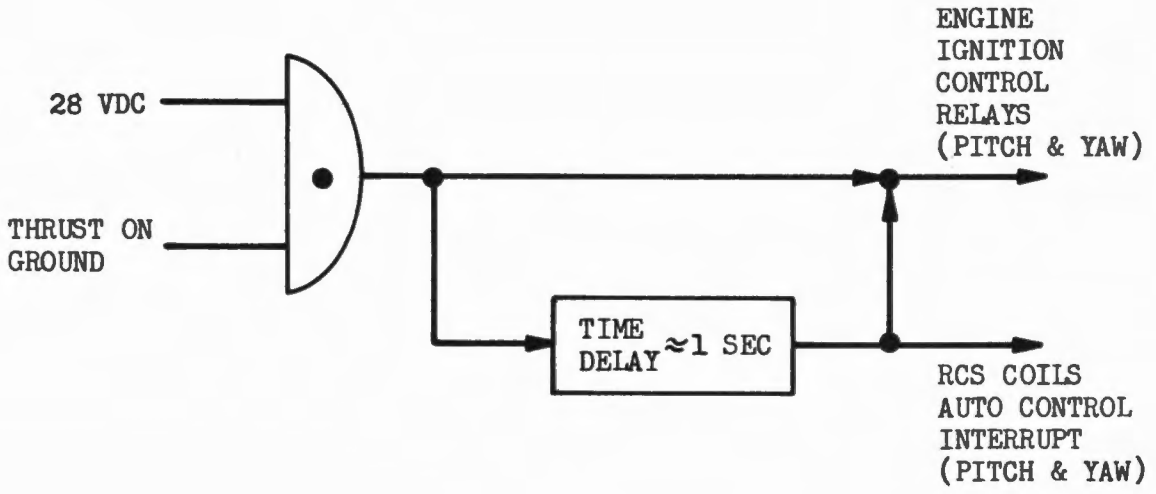

Figure 5-21. Thrust On Signal Control Functions

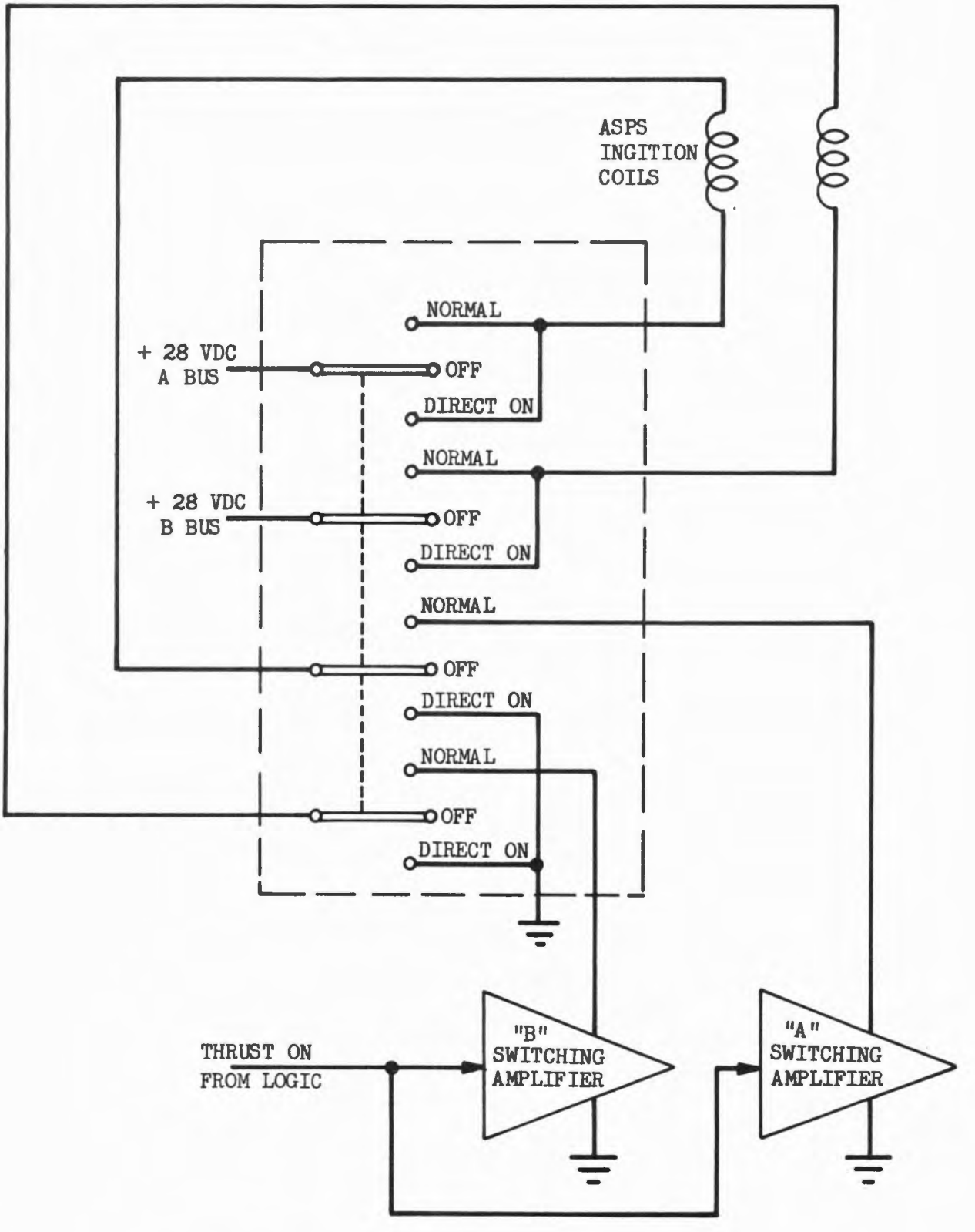

Figure 5-22. Thrust Control Switch Circuitry

5.2.2.2.3 Placing the thrust control switch in the "off" position will provide a positive SPS "off" for any failure condition. Both the 28 vdc and the ground paths to the parallel SPS coils are open in this switch position, so a failure on either side of the control path to the SPS coils will be neutralized.

5.2.2.2.4 There are several possible causes for an "on" circuitry malfunction. The G&N pulse train output may be a malfunction in the detection circuitry, or the "and" circuitry may have malfunctioned. The remainder of the 'on" path is parallel redundant so a failure in either path should not prevent "engine on". In case of a failure in either of the parallel circuits the SCS thrust control path can be activated by depressing the THRUST ON pushbutton on the Delta V display.

5.2.2.2.5 A Flight Combustion Stability Monitor (FCSM) circuit has been added. This circuit can also cause a failure-to-fire, or a cutoff during the SPS firing. This circuit interfaces with the SCS as shown in Figure 5-23. The logic involved, uses the interruption of the Delta V mode signal to cause engine cutoff in either the G&N or SCS Delta V mode. A special section describes the function of the circuit in greater detail including restart procedures. When the circuit has actuated, the caution and warning panel labeled "SPS ROUGH ECO" is illuminated.

5.2.2.3 SCS Automatic Control. SCS control of the SPS engine is manually initiated. Originally the pilot was to initiate the command, but the addition of the Manual TVC mode as the corrective path for G&N, SCS, and/or common TVC electronics control path failures requires the retention of the left hand on the translation control and makes it desirable to retain the right hand on the rotation control (see section describing thrust vector control functions for more details). It now appears that the navigator is in best position to initiate the SPS engine on command as a left handed function. The command is initiated by depressing momentarily the THRUST ON pushbutton just to the left of the thrust control switch on the Delta V display, (see Figure 5-20).

5.2.2.3.1 The logic for SCS "thrust on" is simpler than that for the G&N "thrust on" because it is always manually initiated, (see Figure 5-24). The interlock with ullage (either normal or direct) is unnecessary and the "or", "and" gate input is eliminated. Since a momentary pushbutton input signal is used, a latching circuit from the "thrust on" amplifier is returned to maintain the thrust on signal. Thrust off is accomplished when the Delta V remaining counter reaches zero and opens one of the SCS "and" gate inputs.

5.2.2.3.2 The Delta V remaining counter is a stepping motor that is driven by signals from an accelerometer that senses velocity changes along the SC X axis. The circuitry, once an ullage signal is present, counts down with a + X acceleration or up with a - X acceleration from the present shaft position. The value stored is available visually on the Delta V display, (see Figure 5-20). This value can be adjusted in either direction with the Delta V switch on the same panel. This indicator will be preset to the velocity gain desired along the X axis as part of the Delta V procedure. A coincidence detector switch is connected to close at the shaft position equivalent to a Delta V remaining

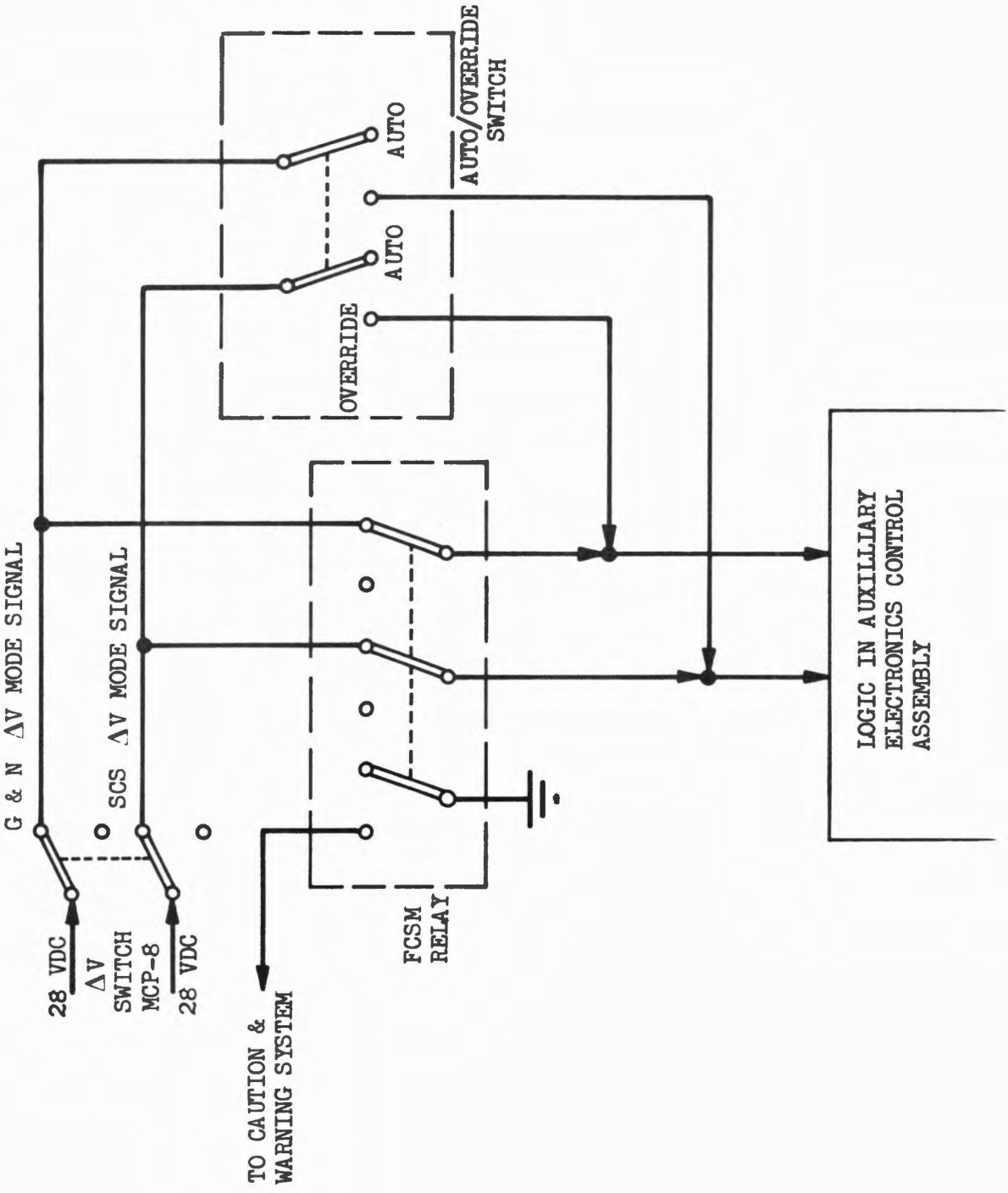

Figure 5-23. Flight Combustion Stability Monitor/SCS Interfaces

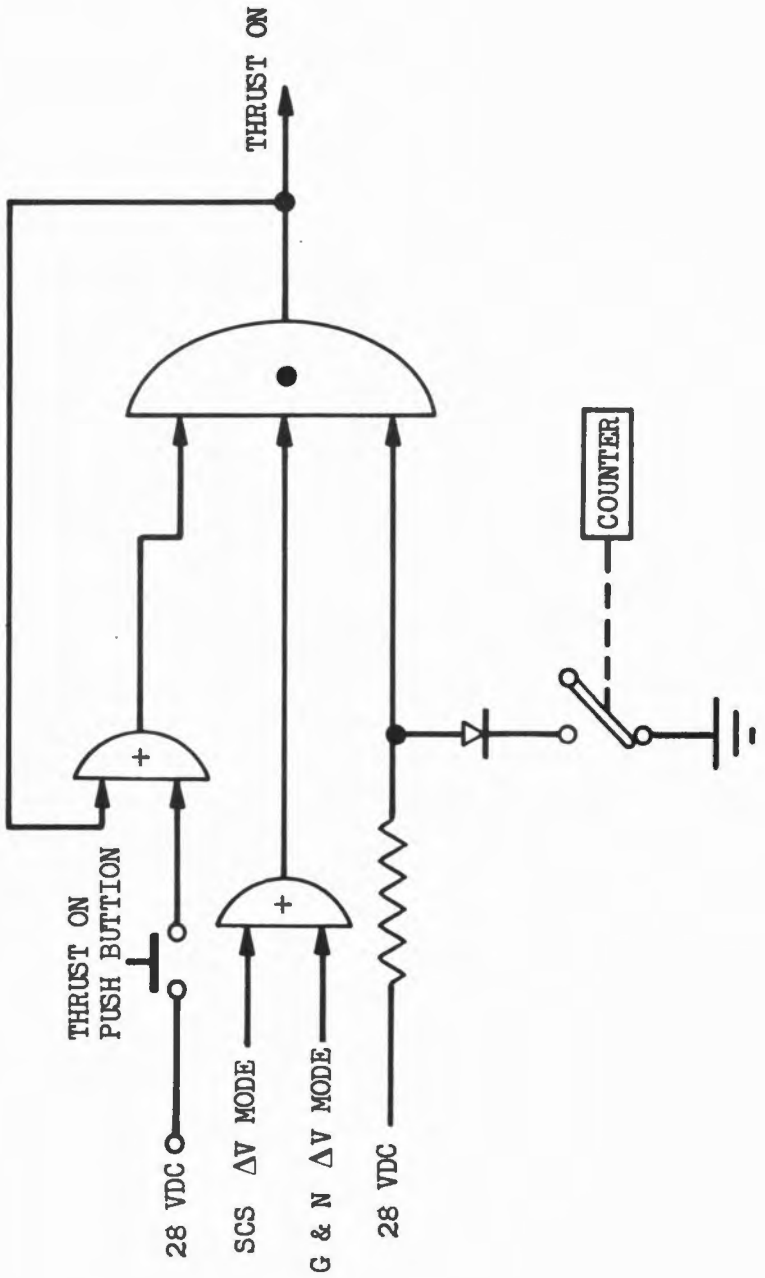

Figure 5-24. SCS Thrust On Logic

reading of 00000. The switch applies ground momentarily to remove one of the inputs to the SCS auto logic "and" gate causing interruption of the SCS auto on signal, (see Figure 5-25). The following operation is the same as the G&N automatic control function. Placing the thrust control switch in the OFF position opens both the 28 vdc and ground paths to the SPS coils providing a positive interruption of SPS firing regardless of the malfunction causing the continuing engine on signal, (see Figure 5-23).

5.2.2.3.3 Figure 5-25 shows the method of SPS ON/OFF control that may be used if a failure in the G&N auto on path is suspected. The SCS auto on logic is satisfied by the presence of either a G&N Delta V mode signal or an SCS Delta V mode signal. The SCS thrust on pushbutton signal or the latching signal is used as an inhibiting signal in the G&N auto control loop. Depressing the thrust on pushbutton, while in the G&N Delta V mode, will turn on the SPS, inhibit the G&N auto control path, and permit continued use of the G&N control and display signals.

5.2.2.4 Direct On/Direct Off. The direct off function has been discussed in both of the preceding sections. As has been seen by inspecting Figure 5-22, both of the 28 vdc inputs and both ground return paths for the SPS coils are opened by placing the thrust on switch in the off position. This provides a positive off control of the SPS.

5.2.2.4.1 To cover the cases when the common power supply logic line or other failures prevent an automatic on, a direct on position has been provided for manned flights, (see Figure 5-22). Seperate paths of the direct 28 vdc paths are connected from the direct circuit breaker to the top of the SPS coils. The dc ground is connected to the return side of each path.

5.2.2.5 Functional Priorities.

a. "Direct on" and/or "direct off" override any other function.

b. SCS auto control will pre-empt G&N auto control if activated.

5.2.2.6 Flight Combustion Stability Monitor. The possibility of a combustion instability developing during SPS ignition or burn has caused the addition of detection circuitry to the SCS that will cutoff the thrust signal. The interface of this signal with the SCS is shown in Figure 5-23. Activation of the detector will open both the G&N and SCS Delta V mode lines causing both auto control circuits to open and return the switching amplifiers to the "off" state. The override position of the auto/override switch bypasses the circuitry for emergency or malfunction cases. For example, for SPS abort during launch the switch would be in the override position. It is important to be able to separate from the S-IVB in an emergency. A false shutdown could add a significant time delay to SPS ignition or reignition. The direct on circuit also completely bypasses the FCSM circuitry.

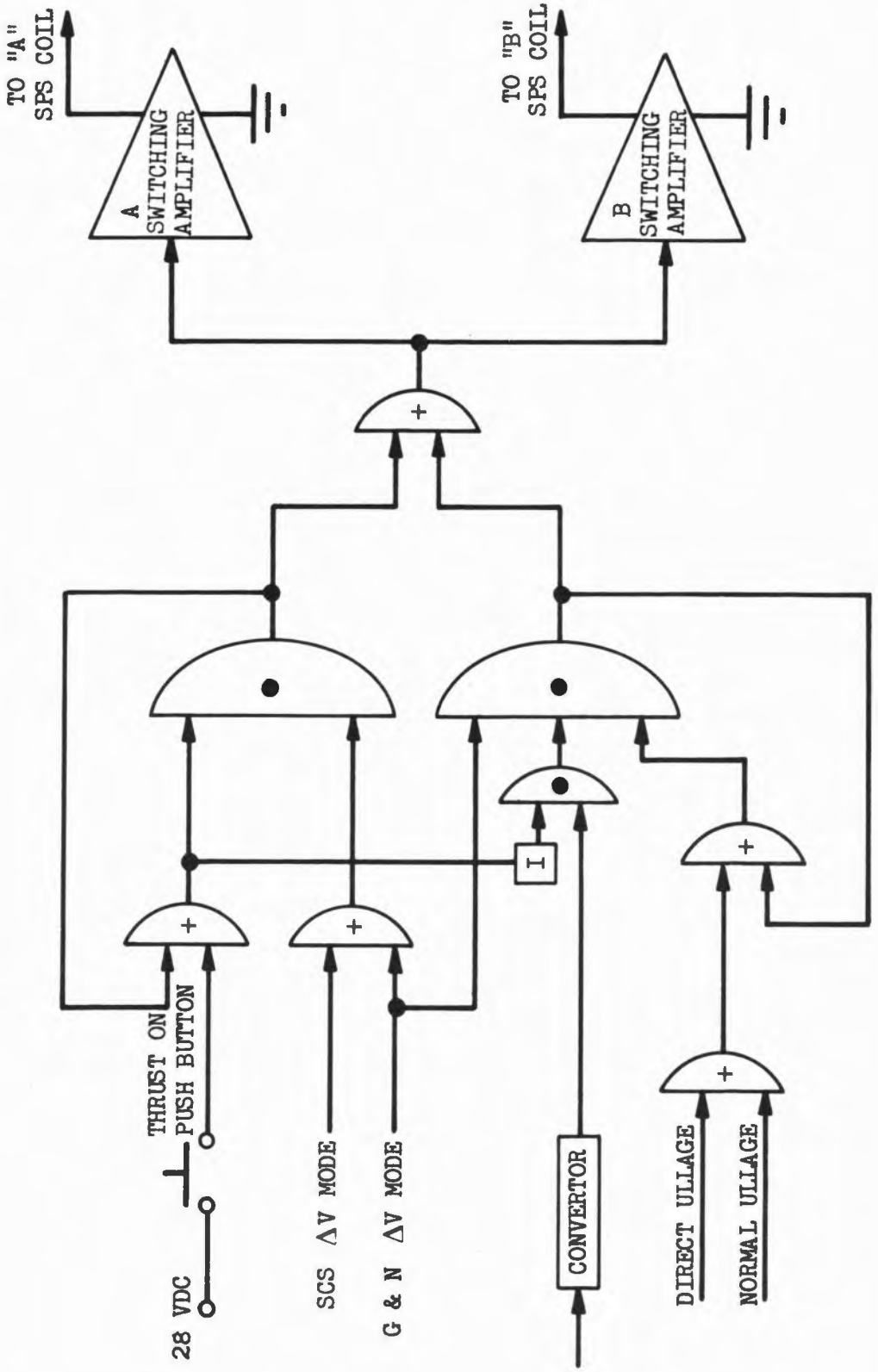

Figure 5-25. Integrated Thrust On Control Logic

5.2.2.6.1 For most burns the FCSM would not be reset with an attendant reignition try. The ignition could be delayed on most plane changes, etc., until the problem had been checked out and a new change scheduled. In the case of deorbit though it is important to continue the burn, especially, if several seconds of SPS combustion have occurred. The three possible methods of continuing the velocity change will be discussed below. It will be assumed that the deorbit burn is occurring in the planned G&N Delta V mode.

(1) Confirm from the caution and warning system (illumination of the "SPS Rough ECO" panel and alarm present" that the FCSM has triggered.

(2) Wait ≈11 seconds for the G&N to remove its thrust on signal (the thrust on light will go out).

(3) Initiate the 15 second normal ullage.

(4) During the ullage period place the FCSM switch to Reset and then back to "On".

(5) The navigator should press enter when ready for the G&N to send a thrust on signal again.

or

(1) Confirm from the caution and warning system (Illumination of the "SPS Rough ECO" panel and alarm present) that the FCSM has triggered.

(2) Initiate the 15 second normal ullage.

(3) Switch to the SCS Delta V mode during ullage.

(4) Also during ullage place the FCSM switch to "Reset" then back to "ON".

(5) The navigator should press the thrust on push-button when the 15 second ullage has been completed.

or

(1) Confirm from the caution and warning system (illumination of the "SPS Rough ECO" panel and alarm present) that the FCSM has triggered.

(2) Initiate normal ullage.

(3) The navigator should place the thrust control switch to "direct on" on command from the pilot.

5.2.2.6.2 The third method includes the possibility of a second instability condition developing and possibly proceeding to an explosion. The procedures are being studied for impact on the entry interface and impact point. Studies have been requested to determine if the attitude and velocity change magnitude settings available for the SCS mode are still sufficiently valid to use after a shutdown.

CAUTION: Care must be exercised in switching the thrust control switch to "Off". For all normal SPS firings, the automatic cutoff should be allowed to function, and then a second or two should elapse to allow the arc suppression diodes to discharge the energy stored in the SPS coils. If the thrust control switch itself is used to interrupt the circuit, arcing will occur across the switch contacts. Some arcing has been provided for in the selection of the switch, but repeated and or unnecessary arcing could not be considered beneficial.

The ullage interlock with the G&N automatic "on" function was intended to insure that the G&N "on"" command could not come without ullage. The ullage must be adequate to settle the propellant and studies have shown ≈15 seconds of ullage to be required. The interlock is not sufficient of itself in that if the G&N Delta V mode exists and the pulse train is present from the G&N, the initiation of ullage will satisfy the "and" gates and a premature SPS ignition is possible. MIT was requested to provide an automatic interlock on their thrust on signal by requiring the accumulation of the ullage as a velocity change (7-8 feet per second in the case of present SC 012 data) before sending out a SPS on signal. MIT has not complied with this request. Instead an enter is required by the navigator to permit transmission the SPS on signal in normal operating conditions.

This places the responsibility for insuring sufficient ullage on the navigator. He can use the change on the Delta V remaining counter and/or the change in the Delta V value shown in Register 3 of the DSKY to satisfy this function. This will cover the normal operation. It is also possible that an erroneous SPS pulse train may be present. The pilot can check for this by watching the THRUST ON light behind the THRUST ON pushbutton. Figure 5-26 shows the signals that will cause the THRUST ON light to be "on". Notice that a pulse train and the G&N Delta V mode will light the pushbutton. If the

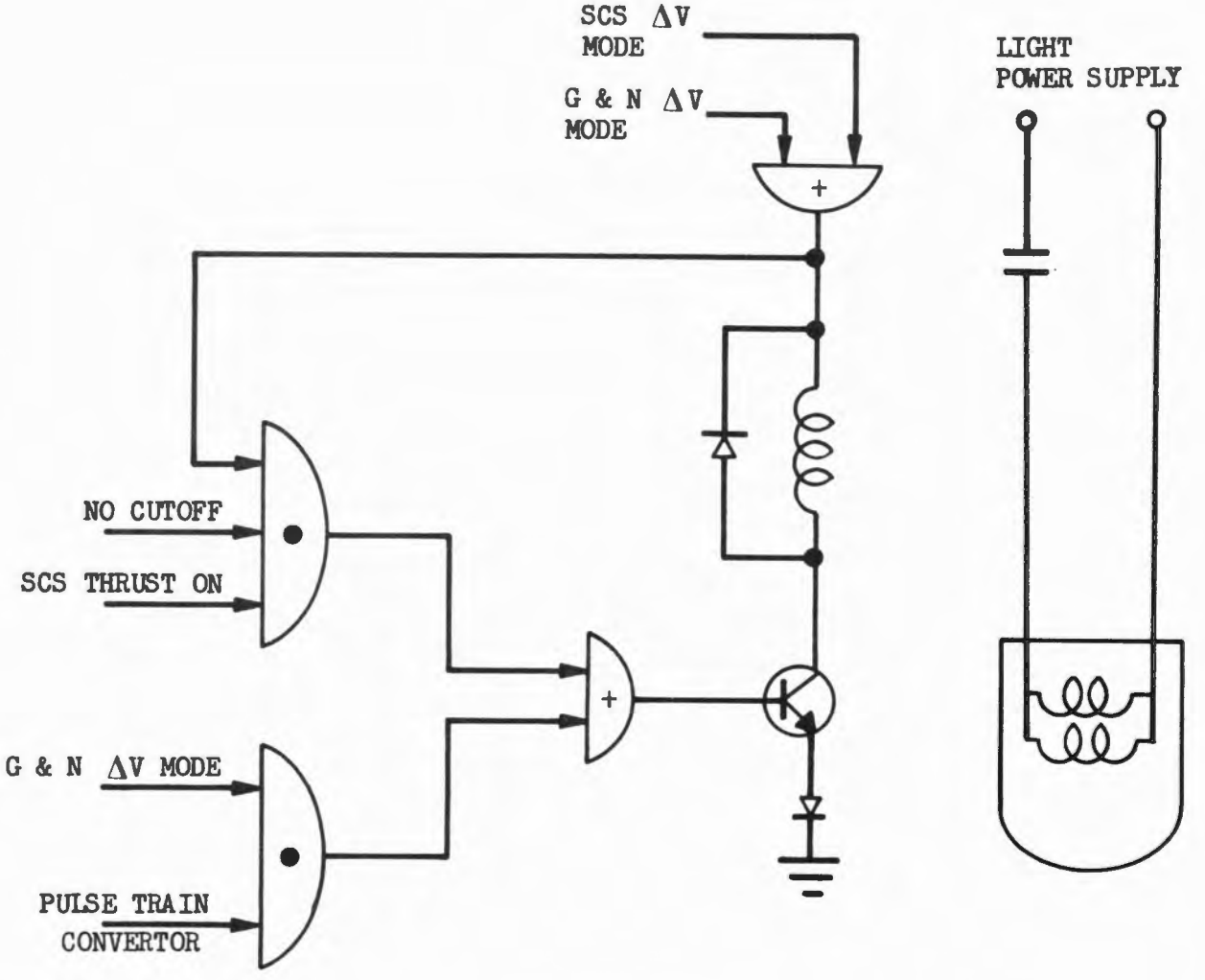

Figure 5-26. THRUST ON Pushbutton Light Logic

light is on before ullage and without a manually initiated signal either a premature pulse train is present or the detector has failed in the "on" condition. Ullage should not be initiated until the condition is corrected or an alternate means of accomplishing the Delta V has been selected.

5.3 G&N Functional Descriptions. Complete functional descriptions of the G&N Subsystem are included in Volumes 1 and 2 of Report Number 1021041, (prepared for NASA by AC Electronics), Revision A, dated September 1, 1965.

6 G&C ANALYTICAL AND FUNCTIONAL BLOCK DIAGRAMS

To be supplied.

7 G&C TELEMETRY DATA

To be supplied.

8 G&C TESTING REFERENCES

To be supplied.

9 G&C POST-FLIGHT ANALYSIS

To be supplied.

10 G&C PROCEDURES

10.1 G&C Power Down.

10.1.1 Confirm or select the following switch condition:

MDC 8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - OFF
3. ATTITUDE DEADBAND - MAXIMUM
4. .05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - OFF
7. G&N/SCS - SCS
8. ATTITUDE/MONITOR/ENTRY - MONITOR
9. A&C ROLL CHANNEL - OFF
10. B&D ROLL CHANNEL - OFF
11. PITCH CHANNEL - OFF
12. YAW CHANNEL - OFF
13. ROLL RATE GYRO - BMAG
14. PITCH RATE GYRO - BMAG
15. YAW RATE GYRO - BMAG

MDC 25

1. FDAI LTG - AC 1
2. GROUP 1-AC 1 - CLOSED
3. GROUP 1-AC 2 - CLOSED
4. GROUP 2-AC 1 - CLOSED
5. GROUP 2-AC 2 - CLOSED
6. GROUP 1-MNA - CLOSED
7. GROUP 1-MNB - CLOSED
8. GROUP 2-MNA - CLOSED
9. GROUP 2-MNB - CLOSED
10. DIRECT CONTROL-MNA - CLOSED
11. DIRECT CONTROL-MNB - CLOSED
12. A&C ROLL-MNA - CLOSED
13. A&C ROLL-MNB - CLOSED
14. B&D ROLL-MNA - CLOSED
15. B&D ROLL-MNB - CLOSED
16. PITCH-MNA - CLOSED
17. PITCH-MNB - CLOSED
18. YAW-MNA - CLOSED
19. YAW-MNB - CLOSED
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL-PITCH-BAT A - OPEN
22. GIMBAL MOTOR CONTROL-YAW-BAT A - OPEN

MDC 24

1. SCS POWER - OFF
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC 3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC 6

ATTITUDE SET - OFF

MDC 7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - PINNED
TRANSLATION CONTROLS - LOCKED

MDC 14

1. PROGRAM - 00
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - MAX. DIM.

MDC 2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - OFF
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

MDC 22

1. IMU HTR-MNA - CLOSED
2. IMU HTR-MNB - CLOSED
3. IMU-MNA - OPEN
4. IMU-MNB - OPEN
5. COMPUTER-MNA - CLOSED
6. COMPUTER-MNB - CLOSED

7. OPTICS-MNA - OPEN
8. OPTICS-MNB - OPEN
9. G&N AC POWER-AC 1 - OPEN
10. G&N AC POWER-AC 2 - OPEN
11. G&N AC POWER-AC 1

LEB NAV STATION SWITCHES

1. IMU TRANSFER - COMPUTER
2. OPTICS SLAVE TELESCOPE - STAR LOS
3. OPTICS MODE - ZERO OPTICS
4. OPTICS HOLD - OFF
5. OPTICS CONTROLLER SPEED - HIGH
6. OPTICS CONTROLLER MODE - DIRECT
7. IMU TEMP. MODE - AUTO OVERRIDE
8. AGC MODE - STAND BY
9. ATTITUDE IMPULSE ENABLE - OFF
10. CONDITION LAMPS - OFF
11. FLOODLIGHT CONTROL PRIMARY - OFF
12. FLOODLIGHT CONTROL SECONDARY - OFF
13. PANEL BRIGHTNESS CONTROL - MAX. DIM.
14. AGC BRIGHTNESS CONTROL - MAX. DIM.

10.2 Free Drift Establishment and Adjustment.

10.2.1 Confirm or select the following switch positions:

MDC-8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - ON
3. ATTITUDE DEADBAND - MAXIMUM
4. 0.05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - OFF
7. G&N/SCS - SCS
8. ATTITUDE/MONITOR/ENTRY - MONITOR
9. A&C ROLL CHANNEL - OFF
10. B&D ROLL CHANNEL - OFF
11. PITCH CHANNEL - OFF
12. YAW CHANNEL - OFF
13. ROLL RATE GYRO - BMAG
14. PITCH RATE GYRO - BMAG
15. YAW RATE GYRO - BMAG

MDC-25

1. FDAI LTG - OFF
2. GROUP 1-AC 1 - CLOSED
3. GROUP 1-AC 2 - CLOSED
4. GROUP 2-AC 1 - CLOSED
5. GROUP 2-AC 2 - CLOSED
6. GROUP 1-MNA - CLOSED
7. GROUP 1-MNB - CLOSED
8. GROUP 2-MNA - CLOSED
9. GROUP 2-MNB - CLOSED
10. DIRECT CONTROL-MNA - CLOSED
11. DIRECT CONTROL-MNB - CLOSED
12. A&C ROLL-MNA -
13. A&C ROLL-MNB - } ONE CLOSED, THREE OPEN
14. B&D ROLL-MNA - } ONE FOR FULLEST QUAD CLOSED
15. B&D ROLL-MNB -
16. PITCH-MNA - } ONE OPEN, ONE CLOSED
17. PITCH-MNB -
18. YAW-MNA - } ONE OPEN, ONE CLOSED
19. YAW-MNB -
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL-PITCH-BAT A - OPEN
22. GIMBAL MOTOR CONTROL-YAW-BAT A - OPEN

MDC-24

1. SCS POWER - AC 1
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2

4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC-3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC-6

ATTITUDE SET - OFF

MDC-7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - PINNED
TRANSLATION CONTROLS - LOCKED

MDC-14

1. PROGRAM - 00
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - MAX DIM

MDC-2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - OFF
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

MDC-22

1. IMU HTR-MNA - CLOSED
2. IMU HTR-MNB - CLOSED
3. IMU-MNA - OPEN
4. IMU-MNB - OPEN
5. COMPUTER-MNA - CLOSED
6. COMPUTER-MNB - CLOSED
7. OPTICS-MNA - OPEN
8. OPTICS-MNB - OPEN
9. G&N AC POWER-AC 1 - OPEN
10. G&N AC POWER-AC 2 - OPEN
11. G&N AC POWER-AC 1

LEB NAV STATION SWITCHES

1. IMU TRANSFER - COMPUTER
2. OPTICS SLAVE TELESCOPE - STAR LOS
3. OPTICS MODE - ZERO OPTICS
4. OPTICS HOLD - OFF
5. OPTICS CONTROLLER SPEED - HIGH
6. OPTICS CONTROLLER MODE - DIRECT
7. IMU TEMP MODE - AUTO OVERRIDE
8. AGC MODE - STANDBY
9. ATTITUDE IMPULSE ENABLE - OFF
10. CONDITION LAMPS - OFF
11. FLOODLIGHT CONTROL PRIMARY - OFF
12. FLOODLIGHT CONTROL SECONDARY - OFF
13. PANEL BRIGHTNESS CONTROL - MAX DIM
14. AGC BRIGHTNESS CONTROL - MAX DIM

When it is necessary to adjust the drift rates or directions perform the following.

10.2.2 Place the SPS Power switch on MDC-24 to AC-1.

10.2.3 Place the Pitch, and Yaw Channel Enable Switches on MDC-8 to ON.

10.2.4 Place the Roll enable switch on MDC-8 related to the closed circuit breaker on MDC-25 (for fullest quad) to ON.

10.2.5 Confirm that the Limit Cycle switch on MDC-8 is ON.

10.2.6 Place the Attitude Impulse Enable switch at the LEB to ON.

10.2.7 Adjust the vehicle rates as necessary.

10.2.8 Return all channel enable switches on MDC-8 to Off.

10.2.9 Place the SCS Power switch on MDC-24 to Off.

10.3 G&N Velocity Change (Including Deorbit)

NOTE: Steps 10.3.1 through 10.3.5 will have preceded this procedure. They are included to show the Delta V preparation continuity.

10.3.1 Using SPS propellant readings taken following the previous SPS burn and onboard curves, read pitch and yaw gimbal trim angles required.

10.3.2 Check with MSFN for following data after confirming SPS fuel quantity remaining to MSFN as a part of procedure 10.46, AGC Update.

a. GMT time of firing.

b. Delta V change required (less tail-off allowance)

c. Firing duration (± 1 second)

d. Attitude required for delta V both as IMU gimbal angles read out from last IMU alignment and as visual references expected out the docking window when aligned.

e. Pitch and yaw trim angles.

10.3.3 Compare G&N data with MSFN using procedure 10.42, Orbit Change and SPS Minimum Impulse Prethrusting.

10.3.4 Using procedures 10.44, IMU Orientation Determination and 10.45, IMU Align, align the IMU and orient the vehicle to the required attitude.

10.3.5 Confirm S/C attitude through the docking window.

10.3.6 At 12 minutes before the burn the following initial switch conditions should exist or be selected.

MDC-8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - ON
3. ATTITUDE DEADBAND - MAXIMUM
4. 0.05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - OFF
7. G&N/SCS - G&N
8. ATTITUDE/MONITOR/ENTRY - ATTITUDE
9. A&C ROLL CHANNEL - OFF
10. B&D ROLL CHANNEL - ON
11. PITCH CHANNEL - ON
12. YAW CHANNEL - ON
13. ROLL RATE GYRO - NORMAL
14. PITCH RATE GYRO - NORMAL
15. YAW RATE GYRO - NORMAL

G+N ΔV

MDC-25

1. FDAI LTG - AC 1
2. GROUP 1 - AC 1 - CLOSED
3. GROUP 1 - AC 2 - CLOSED
4. GROUP 2 - AC 1 - CLOSED
5. GROUP 2 - AC 2 - CLOSED
6. GROUP 1 - MNA - CLOSED
7. GROUP 1 - MNB - CLOSED
8. GROUP 2 - MNA - CLOSED
9. GROUP 2 - MNB - CLOSED
10. DIRECT CONTROL - MNA - CLOSED
11. DIRECT CONTROL - MNB - CLOSED
12. A&C ROLL - MNA - CLOSED
13. A&C ROLL - MNB - CLOSED
14. B&D ROLL - MNA - CLOSED
15. B&D ROLL - MNB - CLOSED
16. PITCH - MNA - CLOSED
17. PITCH - MNB - CLOSED
18. YAW - MNA - CLOSED
19. YAW - MNB - CLOSED
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL - PITCH - BAT A - CLOSED
22. GIMBAL MOTOR CONTROL - YAW - BAT A - CLOSED
23. SPS GAUGING - AC 1

MDC-24

1. SCS POWER - AC 1
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC-3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC-6

ATTITUDE SET - OFF

G+N ΔV

MDC-7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - PINNED
TRANSLATION CONTROLS - LOCKED

MDC-14

1. PROGRAM - 00
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - ADJUST AS REQUIRED

MDC-2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - ADJUST AS REQUIRED
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

MDC-22

1. IMU HTR - MNA - CLOSED
2. IMU HTR - MNB - CLOSED
3. IMU - MNA - CLOSED
4. IMU - MNB - CLOSED
5. COMPUTER - MNA - CLOSED
6. COMPUTER - MNB - CLOSED
7. OPTICS - MNA - OPEN
8. OPTICS - MNB - OPEN
9. G&N AC POWER - AC 1 - CLOSED
10. G&N AC POWER - AC 2 - CLOSED
11. G&N AC POWER - AC 1

LEB NAV STATION SWITCHES

1. IMU TRANSFER - COMPUTER
2. OPTICS SLAVE TELESCOPE - STAR LOS
3. OPTICS MODE - ZERO OPTICS
4. OPTICS HOLD - OFF
5. OPTICS CONTROLLER SPEED - HIGH
6. OPTICS CONTROLLER MODE - DIRECT
7. IMU TEMP. MODE - AUTO OVERRIDE
8. AGC MODE - ON
9. ATTITUDE IMPULSE ENABLE - OFF
10. CONDITION LAMPS - ON
11. FLOODLIGHT CONTROL PRIMARY - OFF
12. FLOODLIGHT CONTROL SECONDARY - OFF
13. PANEL BRIGHTNESS CONTROL - MAX. DIM.
14. AGC BRIGHTNESS CONTROL - MAX. DIM.

10.3.7 Approximately 10 minutes before the burn, enter V37E**E on MDC-14. *May be 41 for orbital change,42 for deorbit,or 43 for min. impulse.

G+N ΔV

10.3.8 In response to V50N25 flash key in V33E on MDC-14 to bypass the mode check (which is too early).

10.3.9 In response to V16N20 flash key in V33E on MDC-14 to bypass AGCU set routine.

10.3.10 In response to V16N51 flash, set Digital Event Timer to minutes and seconds to go in R1. Note total velocity change required in R2. (For a minimum impulse burn R2 will display the burn time.)

10.3.11 Set pitch and yaw gimbal trim angles coarsly to +4 degrees and +6 degrees respectively using numerical values on thumbwheels on MDC-6.

10.3.12 Set the attitude set dials on MDC-6 to 0 degrees roll, 0 degrees yaw, and 32 degrees pitch and depress the FDAI align pushbutton (all ON MDC-6) for ≈30 seconds. For deorbit the attitude set dials would now be reset to degrees roll, degrees pitch, and degrees yaw to save time during the CM-SM Separation preparation period.

10.3.13 Set TVC 1 switch to AC 1 (MDC-24).

10.3.14 Set the delta V remaining counter on MDC-7 to the value of delta V required received from MSFN using the delta V set switch on the same panel.

10.3.15 Set TVC 2 switch to AC 2 (MDC-24).

10.3.16 Set Inject Prevalve switches A and B to ON (MDC-3).

10.3.17 Approximately 5 minutes before the burn set the Attitude Deadband switch on MDC-8 to Minimum.

10.3.18 Delta V switch on MDC-8 to ON.

10.3.19 Gimbal motors switches on MDC-3 in sequence approximately 4 minutes before ignition.

a. Pitch 2 to momentary start then ON.

b. Yaw 2 to momentary start then ON.

10.3.20 Confirm on MDC-6 the drive of the pitch and yaw gimbals to +4 degrees and +6 degrees respectively.

10.3.21 Gimbal motor switches on MDC-3 in sequence.

a. Pitch 1 to momentary start then ON.

b. Yaw 2 to momentary start then ON.

10.3.22 After any transients settle out, fine adjust the pitch and yaw required trim angles (MDC-6).

10.3.23 Confirm that the pitch and yaw gimbals go to the final values (MDC-6).

10.3.24 Unlock the prime translation control only.

10.3.25 Set the thrust control switch on MDC-7 to NORMAL.

10.3.26 Unpin the rotation control.

10.3.27 At T-25 seconds R3 on MDC-14 should begin to display accumulated ullage. R3 should remain 00000 until ullage commences.

10.3.28 When the digital event timer on MDC-5 reads 00 15 initiate a +X command with the translation control.

10.3.29 At -5 seconds, the Verb Noun flash will change to V50N11 flashing.

10.3.30 At 00 00 the navigator should press Enter on MDC-14 if 15 seconds of ullage have occurred. The light behind the thrust-on pushbutton on MDC-7 should come on and SPS thrust buildup should commence.

NOTE: The exact velocity change is not important in ullage. There must have been a steady ullage of 2 or more +X jets to settle the propellant.

10.3.31 At ignition the Verb Noun display will change to V16N51. R1 will change to time to engine cutoff (decreasing), R2 will display velocity to be gained (decreasing), and R3 will continue to display ullage velocity accumulated. For minimum impulse burns, R2 will display the delta time for the burn and the Verb Noun will be V06N50.

10.3.32 Retain the +X command for approximately 1 second after SPS ignition.

10.3.33 Keep the left hand on the translation control to select MTVC, if necessary. The pilot should monitor attitude, the attitude error indicators, and the rate indicators on MDC-4 for any indication of failure and required takeover.

10.3.34 The navigator must monitor thrust control to backup the automatic thrust off by returning the thrust control switch to off (MDC-7) if necessary. Total time from SPS ignition and the delta V remaining counter (MDC-7) are the items checked. When the ΔV remaining counter reads 00000, and R2 reads the tail off value for this burn, the light behind the thrust on pushbutton should go out. In the case of the minimum impulse burn the light will come on and then go off again in less than a second.

10.3.35 Following tail off of SPS engine

a. B&D Roll, Pitch, and Yaw Channel Enable switches to Off (MDC-8).

NOTE: The enable switches must be off for 10 minutes minimum to allow the SPS propellant to damp itself or excessive SM/RCS propellant will be expended in this time period.

b. Gimbal motors in sequence (MDC-3)

1. Pitch 1 to OFF

2. Pitch 2 to OFF

3. Yaw 1 to OFF

4. Yaw 2 to OFF

c. Inject Prevalve A and B - both OFF (MDC-3)

d. Thrust control switch OFF (MDC-7)

e. TVC 2 OFF (MDC-24)

f. TVC 1 OFF (MDC-24)

g. Delta V OFF (MDC-8)

h. Repin rotation control

i. Lock translation control

j. Open the two BAT A circuit breakers for gimbal motor control on MDC-25.

k. SPS gauging switch on MDC-25 to OFF

10.3.36 Read and record delta V accomplished from the delta V remaining counter (MDC-7).

10.3.37 Read and record SPS propellant quantities remaining from MDC-20.

10.3.38 Read delta V accomplished from register 2 of MDC-14.

10.3.39 If in P-42 enter V34E on MDC-14 and exit procedure. If in P-41 or P-43 enter V33E on MDC-14. Procedure 10.33, Orbit Parameter Display will now follow. Upon the final V33E entry on MDC-14 the program will change from 41 or 43 to 00.

10.4 Precise SCS Attitude Reference Alignment to IMU Gimbal Angles.

10.4.1 Confirm or select the following switch positions:

MDC 8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - ON
3. ATTITUDE DEADBAND - MINIMUM
4. .05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - OFF
7. G&N/SCS - ENTER G&N OR SCS
8. ATTITUDE/MONITOR/ENTRY - ATTITUDE
9. A&C ROLL CHANNEL - } ONE ON,
10. B&D ROLL CHANNEL - } ONE OFF
11. PITCH CHANNEL - ON
12. YAW CHANNEL - ON
13. ROLL RATE GYRO - NORMAL
14. PITCH RATE GYRO - NORMAL
15. YAW RATE GYRO - NORMAL

MDC 25

1. FDAI LTG - AC 1
2. GROUP 1-AC 1 - CLOSED
3. GROUP 1-AC 2 - CLOSED
4. GROUP 2-AC 1 - CLOSED
5. GROUP 2-AC 2 - CLOSED
6. GROUP 1-MNA - CLOSED
7. GROUP 1-MNB - CLOSED
8. GROUP 2-MNA - CLOSED
9. GROUP 2-MNB - CLOSED
10. DIRECT CONTROL-MNA - CLOSED
11. DIRECT CONTROL-MNB - CLOSED
12. A&C ROLL-MNA - } ONE OPEN,
13. A&C ROLL-MNB - } ONE CLOSED
14. B&D ROLL-MNA - } ONE OPEN,
15. B&D ROLL-MNB - } ONE CLOSED
16. PITCH-MNA - } ONE OPEN,
17. PITCH-MNB - } ONE CLOSED
18. YAW-MNA - } ONE OPEN,
19. YAW-MNB - } ONE CLOSED
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL-PITCH-BAT A - OPEN
22. GIMBAL MOTOR CONTROL-YAW-BAT A - OPEN

SCS ARS ALIGN

MDC 24

1. SCS POWER - AC 1
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC 3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC 6

ATTITUDE SET - OFF

MDC 7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - PINNED
TRANSLATION CONTROLS - LOCKED

MDC 14

1. PROGRAM - 00
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - ADJUST AS REQUIRED

MDC 2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - ADJUST AS REQUIRED
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

MDC 22

1. IMU HTR - MNA - CLOSED
2. IMU HTR - MNB - CLOSED
3. IMU - MNA - CLOSED
4. IMU - MNB - CLOSED
5. COMPUTER - MNA - CLOSED
6. COMPUTER - MNB - CLOSED
7. OPTICS - MNA - OPEN
8. OPTICS - MNB - OPEN
9. G&N AC POWER - AC 1 - CLOSED
10. G&N AC POWER - AC 2 - CLOSED
11. G&N AC POWER - AC 1

LEB NAV STATION SWITCHES

1. IMU TRANSFER - COMPUTER
2. OPTICS SLAVE TELESCOPE - STAR LOS
3. OPTICS MODE - ZERO OPTICS
4. OPTICS HOLD - OFF
5. OPTICS CONTROLLER SPEED - HIGH
6. OPTICS CONTROLLER MODE - DIRECT
7. IMU TEMP. MODE - AUTO OVERRIDE
8. AGC MODE - ON
9. ATTITUDE IMPULSE ENABLE - OFF
10. CONDITION LAMPS - ON
11. FLOODLIGHT CONTROL PRIMARY - OFF
12. FLOODLIGHT CONTROL SECONDARY - OFF
13. PANEL BRIGHTNESS CONTROL - ADJUST AS REQUIRED
14. AGC BRIGHTNESS CONTROL - ADJUST AS REQUIRED

10.4.2 On the DSKY (MDC 14) Enter V16N20E.

10.4.3 On Attitude Set/Gimbal Position Indicator (MDC 6) Set:

a. Roll IMU gimbal angle from R1 on Roll attitude set dial.

b. Pitch IMU gimbal angle from R2 on pitch attitude set dial.

c. Yaw IMU gimbal angle from R3 on Yaw attitude set dial.

10.4.4 Depress FDAI align pushbutton on attitude set/gimbal position indicator for 32 seconds minimum.

10.4.5 Mode select (using G&N/SCS SWITCH MDC 8) to either G&N or SCS Attitude Control from present mode.

10.4.6 Verify the lack of motion of the total attitude Ball and Roll BUG.

10.4.7 Mode Select back to original control mode.

10.4.8 Return attitude deadband switch to maximum.

10.4.9 Clear DSKY Display by entering V34E.

10.5 Coarse SCS Attitude Reference Alignment To IMU Gimbal Angles.

10.5.1 Confirm or select the following switch positions:

MDC 8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - ON
3. ATTITUDE DEADBAND - MAXIMUM
4. .05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - OFF
7. G&N/SCS - G&N
8. ATTITUDE/MONITOR/ENTRY - ATTITUDE
9. A&C ROLL CHANNEL - } ONE ON,
10. B&D ROLL CHANNEL - } ONE OFF
11. PITCH CHANNEL - ON
12. YAW CHANNEL - ON
13. ROLL RATE GYRO - NORMAL
14. PITCH RATE GYRO - NORMAL
15. YAW RATE GYRO - NORMAL

MDC 25

1. FDAI LTG - AC 1
2. GROUP 1-AC 1 - CLOSED
3. GROUP 1-AC 2 - CLOSED
4. GROUP 2-AC 1 - CLOSED
5. GROUP 2-AC 2 - CLOSED
6. GROUP 1-MNA - CLOSED
7. GROUP 1-MNB - CLOSED
8. GROUP 2-MNA - CLOSED
9. GROUP 2-MNB - CLOSED
10. DIRECT CONTROL-MNA - CLOSED
11. DIRECT CONTROL-MNB - CLOSED
12. A&C ROLL-MNA - CLOSED } ONE MAY BE OPEN
13. A&C ROLL-MNB - CLOSED }
14. B&D ROLL-MNA - CLOSED } ONE MAY BE OPEN
15. B&D ROLL-MNB - CLOSED
16. PITCH-MNA - } ONE OPEN, ONE CLOSED
17. PITCH-MNB - }
18. YAW-MNA - } ONE OPEN, ONE CLOSED
19. YAW-MNB - }
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL-PITCH-BAT A - OPEN
22. GIMBAL MOTOR CONTROL-YAW-BAT A - OPEN

MDC 24

1. SCS POWER - AC 1
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC 3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC 6

ATTITUDE SET - OFF

MDC 7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - PINNED
TRANSLATION CONTROLS - LOCKED

MDC 14

1. PROGRAM - 00
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - ADJUST AS DESIRED

MDC 2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - ADJUST AS REQUIRED
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

MDC 22

1. IMU HTR - MNA - CLOSED
2. IMU HTR - MNB - CLOSED
3. IMU - MNA - CLOSED
4. IMU - MNB - CLOSED
5. COMPUTER - MNA - CLOSED
6. COMPUTER - MNB - CLOSED
7. OPTICS - MNA - OPEN
8. OPTICS - MNB - OPEN
9. G&N AC POWER - AC 1 - CLOSED
10. G&N AC POWER - AC 2 - CLOSED
11. G&N AC POWER - AC 1

LEB NAV STATION SWITCHES

1. IMU TRANSFER - COMPUTER
2. OPTICS SLAVE TELESCOPE - STAR LOS
3. OPTICS MODE - ZERO OPTICS
4. OPTICS HOLD - OFF
5. OPTICS CONTROLLER SPEED - HIGH
6. OPTICS CONTROLLER MODE - DIRECT
7. IMU TEMP. MODE - AUTO OVERRIDE
8. AGC MODE - ON
9. ATTITUDE IMPULSE ENABLE - OFF
10. CONDITION LAMPS - ON
11. FLOODLIGHT CONTROL PRIMARY - OFF
12. FLOODLIGHT CONTROL SECONDARY - OFF
13. PANEL BRIGHTNESS CONTROL - ADJUST AS REQUIRED
14. AGC BRIGHTNESS CONTROL - ADJUST AS REQUIRED

10.5.2 Read Roll BUG against outer ball shield markings and set value on roll attitude set dial.

10.5.3 Read attitude ball pitch angle against entry symbol and set value on pitch attitude set dial.

10.5.4 Read attitude ball yaw angle against entry symbol and set value on yaw attitude set dial.

10.5.5 Depress FDAI align pushbutton on attitude set/gimbal position indicator for 32 seconds minimum.

10.5.6 Place the G&N/SCS Switch on MDC 8 to SCS.

10.5.7 Verify the lack of motion of the total attitude ball and roll BUG.

10.5.8 Return the G&N/SCS Switch on MDC 8 to the G&N position.

10.6 Bar-B-Q Mode Establishment.

10.6.1 Confirm or select the following switch positions:

MDC 8

1. DIRECT RCS - ON
2. LIMIT CYCLE - ON
3. ATTITUDE DEADBAND - MAXIMUM
4. .05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - OFF
7. G&N/SCS - SCS
8. ATTITUDE/MONITOR/ENTRY - ATTITUDE
9. A&C ROLL CHANNEL - } ONE OFF, ONE ON
10. B&D ROLL CHANNEL - }
11. PITCH CHANNEL - ON
12. YAW CHANNEL - ON
13. ROLL RATE GYRO - BMAG
14. PITCH RATE GYRO - NORMAL
15. YAW RATE GYRO - NORMAL

MDC 25

1. FDAI LTG - AC 1
2. GROUP 1-AC 1 - CLOSED
3. GROUP 1-AC 2 - CLOSED
4. GROUP 2-AC 1 - CLOSED
5. GROUP 2-AC 2 - CLOSED
6. GROUP 1-MNA - CLOSED
7. GROUP 1-MNB - CLOSED
8. GROUP 2-MNA - CLOSED
9. GROUP 2-MNB - CLOSED
10. DIRECT CONTROL-MNA - CLOSED
11. DIRECT CONTROL-MNB - CLOSED
12. A&C ROLL-MNA - } ONE PAIR OPEN - ONE PAIR CLOSED (OPEN THE PAIR FOR THE ON ENABLE SWITCH)
13. A&C ROLL-MNB - }
1 B&D ROLL-MNA - }
15. B&D ROLL-MNB - }
16. PITCH-MNA - } ONE CLOSED, ONE OPEN
17. PITCH-MNB - }
18. YAW-MNA - } ONE CLOSED, ONE OPEN
19. YAW-MNB - }
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL-PITCH-BAT A - OPEN
22. GIMBAL MOTOR CONTROL-YAW-BAT A - OPEN

MDC 24

1. SCS POWER - AC 1
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC 3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC 6

ATTITUDE SET - OFF

MDC 7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - PINNED
TRANSLATION CONTROLS - LOCKED

MDC 14

1. PROGRAM - 00
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - MAX. DIM.

MDC 2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - ADJUST AS REQUIRED
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

MDC 22

1. IMU HTR-MNA - CLOSED
2. IMU HTR-MNB - CLOSED
3. IMU-MNA - OPEN
4. IMU-MNB - OPEN
5. COMPUTER-MNA - CLOSED
6. COMPUTER-MNB - CLOSED
7. OPTICS-MNA - OPEN
8. OPTICS-MNB - OPEN
9. G&N AC POWER-AC 1 - OPEN
10. G&N AC POWER-AC 2 - OPEN
11. G&N AC POWER-AC 1

LEB NAV STATION SWITCHES

1. FLOODLIGHT CONTROL PRIMARY - OFF
2. FLOODLIGHT CONTROL SECONDARY - OFF
3. PANEL BRIGHTNESS CONTROL - MAX. DIM.
4. AGC BRIGHTNESS CONTROL - MAX. DIM.
5. IMU TRANSFER - COMPUTER
6. OPTICS SLAVE TELESCOPE - STAR LOS
7. OPTICS MODE - ZERO OPTICS
8. OPTICS HOLD - OFF
9. OPTICS CONTROLLER SPEED - HIGH
10. OPTICS CONTROLLER MODE - DIRECT
11. IMU TEMP. MODE - AUTO OVERRIDE
12. AGC MODE - STANDBY
13. ATTITUDE IMPULSE ENABLE - OFF
14. CONDITION LAMPS - OFF

10.6.2 Unpin the rotation control.

10.6.3 Impart a 0.6 degrees per second clockwise roll to the spacecraft using direct rotation control and the roll rate display on the FDAI.

10.6.4 Return the rotation control to neutral.

10.6.5 Direct RCS switch - OFF.

CAUTION: The positions called out with respect to A&C and B&D roll switches and circuit breakers are interchangeable. One of the roll channel enable switches must remain on in the mode or the pitch and yaw BMAG's will be switches out of attitude hold).

10.6.6 Repin the rotation control.

10.6.7 Periodically check the + X axis direction through the docking window to monitor the amount of drift from the desired attitude. When the pointing error becomes too large one of the maneuver procedures will be used to re-establish the desired attitude.

10.7 Precise Wobble Mode Establishment.

10.7.1 Following orientation of the vehicle to the desired attitude, remain in minimum deadband until residual vehicle rates in pitch and yaw have decreased to between 0.01 and 0.02 degrees per second ($\approx$ 60 minutes).

10.7.2 Confirm or select the following switch positions as the rates settle:

MDC 8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - ON
3. ATTITUDE DEADBAND - MINIMUM
4. .05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - OFF
7. G&N/SCS - SCS
8. ATTITUDE/MONITOR/ENTRY - ATTITUDE
9. A&C ROLL CHANNEL - ON
10. B&D ROLL CHANNEL - ON
11. PITCH CHANNEL - ON
12. YAW CHANNEL - ON
13. ROLL RATE GYRO - NORMAL
14. PITCH RATE GYRO - NORMAL
15. YAW RATE GYRO - NORMAL

MDC 25

1. FDAI LTG - AC 1
2. GROUP 1-AC 1 - CLOSED
3. GROUP 1-AC 2 - CLOSED
4. GROUP 2-AC 1 - CLOSED
5. GROUP 2-AC 2 - CLOSED
6. GROUP 1-MNA - CLOSED
7. GROUP 1-MNB - CLOSED
8. GROUP 2-MNA - CLOSED
9. GROUP 2-MNB - CLOSED
10. DIRECT CONTROL-MNA - CLOSED
11. DIRECT CONTROL-MNB - CLOSED
12. A&C ROLL-MNA - CLOSED
13. A&C ROLL-MNB - CLOSED
14. B&D ROLL-MNA - CLOSED
15. B&D ROLL-MNB - CLOSED
16. PITCH-MNA - CLOSED
17. PITCH-MNB - CLOSED
18. YAW-MNA - CLOSED
19. YAW-MNB - CLOSED
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL-PITCH-BAT A - OPEN
22. GIMBAL MOTOR CONTROL-YAW-BAT A - OPEN

MDC 24

1. SCS POWER - AC 1
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC 3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC 6

ATTITUDE SET - OFF

MDC 7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - UNPINNED
TRANSLATION CONTROLS - LOCKED

MDC 14

1. PROGRAM - 00
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - MAX. DIM.

MDC 2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - ADJUST AS REQUIRED
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

MDC 22

1. IMU HTR-MNA - CLOSED
2. IMU HTR-MNB - CLOSED
*3. IMU-MNA - CLOSED
*4. IMU-MNB - CLOSED
5. COMPUTER-MNA - CLOSED
6. COMPUTER-MNB - CLOSED
7. OPTICS-MNA - OPEN
8. OPTICS-MNB - OPEN
*9. G&N AC POWER-AC 1 - CLOSED
*10. G&N AC POWER-AC 2 - CLOSED
11. G&N AC POWER-AC 1

LEB NAV STATION SWITCHES

1. FLOODLIGHT CONTROL PRIMARY - OFF
2. FLOODLIGHT CONTROL SECONDARY - OFF
3. PANEL BRIGHTNESS CONTROL - MAX. DIM.
4. AGC BRIGHTNESS CONTROL - MAX. DIM.
5. IMU TRANSFER COMPUTER
6. OPTICS SLAVE TELESCOPE - STAR LOS
7. OPTICS MODE - ZERO OPTICS
8. OPTICS HOLD - OFF
9. OPTICS CONTROLLER SPEED - HIGH
10. OPTICS CONTROLLER MODE - DIRECT
11. IMU TEMP. MODE - AUTO OVERRIDE
*12. AGC MODE - ON
13. ATTITUDE IMPULSE ENABLE - OFF
14. CONDITION LAMPS - OFF

NOTE: * These switch positions assume the G&N has been on and the IMU is aligned. If this assumption is not correct, then the IMU circuit breakers should be open and the AGC mode switch in standby and later references in this procedure of opening the IMU circuit breakers and switching the computer to standby should then be deleted. They are also keyed by an *.

10.7.3 Watch the pitch and yaw attitude error indicators for a moving down and left coincidence. (If necessary a. enable the minimum impulse control, b. adjust either the pitch or yaw rate within the minimum impulse control, c. return the minimum impulse enable switch to off).

10.7.4 Pitch and yaw channel enable switches - OFF.

10.7.5 Impart a clockwise roll rate of 0.5 degrees-per-second with the rotation control using the roll rate display as a reference.

10.7.6 After the rate is established, but before returning the rotation control to neutral, A&C and B&D roll enable switches set off.

10.7.7 Rotation control - neutral.

10.7.8 Place all three rate switches on MDC 8 to BMAG.

10.7.9 SCS power - OFF.

10.7.10 Attitude deadband - maximum.

10.7.11 Limit cycle - OFF.

10.7.12 Re-pin the rotation control.

10.7.13* Open the A&B IMU circuit breakers on Panel 22.

10.7.14* Switch the AGC mode switch to standby at the lower equipment bay.

10.7.15 Periodically check the + X axis direction through the docking window (unless + X is $\pm$ 15 degrees of sun) to monitor the amount of drift from the desired attitude. When the pointing error becomes too large, one of the maneuver procedures will be used to reestablish the desired attitude and then this procedure would be repeated.

10.8 Coarse Wobble Mode Establishment.

10.8.1 Following orientation of the vehicle to the desired attitude, remain in minimum deadband until residual vehicle rates in pitch and yaw have decreased to between 0.01 and 0.02 degree per second ($\approx$ 60 minutes).

10.8.2 Confirm or select the following switch conditions as the rates settle:

MDC 8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - ON
3. ATTITUDE DEADBAND - MINIMUM
4. .05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - OFF
7. G&N/SCS - SCS
8. ATTITUDE/MONITOR/ENTRY - ATTITUDE
9. A&C ROLL CHANNEL - ON
10. B&D ROLL CHANNEL - ON
11. PITCH CHANNEL - ON
12. YAW CHANNEL - ON
13. ROLL RATE GYRO - NORMAL
14. PITCH RATE GYRO - NORMAL
15. YAW RATE GYRO - NORMAL

MDC 25

1. FDAI LTG - AC 1
2. GROUP 1-AC 1 - CLOSED
3. GROUP 1-AC 2 - CLOSED
4. GROUP 2-AC 1 - CLOSED
5. GROUP 2-AC 2 - CLOSED
6. GROUP 1-MNA - CLOSED
7. GROUP 1-MNB - CLOSED
8. GROUP 2-MNA - CLOSED
9. GROUP 2-MNB - CLOSED
10. DIRECT CONTROL-MNA - CLOSED
11. DIRECT CONTROL-MNB - CLOSED
12. A&C ROLL-MNA - CLOSED
13. A&C ROLL-MNB - CLOSED
14. B&D ROLL-MNA - CLOSED
15. B&D ROLL-MNA - CLOSED
16. PITCH-MNA - CLOSED
17. PITCH-MNB - CLOSED
18. YAW-MNA - CLOSED
19. YAW-MNB - CLOSED
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL PITCH-BAT A - OPEN
22. GIMBAL MOTOR CONTROL-YAW-BAT A - OPEN

MDC 24

1. SCS POWER - AC 1
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC 3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC 6

ATTITUDE SET - OFF

MDC 7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - UNPINNED
TRANSLATION CONTROLS - LOCKED

MDC 14

1. PROGRAM - 00
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - MAX. DIM.

MDC 2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - ADJUST AS REQUIRED
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

MDC 22

1. IMU HTR-MNA - CLOSED
2. IMU HTR-MNB - CLOSED
*3. IMU-MNA - CLOSED
*4. IMU-MNB - CLOSED
5. COMPUTER-MNA - CLOSED
6. COMPUTER-MNB - CLOSED
7. OPTICS-MNA - OPEN
8. OPTICS-MNB - OPEN
*9. G&N AC POWER-AC 1 - CLOSED
*10. G&N AC POWER-AC 2 - CLOSED
11. G&N AC POWER-AC 1

LEB NAV STATION SWITCHES

1. FLOODLIGHT CONTROL PRIMARY - OFF
2. FLOODLIGHT CONTROL SECONDARY - OFF
3. PANEL BRIGHTNESS CONTROL - MAX. DIM.
4. AGC BRIGHTNESS CONTROL - MAX. DIM.
5. IMU TRANSFER - COMPUTER
6. OPTICS SLAVE TELESCOPE - STAR LOS
7. OPTICS MODE - ZERO OPTICS
8. OPTICS HOLD - OFF
9. OPTICS CONTROLLER SPEED - HIGH
10. OPTICS CONTROLLER MODE - DIRECT
11. IMU TEMP. MODE - AUTO OVERRIDE
*12. AGC MODE - ON
13. ATTITUDE IMPULSE ENABLE - OFF
14. CONDITION LAMPS - OFF

NOTE: * These switch positions assume the G&N has been on and the IMU is aligned. If this assumption is not correct, then the IMU circuit breaker should be open and the AGC mode switch in standby. Later references in this procedure of opening the IMU circuit breakers and switching the computer to standby should then be deleted. They are also keyed by an *.

10.8.3 Pitch and Yaw channel enable switches - OFF.

10.8.4 Impart a clockwise roll rate of 0.5 degree per second with the rotation control using the roll rate display as a reference.

10.8.5 After the rate is established, but <u>before</u> return of the rotation control to neutral, place A&C and B&D roll enable switches OFF.

10.8.6 Rotation control to neutral.

10.8.7 SCS power - OFF.

10.8.8 Attitude deadband - Maximum.

10.8.9 Limit cycle - OFF.

10.8.10 Re-pin the rotation control.

10.8.11* On the DSKY enter V37E00E.

10.8.12* Open the A&B IMU circuit breakers on Panel 22.

10.8.13* Switch the AGC mode switch to standby at the lower equipment bay.

10.8.14 Periodically check the + X axis direction through the docking window (unless + X is $\pm$ 15 degrees of sun) to monitor the amount of drift from the desired attitude. When the pointing error becomes too large, one of the maneuver procedures will be used to re-establish the desired attitude and the wobble mode must be re-established.

10.9 G&C Power Up Sequence.

10.9.1 Prior to required G&C operations, confirm or select the following switch conditions:

MDC-8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - OFF
3. ATTITUDE DEADBAND - MAXIMUM
4. 0.05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - OFF
7. G&N/SCS - SCS
8. ATTITUDE/MONITOR/ENTRY - MONITOR
9. A&C ROLL CHANNEL - OFF
10. B&D ROLL CHANNEL - OFF
11. PITCH CHANNEL - OFF
12. YAW CHANNEL - OFF
13. ROLL RATE GYRO - BMAG
14. PITCH RATE GYRO - BMAG
15. YAW RATE GYRO - BMAG

MDC-25

1. FDAI LTG - OFF
2. GROUP 1 - AC 1 - CLOSED
3. GROUP 1 - AC 2 - CLOSED
4. GROUP 2 - AC 1 - CLOSED
5. GROUP 2 - AC 2 - CLOSED
6. GROUP 1 - MNA - CLOSED
7. GROUP 1 - MNB - CLOSED
8. GROUP 2 - MNA - CLOSED
9. GROUP 2 - MNB - CLOSED
10. DIRECT CONTROL - MNA - CLOSED
11. DIRECT CONTROL - MNB - CLOSED
12. A&C ROLL - MNA - CLOSED
13. A&C ROLL - MNB - CLOSED
14. B&D ROLL - MNA - CLOSED
15. B&D ROLL-- MNB - CLOSED
16. PITCH - MNA - CLOSED
17. PITCH - MNB - CLOSED
18. YAW - MNA - CLOSED
19. YAW - MNB - CLOSED
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL - PITCH - BAT A - OPEN
22. GIMBAL MOTOR CONTROL - YAW - BAT A - OPEN

MDC-24

1. SCS POWER - OFF
2. RATE GYRO POWER - AC 1

3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC-3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC-6

ATTITUDE SET - OFF

MDC-7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - PINNED
TRANSLATION CONTROLS - LOCKED

MDC-14

1. PROGRAM - 00
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - MAX DIM

MDC-2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - OFF
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

MDC-22

1. IMU HTR-MNA - CLOSED
2. IMU HTR-MNB - CLOSED
3. IMU-MNA - OPEN
4. IMU-MNB - OPEN
5. COMPUTER-MNA - CLOSED
6. COMPUTER-MNB - CLOSED
7. OPTICS-MNA - OPEN
8. OPTICS-MNB - OPEN
9. G&N AC POWER - AC 1 - OPEN
10. G&N AC POWER - AC 2 - OPEN
11. G&N AC POWER - AC 1

LEB NAV STATION SWITCHES

1. IMU TRANSFER - COMPUTER
2. OPTICS SLAVE TELESCOPE - STAR LOS
3. OPTICS MODE - ZERO OPTICS
4. OPTICS HOLD - OFF
5. OPTICS CONTROLLER SPEED - HIGH
6. OPTICS CONTROLLER MODE - DIRECT
7. IMU TEMP MODE - AUTO OVERRIDE
8. AGC MODE - STANDBY
9. ATTITUDE IMPULSE ENABLE - OFF
10. CONDITION LAMPS - OFF
11. FLOODLIGHT CONTROL PRIMARY - OFF
12. FLOODLIGHT CONTROL SECONDARY - OFF
13. PANEL BRIGHTNESS CONTROL - MAX DIM
14. AGC BRIGHTNESS CONTROL - MAX DIM

10.9.4 The following constraints should be kept in mind:

a. The channel enable switches should be the last ones turned on.

b. All jets need not always be enabled.

c. Allow the SCS electronics 1 minute to stabilize before enabling the jets.

d. When the system has settled and while still in Monitor, with Limit Cycle off, and deadband at maximum, return the three rate gyro switches from BMAG to NORMAL.

NOTE: The G&N portion of the power up sequence is not available at this time. It was not included in R-507.

10.10 SCS Attitude Hold.

10.10.1 From retest recording of RCS fuel and oxidizer levels by quad determine which quad is fullest.

10.10.2 Confirm or select the following switch conditions:

MDC 8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - ON
3. ATTITUDE DEADBAND - MAXIMUM
4. .05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - OFF
7. G&N/SCS - SCS
8. ATTITUDE/MONITOR/ENTRY - ATTITUDE
9. A&C ROLL CHANNEL - } ONE OFF/ONE ON - SWITCH FOR
10. B&D ROLL CHANNEL - } FULLEST QUAD LEFT ON
11. PITCH CHANNEL - ON
12. YAW CHANNEL - ON
13. ROLL RATE GYRO - NORMAL
14. PITCH RATE GYRO - NORMAL
15. YAW RATE GYRO - NORMAL

MDC 25

1. FDAI LTG - AC 1
2. GROUP 1-AC 1 - CLOSED
3. GROUP 1-AC 2 - CLOSED
4. GROUP 2-AC 1 - CLOSED
5. GROUP 2-AC 2 - CLOSED
6. GROUP 1-MNA - CLOSED
7. GROUP 1-MNB - CLOSED
8. GROUP 2-MNA - CLOSED
9. GROUP 2-MNB - CLOSED
10. DIRECT CONTROL-MNA - CLOSED
11. DIRECT CONTROL-MNB - CLOSED
12. A&C ROLL-MNA - } THREE OPEN - 1 CLOSED - BREAKER
13. A&C ROLL-MNB - } FOR FULLEST QUAD IS CLOSED, QUAD
14. B&D ROLL-MNB - } RELATIONSHIPS ARE A&C A-A, A&C
15. B&D ROLL-MNB } B-B, B&D A-C, and B&D B-D
16. PITCH-MNA - } ONE OPENED - ONE CLOSED
17. PITCH-MNB - }
18. YAW-MNA - } ONE OPENED - ONE CLOSED
19. YAW-MNB - }
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL-PITCH-BAT A - OPEN
22. GIMBAL MOTOR CONTROL-YAW-BAT A - OPEN

MDC 24

1. SCS POWER - AC 1
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC 3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC 6

ATTITUDE SET - OFF

MDC 7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - PINNED
TRANSLATION CONTROLS - LOCKED

MDC 14

1. PROGRAM - 00
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - MAX. DIM.

MDC 2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - ADJUST AS REQUIRED
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

NOTE: The G&N may or may not be on during SCS attitude holds. Switch conditions below assume the G&N is on. If the G&N is off, or if the G&N is performing a special task i.e. nav sighting, orbital tracking, etc. these switch call outs will be modified to the specific requirements of the special task.

MDC 22

1. IMU HTR-MNA - CLOSED
2. IMU HTR-MNB - CLOSED
3. IMU-MNA - CLOSED
4. IMU-MNB - CLOSED
5. COMPUTER-MNA - CLOSED
6. COMPUTER-MNB - CLOSED
7. OPTICS-MNA - OPEN
8. OPTICS-MNB - OPEN
9. G&N AC POWER-AC 1 - CLOSED
10. G&N AC POWER-AC 2 - CLOSED
11. G&N AC POWER-AC 1

LEB NAV STATION SWITCHES

1. FLOODLIGHT CONTROL PRIMARY -
2. FLOODLIGHT CONTROL SECONDARY -
3. PANEL BRIGHTNESS CONTROL -
4. AGC BRIGHTNESS CONTROL -

} ADJUST AS DESIRED

5. IMU TRANSFER - COMPUTER
6. OPTICS SLAVE TELESCOPE - STAR LOS
7. OPTICS MODE - ZERO OPTICS
8. OPTICS HOLD - OFF
9. OPTICS CONTROLLER SPEED - HIGH
10. OPTICS CONTROLLER MODE - DIRECT
11. IMU TEMP. MODE - AUTO OVERRIDE
12. AGC MODE - ON
13. ATTITUDE IMPULSE ENABLE - OFF
14. CONDITION LAMPS - ON

10.10.3 Monitor limit cycling in attitude by attitude error indicators for malfunction cues.

CAUTION: SM RCS firings should all be $\approx$ 18 millisecond pulses spaced 200 to 300 seconds apart after settling out. Longer or continuous firings indicate possible malfunctions. Attitude error indication movement may naturally cease at one extreme of attitude deadband. Check to exterior reference if this occurs to assure that motion has been stopped in the relevant direction. If motion is continuing a non-firing malfunction or display failure may have occurred.

10.11 SC Inertial Attitude Determination With Telescope.

10.11.1 Confirm or select the following switch conditions:

MDC 8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - ON
3. ATTITUDE DEADBAND - MAXIMUM
4. .05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - OFF
7. G&N/SCS - SCS
8. ATTITUDE/MONITOR/ENTRY - ATTITUDE
9. A&C ROLL CHANNEL -
10. B&D ROLL CHANNEL - } ONE ON, ONE OFF
11. PITCH CHANNEL - ON
12. YAW CHANNEL - ON
13. ROLL RATE GYRO - NORMAL
14. PITCH RATE GYRO - NORMAL
15. YAW RATE GYRO - NORMAL

MDC 25

1. FDAI LTG - AC 1
2. GROUP 1-AC 1 - CLOSED
3. GROUP 1-AC 2 - CLOSED
4. GROUP 2-AC 1 - CLOSED
5. GROUP 2-AC 2 - CLOSED
6. GROUP 1-MNA - CLOSED
7. GROUP 1-MNB - CLOSED
8. GROUP 2-MNA - CLOSED
9. GROUP 2-MNB - CLOSED
10. DIRECT CONTROL-MNA - CLOSED
11. DIRECT CONTROL-MNB - CLOSED
12. A&C ROLL-MNA -
13. A&C ROLL-MNB - } ONE PAIR CLOSED - ONE OF THE
14. B&D ROLL-MNA - } OTHER PAIR OPEN, THE OTHER
15. B&D ROLL-MNB - } CLOSED - CLOSED C. B. WILL BE FOR FULLEST QUAD
16. PITCH-MNA -
17. PITCH-MNB - } ONE OPEN, ONE CLOSED
18. YAW-MNA -
19. YAW-MNB - } ONE OPEN, ONE CLOSED
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL-PITCH-BAT A - OPEN
22. GIMBAL MOTOR CONTROL-YAW-BAT A - OPEN

MDC 24

1. SCS POWER - AC 1
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC 3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC 6

ATTITUDE SET - OFF

MDC 7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - PINNED
TRANSLATION CONTROLS - LOCKED

MDC 14

1. PROGRAM - 00
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - MAX. DIM.

MDC 2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - ADJUST AS REQUIRED
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

NOTE: This procedure will be used when the IMU is OFF. For SC 012 the G&N will be on and the IMU aligned to check the accuracy of this method. Switches and circuit breakers are shown in SC 012 condition. Those marked with an * may be reversed or deleted for later missions.

MDC 22

1. IMU HTR-MNA - CLOSED
2. IMU HTR-MNB - CLOSED
*3. IMU-MNA - CLOSED
*4. IMU-MNB - CLOSED
5. COMPUTER-MNA - CLOSED
6. COMPUTER-MNB - CLOSED
7. OPTICS-MNA - CLOSED
8. OPTICS-MNB - CLOSED
9. G&N AC POWER-AC 1 - CLOSED
10. G&N AC POWER-AC 2 - CLOSED
11. G&N AC POWER-AC 1

LEB NAV STATION SWITCHES

1. FLOODLIGHT CONTROL PRIMARY - ADJUST AS REQUIRED
2. FLOODLIGHT CONTROL SECONDARY - ADJUST AS REQUIRED
3. PANEL BRIGHTNESS CONTROL - ADJUST AS REQUIRED
4. AGC BRIGHTNESS CONTROL - ADJUST AS REQUIRED
5. IMU TRANSFER - COMPUTER
6. OPTICS SLAVE TELESCOPE - STAR LOS
7. OPTICS MODE - MANUAL
8. OPTICS HOLD - OFF
9. OPTICS CONTROLLER SPEED - HIGH
10. OPTICS CONTROLLER MODE - DIRECT
11. IMU TEMP. MODE - AUTO OVERRIDE
*12. AGC MODE - ON
13. ATTITUDE IMPULSE ENABLE - OFF
14. CONDITION LAMPS - ON

10.11.2 Assure that the optics either a. point toward the starfield or b. have sufficient travel to point toward the starfield.

10.11.3* Select minimum deadband on MDC 8.

10.11.4 At the navigation station look out the telescope at the star field.

10.11.5 Manually, or, if the optics drive is functional, using the optics drive control, center an identifiable star while locating another identifiable star on the M or R line of the telescope.

10.11.6 Actuate the attitude impulse control enable switch for 5 seconds.

10.11.7 Deactivate the attitude impulse control enable switch.

10.11.8 Read and record the telescope shaft and trunnion angles.

10.11.9 Discribe the stars located, give their relative positions, and read the shaft and trunnion angles to DSIF.

10.11.10 DSIF will identify the specific inertial attitude held.

10.11.11 Set the attitude set dials to values given by DSIF in all three axes (panel 6).

10.11.12 Depress the FDAI align push button for $\approx$32 seconds.

10.11.13* On the DSKY enter V16N20E.

10.11.14* Record the gimbal angles displayed on R1, R2, and R3.

10.11.15* On the DSKY enter V34E.

10.11.16* Select maximum deadband MDC 8.

10.11.17* Open the two optics circuit breakers on MDC 22.

10.12 Attitude Maneuver to Attitude Set Reference.

10.12.1 Confirm or select the following switch conditions:

MDC 8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - ON
3. ATTITUDE DEADBAND - MAXIMUM
4. .05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - OFF
7. G&N/SCS - SCS
8. ATTITUDE/MONITOR/ENTRY - ATTITUDE
9. A&C ROLL CHANNEL - } ONE ON, ONE OFF (ONE
10. B&D ROLL CHANNEL - } CONTAING FULLEST QUAD ON)
11. PITCH CHANNEL - ON
12. YAW CHANNEL - ON
13. ROLL RATE GYRO - NORMAL
14. PITCH RATE GYRO - NORMAL
15. YAW RATE GYRO - NORMAL

MDC 25

1. FDAI LTG - AC 1
2. GROUP 1-AC 1 - CLOSED
3. GROUP 1-AC 2 - CLOSED
4. GROUP 2-AC 1 - CLOSED
5. GROUP 2-AC 2 - CLOSED
6. GROUP 1-MNA - CLOSED
7. GROUP 1-MNB - CLOSED
8. GROUP 2-MNA - CLOSED
9. GROUP 2-MNB - CLOSED
10. DIRECT CONTROL-MNA - CLOSED
11. DIRECT CONTROL-MNB - CLOSED
12. A&C ROLL-MNA - CLOSED
13. A&C ROLL-MNB - CLOSED
14. B&D ROLL-MNA - CLOSED
15. B&D ROLL-MNB - CLOSED
16. PITCH-MNA - CLOSED
17. PITCH-MNB - CLOSED
18. YAW-MNA - CLOSED
19. YAW-MNB - CLOSED
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL-PITCH-BAT A - OPEN
22. GIMBAL MOTOR CONTROL-YAW-BAT A - OPEN

MDC 24

1. SCS POWER - AC 1
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC 3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC 6

ATTITUDE SET - OFF

MDC 7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - PINNED
TRANSLATION CONTROLS - LOCKED

MDC 14

1. PROGRAM - 00
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - MAX. DIM.

MDC 2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - ADJUST AS REQUIRED
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

NOTE: It is assumed that the G&N will be on with the IMU aligned for at least the first maneuver to the attitude set reference. For later applications the IMU can be OFF, the computer in stand by and steps 7, 19, 20, and 21 deleted. The variable items in the procedure are marked with an *.

MDC 22

1. IMU HTR-MNA - CLOSED
2. IMU HTR-MNB - CLOSED
*3. IMU-MNA - CLOSED
*4. IMU-MNB - CLOSED
5. COMPUTER-MNA - CLOSED
6. COMPUTER-MNB - CLOSED
7. OPTICS-MNA - OPEN
8. OPTICS-MNB - OPEN
*9. G&N AC POWER-AC 1 - CLOSED
*10. G&N AC POWER-AC 2 - CLOSED
11. G&N AC POWER-AC 1

LEB NAV STATION SWITCHES

1. IMU TRANSFER - COMPUTER
2. OPTICS SLAVE TELESCOPE - STAR LOS
3. OPTICS MODE - ZERO OPTICS
4. OPTICS HOLD - OFF
5. OPTICS CONTROLLER SPEED - HIGH
6. OPTICS CONTROLLER MODE - DIRECT
7. IMU TEMP. MODE - AUTO OVERRIDE
*8. AGC MODE -ON
9. ATTITUDE IMPULSE ENABLE - OFF
10. CONDITION LAMPS - ON
11. FLOODLIGHT CONTROL PRIMARY - OFF
12. FLOODLIGHT CONTROL SECONDARY - OFF
13. PANEL BRIGHTNESS CONTROL - ADJUST AS REQUIRED
14. AGC BRIGHTNESS CONTROL - ADJUST AS REQUIRED

10.12.2 From MSFN and/or on board mission timeline data determine roll, pitch, and yaw angle desired.

10.12.3 Set roll, pitch, and yaw attitude set dials (MDC 6) to desired angles.

10.12.4 Compare desired attitude with present attitude and determine magnitude and direction of changes required.

10.12.5 Unpin rotation control to be used.

10.12.6 Attitude set switch - ON

10.12.7 Limit cycle switch - OFF

10.12.8 Simultaneously displace the rotation control in all three axes to command proportional rates in the appropriate directions and in the same ratic as the magnitudes of the angular changes required. After the rates are established, return the rotation control toward the neutral point. This will reduce the probability of inadvertent RCS firings due to hand movements. If very low rates are used and the maneuver time is long, the channel enable switches may be placed in off then turned on again as each attitude error indicator nulls out.

NOTE: On large angle changes, the ball should be the primary reference and the attitude error indicators secondary as they may have false null signals and/or wrong directions may be indicated while large errors exist. As the errors become less than 20 degrees, the meter direction should become primary and as the error becomes less than 5 degrees the meter should become prime for magnitude. The meters function as a vernier readout for the attitude ball.

10.12.9 Attitude deadband to minimum.

10.12.10 As the attitude ball nears the correct attitude, restore the rotation control to neutral.

10.12.11 Make minor adjustments as necessary to null the attitude error indicators.

10.12.12 Limit cycle switch - ON.

10.12.13 Visually confirm the attitude acquired through the docking window.

10.12.14 Select maximum attitude deadband.

10.12.15 Repin the rotation control.

10.12.16 Rate gyro - OFF.

10.12.17 Rotation control - OFF.

10.12.18* Enter on DSKY V16N, 20E.

10.12.19* Record roll, pitch, and yaw angles from registers 1, 2, and 3.

10.12.20* Enter on DSKY V34E.

10.13 Attitude Maneuver to Attitude Ball Reference.

10.13.1 Confirm or select the following switch conditions:

MDC 8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - ON
3. ATTITUDE DEADBAND - MAXIMUM
4. .05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - OFF
7. G&N/SCS - SCS
8. ATTITUDE/MONITOR/ENTRY - ATTITUDE
9. A&C ROLL CHANNEL - } ONE OFF, ONE ON (ONE
10. B&D ROLL CHANNEL - } CONTAINING FULLEST QUAD ON)
11. PITCH CHANNEL - ON
12. YAW CHANNEL - ON
13. ROLL RATE GYRO - NORMAL
14. PITCH RATE GYRO - NORMAL
15. YAW RATE GYRO - NORMAL

MDC 25

1. FDAI LTG - AC 1
2. GROUP 1-AC 1 - CLOSED
3. GROUP 1-AC 2 - CLOSED
4. GROUP 2-AC 1 - CLOSED
5. GROUP 2-AC 2 - CLOSED
6. GROUP 1-MNA - CLOSED
7. GROUP 1-MNB - CLOSED
8. GROUP 2-MNA - CLOSED
9. GROUP 2-MNB - CLOSED
10. DIRECT CONTROL-MNA - CLOSED
11. DIRECT CONTROL-MNB - CLOSED
12. A&C ROLL-MNA - CLOSED
13. A&C ROLL-MNB - CLOSED
14. B&D ROLL-MNA - CLOSED
15. B&D ROLL-MNB - CLOSED
16. PITCH-MNA - CLOSED
17. PITCH-MNB - CLOSED
18. YAW-MNA - CLOSED
19. YAW-MNB - CLOSED
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL-PITCH-BAT A - OPEN
22. GIMBAL MOTOR CONTROL-YAW-BAT A - OPEN

MDC 24

1. SCS POWER - AC 1
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC 3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC 6

ATTITUDE SET - OFF

MDC 7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - PINNED
TRANSLATION CONTROLS - LOCKED

MDC 14

1. PROGRAM - 00
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - MAX. DIM.

MDC 2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - ADJUST AS REQUIRED
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

NOTE: It is assumed that the G&N will be on with the IMU aligned for at least one maneuver to the Attitude Ball reference. For other applications the IMU can be off, the computer in standby, and G&N steps deleted. The variable items in the procedure are marked with an *.

MDC 22

1. IMU HTR-MNA - CLOSED
2. IMU HTR-MNB - CLOSED
*3. IMU-MNA - CLOSED
*4. IMU-MNB - CLOSED
5. COMPUTER-MNA - CLOSED
6. COMPUTER-MNB - CLOSED
7. OPTICS-MNA - OPEN
8. OPTICS-MNB - OPEN
*9. G&N AC POWER-AC 1 - CLOSED
*10. G&N AC POWER-AC 2 - CLOSED
11. G&N AC POWER-AC 1

LEB NAV STATION SWITCHES

1. FLOODLIGHT CONTROL PRIMARY - OFF
2. FLOODLIGHT CONTROL SECONDARY - OFF
3. PANEL BRIGHTNESS CONTROL - MAX. DIM.
4. AGC BRIGHTNESS CONTROL - MAX. DIM.
5. IMU TRANSFER - COMPUTER
6. OPTICS SLAVE TELESCOPE - STAR LOS
7. OPTICS MODE - ZERO OPTICS
8. OPTICS HOLD - OFF
9. OPTICS CONTROLLER SPEED - HIGH
10. OPTICS CONTROLLER MODE - DIRECT
11. IMU TEMP. MODE - AUTO OVERRIDE
*12. AGC MODE - ON
13. ATTITUDE IMPULSE ENABLE - OFF
14. CONDITION LAMPS - OFF

10.13.2 From DSIF and/or onboard mission timeline data determine roll, pitch, and yaw angles desired.

10.13.3 Compare desired attitude with present attitude and determine magnitude and direction of attitude changes required.

10.13.4 Unpin the rotation control to be used.

10.13.5 Limit cycle - OFF

10.13.6 Simultaneously displace the rotation control into all three axes to command proportional rates in the appropriate directions and in the same ratio as the magnitudes of the angular changes desired. After the desired rates are established, ease the Rotation Control slightly back toward neutral to avoid unnecessary RCS pulsing.

10.13.7 Attitude deadband to minimum during the maneuver.

10.13.8 As the attitude ball nears the correct attitude restore the rotation control to neutral.

10.13.9 Adjust the final attitude if required.

10.13.10 Visually confirm the attitude acquired through docking window.

10.13.11 Limit cycle ON.

10.13.12 Repin the rotation controls.

10.13.13* Enter on DSKY V16N20E.

10.13.14* Attitude deadband maximum.

10.13.15* Read and record the roll, pitch, and yaw angles from registers 1, 2, and 3.

10.13.16* Enter V34E on DSKY.

10.13.17 Attitude set switch on (Panel 6).

10.13.18 Drive the attitude error indicators to null by adjusting the attitude set dials.

10.13.19 Record the attitude set indicator values.

10.13.20 Attitude set switch off.

10.14 CM-SM Separation Orientation and Separation.

10.14.1 The initial switch positions are:

MDC-8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - ON
3. ATTITUDE DEADBAND - MAXIMUM
4. 0.05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - OFF
7. G&N/SCS - G&N
8. ATTITUDE/MONITOR/ENTRY - ATTITUDE
9. A&C ROLL CHANNEL - OFF
10. B&D ROLL CHANNEL - ON
11. PITCH CHANNEL - ON
12. YAW CHANNEL - ON
13. ROLL RATE GYRO - NORMAL
14. PITCH RATE GYRO - NORMAL
15. YAW RATE GYRO - NORMAL

MDC-25

1. FDAI LTG - AC 1
2. GROUP 1-AC 1 - CLOSED
3. GROUP 1-AC 2 - CLOSED
4. GROUP 2-AC 1 - CLOSED
5. GROUP 2-AC 2 - CLOSED
6. GROUP 1-MNA - CLOSED
7. GROUP 1-MNB - CLOSED
8. GROUP 2-MNA - CLOSED
9. GROUP 2-MNB - CLOSED
10. DIRECT CONTROL-MNA - CLOSED
11. DIRECT CONTROL-MNB - CLOSED
12. A&C ROLL-MNA - CLOSED
13. A&C ROLL-MNB - CLOSED
14. B&D ROLL-MNA - CLOSED
15. B&D ROLL-MNB - CLOSED
16. PITCH-MNA - CLOSED
17. PITCH-MNB - CLOSED
18. YAW-MNA - CLOSED
19. YAW-MNB - CLOSED
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL-PITCH-BAT A - OPEN
22. GIMBAL MOTOR CONTROL-YAW-BAT A - OPEN

MDC-24

1. SCS POWER - AC 1
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2

4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC-3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC-6

ATTITUDE SET - OFF

MDC-7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - UNPINNED
TRANSLATION CONTROLS - UNLOCKED

MDC-14

1. PROGRAM - 42
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - ADJUST AS REQUIRED

MDC-2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - ADJUST AS REQUIRED
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - AUTO

MDC-22

1. IMU HTR-MNA - CLOSED
2. IMU HTR-MNB - CLOSED
3. IMU-MNA - CLOSED
4. IMU-MNB - CLOSED
5. COMPUTER-MNA - CLOSED
6. COMPUTER-MNB - CLOSED
7. OPTICS-MNA - OPEN
8. OPTICS-MNB - OPEN
9. G&N AC POWER-AC 1 - CLOSED
10. G&N AC POWER-AC 2 - OPEN
11. G&N AC POWER-AC 1

LEB NAV STATION SWITCHES

1. IMU TRANSFER - COMPUTER
2. OPTICS SLAVE TELESCOPE - STAR LOS
3. OPTICS MODE - ZERO OPTICS
4. OPTICS HOLD - OFF
5. OPTICS CONTROLLER SPEED - HIGH
6. OPTICS CONTROLLER MODE - DIRECT
7. IMU TEMP MODE - AUTO OVERRIDE
8. AGC MODE - ON
9. ATTITUDE IMPULSE ENABLE - OFF
10. CONDITION LAMPS - OFF
11. FLOODLIGHT CONTROL PRIMARY - OFF
12. FLOODLIGHT CONTROL SECONDARY - OFF
13. PANEL BRIGHTNESS CONTROL - MAX DIM
14. AGC BRIGHTNESS CONTROL - MAX DIM

10.14.2 On DSKY Enter V37E61E.

10.14.3 Note display of max "g" expected in R1 and time to 300,000 feet in R2 and enter V33E on MDC-14.

10.14.4 Limit cycle switch to OFF

10.14.5 Key in V33E in response to V06N17 flash.

NOTE: Monitor the G&N initiation of a minus pitch rate of 4 degrees per second. Maneuver will be towards 60 degree pitch at the body reference on the FDAI. Yaw will be held at zero and a 180 degree roll maneuver will also occur.

10.14.6 During the maneuver, manually activate A&B CM/RCS pressurization and verify on pressure indicator on MDC-12.

NOTE: Leave RCS indicator selector on CM B.

10.14.7 Program 61 will change to program 62 on the MDC-14 automatically.

10.14.8 Limit cycle switch to ON.

10.14.9 G&N/SCS switch to SCS.

10.14.10 On MDC-14 press Enter. V50N25 flash will begin. Disregard until ready to place G&N/SCS switch to G&N.

10.14.11 Depress FDAI align push button for approximately 10 seconds.

10.14.12 Set FCSM switches (MDC-2) to Override and Off respectively.

10.14.13 Open the following circuit breakers on MDC-25.

check input from Mc Daniel.

A&C Roll	MNA
A&C Roll	MNB
B&D Roll	MNB
Pitch	MNB
Yaw	MNB

exercise of B system may be necessary to solve blatter heating problem. Mc. Daniel. Ex. 4864,5

10.14.14 Set attitude set dials to 0 roll, 0 yaw, and 152 pitch.

10.14.15 Direct RCS ON.

10.14.16 G&N/SCS to G&N

10.14.17 Attitude/Monitor/Entry to Entry, stopping in monitor for a moment to confirm the attitude error indicators are at or near null.

10.14.18 Key in V33E on MDC-14. V50N25 flash will begin. Disregard until ready to separate.

10.14.19 Limit cycle switch to OFF.

NOTE: This must be done or excessive propellant will be used in entry.

10.14.20 Momentarily set FDAI Self Test switch (MDC-2) to ON. Verify movement of all three rate indicators. Return the switch to OFF.

10.14.21 Activate CM-SM separation switch on MDC-15.

10.14.22 Backup CM-SM RCS transfer manually by placing the RCS transfer switch on MDC-16 momentarily to C/M.

10.14.23 Confirm CM/SM separation rate damping.

10.14.24 Perform procedure 10.46, AGC Update Automatic.

10.15 0.05 G Orientation, Attitude Hold, and Automatic G&N Entry.

10.15.1 The following switch positions exist from the CM-SM separation procedure:

MDC-8

1. DIRECT RCS - ON
2. LIMIT CYCLE - OFF
3. ATTITUDE DEADBAND - MAXIMUM
4. 0.05 G ENTRY - OFF
5. LOCAL VERTICAL- OFF
6. DELTA V - OFF
7. G&N/SCS - G&N
8. ATTITUDE/MONITOR/ENTRY - ENTRY
9. A&C ROLL CHANNEL - OFF
10. B&D ROLL CHANNEL - ON
11. PITCH CHANNEL - ON
12. YAW CHANNEL - ON
13. ROLL RATE GYRO - NORMAL
14. PITCH RATE GYRO - NORMAL
15. YAW RATE GYRO - NORMAL

MDC-25

1. FDAI LTG - AC 1
2. GROUP 1 - AC 1 - CLOSED
3. GROUP 1 - AC 2 - CLOSED
4. GROUP 2 - AC 1 - CLOSED
5. GROUP 2 - AC 2 - CLOSED
6. GROUP 1 - MNA - CLOSED
7. GROUP 1 - MNB - CLOSED
8. GROUP 2 - MNA - CLOSED
9. GROUP 2 - MNB - CLOSED
10. DIRECT CONTROL - MNA - CLOSED
11. DIRECT CONTROL - MNB - CLOSED
12. A&C ROLL - MNA - OPEN
13. A&C ROLL - MNB - OPEN
14. B&D ROLL - MNA - CLOSED
15. B&D ROLL - MNB - OPEN
16. PITCH - MNA - CLOSED
17. PITCH - MNB - OPEN
18. YAW - MNA - CLOSED
19. YAW - MNB - OPEN
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL-PITCH-BAT A - OPEN
22. GIMBAL MOTOR CONTROL-YAW-BAT A - OPEN

MDC-24

1. SCS POWER - AC 1
2. RATE GYRO POWER - AC 1

3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC-3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC-6

ATTITUDE SET - OFF

MDC-7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - UNPINNED
TRANSLATION CONTROLS - LOCKED

MDC-14

1. PROGRAM - 62
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - ADJUST AS REQUIRED

MDC-2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - ADJUST AS REQUIRED
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

MDC-22

1. IMU HTR-MNA - CLOSED
2. IMU HTR-MNB - CLOSED
3. IMU-MNA - CLOSED
4. IMU-MNB - CLOSED
5. COMPUTER-MNA - CLOSED
6. COMPUTER-MNB - CLOSED
7. OPTICS-MNA - OPEN
8. OPTICS-MNB - OPEN
9. G&N AC POWER-AC 1 - CLOSED
10. G&N AC POWER-AC 2 - OPEN
11. G&N AC POWER-AC 1

LEB NAV STATION SWITCHES

1. IMU TRANSFER - COMPUTER
2. OPTICS SLAVE TELESCOPE - STAR LOS
3. OPTICS MODE - ZERO OPTICS
4. OPTICS HOLD - OFF
5. OPTICS CONTROLLER SPEED - HIGH
6. OPTICS CONTROLLER MODE - DIRECT
7. IMU TEMP MODE - AUTO OVERRIDE
8. AGC MODE - ON
9. ATTITUDE IMPULSE ENABLE - OFF
10. CONDITION LAMPS - OFF
11. FLOODLIGHT CONTROL PRIMARY - OFF
12. FLOODLIGHT CONTROL SECONDARY - OFF
13. PANEL BRIGHTNESS CONTROL - MAX DIM
14. AGC BRIGHTNESS CONTROL - MAX DIM

10.15.2 On MDC-14 Press ENTER.

10.15.3 In response to V06N17 flash enter V33E on MDC-14.

NOTE: The G&N will initiate a positive pitch maneuver at 4 degrees per second until the ball reads a pitch angle of 152 degrees with respect to the body symbol. Yaw and roll should remain at zero degrees.

10.15.4 Confirm the program change to 63 on MDC-14.

10.15.5 Visually confirm entry attitude out the docking window to exterior reference cues given by DSIF and from onboard mission data.

10.15.6 The DSKY will ~~flash~~ V16N54 and display the following:

R1 - Commanded bank angle to 0.01 degrees
R2 - G actual to 0.1 g
R3 - ~~Indicates attitude to 0.1 NM~~

10.15.7 Monitor attitude hold limit cycle during this period. Depress the FDAI align pushbutton for approximately 10 seconds.

10.15.8 Watch the DSKY for major mode change to 64 and display of 0.05 g in register 2.

10.15.9 Change the 0.05 g switch to ON.

10.15.10 Monitor register 2 for a 0.2 g indication from the display of a 2 in the right columns.

10.15.11 Program 64 will change to Program 67 on the MDC-14 automatically.

10.15.12 Monitor G&N control of roll attitude.

10.15.13 Monitor the pitch and yaw rate displays for rate damping to ± 2 degrees per second.

10.15.14 Monitor the pressure gauge for the CM B propellant system to assure no loss of propellant (i.e., constant pressure reading from initial value when tuned on and allowed to stabilize.)

10.15.15 When register 3 reads 14 NM discontinue roll control by rotating the Translation Control clockwise into the stop.

10.15.16 When register 3 reads 4 NM switch off the pitch, yaw, and B&D Roll Channel Enable Switches to backup the Mission Sequences RCS inhibit functions and momentarily move the RCS CMD switch on MDC-16 to OFF.

10.16 Prelaunch G&C Functions.

10.16.1 Confirm the following initial switch conditions:

MDC 8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - OFF
3. ATTITUDE DEADBAND - MAXIMUM
4. .05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - ON
7. G&N/SCS - SCS
8. ATTITUDE/MONITOR/ENTRY - MONITOR
9. A&C ROLL CHANNEL - OFF
10. B&D ROLL CHANNEL - OFF
11. PITCH CHANNEL - OFF
12. YAW CHANNEL - OFF
13. ROLL RATE GYRO - NORMAL
14. PITCH RATE GYRO - NORMAL
15. YAW RATE GYRO - NORMAL

MDC 25

1. FDAI LTG - AC 1
2. GROUP 1-AC 1 - CLOSED
3. GROUP 1-AC 2 - CLOSED
4. GROUP 2-AC 1 - CLOSED
5. GROUP 2-AC 2 - CLOSED
6. GROUP 1-MNA - CLOSED
7. GROUP 1-MNB - CLOSED
8. GROUP 2-MNA - CLOSED
9. GROUP 2-MNB - CLOSED
10. DIRECT CONTROL-MNA - CLOSED
11. DIRECT CONTROL-MNB - CLOSED
12. A&C ROLL-MNA - CLOSED
13. A&C ROLL-MNB - CLOSED
14. B&D ROLL-MNA - CLOSED
15. B&D ROLL-MNB - CLOSED
16. PITCH-MNA - CLOSED
17. PITCH-MNB - CLOSED
18. YAW-MNA - CLOSED
19. YAW-MNB - CLOSED
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL-PITCH-BAT A - OPEN
22. GIMBAL MOTOR CONTROL-YAW-BAT A - OPEN

MDC 24

1. SCS POWER - AC 1
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC 3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC 6

ATTITUDE SET - OFF

MDC 7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - PINNED
TRANSLATION CONTROLS - LOCKED

MDC 14

1. PROGRAM - 03
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - ADJUST AS REQUIRED

MDC 2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - ADJUST AS REQUIRED
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

MDC 22

1. IMU HTR-MNA - CLOSED
2. IMU HTR-MNB - CLOSED
3. IMU-MNA - CLOSED
4. IMU-MNB - CLOSED
5. COMPUTER-MNA - CLOSED
6. COMPUTER-MNB - CLOSED
7. OPTICS-MNA - OPEN
8. OPTICS-MNB - OPEN
9. G&N AC POWER-AC 1 - CLOSED
10. G&N AC POWER-AC 2 - CLOSED
11. G&N AC POWER-AC 1

LEB NAV STATION SWITCHES

1. IMU TRANSFER - COMPUTER
2. OPTICS SLAVE TELESCOPE - STAR LOS
3. OPTICS MODE - ZERO OPTICS
4. OPTICS HOLD - OFF
5. OPTICS CONTROLLER SPEED - HIGH
6. OPTICS CONTROLLER MODE - DIRECT
7. IMU TEMP. MODE - AUTO OVERRIDE
8. AGC MODE - ON
9. ATTITUDE IMPULSE ENABLE - OFF
10. CONDITION LAMPS - ON
11. FLOODLIGHT CONTROL PRIMARY - OFF
12. FLOODLIGHT CONTROL SECONDARY - OFF
13. PANEL BRIGHTNESS CONTROL - ADJUST AS REQUIRED
14. AGC BRIGHTNESS CONTROL - ADJUST AS REQUIRED

10.16.2 Place the FDAI self test switch ON. Observe the rate indicator. All three should deflect to approximately - 2/3 of full scale. (i.e., roll and yaw right, and pitch up)

10.16.3 Return the FDAI self test switch to OFF. The rate indicators should return to null.

10.16.4 Switch the ATTITUDE/MONITOR/ENTRY switch to attitude.

10.16.5 Confirm the following attitude set dial values. Roll 164.8 degrees, Pitch 58.3 degrees, Yaw 9.7 degrees. (For launch pad 37 only. Pad 34 values would all be different and this step and steps 7 and 11 may also change).

10.16.6 Depress the FDAI Align pushbutton $\approx$10 seconds.

10.16.7 Set the attitude set dials to Roll 150 degrees, Pitch 80 degrees, Yaw 20 degrees.

10.16.8 Place the attitude set switch ON and confirm the displacement of all three attitude error indicators. Roll, full left; Pitch, full down; Yaw, full left.

10.16.9 Return the attitude set switch to OFF.

10.16.10 Depress the FDAI align pushbutton for $\approx$ 10 seconds. Confirm that the attitude ball moves to the above angles when references to the entry symbol (⊕).

10.16.11 Return the attitude set dials to Roll 164.8 degrees, Pitch 58.3 degrees, Yaw 9.7 degrees.

10.16.12 Place the attitude set switch on. Confirm the displacement of all three attitude error indicators. Roll, full right; Pitch, full up; Yaw, full right.

10.16.13 Return the attitude set switch to OFF.

10.16.14 Depress the FDAI align pushbutton for $\approx$ 10 seconds. Confirm that the attitude ball returns to the above angles when referenced to the entry symbol (⊕).

10.16.15 Place the TVC 1 switch to AC 1.

10.16.16 Place the TVC 2 switch to AC 2.

10.16.17 Depress the delta V set switch to the maximum, increasing drive position until the delta V remaining indicator reads $\approx$ 2,500* feet per second.

10.16.18 Depress the delta V set switch to the maximum, then minimum decreasing drive position until the delta V remaining indicator reads, $\approx$ 2,450* feet per second.

*NOTE: The values listed in paragraph 10.16.17 and 10.16.18 are variable depending upon the final SPS propellant loading values and should be recalculated whenever the planned SPS propellant loading is varied. The values are derived from the following formulas:

10.16.17 Initial setting = $\Delta V_C + 50$

$\Delta V_C = \Delta V_{T_{SPS}} - \Delta V_T - \Delta V_D$

10.16.18 ΔV_C - counter setting

$\Delta V_{T_{sps}}$ = Total SPS change

ΔV_T = Tailoff

ΔV_D = SPS deorbit velocity

CAUTION: The delta V remaining drive circuitry design has an operational problem with respect to setting these values on the pad. The accelerometer input adds to the delta v set drive rate to produce the following drive rates:

Increasing fast	32 feet per second
Increasing slow	-30 feet per second
Decreasing slow	-34 feet per second
Decreasing fast	-96 feet per second

This requires tapping the set switch when near the final value to approximate the required setting. The setting in step 17 has a large tolerance. The setting in step 18 should be within 10 feet per second of the required value as it will be used to override G&N control of an SPS abort to orbit. The value reserves deorbit delta V and indicates a possible computer malfunction.

10.16.19 Adjust the pitch and yaw gimbal position thumbwheels to 0 degrees and + 4 degrees respectively.

10.16.20 Place to momentary start then ON, in sequence, the gimbal motor drive switches PITCH 1, PITCH 2, YAW 1, and YAW 2.

10.16.21 Confirm that the gimbal position indicators settle at approximately the above angles.

10.16.22 Adjust the pitch and yaw gimbal position thumbwheels to + 2 degrees and + 6 degrees respectively. Confirm that the indicators follow the thumbwheel commands and settle at the new values.

10.16.23 Place the PITCH 1 and YAW 1 gimbal motor switches to OFF. Confirm that the pitch and yaw indicators remain at approximately the set values.

10.16.24 Adjust the pitch and yaw gimbal position thumbwheels to +0.4 degrees and + 3.6 degrees respectively. Confirm that the indicators follow the thumbwheel commands and settle at the new values. Use the indicators for fine adjusting to the + 0.4 degree and + 3.6 degrees positions. (The final SPS gimbal trim angles are also based upon the presently planned SPS propellant load for SC 012 and will vary with any changes in that value).

10.16.25 Place the PITCH 2 and YAW 2 switches to OFF.

10.16.26 Return the ATTITUDE/MONITOR/ENTRY switch to monitor.

10.16.27 Confirm that the ball continues to indicate Roll 164.8 degrees, Pitch 58.3 degrees and Yaw 9.7 degrees against the entry symbol (+).

10.16.28 Confirm major mode 03 is displayed on the main display panel DSKY.

NOTE: The following steps should be delayed until immediately before launch.

10.16.29 Place the INJECT PREVALVE A and B switches to ON.

NOTE: G&N lower equipment bay setup was accomplished prior to installation of boost protective cover.

10.16.30 Place the DIRECT RCS switch ON.

10.16.31 On MDC ENTER V37E11. Do not PRESS ENTER after 11.

10.16.32 Unpin the ROTATION CONTROLS.

10.16.33 Place the NORMAL/OFF/DIRECT ON switch to the NORMAL position.

10.16.34 Place the RCS COMMAND switch to momentary OFF.

10.16.35 Place the SCS CHANNEL ENABLE switches, (PITCH, YAW, B&D ROLL, and A&C ROLL) to ON.

10.16.36 Depress the FDAI align pushbutton for $\approx$ 10 seconds.

10.16.37 Place the G&N/SCS switch to G&N

10.17 Launch G&C Functions.

CAUTION: During launch parts of the G&C systems are used as abort cues. In all cases two independant cues are to be used in deciding to initiate an abort. Sources available are Launch Vehicle displays, G&N displays, SCS displays, angle of attach display, ground requests, and physical sensing on the part of the astronaut.

10.17.1 Initial Switch Conditions are:

MDC 8

1. DIRECT RCS - ON
2. LIMIT CYCLE - OFF
3. ATTITUDE DEADBAND - MAXIMUM
4. .05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - ON
7. G&N/SCS - G&N
8. ATTITUDE/MONITOR/ENTRY - MONITOR
9. A&C ROLL CHANNEL - ON
10. B&D ROLL CHANNEL - ON
11. PITCH CHANNEL - ON
12. YAW CHANNEL - ON
13. ROLL RATE GYRO - NORMAL
14. PITCH RATE GYRO - NORMAL
15. YAW RATE GYRO - NORMAL

MDC 25

1. FDAI LTG - AC 1
2. GROUP 1-AC 1 - CLOSED
3. GROUP 1-AC 2 - CLOSED
4. GROUP 2-AC 1 - CLOSED
5. GROUP 2-AC 2 - CLOSED
6. GROUP 1-MNA - CLOSED
7. GROUP 1-MNB - CLOSED
8. GROUP 2-MNA - CLOSED
9. GROUP 2-MNB - CLOSED
10. DIRECT CONTROL-MNA - CLOSED
11. DIRECT CONTROL-MNB - CLOSED
12. A&C ROLL-MNA - CLOSED
13. A&C ROLL-MNB - CLOSED
14. B&D ROLL-MNA - CLOSED
15. B&D ROLL-MNB - CLOSED
16. PITCH-MNA - CLOSED
17. PITCH-MNB - CLOSED
18. YAW-MNA - CLOSED
19. YAW-MNB - CLOSED

LAUNCH

20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL-PITCH-BAT A - OPEN
22. GIMBAL MOTOR CONTROL-YAW-BAT A - OPEN

MDC 24

1. SCS POWER - AC 1
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - AC 1
6. TVC 2 POWER - AC 2

MDC 3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - ON
6. INJECT PREVALVE B - ON

MDC 6

ATTITUDE SET - OFF

MDC 7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - UNPINNED
TRANSLATION CONTROLS - LOCKED

MDC 14

1. PROGRAM - 00
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - ADJUST AS REQUIRED

MDC 2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - ADJUST AS REQUIRED
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

LAUNCH

MDC 22

1. IMU HTR-MNA - CLOSED
2. IMU HTR-MNB - CLOSED
3. IMU-MNA - CLOSED
4. IMU-MNB - CLOSED
5. COMPUTER-MNA - CLOSED
6. COMPUTER-MNB - CLOSED
7. OPTICS-MNA - OPEN
8. OPTICS-MNB - OPEN
9. G&N AC POWER-AC 1 - CLOSED
10. G&N AC POWER-AC 2 - CLOSED
11. G&N AC POWER - AC 1

LEB NAV STATION SWITCHES

1. IMU TRANSFER - COMPUTER
2. OPTICS SLAVE TELESCOPE - STAR LOS
3. OPTICS MODE - ZERO OPTICS
4. OPTICS HOLD - OFF
5. OPTICS CONTROLLER SPEED - HIGH
6. OPTICS CONTROLLER MODE - DIRECT
7. IMU TEMP. MODE - AUTO OVERRIDE
8. AGC MODE - ON
9. ATTITUDE IMPULSE ENABLE - OFF
10. CONDITION LAMPS - ~~ON~~ OFF
11. FLOODLIGHT CONTROL PRIMARY - OFF
12. FLOODLIGHT CONTROL SECONDARY - OFF
13. PANEL BRIGHTNESS CONTROL - ~~ADJUST AS REQUIRED~~ MAX DIM
14. AGC BRIGHTNESS CONTROL - ADJUST AS REQUIRED MAX DIM

10.17.2 At liftoff - 3 seconds, confirm the major mode change from 03 to 05 on the main display DSKY panel.

10.17.3 At liftoff, confirm the major mode change from 05 to 11 on the main display DSKY panel. If this occurs, press verb then key release. If it does not occur, press enter.

10.17.4 Monitor on the FDAI for any full scale rate indication as an abort cue.

10.17.5 Monitor on the FDAI the attitude error indicators as follows: Roll - Liftoff to LET jettison - full scale is an abort cue. Pitch and Yaw - Lift off to 50 seconds - 2/3 full scale is an abort cue (± 10 degrees) - 50 seconds to LET jettison - full scale is an abort cue (± 15 degrees).

10.17.6 Monitor on the FDAI the attitude ball indications as follows against the entry symbol (⊕).

Up to lift off	Roll	164.8 deg.
	Pitch	58.3 deg.
	Yaw	9.7 deg.
Roll maneuver complete	Roll	180 deg.
(Immediately after liftoff)	Pitch	58 deg.
	Yaw	0 deg.

Yaw and Roll should remain ≈ 0 degrees and 180 degrees respectively as Pitch gradually changes from 58 degrees to 0 degree to - 49.5 degrees at orbital insertion. Significant differences from this attitude program would constitute an abort cue.

10.17.7 At + 110 seconds place the four gimbal Motor switches (Pitch 1 and 2 and Yaw 1 and 2) momentarily to start then ON. Confirm Pitch and Yaw gimbal position indicators to remain at or near + 0.4 degree and + 3.6 degrees respectively.

10.17.8 The DSKY displays from lift-off to 171 seconds will be:

Register 1 - Altitude in nautical miles to .01 (an increasing value).

Register 2 - Inertial velocity in feet per second (an increasing value).

Register 3 - An angle to 0.1 degrees representing the differences between the inertial velocity vector and the local horizontal.

10.17.9 At 171 seconds confirm the major mode change from 11 to 12 on the MDC 14

NOTE: At 176 seconds the attitude error indicators on the FDAI should go to and remain at 0 degree in all axes as the IMU has been switched to a fine align mode.

10.17.10 The DSKY displays will now indicate:

Register 1 - Maximum g predicted for free fall to entry to 0.1 g (variable then decreasing to zero).

Register 2 - Perigee Altitude to the nearest 0.1 nautical mile (increasing).

Register 3 - Time of free fall in minutes and seconds to 300,000 feet (increasing to maximum of 59 minutes 59 seconds unless perigee is $>$300,000 feet. In that case, R3 will read 99999).

10.17.11 At successful orbit injection (S-IVB shutdown) the DSKY display changes from the above to:

Register 1 - Delta R or miss distance to the recovery area in nautical miles (maybe plus or minus).

Register 2 - Perigee Altitude to the nearest 0.1 nautical mile (increasing).

Register 3 - Time of free fall in minutes and seconds to 300,000 feet (increasing to maximum of 59 minutes 59 seconds unless perigee is $>$300,000 feet. In that case, R3 will read 99999).

10.17.12 Safe orbit confirmation must be received from MSFN.

10.17.13 At this time the Pitch and Yaw Gimbal Motor switches should be successively placed to OFF.

10.17.14 Enter V33E on MDC 14.

10.17.15 On the Main display panel DSKY monitor the display of Verb 16 Noun 43 flashing and the values below.

Register 1 - Apogee attitude in nautical miles to 0.1

Register 2 - Perigee attitude in nautical miles to 0.1

Register 3 - same as above

10.17.16 When finished V33E should be entered on MDC-14.

10.17.17 Verb 16N34 will now Flash and time to perigee will be displayed in R1, R2, and R3 as follows:

Register 1 - Time perigee (hours)

Register 2 - Time perigee (minutes)

Register 3 - Time perigee (seconds to 0.01)

10.17.18 When finished V33E should be entered on MDC 14.

10.17.19 The program number should now go to 00 on the DSKY panel MDC 14.

10.17.20 Procedure 10.23, SCS-G&N Attitude Reference Comparison should not be followed.

10.17.21 The SCS portion of the 10.1, G&C Power Down Procedure should now be followed.

10.17.22 Open the two BAT A circuit breakers for gimbal motor control on MDC 25.

10.18 SC Attitude Maneuver to External Reference.

10.18.1 Confirm or select the following initial switch conditions:

MDC 8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - ON
3. ATTITUDE DEADBAND - MAXIMUM
4. .05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - OFF
7. G&N/SCS - SCS
8. ATTITUDE/MONITOR/ENTRY - ATTITUDE
9. A&C ROLL CHANNEL - } ONE ON, ONE OFF -
10. B&D ROLL CHANNEL - } ONE FOR FULLEST QUAD ON
11. PITCH CHANNEL - ON
12. YAW CHANNEL - ON
13. ROLL RATE GYRO - NORMAL
14. PITCH RATE GYRO - NORMAL
15. YAW RATE GYRO - NORMAL

MDC 25

1. FDAI LTG - AC 1
2. GROUP 1-AC 1 - CLOSED
3. GROUP 1-AC 2 - CLOSED
4. GROUP 2-AC 1 - CLOSED
5. GROUP 2-AC 2 - CLOSED
6. GROUP 1-MNA - CLOSED
7. GROUP 1-MNB - CLOSED
8. GROUP 2-MNA - CLOSED
9. GROUP 2-MNB - CLOSED
10. DIRECT CONTROL-MNA - CLOSED
11. DIRECT CONTROL-MNB - CLOSED
12. A&C ROLL-MNA - CLOSED
13. A&C ROLL-MNB - CLOSED
14. B&D ROLL-MNA - CLOSED
15. B&D ROLL-MNB - CLOSED
16. PITCH-MNA - CLOSED
17. PITCH-MNB - CLOSED
18. YAW-MNA - CLOSED
19. YAW-MNB - CLOSED
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL-PITCH-BAT A - OPEN
22. GIMBAL MOTOR CONTROL-YAW-BAT A - OPEN

MDC 24

1. SCS POWER - AC 1
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC 3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC 6

ATTITUDE SET - OFF

MDC 7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - PINNED
TRANSLATION CONTROLS - LOCKED

MDC 14

1. PROGRAM - 00
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - ADJUST AS REQUIRED

MDC 2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - ADJUST AS REQUIRED
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

NOTE: This procedure is intended for cases where either the G&N has failed or where the accuracy of the final attitude does not require a precise maneuver. The G&N will be on with the IMU aligned for some of these maneuvers on SC 012 and the switches are called out for those positions. Steps that can be deleted and position that would be changed for a G&N off condition are called out with an *.

MDC 22

1. IMU HTR-MNA - CLOSED
2. IMU HTR-MNB - CLOSED
*3. IMU-MNA - CLOSED
*4. IMU-MNB - CLOSED
5. COMPUTER-MNA - CLOSED
6. COMPUTER-MNB - CLOSED
7. OPTICS-MNA - OPEN
8. OPTICS-MNB - OPEN
*9. G&N AC POWER-AC 1 - CLOSED
*10. G&N AC POWER-AC 2 - CLOSED
11. G&N AC POWER-AC 1

LEB NAV STATION SWITCHES

1. IMU TRANSFER - COMPUTER
2. OPTICS SLAVE TELESCOPE - STAR LOS
3. OPTICS MODE - ZERO OPTICS
4. OPTICS HOLD - OFF
5. OPTICS CONTROLLER SPEED - HIGH
6. OPTICS CONTROLLER MODE - DIRECT
7. IMU TEMP MODE - AUTO OVERRIDE
*8. AGC MODE - ON
9. ATTITUDE IMPULSE ENABLE - OFF
10. CONDITION LAMPS - ON
11. FLOODLIGHT CONTROL PRIMARY - OFF
12. FLOODLIGHT CONTROL SECONDARY - OFF
13. AGC BRIGHTNESS CONTROL - ADJUST AS REQUIRED
14. PANEL BRIGHTNESS CONTROL - ADJUST AS REQUIRED

10.18.2 From MSFN and/or on board mission timeline data determine the attitude to be attained. The external reference can be stellar, solar, and/or earth oriented.

10.18.3 Use on board star charts and/or earth maps to review for present attitude, desired attitude, and the magnitude and direction of the required attitude changes.

CAUTION: Care should be taken to avoid pointing the + X axis within $\pm$ 15 degrees of the sun during the maneuver. If the final attitude is within $\pm$ 15 degrees of the sun 10.24 the precise SC orientation using telescope procedure should be used.

10.18.4 Adjust seat back to docking position.

10.18.5 Unpin Rotation control to be used.

10.18.6 Limit cycle switch - OFF (MDC 8).

10.18.7 Simultaneously displace the rotation control in all three axes to command proportional rates in the appropriate directions and in the same ratios as the magnitudes of the angular changes required.

10.18.8 Attitude deadband - minimum during the maneuver (MDC 8).

10.18.9 Monitor the attitude change against the external references.

10.18.10 As the attitude nears that desired restore the rotation control to neutral in the appropriate axes.

10.18.11 Confirm achievement of the desired attitude making final adjustments as required.

10.18.12 Limit cycle switch - ON (MDC 8).

10.18.13 Use procedure 10.23, Attitude Reference Comparison, at this point.

10.18.14 Repin the rotation control.

10.18.15 Readjust the seat back to normal position.

10.19 RCS De-Orbit (G&N and SPS Inoperative), CM-SM Separation, and SCS Entry.

10.19.1 Confirm or select the following switch positions:

MDC 8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - ON
3. ATTITUDE DEADBAND - MAXIMUM
4. .05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - OFF
7. G&N/SCS - SCS
8. ATTITUDE/MONITOR/ENTRY - ATTITUDE
9. A&C ROLL CHANNEL - OFF
10. B&D ROLL CHANNEL - ON
11. PITCH CHANNEL - ON
12. YAW CHANNEL - ON
13. ROLL RATE GYRO - NORMAL
14. PITCH RATE GYRO - NORMAL
15. YAW RATE GYRO - NORMAL

MDC 25

1. FDAI LTG - AC 1
2. GROUP 1-AC 1 - CLOSED
3. GROUP 1-AC 2 - CLOSED
4. GROUP 2-AC 1 - CLOSED
5. GROUP 2-AC 2 - CLOSED
6. GROUP 1-MNA - CLOSED
7. GROUP 1-MNB - CLOSED
8. GROUP 2-MNA - CLOSED
9. GROUP 2-MNB - CLOSED
10. DIRECT CONTROL-MNA - CLOSED
11. DIRECT CONTROL-MNB - CLOSED
12. A&C ROLL-MNA - CLOSED
13. A&C ROLL-MNB - CLOSED
14. B&D ROLL-MNA - CLOSED
15. B&D ROLL-MNB - CLOSED
16. PITCH-MNA - CLOSED
17. PITCH-MNB - CLOSED
18. YAW-MNA - CLOSED
19. YAW-MNB - CLOSED
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL-PITCH-BAT A - OPEN
22. GIMBAL MOTOR CONTROL-YAW-BAT A - OPEN

MDC 24

1. SCS POWER - AC 1
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC 3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC 6

ATTITUDE SET - OFF

MDC 7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - PINNED
TRANSLATION CONTROLS - LOCKED

MDC 14

1. PROGRAM - 00
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - MAX. DIM.

MDC 2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - ADJUST AS REQUIRED
3. ECSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

MDC 22

1. IMU HTR-MNA - CLOSED
2. IMU HTR-MNB - CLOSED
3. IMU-MNA - OPEN
4. IMU-MNB - OPEN
5. COMPUTER-MNA - OPEN
6. COMPUTER-MNB - OPEN
7. OPTICS-MNA - OPEN
8. OPTICS-MNB - OPEN
9. G&N AC POWER-AC 1 - OPEN
10. G&N AC POWER-AC 2 - OPEN
11. G&N AC POWER-AC 1

LEB NAV STATION SWITCHES

1. IMU TRANSFER - COMPUTER
2. OPTICS SLAVE TELESCOPE - STAR LOS
3. OPTICS MODE - ZERO OPTICS
4. OPTICS HOLD - OFF
5. OPTICS CONTROLLER SPEED - HIGH
6. OPTICS CONTROLLER MODE - DIRECT
7. IMU TEMP. MODE - AUTO OVERRIDE
8. AGC MODE - STANDBY
9. ATTITUDE IMPULSE ENABLE - OFF
10. CONDITION LAMPS - OFF
11. FLOODLIGHT CONTROL PRIMARY - OFF
12. FLOODLIGHT CONTROL SECONDARY - OFF
13. PANEL BRIGHTNESS CONTROL - MAX. DIM.
14. AGC BRIGHTNESS CONTROL - MAX. DIM.

10.19.2 Confirm with MSFN the following data:

a. GMT time of firing of CM-SM separation, and of reaching the 0.05 g interface.

b. Actual delta V change required (feet per second).

c. Firing duration (seconds).

d. Attitude required for deorbit with respect to visual external reference cues to be used and attitude set values for RCS Deorbit Attitude.

NOTE: An average attitude must be held in this case which will require a higher delta V than in the case where all of the change is opposite the velocity vector.

10.19.3 Set digital event timer to reach 00 - 00 at time for ullage.

10.19.4 Using G&C procedure 10.18, SC Attitude Maneuver to external reference, maneuver SC to required Attitude.

10.19.5 Attitude deadband switch to minimum during maneuver.

10.19.6 TVC number 1 switch to AC 1.

10.19.7 Set delta V remaining counter (MDC 7) to value received from MSFN using delta V set switch.

10.19.8 Set attitude set dials to values received from MSFN Roll 000, Yaw 000, Pitch

10.19.9 Unlock the prime and alternate translation controls.

10.19.10 Unpin the rotation control.

10.19.11 Direct RCS switch ON.

10.19.12 Limit cycle switch OFF (within less than one minute of ON time).

10.19.13 Standby to takeover manually to the external reference if the automatic hold function fails.

10.19.14 On cue from the navigator, who is monitoring either the elapsed time indicator or the GMT clock, initiate a + X translation command.

10.19.15 On cue from the navigator, who is monitoring the delta V remaining counter and the time cues, cease the + X translation command.

10.19.16 Attitude deadband switch to maximum.

10.19.17 TVC 1 power switch to OFF (MDC 24).

10.19.18 Relock the translation control.

10.10.19 Using G&C Procedure 10.13, Attitude Maneuver, to Attitude Ball Reference, change the pitch angle to which will be the attitude for CM-SM at the separation time. Yaw and roll should be held at 000.

10.19.20 Confirm the separation attitude to external visual cues.

10.19.21 Open the following circuit breakers on MDC 25.

A&C Roll	MNA
A&C Roll	MNB
B&D Roll	MNB
Pitch	MNB
Yaw	MNB

10.19.22 Manually activate A&B CM RCS pressurization and verify on pressure indicator on MDC 12.

NOTE: Leave RCS Indicator selector on CMB.

10.19.23 Recheck Limit Cycle switch on MDC 8 is OFF. (An incorrect setting of this switch will use excessive propellant in entry).

10.19.24 Momentarily set FDAI Self-Test switch on MDC 2 to ON. Verify movement of all three rate indicators.

10.19.25 Place the Attitude/Monitor/Entry switch on MDC 8 to Entry.

10.19.26 When Digital Event Timer reads activate CM-SM Separation switch on MDC 16.

10.19.27 Confirm CM-SM separation rate damping.

10.19.28 Command a negative pitch maneuver to again holding Yaw and Roll 000.

10.19.29 At on the Digital Event Timer and when the first "g" buildup is sensed place the 0.05 g switch on MDC 8 to ON.

NOTE: The "g" meter on MDC 2 may also be useful as a cue.

10.19.30 Initiate a 15 degrees per second clockwise roll.

10.19.31 Place the B&D Roll Enable switch off on MDC 8 and return the rotation control to neutral.

10.19.32 Monitor the pitch and yaw rate displays for rate damping to $\pm$ 2 degrees per second. The roll rate display should continue to read 15 $\pm$ 3 degrees per second.

10.19.33 At $\approx$ 35,000 feet stop the roll rate with direct.

10.19.34 At $\approx$ 25,000 feet place the Pitch and Yaw Enable switches on MDC 8 to OFF and momentarily move the RCS CMD switch on MDC 16 to OFF to Backup Sequencer inhibition of RCS firings.

10.20 Manual TVC to FDAI Attitude Reference.

CAUTION: An MTVC, using the FDAI as a reference, is only possible if the IMU is aligned and operating. The SCS attitude reference is not available for MTVC as an inherrent part of the design of the MTVC mode.

NOTE: Steps 10.20.1 through 10.20.5 will have preceded this procedure. They are included to show the Delta V preparation continuity.

10.20.1 Using SPS propellant readings taken following the previous SPS burn and onboard curves, read pitch and yaw gimbal trim angles required.

10.20.2 Check with MSFN for following data after confirming SPS fuel quantity remaining to MSFN as a part of procedure 10.46, AGC Update.

a. GMT time of firing

b. Delta V change required (less tail-off allowance)

c. Firing duration ($\pm$ 1 second)

d. Attitude required for delta V both as IMU gimbal angles readout from last IMU alignment and as visual references expected out the docking window when aligned.

e. Pitch and yaw trim angles

10.20.3 Compare G&N data with MSFN using procedure 10.43, Orbit Change and SPS Minimum Impulse Prethrusting.

10.20.4 Using procedures 10.44, IMU Orientation Determination and 10.45, IMU Align, align the IMU and orient the vehicle to the required attitude.

10.20.5 Confirm S/C attitude through the docking window.

10.20.6 At 12 minutes before the burn the following initial switch conditions should exist or be selected.

MDC-8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - ON
3. ATTITUDE DEADBAND - MAXIMUM
4. 0.05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - OFF
7. G&N/SCS - G&N
8. ATTITUDE/MONITOR/ENTRY - ATTITUDE
9. A&C ROLL CHANNEL - OFF

10. B&D ROLL CHANNEL - ON
11. PITCH CHANNEL - ON
12. YAW CHANNEL - ON
13. ROLL RATE GYRO - NORMAL
14. PITCH RATE GYRO - NORMAL
15. YAW RATE GYRO - NORMAL

MDC-25

1. FDAI LTG - AC 1
2. GROUP 1 - AC 1 - CLOSED
3. GROUP 1 - AC 2 - CLOSED
4. GROUP 2 - AC 1 - CLOSED
5. GROUP 2 - AC 2 - CLOSED
6. GROUP 1 - MNA - CLOSED
7. GROUP 1 - MNB - CLOSED
8. GROUP 2 - MNA - CLOSED
9. GROUP 2 - MNB - CLOSED
10. DIRECT CONTROL - MNA - CLOSED
11. DIRECT CONTROL - MNB - CLOSED
12. A&C ROLL - MNA - CLOSED
13. A&C ROLL - MNB - CLOSED
14. B&D ROLL - MNA - CLOSED
15. B&D ROLL - MNB - CLOSED
16. PITCH - MNA - CLOSED
17. PITCH - MNB - CLOSED
18. YAW - MNA - CLOSED
19. YAW - MNB - CLOSED
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL - PITCH - BAT A - CLOSED
22. GIMBAL MOTOR CONTROL - YAW - BAT A - CLOSED
23. SPS GAUGING - AC 1

MDC-24

1. SCS POWER - AC 1
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC-3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC-6

ATTITUDE SET - OFF

MDC-7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - PINNED
TRANSLATION CONTROLS - LOCKED

MDC-14

1. PROGRAM - 00
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - ADJUST AS REQUIRED

MDC-2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - ADJUST AS REQUIRED
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

MDC -22

1. IMU HTR - MNA - CLOSED
2. IMU HTR - MNB - CLOSED
3. IMU - MNA - CLOSED
4. IMU - MNB - CLOSED
5. COMPUTER - MNA - CLOSED
6. COMPUTER - MNB - CLOSED
7. OPTICS - MNA - OPEN
8. OPTICS - MNB - OPEN
9. G&N AC POWER - AC 1 - CLOSED
10. G&N AC POWER - AC 2 - CLOSED
11. G&N AC POWER - AC 1

LEB NAV STATION SWITCHES

1. IMU TRANSFER - COMPUTER
2. OPTICS SLAVE TELESCOPE - STAR LOS
3. OPTICS MODE - ZERO OPTICS
4. OPTICS HOLD - OFF
5. OPTICS CONTROLLER SPEED - HIGH
6. OPTICS CONTROLLER MODE - DIRECT
7. IMU TEMP MODE - AUTO OVERRIDE
8. AGC MODE - ON
9. ATTITUDE IMPULSE ENABLE - OFF
10. CONDITION LAMPS - ON
11. FLOODLIGHT CONTROL PRIMARY - OFF
12. FLOODLIGHT CONTROL SECONDARY - OFF

13. PANEL BRIGHTNESS CONTROL - MAX DIM
14. AGC BRIGHTNESS CONTROL - MAX DIM

10.20.7 Approximately 10 minutes before the burn, enter V37E41E on MDC-14.

10.20.8 In response to V50N25 flash key in V33E on MDC-14 to bypass the mode check (which is too early).

10.20.9 In response to V16N20 flash key in V33E on MDC-14 to bypass AGCU set routine.

10.20.10 In response to V16N57 flash set Digital Event Timer to minutes and seconds to go in R1. Note total velocity change required in R2.

10.20.11 Set pitch and yaw gimbal trim angles coarsly to +4 degrees and +6 degrees respectively using numerical values on thumbwheels on MDC-6.

10.20.12 Set the attitude set dials on MDC-6 to 0 degrees roll, 0 degrees yaw, and 32 degrees pitch and depress the FDAI align pushbutton (all on MDC-6) for approximately 30 seconds.

10.20.13 Set TVC 1 switch to AC 1 (MDC-24).

10.20.14 Set the delta V remaining counter on MDC-7 to the value of delta V required received from MSFN using the delta V set switch on the same panel.

10.20.15 Set TVC 2 switch to AC 2 (MDC-24).

10.20.16 Set Inject Prevalve switches A and B to ON (MDC-3).

10.20.17 Approximately 5 minutes before the burn set the Attitude Deadband switch on MDC-8 to Minimum.

10.20.18 Delta V switch on MDC-8 to ON.

10.20.19 Gimbal motors switches on MDC-3 in sequence approximately 4 minutes before ignition.

a. Pitch 2 to momentary start then ON.

b. Yaw 2 to momentary start then ON.

10.20.20 Confirm on MDC-6 the drive of the pitch and yaw gimbals to +4 degrees and +6 degrees respectively.

10.20.21 Gimbal motor switches on MDC-3 in sequence.

a. Pitch 1 to momentary start then ON.

b. Yaw 2 to momentary start then ON.

10.20.22 After any transients settle out, fine adjust the pitch and yaw required trim angles (MDC-6).

10.20.23 Confirm that the pitch and yaw gimbals go to the final values (MDC-6).

10.20.24 Unlock the prime translation control only.

10.20.25 Set the thrust control switch on MDC-7 to NORMAL.

10.20.26 Unpin the rotation control.

10.20.27 At T-25 seconds R3 on MDC-14 should begin to display accumulated ullage. R3 should remain 00000 until ullage commences.

10.20.28 When the digital event timer on MDC-5 reads 00 15 initiate a +X command with the translation control.

10.20.29 At -5 seconds, the Verb Noun flash will change to V50N11 flashing.

10.20.30 At 00 00 the navigator should press Enter on MDC-14 if 15 seconds of ullage have occurred. The light behind the thrust-on pushbutton on MDC-7 should come on and SPS thrust buildup should commence.

NOTE: The exact velocity change is not important in ullage. There must have been a steady ullage of 2 or more +X jets to settle the propellant.

10.20.31 At ignition the Verb Noun display will change to V16N51. R1 will change to time to engine cutoff (decreasing), R2 will display velocity to be gained (decreasing), and R3 will continue to display ullage velocity accumulated.

10.20.32 After 15 seconds, when thrust on light behind thrust on push button comes on, rotate translation control handle clockwise to select MTVC mode. Do not enter V71 or the G&N will terminate thrusting.

10.20.33 Control attitude to attitude ball reference for total attitude and the rate displays as a cross check.

CAUTION: For any failure in this mode during SPS thrusting, the corrective action is to place the thrust control switch on MDC-7 to OFF and either allow the automatic system to reduce the vehicle rates with RCS or to do so manually with Direct Control. New orbital parameters data should be obtained from MSFN and the appropriate contingency mission path selected.

10.20.34 Retain the +X command for approximately 1 second after SPS ignition.

10.20.35 The navigator must monitor thrust control to backup the automatic thrust off by returning the thrust control switch to off (MDC-7) if necessary. Total time from SPS ignition and the delta V remaining counter (MDC-7) are the items checked. When the delta V remaining counter reads 00000, and R2 reads the tail off value for this burn, the light behind the thrust on pushbutton should go out.

10.20.36 Following tail-off of SPS engine

a. B&D Roll, Pitch, and Yaw Channel Enable switches to OFF (MDC-8).

NOTE: The enable switches must be off for 5 minutes minimum to allow the SPS propellant to damp itself or excessive SM/RCS propellant will be expended in this time period.

b. Gimbal motors in sequence (MDC-3)

1. Pitch 1 to OFF

2. Pitch 2 to OFF

3. Yaw 1 to OFF

4. Yaw 2 to OFF

c. Inject Prevalve A and B - both OFF (MDC-3)

d. Thrust control switch OFF (MDC-7)

e. TVC 2 OFF (MDC-24)

f. TVC 1 OFF (MDC-24)

g. Delta V OFF (MDC-8)

h. Repin rotation control

i. Center and lock the translation control

j. Open the two BAT A circuit breakers for gimbal motor control on MDC-25

k. SPS gauging switch on MDC-25 to OFF

10.20.37 Read and record delta V accomplished from the delta V remaining counter (MDC-7).

10.20.38 Read and record SPS propellant quantities remaining from MDC-20.

10.20.39 Read delta V accomplished from register 2 of MDC-14.

10.20.40 Enter V33E on MDC-14. Procedure 10.33, Orbit Parameter Display will now follow. Upon the final V33E entry on MDC-14 the program will change from 41 to 00.

10.21 Manual TVC to Docking Window Reference

CAUTION: An SCS MTVC, using the FDAI, is not possible. The BMAG's are providing the MTVC rate reference and so cannot update the AGCU position data or display attitude error.

NOTE: Although this procedure would not normally be employed unless there has been a failure in the G&N or SCS, on S/C 012 this method will be tested with the G&N ON to monitor the performance. For later applications the G&N may be OFF or only partially ON. The variable items in this procedure are marked with an *.

NOTE: Steps 10.21.1 through 10.21.5 will have preceded this procedure. They are included to show the Delta V preparation continuity.

10.21.1 Using SPS propellant readings taken following the previous SPS burn and onboard curves, read pitch and yaw gimbal trim angles required.

10.21.2 Check with MSFN for following data after confirming SPS fuel quantity remaining to MSFN as a part of procedure 10.46, AGC Update.

a. GMT time of firing

b. Delta V change required (less tail-off allowance)

c. Firing duration (± 1 second)

d. Attitude required for delta V both as IMU gimbal angles readout from last IMU alignment and as visual references expected out the docking window when aligned.

e. Pitch and yaw trim angles

10.21.3* Compare G&N data with MSFN using procedure 10.42, Orbit Change and SPS Minimum Impulse Prethrusting.

10.21.4* Using procedure 10.44, IMU Orientation Determination and 10.45, IMU Align, align the IMU and orient the vehicle to the required attitude.

10.21.5 Confirm SC attitude through the docking window.

10.21.6 At 12 minutes before the burn the following initial switch conditions should exist or be selected.

MDC-8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - ON
3. ATTITUDE DEADBAND - MAXIMUM

4. 0.05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - OFF
7. G&N/SCS - SCS
8. ATTITUDE/MONITOR/ENTRY - ATTITUDE
9. A&C ROLL CHANNEL - OFF
10. B&D ROLL CHANNEL - ON
11. PITCH CHANNEL - ON
13. ROLL RATE GYRO - NORMAL
14. PITCH RATE GYRO - NORMAL
15. YAW RATE GYRO - NORMAL

MDC-25

1. FDAI LTG - AC 1
2. GROUP 1 - AC 1 - CLOSED
3. GROUP 1 - AC 2 - CLOSED
4. GROUP 2 - AC 1 - CLOSED
5. GROUP 2 - AC 2 - CLOSED
6. GROUP 1 - MNA - CLOSED
7. GROUP 1 - MNB - CLOSED
8. GROUP 2 - MNA - CLOSED
9. GROUP 2 - MNB - CLOSED
10. DIRECT CONTROL - MNA - CLOSED
11. DIRECT CONTROL - MNB - CLOSED
12. A&C ROLL - MNA - CLOSED
13. A&C ROLL - MNB - CLOSED
14. B&D ROLL - MNA - CLOSED
15. B&D ROLL - MNB - CLOSED
16. PITCH - MNA - CLOSED
17. PITCH - MNB - CLOSED
18. YAW - MNA - CLOSED
19. YAW - MNB - CLOSED
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL - PITCH - BAT A - CLOSED
22. GIMBAL MOTOR CONTROL - YAW - BAT A - CLOSED
23. SPS GAUGING - AC 1

MDC-24

1. SCS POWER - AC 1
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC-3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF

4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC-6

ATTITUDE SET - OFF

MDC-7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - PINNED
TRANSLATION CONTROLS - LOCKED

MDC-14

* 1. PROGRAM - 00
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - ADJUST AS REQUIRED

MDC-2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - ADJUST AS REQUIRED
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

MDC-22

1. IMU HTR - MNA - CLOSED
2. IMU HTR - MNB - CLOSED
* 3. IMU - MNA - CLOSED
* 4. IMU - MNB - CLOSED
* 5. COMPUTER - MNA - CLOSED
6. COMPUTER - MNB - CLOSED
7. OPTICS - MNA - OPEN
8. OPTICS - MNB - OPEN
* 9. G&N AC POWER - AC 1 - CLOSED
*10. G&N AC POWER - AC 2 - CLOSED
11. G&N AC POWER - AC 1

LEB NAV STATION SWITCHES

1. IMU TRANSFER - COMPUTER
2. OPTICS SLAVE TELESCOPE - STAR LOS
3. OPTICS MODE - ZERO OPTICS
4. OPTICS HOLD - OFF
5. OPTICS CONTROLLER SPEED - HIGH
6. OPTICS CONTROLLER MODE - DIRECT
7. IMU TEMP MODE - AUTO OVERRIDE
* 8. AGC MODE - ON

9. ATTITUDE IMPULSE ENABLE - OFF
*10. CONDITION LAMPS - ON
11. FLOODLIGHT CONTROL PRIMARY - OFF
12. FLOODLIGHT CONTROL SECONDARY - OFF
13. PANEL BRIGHTNESS CONTROL - MAX DIM
14. AGC BRIGHTNESS CONTROL - MAX DIM

10.21.7 * Approximately 10 minutes before the burn, enter V37E46E on MDC-14. Confirm program 46 on MDC-14.

10.21.8 Set the DET from the GMT clock to reach 00 00 at engine ignition time.

10.21.9 Set pitch and yaw gimbal trim angles coarsly to +4 degrees and +6 degrees respectively using numerical values on thumbwheels on MDC-6.

10.21.10 Set the attitude set dials on MDC-6 to 0 degrees roll, 0 degrees yaw, and 32 degrees pitch and depress the FDAI align pushbutton (all on MDC-6).

10.21.11 Set TVC 1 switch to AC 1 (MDC-24).

10.21.12 Set the delta V remaining counter on MDC-7 to the value of delta V required received from MSFN using the delta V set switch on the same panel.

10.21.13 Set TVC 2 switch to AC 2 (MDC-24).

10.21.14 Set Inject Prevalve switches A and B to ON (MDC-3).

10.21.15 Approximately 5 minutes before the burn set the Attitude Deadband switch on MDC-8 to Minimum.

10.21.16 Delta V switch on MDC-8 to ON.

10.21.17 Gimbal motors switches on MDC-3 in sequence approximately 4 minutes before ignition.

a. Pitch 2 to momentary start then ON.

b. Yaw 2 to momentary start then ON.

10.21.18 Confirm on MDC-6 the drive of the pitch and yaw gimbals to +4 degrees and +6 degrees respectively.

10.21.19 Gimbal motor switches on MDC-3 in sequence.

a. Pitch 1 to momentary start then ON.

b. Yaw 2 to momentary start then On.

10.21.20 After any transients settle out, fine adjust the pitch and yaw required trim angles (MDC-6).

10.21.21 Confirm that the pitch and yaw gimbals go to the final values (MDC-6).

10.21.22 Unlock the prime translation control only.

10.21.23 Set the thrust control switch on MDC-7 to NORMAL.

10.21.24 Unpin the rotation control.

10.21.25 When the digital event timer on MDC-5 reads 00 15 initiate a +X command with the translation control.

10.21.26 At the time of initiating ullage, the pilot should shift his attention to the external attitude references in anticipation of selecting MTVC.

10.21.27 * When the pilot initiates ullage the navigator should press ENTER on MDC-14.

10.21.28 At 00 00 the navigator should press the thrust on pushbutton on MDC-7 if 15 seconds of ullage have occurred. The light behind the thrust-on pushbutton on MDC-7 should come on and SPS thrust buildup should commence.

NOTE: The exact velocity change is not important in ullage. There must have been a steady ullage of 2 or more +X jets to settle the propellant.

10.21.29 Simultaneously with the initiation of thrust on by the navigator, the pilot should select the MTVC mode by rotating the translation control handle clockwise.

10.21.30 Retain the +X command for approximately 1 second after SPS ignition.

NOTE: The attitude ball is not driven in the SCS MTVC mode. The BMAG's are providing the rate inner loop signals.

10.21.31 The navigator must monitor thrust control to backup the SCS automatic thrust off by returning the thrust control switch to off (MDC-7) if necessary. This same action will correct for any failure during thrusting. Total time from SPS ignition and the delta V remaining counter (MDC-7) are the two items checked. When the counter reads 00000, the light behind the thrust on pushbutton should go out.

CAUTION: For any failure in this mode during SPS thrusting, the corrective action is to place the thrust control switch on MDC-7 to OFF and either allow the automatic system to reduce the vehicle rates with RCS or to do so manually with Direct Control. New orbital parameters data should be obtained from MSFN and the appropriate contingency mission path selected.

10.21.32 Following tail-off of SPS engine

a. B&D Roll, Pitch, and Yaw Channel Enable switches to OFF (MDC-8).

NOTE: The enable switches must be off for 5 minutes minimum to allow the SPS propellant to damp itself or excessive SM/RCS propellant will be expended in this time period.

b. Gimbal motors in sequence (MDC-3)

1. Pitch 1 to OFF

2. Pitch 2 to OFF

3. Yaw 1 to OFF

4. Yaw 2 to OFF

c. Inject Prevalve A and B - both OFF (MDC-3)

d. Thrust control switch OFF (MDC-7)

e. TVC 2 OFF (MDC-24)

f. TVC 1 OFF (MDC-24)

g. Delta V Off (MDC-8)

h. Repin rotation control

i. Lock translation control

j. Open the two BAT A circuit breakers for gimbal motor control on MDC-25

k. SPS gauging switch on MDC-25 to OFF

10.21.33 Read and record delta V accomplished from the delta V remaining counter (MDC-7).

10.21.34 Read and record SPS propellant quantities remaining from MDC-20.

10.21.35 * Read delta V accomplished from register 2 of MDC-14.

10.21.36 Enter V33E on MDC-14.

10.21.37 * Accomplish procedure 10.33, Orbit Parameter Display.

10.21.38 Report delta V accomplished, SPS propellant remaining, and Orbital parameter changes (if available) to MSFN.

10.22 SCS Velocity Change.

NOTE: The following switch and circuit breakers are called out as if the G&N is functional and in a monitoring mode for the SCS controlled velocity change. Items that would be deleted or reversed if the G&N is not on are marked with a *.

NOTE: Steps 10.22.1 through 10.22.5 will have preceded this procedure. They are included to show the Delta V preparation continuity.

10.22.1 Using SPS propellant readings taken following the previous SPS burn and onboard curves, read pitch and yaw gimbal trim angles required.

10.22.2 Check with MSFN for following data after confirming SPS fuel quantity remaining to MSFN as a part of procedure 10.46, AGC Update.

a. GMT time of firing

b. Delta V change required (less tail-off allowance)

c. Firing duration (± 1 second)

d. Attitude required for delta V both as IMU gimbal angles readout from last IMU alignment and as visual references expected out the docking window when aligned.

e. Pitch and yaw trim angles

10.22.3 * Compare G&N data with MSFN using procedure 10.42, Orbit Change and SPS Minimum Impulse Prethrusting.

10.22.4 * Using procedures 10.44, IMU Orientation Determination and 10.45, IMU Align, align the IMU and orient the vehicle to the required attitude, then deliberately offset the vehicle 5 degrees per axis and use procedure 10.24 Precise SC Orientation using the telescope to realign.

10.22.5 Confirm SC attitude through the docking window.

10.22.6 At 12 minutes before the burn the following initial switch conditions should exist or be selected.

MDC-8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - ON
3. ATTITUDE DEADBAND - MAXIMUM
4. 0.05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - OFF
7. G&N/SCS - SCS

8. ATTITUDE/MONITOR/ENTRY - ATTITUDE
9. A&C ROLL CHANNEL - OFF
10. B&D ROLL CHANNEL - ON
11. PITCH CHANNEL - ON
12. YAW CHANNEL - ON
13. ROLL RATE GYRO - NORMAL
14. PITCH RATE GYRO - NORMAL
15. YAW RATE GYRO - NORMAL

MDC-25

1. FDAI LTG - AC 1
2. GROUP 1 - AC 1 - CLOSED
3. GROUP 1 - AC 2 - CLOSED
4. GROUP 2 - AC 1 - CLOSED
5. GROUP 2 - AC 2 - CLOSED
6. GROUP 1 - MNA - CLOSED
7. GROUP 1 - MNB - CLOSED
8. GROUP 2 - MNA - CLOSED
9. GROUP 2 - MNB - CLOSED
10. DIRECT CONTROL - MNA - CLOSED
11. DIRECT CONTROL - MNB - CLOSED
12. A&C ROLL - MNA - CLOSED
13. S&C ROLL - MNB - CLOSED
14. B&D ROLL - MNA - CLOSED
15. B&D ROLL - MNB - CLOSED
16. PITCH - MNA - CLOSED
17. PITCH - MNB - CLOSED
18. YAW - MNA - CLOSED
19. YAW - MNB - CLOSED
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL - PITCH - BAT A - CLOSED
22. GIMBAL MOTOR CONTROL - YAW - BAT A - CLOSED
23. SPS GAUGING - AC 1

MDC-24

1. SCS POWER - AC 1
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC-3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC-6

ATTITUDE SET - OFF

MDC-7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - PINNED
TRANSLATION CONTROLS - LOCKED

MDC-14

* 1. PROGRAM - 00
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - ADJUST AS REQUIRED

MDC-2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - ADJUST AS REQUIRED
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

MDC-22

1. IMU HTR - MNA - CLOSED
2. IMU HTR - MNB - CLOSED
* 3. IMU - MNA - CLOSED
* 4. IMU - MNB - CLOSED
5. COMPUTER - MNA - CLOSED
6. COMPUTER - MNB - CLOSED
7. OPTICS - MNA - OPEN
8. OPTICS - MNB - OPEN
* 9. G&N AC POWER - AC 1 - CLOSED
*10. G&N AC POWER - AC 2 - CLOSED
11. G&N AC POWER - AC 1

LEB NAV STATION SWITCHES

1. IMU TRANSFER - COMPUTER
2. OPTICS SLAVE TELESCOPE - STAR LOS
3. OPTICS MODE - ZERO OPTICS
4. OPTICS HOLD - OFF
5. OPTICS CONTROLLER SPEED - HIGH
6. OPTICS CONTROLLER MODE - DIRECT
7. IMU TEMP MODE - AUTO OVERRIDE
8. AGC MODE - ON
9. ATTITUDE IMPULSE ENABLE - OFF
10. CONDITION LAMPS - ON
11. FLOODLIGHT CONTROL PRIMARY - OFF
12. FLOODLIGHT CONTROL SECONDARY - OFF

13. PANEL BRIGHTNESS CONTROL - MAX DIM
14. AGC BRIGHTNESS CONTROL - MAX DIM

10.22.7 Approximately 10 minutes before the burn, enter V37E46E on MDC-14. Confirm program 46 on MDC-14.

10.22.8 Set Digital Event Timer using the GMT clock to reach 00 00 at engine ignition time.

10.22.9 Set pitch and yaw gimbal trim angles coarsly to +4 degrees and +6 degrees respectively using numerical values on thumbwheels on MDC-6.

10.22.10 Set the attitude set dials on MDC-6 to 0 degrees roll, 0 degrees yaw, and 32 degrees pitch and depress the FDAI align pushbutton (all ON MDC-6) for 30 seconds.

10.22.11 Set TVC 1 switch to AC 1 (MDC-24).

10.22.12 Set the delta V remaining counter on MDC-7 to the value of delta V required received from MSFN using the delta V set switch on the same panel.

10.22.13 Set TVC 2 switch to AC 2 (MDC-24).

10.22.14 Set Inject Prevalve switches A and B to ON (MDC-3).

10.22.15 Approximately 5 minutes before the burn set the Attitude Deadband switch on MDC-8 to Minimum.

10.22.16 Delta V switch on MDC-8 to ON.

10.22.17 Gimbal motors switches on MDC-3 in sequence approximately 4 minutes before ignition.

a. Pitch 2 to momentary start then On.

b. Yaw 2 to momentary start then ON.

10.22.18 Confirm on MDC-6 the drive of the pitch and yaw gimbals to +4 degrees and +6 degrees respectively.

10.22.19 Gimbal motor switches on MDC-3 in sequence.

a. Pitch 1 to momentary start then ON.

b. Yaw 2 to momentary start then On.

10.22.20 After any transients settle out, fine adjust the pitch and yaw required trim angles (MDC-6).

10.22.21 Confirm that the pitch and yaw gimbals go to the final values (MDC-6).

10.22.22 Unlock the prime translation control only.

10.22.23 Set the thrust control switch on MDC-7 to NORMAL.

10.22.24 Unpin the rotation control.

10.22.25 When the digital event timer on MDC-5 reads 00 15 initiate a +X command with the translation control. The navigator should press ENTER on MDC-14.

10.22.26 At 00 00 the navigator should press the thrust on pushbutton on MDC-7 if 15 seconds of ullage have occurred. The light behind the thrust-on pushbutton on MDC-7 should come on and SPS thrust buildup should commence.

NOTE: The exact velocity change is not important in ullage. There must have been a steady ullage of 2 or more +X jets to settle the propellant.

10.22.27 Retain the +X command for approximately 1 second after SPS ignition.

10.22.28 The Pilot should monitor the attitude error indicators and the rate indicators on MDC-4 for any indication of failure and required emergency thrust cutoff.

10.22.29 The navigator must monitor total time from SPS ignition and the delta V remaining counter (MDC-7). When the delta V remaining counter reads 00000, the light behind the thrust on pushbutton should go out. If this does not occur he should cue the pilot to cutoff thrusting.

CAUTION: For any failure in this mode during SPS thrusting, the corrective action is to place the thrust control switch on MDC-7 to OFF and either allow the automatic system to reduce the vehicle rates with RCS or to do so manually with Direct Control. New orbital parameters data should be obtained from MSFN and the appropriate contingency mission path selected.

10.22.30 Following tail-off of SPS engine

a. B&D Roll, Pitch, and Yaw Channel Enable switches to OFF (MDC-8)

NOTE: The enable switches must be off for 5 minutes minimum to allow the SPS propellant to damp itself or excessive SM/RCS propellant will be expended in this time period.

b. Gimbal motors in sequence (MDC-3)

1. Pitch 1 to OFF

2. Pitch 2 to OFF

3. Yaw 1 to OFF

4. Yaw 2 to OFF

c. Inject Prevalve A and B - both OFF (MDC-3)

d. Thrust control switch OFF (MDC-7)

e. TVC 2 OFF (MDC-24)

f. TVC 1 OFF (MDC-24)

g. Delta V OFF (MDC-8)

h. Repin rotation control

i. Lock translation control

j. Open the two BAT A circuit breakers for gimbal motor control on MDC-25

k. SPS gauging switch on MDC-25 to OFF

10.22.31 Read and record delta V accomplished from the delta V remaining counter (MDC-7).

10.22.32 Read and record SPS propellant quantities remaining from MDC-20.

10.22.33 * Read delta V accomplished from register of MDC-14.

10.22.34 Enter V33E on MDC-14.

10.22.35 * Accomplish procedure 10.33, Orbit Parameters Display.

10.22.36 Report delta V accomplished, SPS propellant remaining, and orbital parameter changes (if available) to MSFN.

10.23 Attitude Reference Comparison.

NOTE: This procedure will be used to record comparative performance data on the SCS and G&N attitude reference systems following maneuvers or specific mission phases.

10.23.1 Confirm or select the following initial switch positions:

MDC 8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - ON
3. ATTITUDE DEADBAND - MINIMUM
4. .05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - OFF
7. G&N/SCS - SCS
8. ATTITUDE/MONITOR/ENTRY - ATTITUDE
9. A&C ROLL CHANNEL - } ONE ON, ONE OFF -
10. B&D ROLL CHANNEL - } ONE FOR THE FULLEST QUAD ON
11. PITCH CHANNEL - ON
12. YAW CHANNEL - ON
13. ROLL RATE GYRO - NORMAL
14. PITCH RATE GYRO - NORMAL
15. YAW RATE GYRO - NORMAL

MDC 25

1. FDAI LTG - AC 1
2. GROUP 1-AC 1 - CLOSED
3. GROUP 1-AC 2 - CLOSED
4. GROUP 2-AC 1 - CLOSED
5. GROUP 2-AC 2 - CLOSED
6. GROUP 1-MNA - CLOSED
7. GROUP 1-MNB - CLOSED
8. GROUP 2-MNA - CLOSED
9. GROUP 2-MNB - CLOSED
10. DIRECT CONTROL-MNA - CLOSED
11. DIRECT CONTROL-MNB - CLOSED
12. A&C ROLL-MNA - CLOSED
13. A&C ROLL-MNB - CLOSED
14. B&D ROLL-MNA - CLOSED
15. B&D ROLL-MNB - CLOSED
16. PITCH-MNA - CLOSED
17. PITCH-MNB - CLOSED
18. YAW-MNA - CLOSED
19. YAW-MNB - CLOSED
20. G&C SYNC - OFF
21. GIMBAL MOTOR CONTROL-PITCH-BAT A - OPEN
22. GIMBAL MOTOR CONTROL-YAW-BAT A - OPEN

MDC 24

1. SCS POWER - AC 1
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC 3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC 6

ATTITUDE SET - OFF

MDC 7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - PINNED
TRANSLATION CONTROLS - LOCKED

MDC 14

1. PROGRAM - 00
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - ADJUST AS REQUIRED

MDC 2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - ADJUST AS REQUIRED
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

MDC 22

1. IMU HTR-MNA - CLOSED
2. IMU HTR-MNB - CLOSED
3. IMU-MNA - CLOSED
4. IMU-MNB - CLOSED
5. COMPUTER-MNA - CLOSED
6. COMPUTER-MNB - CLOSED
7. OPTICS-MNA - OPEN
8. OPTICS-MNB - OPEN
9. G&N AC POWER-AC 1 - CLOSED
10. G&N AC POWER-AC 2 - CLOSED
11. G&N AC POWER-AC 1

LEB NAV STATION SWITCHES

1. IMU TRANSFER - COMPUTER
2. OPTICS SLAVE TELESCOPE - STAR LOS
3. OPTICS MODE - ZERO OPTICS
4. OPTICS HOLD - OFF
5. OPTICS CONTROLLER SPEED - HIGH
6. OPTICS CONTROLLER MODE - DIRECT
7. IMU TEMP. MODE - AUTO OVERRIDE
8. AGC MODE - ON
9. ATTITUDE IMPULSE ENABLE - OFF
10. CONDITION LAMPS - ON
11. FLOODLIGHT CONTROL PRIMARY - OFF
12. FLOODLIGHT CONTROL SECONDARY - OFF
13. PANEL BRIGHTNESS CONTROL - ADJUST AS REQUIRED
14. AGC BRIGHTNESS CONTROL - ADJUST AS REQUIRED

10.23.2 Enter V16N20E on MDC 14 to call up the outer middle and inner gimbal angles on registers 1, 2, and 3 respectively.

10.23.3 Enter V34E on MDC 14 after recording the values displayed.

10.23.4 Read the ball indications against the entry symbol (⊕) for pitch and yaw and the roll bug for roll (MDC 4).

10.23.5 Set the attitude set dials on MDC 6 the values read.

10.23.6 Place the attitude set switch on MDC 6 to ON.

10.23.7 Fine adjust the attitude set dial readings by driving all three attitude error indicators on MDC 4 to null with the three thumbwheels on MDC 6.

10.23.8 Record the final readings on the attitude set dials.

10.23.9 Set the attitude deadband switch (MDC 8) to maximum.

10.23.10 Attitude set switch (MDC 6) to OFF.

NOTE: If possible, a fine alignment of the IMU and a display of the corrections required by the DSKY will permit a determination of IMU drift during the preceding period.

10.24 Precise SC Orientation Using Telescope.

10.24.1 Confirm or select the following initial switch conditions:

MDC 8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - ON
3. ATTITUDE DEADBAND - MAXIMUM
4. .05 G ENTRY - OFF
5. LOCAL VERTICAL _ OFF
6. DELTA V - OFF
7. G&N/SCS - SCS
8. ATTITUDE/MONITOR/ENTRY - ATTITUDE
9. A&C ROLL CHANNEL - } ONE ON, ONE OFF -
10. B&D ROLL CHANNEL - } ONE FOR FULLEST QUAD ON
11. PITCH CHANNEL - ON
12. YAW CHANNEL - ON
13. ROLL RATE GYRO - NORMAL
14. PITCH RATE GYRO - NORMAL
15. YAW RATE GYRO - NORMAL

MDC 25

1. FDAI LTG - AC 1
2. GROUP 1-AC 1 - CLOSED
3. GROUP 1-AC 2 - CLOSED
4. GROUP 2-AC 1 - CLOSED
5. GROUP 2-AC 2 - CLOSED
6. GROUP 1-MNA - CLOSED
7. GROUP 1-MNB - CLOSED
8. GROUP 2-MNA - CLOSED
9. GROUP 2-MNB - CLOSED
10. DIRECT CONTROL-MNA - CLOSED
11. DIRECT CONTROL-MNB - CLOSED
12. A&C ROLL-MNA - CLOSED
13. A&C ROLL-MNB - CLOSED
14. B&D ROLL-MNA - CLOSED
15. B&D ROLL-MNB - CLOSED
16. PITCH-MNA - CLOSED
17. PITCH-MNB - CLOSED
18. YAW-MNA - CLOSED
19. YAW-MNB - CLOSED
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL-PITCH-BAT A - OPEN
22. GIMBAL MOTOR CONTROL-YAW-BAT A - OPEN

MDC 24

1. SCS POWER - AC 1
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC 3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC 6

ATTITUDE SET - OFF

MDC 7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - PINNED
TRANSLATION CONTROLS - LOCKED

MDC 14

1. PROGRAM - 00
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - ADJUST AS REQUIRED

MDC 2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - ADJUST AS REQUIRED
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

NOTE: Although this procedure would not normally be employed unless there has been a failure in the G&N, on SC 012 this method will be tested with the G&N on to monitor the performance. For later applications the G&N may be off. The variable items in this procedure are marked with an *.

MDC 22

1. IMU HTR-MNA - CLOSED
2. IMU HTR-MNB - CLOSED
*3. IMU-MNA - CLOSED
*4. IMU-MNB - CLOSED
*5. COMPUTER-MNA - CLOSED
*6. COMPUTER-MNB - CLOSED
7. OPTICS-MNA - OPEN
8. OPTICS-MNB - OPEN
*9. G&N AC POWER-AC 1 - CLOSED
*10. G&N AC POWER-AC 2 - CLOSED
11. G&N AC POWER-AC 1

LEB NAV STATION SWITCHES

1. FLOODLIGHT CONTROL PRIMARY - OFF
2. FLOODLIGHT CONTROL SECONDARY - OFF
*3. PANEL BRIGHTNESS CONTROL - } ADJUST AS REQUIRED
*4. AGC BRIGHTNESS CONTROL - } ADJUST AS REQUIRED
5. IMU TRANSFER - COMPUTER
6. OPTICS SLAVE TELESCOPE - STAR LOS
7. OPTICS MODE - ZERO OPTICS
8. OPTICS HOLD - OFF
9. OPTICS CONTROLLER SPEED - HIGH
10. OPTICS CONTROLLER MODE - DIRECT
11. IMU TEMP. MODE - AUTO OVERRIDE
12. AGC MODE - ON
*13. ATTITUDE IMPULSE ENABLE - OFF
*14. CONDITION LAMPS - ON

10.24.2 Obtain from MSFN the following data:

a. External visual references (stars and/or landmarks) for gross + X orientation.

b. Telescope shaft and trunnion angles to be used.

c. Star pair to be used and star pair location required in the field of view.

10.24.3 Review on board star charts and landmark reference data.

10.24.4 Use procedure 10.18, SC maneuver to External Reference, to orient the SC to the gross + X orientation required.

10.24.5 Select minimum deadband during the maneuver.

10.24.6 Repin the rotation control at the left seat.

10.24.7 Move to the navigation station.

10.24.8* Enter V16N20E on the LEB DSKY.

10.24.9 Set the given shaft and trunnion angles on the telescope manually. (If the optics drive is working, use the optics drive control after calling for the closure of the two optics circuit breakers on MDC 22).

10.24.10 Through the telescope identify the key star pair and note their location in the field of view.

10.24.11 If necessary unpin the rotation control and adjust vehicle attitude to bring the correct star near the center and the second star near the R or M line.

10.24.12 Repin the rotation control.

10.24.13 Turn on the attitude impulse control enable switch.

10.24.14 Using the minimum impulse control adjust vehicle rates to cause the precise location required of the stars.

10.24.15 Return the minimum impulse control enable switch to OFF at the time that the stars are exactly located.

10.24.16 Read and record the Roll, Pitch, and Yaw angles on R1, R2, and R3 then enter V34E on the LEB DSKY.

NOTE: In the case where the G&N is operative 10.24.4 - 10.24.7 would be deleted and replaced by the following:

a. Perform a IMU Align at the attitude required for the delta V (Procedure 10.45, IMU Align).

b. At the completion of the IMU align offset the vehicle ≈ 5 degree per axis from the fine align attitude using the rotation control at the lower equipment bay.

c. Continue with step 10.24.8.

10.25 Manual On/SCS Off SPS Thrust Control Contingency.

NOTE: This procedure covers the second level control method for initiating and terminating SPS engine on commands. To verify its performance it will be used on the second SPS burn as a normal procedure to turn the SPS engine both on and off while the G&N provides attitude control signals.

10.25.1 Verify the following steps.

a. Sufficient ullage has occurred and ullage is present.

b. The SPS Rough Engine ECO light and the master caution and warning light have not come on.

c. The IMU/Computer/CDU's are providing good control signals.

d. At least 10 seconds past the SPS on time have elapsed.

e. SPS ignition has not occurred.

10.25.2 Depress the thrust on pushbutton on MDC 7. (Following a successful manual ignition the SCS will provide an automatic engine off).

10.25.3 Watch for the light behind the thrust on pushbutton on MDC 7 to go out at the time the delta V remaining counter reads 00000.

10.25.4 Place the normal/Off/Direct On switch on MDC 7 to Off.

10.26 Direct ON/OFF SPS Control Contingency.

NOTE: This procedure covers the third level control method for initiating and terminating SPS engine on commands. To verify its performance it will be used on the first burn as a normal procedure to turn the SPS engine both on and off. It is the emergency off control for all cases. When neither of the two normal SPS on methods work it may also be used for SPS engine on.

10.26.1 SPS Direct on switching is accomplished by lifting the lever locked Normal/Off/Direct on switch on MDC 7 up from its normal position of off to unlock it and then placing it to the Direct On position.

10.26.2 SPS Direct off switching is accomplished by returning the Normal/Off/Direct On switch on MDC 7 from either the Normal or Direct On position to the Off position to the Off position.

10.26.3 The Direct On and Off switching by the Navigator should be in response to the illumination and then darking of the lights behind the thrust on pushbutton on MDC 7 for the first burn.

10.27 Application of Direct Ullage.

NOTE: At any time in preparation for a velocity change when there is no response to + X command from the translation control the Direct Ullage control path should be used. The use of the redundant translation control will not correct for some wiring and electronic failures. The direct ullage control path provides for ullage (SPS propellant settling) without unacceptable time delays. This emergency path will be demonstrated in conjunction with the first burn. An undesirable side effect is that the pitch and yaw attitude errors and rates at time of SPS ignition will be larger than from a normal ullage.

10.27.1 If there is no response to a + X command from the translation control, the Direct Ullage pushbutton on MDC 7 should be depressed by the pilots right hand until $\approx$ 1 second after SPS engine ignition, at which time it should be released.

10.28 Application of Direct Rotation Control.

NOTE: Direct rotation control may be substituted for proportional rate control in any of the manual maneuver procedures. Several switching conditions must be changed to accomplish this and they are described below. Exact initial and final switch conditions will depend upon the basic procedure in use and those requirements will override any final switch positions given in this procedure. Direct rotation control is intended for use in the case where either G&N or SCS failures preclude automatic control in any single axis and will not normally be used other than for the single demonstration application called out in the G&C Event Timeline.

10.28.1 Direct RCS switch on MDC 8 to on.

10.28.2 Channel enable switches to off (MDC 8).

a. A&C Roll

b. B&D Roll

c. Pitch

d. Yaw

10.28.3 Unpin the pilots rotation control.

10.28.4 Displace the rotation control into the stop in the appropriate direction to establish the desired rate of change. These signals are acceleration signals going directly to the RCS. Care must be exercised to prevent leaving the rotation control in the stop too long as too high a rate will develop. As each axis approaches the desired attitude the rate must be removed by an equal opposite command.

10.28.5 The channel enable switches in step 10.28.2 that were on should be returned to on to re-establish attitude hold.

10.28.6 Direct RCS switch on MDC 8 to off.

10.28.7 Repin the rotation control.

10.29 CM RCS System A Propellant Deletion and/or Insufficient Pitch and/or Yaw Rate Damping.

NOTE: Undetectable failures within the SCS, RCS, wiring, and/or unplanned atmospheric condition can cause premature depletion of the System A CM RCS propellant. For any of these causes, the same corrective action applied.

10.29.1 Direct RCS control should be applied in the affected axis/axes to continue the entry.

10.30 RCS Deorbit (G&N Operative).

10.30.1 Confirm or select the following switch positions:

MDC 8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - ON
3. ATTITUDE DEADBAND - MAXIMUM
4. .05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - OFF
7. G&N/SCS - G&N
8. ATTITUDE/MONITOR/ENTRY - ATTITUDE
9. A&C ROLL CHANNEL - OFF
10. B&D ROLL CHANNEL - ON
11. PITCH CHANNEL - ON
12. YAW CHANNEL - ON
13. ROLL RATE GYRO - NORMAL
14. PITCH RATE GYRO - NORMAL
15. YAW RATE GYRO - NORMAL

MDC 25

1. FDAI LTG - AC 1
2. GROUP 1-AC 1 - CLOSED
3. GROUP 1-AC 2 - CLOSED
4. GROUP 2-AC 1 - CLOSED
5. GROUP 2-AC 2 - CLOSED
6. GROUP 1-MNA - CLOSED
7. GROUP 1-MNB - CLOSED
8. GROUP 2-MNA - CLOSED
9. GROUP 2-MNB - CLOSED
10. DIRECT CONTROL-MNA - CLOSED
11. DIRECT CONTROL-MNB - CLOSED
12. A&C ROLL-MNA - CLOSED
13. A&C ROLL-MNB - CLOSED
14. B&D ROLL-MNA - CLOSED
15. B&D ROLL-MNB - CLOSED
16. PITCH-MNA - CLOSED
17. PITCH-MNB - CLOSED
18. YAW-MNA - CLOSED
19. YAW-MNB - CLOSED
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL-PITCH-BAT A - OPEN
22. GIMBAL MOTOR CONTROL-YAW-BAT A - OPEN

MDC 24

1. SCS POWER - AC 1
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC 3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC 6

ATTITUDE SET - OFF

MDC 7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - PINNED
TRANSLATION CONTROLS - LOCKED

MDC 14

1. PROGRAM - 00
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - ADJUST AS REQUIRED

MDC 2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - ADJUST AS REQUIRED
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

MDC 22

1. IMU HTR-MNA - CLOSED
2. IMU HTR-MNB - CLOSED
3. IMU-MNA - CLOSED
4. IMU-MNB - CLOSED
5. COMPUTER-MNA - CLOSED
6. COMPUTER-MNB - CLOSED
7. OPTICS-MNA - OPEN
8. OPTICS-MNB - OPEN
9. G&N AC POWER-AC 1 - CLOSED
10. G&N AC POWER-AC 2 - CLOSED
11. G&N AC POWER-AC 1

LEB NAV STATION SWITCHES

1. FLOODLIGHT CONTROL PRIMARY - OFF
2. FLOODLIGHT CONTROL SECONDARY - OFF
3. PANEL BRIGHTNESS CONTROL - ADJUST AS REQUIRED
4. AGC BRIGHTNESS CONTROL - ADJUST AS REQUIRED
5. IMU TRANSFER - COMPUTER
6. OPTICS SLAVE TELESCOPE - STAR LOS
7. OPTICS MODE - ZERO OPTICS
8. OPTICS HOLD - OFF
9. OPTICS CONTROLLER SPEED - HIGH
10. OPTICS CONTROLLER MODE - DIRECT
11. IMU TEMP. MODE - AUTO OVERRIDE
12. AGC MODE - ON
13. ATTITUDE IMPULSE ENABLE - OFF
14. CONDITION LAMPS - ON

NOTE: This procedure assures that the IMU has been aligned for entry.

10.30.2 Confirm with MSFN, the following data:

a. GMT time of firing.

b. Actual delta V change required.

c. Firing duration. (seconds)

d. Attitude required for deorbit including initial visual external reference cues to be used, and platform angles with respect to the entry IMU alignment.

10.30.3 Set digital event timer indicator to reach 00 - 00 at time for firing.

10.30.4 Enter V37E21E on the Main DSKY (MDC 14).

10.30.5 Confirm program 21 on MDC 14.

10.30.6 Enter + 18000 in Register 1 and + 00001 in Register 2 on MDC 14.

10.30.7 No new Digital Event Timer Setting will be required so V33E should be entered on MDC 14.

10.30.8 There will be no FDAI align attitude set function with respect to this maneuver. The bypass by kehing V33E should occur in response to the V16N20 Flash.

10.30.9 Note the final maneuver angles display in conjunction with a V06N17 Flash. Confirm that they agree with MSFN data.

R1 - OG ANGLE (ROLL)

R2 - IG ANGLE (PITCH)

R3 - MG ANGLE (YAW).

10.30.10 Set values displayed on attitude set dials.

10.30.11 When ready to maneuver:

a. Limit cycle switch to OFF (MDC 8).

b. Attitude deadband switch to minimum (MDC 8).

c. Navigator PRESS V33E on MDC 14.

10.30.12 Limit cycle switch (MDC 8) to ON after the maneuver.

10.30.13 Confirm SC attitude and local vertical hold functioning through the docking window.

10.30.14 Confirm the local hold on the attitude ball MDC 4 by the gradual pitch rate.

10.30.15 TVC 1 power switch to AC 1 (MDC 24).

10.30.16 Set delta V remaining counter (MDC 7) to value received from MSFN using the delta V set switch.

10.30.17 Unlock both the prime and alternate translation controls.

10.30.18 Unpin the rotation control.

10.30.19 Direct RCS switch to ON (MDC 8).

10.30.20 Place left hand on prime translation control and right hand on Limit Cycle switch (MDC 8). At time when digital event timer reaches 00 - 00 initiate + X command and place Limit Cycle Switch to OFF (MDC 8).

10.30.21 Monitor on the FDAI (MDC 4) the automatic attitude hold function.

a. The rate indicators should remain at or near null.

b. The attitude error indicators should remain at or near null.

c. Yaw should read 0 degrees and roll should read degrees on the attitude ball.

d. A gradual pitching maneuver will be seen on the attitude ball ($\approx$ 20 degrees pitch change).

10.30.22 When the delta V remaining indicator read 00000 terminate the + X command. (The elapsed time on the digital event timer can be used as a check for cutoff. The delta V remaining counter should show a fairly steady decrease during the presence of the + X command).

10.30.23 Attitude deadband switch to maximum (MDC 8).

10.30.24 Limit cycle switch to ON (MDC 8).

10.30.25 Relock the translation controls.

10.30.26 TVC 1 power switch OFF (MDC 24).

10.30.27 Enter V37E00E on (MDC 14).

10.30.28 Procedure 10.46, AGC Update should occur next to revise the state vector data in the computers.

10.30.29 Procedure 10.14 CM-SM Separation Orientation and Separation Procedure is the next step.

10.31 Earth Orbit Landmark Navigation Procedure While Still Attached to the S-IVB. While the CSM is still attached to the S-IVB, the vehicle attitude is controlled by the S-IVB to allow CSM IMU alignments and navigation sights. This procedure should only be performed just after an IMU align and a S-IVB maneuver to the proper vehicle attitude for navigation sightings.

10.31.1 Confirm or select the following switch conditions:

MDC 8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - OFF
3. ATTITUDE DEADBAND - MAXIMUM
4. .05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - OFF
7. G&N/SCS - SCS
8. ATTITUDE/MONITOR/ENTRY - MONITOR
9. A&C ROLL CHANNEL - OFF
10. B&D ROLL CHANNEL - OFF
11. PITCH CHANNEL - OFF
12. YAW CHANNEL - OFF
13. ROLL RATE GYRO - BMAG
14. PITCH RATE GYRO - BMAG
15. YAW RATE GYRO - BMAG

MDC 25

1. FDAI LTG - OFF
2. GROUP 1-AC 1 - CLOSED
3. GROUP 1-AC 2 - CLOSED
4. GROUP 2-AC 1 - CLOSED
5. GROUP 2-AC 2 - CLOSED
6. GROUP 1-MNA - CLOSED
7. GROUP 1-MNB - CLOSED
8. GROUP 2-MNA - CLOSED
9. GROUP 2-MNB - CLOSED
10. DIRECT CONTROL-MNA - CLOSED
11. DIRECT CONTROL-MNB - CLOSED
12. A&C ROLL-MNA - CLOSED
13. A&C ROLL-MNB - CLOSED
14. B&D ROLL-MNA - CLOSED
15. B&D ROLL-MNB - CLOSED
16. PITCH-MNA - CLOSED
17. PITCH-MNB - CLOSED
18. YAW-MNA - CLOSED
19. YAW-MNB - CLOSED
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL-PITCH-BAT A - OPEN
22. GIMBAL MOTOR CONTROL-YAW-BAT A - OPEN

MDC 24

1. SCS POWER - OFF
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC 3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC 6

ATTITUDE SET - OFF

MDC 7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - PINNED
TRANSLATION CONTROLS - LOCKED

MDC 14

1. PROGRAM - 00
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - ADJUST AS REQUIRED

MDC 2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - OFF
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

MDC 22

1. IMU HTR-MNA - CLOSED
2. IMU HTR-MNB - CLOSED
3. IMU-MNA - CLOSED
4. IMU-MNB - CLOSED
5. COMPUTER-MNA - CLOSED
6. COMPUTER-MNB - CLOSED
7. OPTICS-MNA - CLOSED
8. OPTICS-MNB - CLOSED
9. G&N AC POWER-AC 1 - CLOSED
10. G&N AC POWER-AC 2 - CLOSED
11. G&N AC POWER-AC 1

LEB NAV STATION SWITCHES

1. FLOODLIGHT CONTROL PRIMARY - ADJUST AS REQUIRED
2. FLOODLIGHT CONTROL SECONDARY - ADJUST AS REQUIRED
3. PANEL BRIGHTNESS CONTROL - ADJUST AS REQUIRED
4. AGC BRIGHTNESS CONTROL - ADJUST AS REQUIRED
5. IMU TRANSFER - COMPUTER
6. OPTICS SLAVE TELESCOPE - STAR LOS
7. OPTICS MODE - ZERO OPTICS
8. OPTICS HOLD - OFF
9. OPTICS CONTROLLER SPEED - HIGH
10. OPTICS CONTROLLER MODE - RESOLVED
11. IMU TEMP. MODE - AUTO OVERRIDE
12. AGC MODE - ON
13. ATTITUDE IMPULSE ENABLE - OFF
14. CONDITION LAMPS - ON

10.31.2 Select from the on board charts the proper earth track chart for this landmark sighting. Procedure 10.32 Ground Track Determination may be used to help select the proper earth track chart. Select three landmarks from the earth track charts. These landmarks should be at least ten degrees (16 NM) off the orbital track.

10.31.3 On the LEB DSKY PRESS V37E22E.

10.31.4 Verify PROGRAM 22 is Displayed on DSKY.

10.31.5 Verify the ISS FINE ALIGN MODE light ON.

10.31.6 Respond to V50N25 Flash with R1 code 00011 as follows:

a. If automatic optics positioning is desired PRESS V33E on the DSKY.

1. Respond to V06N44 Flash by entering: (Five digits must be entered after the sign with zeros being entered first if necessary).

PRESS V25N44E on DSKY

R1 - Landmark Latitude (0.01 Deg.)

R2 - Landmark Longitude (0.01 Deg.)

Rw - Landmark Altitude (0.1 NM)

Verify values in register before PRESSING ENTER last time on DSKY.

2. Respond to V50N25 Flash with R1 code 00013 by placing OPTICS MODE Switch to COMPUTER position and PRESS ENTER push button on DSKY.

3. Monitor V16N57 and drive of optics to Shaft and Trunnion value displayed on DSKY.

R1 - Shaft Angle. (0.01 DEG.)

R2 - Trunnion Angle. (0.001 Deg.)

4. Proceed to step 10.31.7

b. If manual optics positioning is desired PRESS ENTER on DSKY.

1. Set OPTICS MODE Switch to MANUAL.

2. Drive the optics in Trunnion until the structure is just tangent to the Telescopes field of view.

NOTE: V51, Please MARK, will begin to Flash on the DSKY. The Flash will continue until MARKS have been made.

10.31.7 Recognize the landmark. If selected landmarks are not visable pick an unknown landmark.

10.31.8 Verify or set OPTICS MODE Switch to MANUAL.

10.31.9 Set OPTICS CONTROLLER SPEED as required.

10.31.10 Perform one of following:

a. Center desired landmark in Telescope and track.

b. Center unknown landmark in Telescope and switch attention to SXT. Track unknown landmark with SXT.

10.31.11 Press the MARK button whenever the landmark is centered in optics. Repeat MARK at least times or more.

NOTE: Any MARK may be rejected immediately after its execution by PRESSING V52E on the DSKY.

10.31.2 After the landmark passes out of range enter one of the following:

NOTE: The Program Alarm LIGHT, PGNS, condition annunciation and comp fail light have come on due to too many MARKS, if so, PRESS ERROR RESET button on DSKY, V25N44, load landmark data will normally be flashing.

a. If known landmark used enter on DSKY: (Five digits must be entered after the sign with zeros being entered first if necessary).

R1 - Landmark Latitude. (0.01 Deg.)

R2 - Landmark Longitude. (0.01 Deg.)

R3 - Landmark Altitude. (0.1 NM)

Verify values in registers before PRESSING ENTER last time on DSKY.

b. If unknown landmark used, enter zeros in R1, R2, and R3.

R1 - 00000

R2 - 00000

R3 - 00000

10.31.13 Monitor V06N75 Flash and Display of orbital parameter changes as a result of the sighting.

R1 - DELTA POSITION (FEET)

R2 - DELTA VELOCITY (FPS)

Record above in Flight Log.

*10.31.14 If data acceptable PRESS V33E on DSKY.

*10.31.15 If data not acceptable PRESS V34E on DSKY.

* The limits to which the Display in 10.31.13 must be compared with, have not been defined.

10.31.16 Verify DSKY PROGRAM goes to 00.

10.31.17 If additional sightings are to be performed, set the OPTICS CONTROLLER SPEED as required and return to step 10.31.2.

10.31.18 Confirm or select the following switch conditions if no additional sightings are to be performed.

MDC 22

1. OPTICS-MNA - OPEN
2. OPTICS-MNB - OPEN

LEB NAV STATION SWITCHES

1. OPTICS ROTARY - ZERO OPTICS
2. OPTICS CONTROLLER SPEED - HIGH
3. OPTICS CONTROLLER MODE - DIRECT
4. FLOODLIGHT CONTROL PRIMARY - ADJUST AS REQUIRED
5. FLOODLIGHT CONTROL SECONDARY - AS REQUIRED
6. PANEL BRIGHTNESS CONTROL - ADJUST AS REQUIRED
7. AGC BRIGHTNESS CONTROL - ADJUST AS REQUIRED

10.31.19 Perform LEB closeout as required. (Depends on next mission phase).

10.31.20 Procedure 10.33 Orbit Parameter Display may be used at this time if desired.

10.32 Ground Track Determination. The following procedure may be performed any time during the mission when the IMU is aligned and operating. This procedure should not be performed during any Major Program.

10.32.1 Depending on what type of information is desired, key in the following on the DSKY.

a. Time of arrival at a specific Longitude PRESS V65E.

1. Respond to V22N44 Flash by entering the specific Longitude. (+ is east, five digits must be entered after the sign, zeros first).

R1 - Longitude (.01 DEG)

Verify value before PRESSING ENTER ON DSKY.

2. Respond to V25N34 Flash by entering T PERM LONG. (Five digits must be entered after the sign, zeros first).

R1 - HOURS (GMT)

R2 - MINUTES (GMT)

R3 - .01 SECONDS (GMT)

Verify values in registers before PRESSING ENTER last time on DSKY.

3. Monitor V06N34 Flash and DSKY. Display of time of arrival at the specific Longitude after T PERM. Time display will be GMT.

R1 - HOURS (GMT)

R2 - MINUTES (GMT)

R3 - 0.01 SECONDS (GMT)

Record if required.

4. Proceed to step 10.32.2.

b. Latitude and Longitude location at a specific time PRESS V66E.

1. Respond to V25N34 Flash by entering the specific time. (After the sign five digits are required with zeros first).

R1 - HOURS (GMT)

R2 - MINUTES (GMT)

R3 - .01 SECOND (GMT)

Verify values in registers before PRESSING ENTER last time on DSKY.

2. Monitor V06N44 Flash and DSKY Display of Latitude and Longitude location at the specific time. (+ is north and east).

R1 - LATITUDE (0.01 DEG)

R2 - LONGITUDE (0.01 DEG)

Record if Required

3. Proceed to step 10.32.2.

c. Maximum Declination of orbit and time to next maximum after T PERM.

1. Respond to V25N34 Flash by entering T PERM DEC. (Five digits must be entered after the sign, zeros first).

R1 - HOURS (GMT)

R2 - MINUTES (GMT)

R3 - .01 SECOND (GMT)

Verify values in registers before PRESSING ENTER last time on DSKY.

2. Monitor V06N44 Flash with R1 Display of MAX DEC.

R1 - MAX DEC. (.01 DEG)

Record if Required

3. When finished with display PRESS V33E on DSKY.

4. Monitor V06N34 Flash with T MAX DEC after T PERM Display on DSKY.

R1 - HOURS (GMT)

R2 - MINUTES (GMT)

R3 - .01 SECONDS (GMT)

Record if required.

5. Proceed to step 10.32.2.

10.32.2 When completed with use of Display V33E button on DSKY.

10.32.3 Verify VERB-NOUN Flash stops.

10.33 Orbit Parameter Display. The following procedure may be performed any time during the mission when the IMU is aligned and operating. This procedure should not be performed during any Major Program.

10.33.1 On the DSKY PRESS V64E. If deorbit thrusting maneuvers has just been completed proceed to step 10.33.6.

10.33.2 Monitor V16N43 Flash and DSKY Display of Perigee and Apogee Attitude and TFF (only if Perigee Altitude is less than or equal to 300,000 feet, TFF will be 99999 if altitude is greater than 300,000 feet).

R1 - Perigee Altitude (0.1 NM).

R2 - Apogee Altitude (0.1 NM).

R3 - TFF (Min. - Sec).

Record if required

10.33.3 When completed with use of Display PRESS V33E on DSKY.

10.33.4 If TFF was 99999, monitor V06N34 Flash and PERIGEE Display on DSKY.

R1 - HRS

R2 - MINS

R3 - .01 SECS

Record if required

10.33.5 When complete with Display proceed to step 10.33.7.

10.33.6 Monitor V16N64 Flash and DSKY Display.

R1 - LAT. SPLASH (.01 DEG)

R2 - LONG. SPLASH (.01 DEG)

R3 - TFF (MIN. - SEC)

Record if required.

10.33.7 When complete with Display PRESS V33E on DSKY.

10.34 IMU Alignment While Still Attached to the S-IVB. While the CSM is still attached the S-IVB, attitude control is provided by the S-IVB reaction control system. Maneuvers are preprogrammed into the S-IVB computer to allow CSM IMU alignments and navigation sightings. This procedure should not be performed unless the S-IVB is at the proper attitude and there is at least ten minutes before the next S-IVB maneuver. This alignment should also be related time wise with other mission functions.

While the CSM is attached to the S-IVB on Mission SA 204A the IMU will always be in operation.

10.34.1 Confirm or select the following switch conditions.

MDC 8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - OFF
3. ATTITUDE DEADBAND - MAXIMUM
4. .05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - OFF
7. G&N/SCS - SCS
8. ATTITUDE/MONITOR/ENTRY - MONITOR
9. A&C ROLL CHANNEL - OFF
10. B&D ROLL CHANNEL - OFF
11. PITCH CHANNEL - OFF
12. YAW CHANNEL - OFF
13. ROLL RATE GYRO - BMAG
14. PITCH RATE GYRO - BMAG
15. YAW RATE GYRO - BMAG

MDC 25

1. FDAI LTG - OFF
2. GROUP 1-AC 1 - CLOSED
3. GROUP 1-AC 2 - CLOSED
4. GROUP 2-AC 1 - CLOSED
5. GROUP 2-AC 2 - CLOSED
6. GROUP 1-MNA - CLOSED
7. GROUP 1-MNB - CLOSED
8. GROUP 2-MNA - CLOSED
9. GROUP 2-MNB - CLOSED
10. DIRECT CONTROL-MNA - CLOSED
11. DIRECT CONTROL-MNB - CLOSED
12. A&C ROLL-MNA - CLOSED
13. A&C ROLL-MNB - CLOSED
14. B&D ROLL-MNA - CLOSED
15. B&D ROLL-MNB - CLOSED

16. PITCH-MNA - CLOSED
17. PITCH-MNB - CLOSED
18. YAW-MNA - CLOSED
19. YAW-MNB - CLOSED
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL-PITCH-BAT A - OPEN
22. GIMBAL MOTOR CONTROL-YAW-BAT A - OPEN

MDC 24

1. SCS POWER - OFF
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC 3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC 6

ATTITUDE SET - OFF

MDC 7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - PINNED
TRANSLATION CONTROLS - LOCKED

MDC 14

1. PROGRAM - 00
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - ADJUST AS REQUIRED

MDC 2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - OFF
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

MDC 22

1. IMU HTR-MNA - CLOSED
2. IMU HTR-MNB - CLOSED
3. IMU-MNA - CLOSED
4. IMU-MNB - CLOSED
5. COMPUTER-MNA - CLOSED
6. COMPUTER-MNB - CLOSED
7. OPTICS-MNA - OPEN
8. OPTICS-MNB - OPEN
9. G&N AC POWER-AC 1 - CLOSED
10. G&N AC POWER-AC 2 - CLOSED
11. G&N AC POWER-AC 1

LEB NAV STATION SWITCHES

1. FLOODLIGHT CONTROL PRIMARY - ADJUST AS REQUIRED
2. FLOODLIGHT CONTROL SECONDARY - AS REQUIRED
3. PANEL BRIGHTNESS CONTROL - ADJUST AS REQUIRED
4. AGC BRIGHTNESS CONTROL - ADJUST AS REQUIRED
5. IMU TRANSFER - COMPUTER
6. OPTICS SLAVE TELESCOPE - STAR LOS
7. OPTICS MODE - ZERO OPTICS
8. OPTICS HOLD - OFF
9. OPTICS CONTROLLER SPEED - HIGH
10. OPTICS CONTROLLER MODE - DIRECT
11. IMU TEMP. MODE - AUTO OVERRIDE
12. AGC MODE - ON
13. ATTITUDE IMPULSE ENABLE - OFF
14. CONDITION LAMPS - ON

10.34.2 Set up LEB as required to perform this procedure.

10.34.3 Select from the on board charts the proper star field chart for the sighting.

10.34.4 On LEB DSKY PRESS V37E52E.

10.34.5 Verify PROGRAM 52 is Displayed on DSKY.

10.34.6 Verify the ISS FINE ALIGN MODE light ON.

NOTE: The COARSE ALIGN MODE light could come on at this time for 45 seconds. Under normal operation this light should not come on. If the COARSE ALIGN MODE light comes on, this fact should be noted in the Flight Log.

10.34.7 Monitor V06N30 Flash with DSKY Display in R-1.

R1 - Star Code number

Record if required.

a. If star code number is acceptable, PRESS V33E on DSKY.

b. If star code number is not acceptable, perform following:

1. PRESS V21N30 on DSKY.

2. ENTER STAR CODE in R1.

10.34.8 Respond the V50N25 Flash with R1 code 00013 by performing one of the following:

a. If Automatic Optics Positioning is desired:

1. Place OPTICS MODE Switch to COMPUTER position and PRESS ENTER button on DSKY.

2. Monitor V16N57 on DSKY and the following Displays:

R1 - Shaft Angle (.01 DEG)

R2 - Trunnion Angle (.001 DEG)

3. Identify star on the star field chart.

4. Verify Optics have driven to Displayed values.

5. Place OPTICS MODE Switch to MANUAL position.

b. If Manual Positioning desired:

1. Place OPTICS MODE Switch to MANUAL position and PRESS V33E on DSKY.

2. Select two stars on chart that are to be MARKED and will be in the Optics field of view.

10.34.9 V51, Please MARK, will begin to Flash. Flash will continue until MARK is performed.

10.34.10 Recognize star field in Telescope and perform one of the following:

a. If desired star is in the field of view, center star in field of view with Optics Hand Controller by first driving Shaft axis to place star on R line and then driving Trunnion axis to center star.

b. If the selected star is out of the field of view, place OPTICS SLAVE TELESCOPE Switch to OFFSET 25 degrees position. Use the Optics Hand Controller to drive in Shaft until the star is on the R line. Place OPTICS SLAVE TELESCOPE Switch to STAR LOS position. Drive the Optics in Trunnion until the star is centered.

10.34.11 Recognize star in Sextant.

10.34.12 Place OPTICS CONTROLLER SPEED SWITCH as required.

10.34.13 Place OPTICS CONTROLLER MODE Switch to RESOLVED position.

10.34.14 Center star in Sextant using the Optics Hand Controller.

10.34.15 Press MARK button when the star is exactly centered.

NOTE: The MARK may be rejected by ENTERING V52 on the DSKY. If so, repeat step 10.34.14.

10.34.16 Respond to V21N30, FLASH by ENTERING the number of the star MARKED into the DSKY. The star number can be obtained from the star chart if necessary PRESS ENTER after star number is confirmed in R1.

10.34.17 Perform MARK on second star by setting the following switches and returning to step 10.34.7.

a. OPTICS CONTROLLER SPEED Switch to HIGH position.

b. OPTICS CONTROLLER MODE Switch to DIRECT.

10.34.18 Monitor one of the following:

a. V06N05, Data Good and Display of differences between actual and measured angle between MARKED stars in R1.

Record data in Flight Log.

*b. V06N05, Data Bad Flash and Display of differences between actual and measured angle between MARKED stars in R1.

1. Record data in Flight Log.

2. To continue program with this data PRESS V33E ON DSKY.

3. If program should be stopped, change program and exit procedure.

10.34.19 Monitor one of the following:

a. V06N67, Data Good and Display of IMU Gyro torquing angles.

R1 - X GYRO

R2 - Y GYRO

R3 - Z GYRO

Record data in Flight Log.

*b. V06N67, Data Bad Flash and Display of IMU gyro torquing angles.

R1 - X GYRO

R2 - Y GYRO

R3 - Z GYRO

1. Record data in Flight Log.

2. To continue program with this data PRESS V33E on DSKY.

3. If program should be stopped, PRESS V34E on DSKY and exit procedure.

* Acceptable limits for data have not been defined.

10.34.20 Respond to V50N25 Flash and R1 code 00014 by:

a. If Fine Align Check is desired PRESS ENTER on DSKY and return to step 10.34.7.

b. If Fine Align Check will not be performed PRESS V33E on DSKY and verify PROGRAM is 00.

c. Verify ISS FINE ALIGN MODE light is ON.

10.34.21 Closeout the LEB as required, this will be a function of the next mission task.

10.35 Midcourse Navigation Sighting. This procedure should only be performed after a maneuver has been made to center the moon in the Telescopes field of view by using procedure 10.24. (Use the moon as the reference during procedure 10.24).

10.35.1 Confirm or select the following switch conditions:

MDC 8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - ON
3. ATTITUDE DEADBAND - MINIMUM
4. .05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - OFF
7. G&N/SCS - SCS
8. ATTITUDE/MONITOR/ENTRY - ATTITUDE
9. A&C ROLL CHANNEL - } ONE ON, ONE OFF (ONE
10. B&D ROLL CHANNEL - } FOR FULLEST QUAD ON)
11. PITCH CHANNEL - ON
12. YAW CHANNEL - ON
13. ROLL RATE GYRO - NORMAL
14. PITCH RATE GYRO - NORMAL
15. YAW RATE GYRO - NORMAL

MDC 25

1. FDAI LTG - AC 1
2. GROUP 1-AC 1 - CLOSED
3. GROUP 1-AC 2- CLOSED
4. GROUP 2-AC 1 - CLOSED
5. GROUP 2-AC 2 - CLOSED
6. GROUP 1-MNA - CLOSED
7. GROUP 1-MNB - CLOSED
8. GROUP 2-MNA - CLOSED
9. GROUP 2-MNB - CLOSED
10. DIRECT CONTROL-MNA - CLOSED
11. DIRECT CONTROL-MNB - CLOSED
12. A&C ROLL-MNA - } ONE OPEN,
13. A&C ROLL-MNB - } ONE CLOSED
14. B&D ROLL-MNA - } ONE OPEN,
15. B&D ROLL-MNB - } ONE CLOSED
16. PITCH-MNA - } ONE OPEN,
17. PITCH-MNB - } ONE CLOSED
18. YAW-MNA - } ONE OPEN,
19. YAW-MNB - } ONE CLOSED
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL-PITCH-BAT A - OPEN
22. GIMBAL MOTOR CONTROL-YAW-BAT A - OPEN

MDC 24

1. SCS POWER - AC 1
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC 3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC 6

ATTITUDE SET - OFF

MDC 7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - PINNED
TRANSLATION CONTROLS - LOCKED

MDC 14

1. PROGRAM - 00
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - ADJUST AS REQUIRED

MDC 2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - ADJUST AS REQUIRED
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

MDC 22

1. IMU HTR-MNA - CLOSED
2. IMU HTR-MNB - CLOSED
3. IMU-MNA - OPEN
4. IMU-NNB - OPEN
5. COMPUTER-MNA - CLOSED
6. COMPUTER-MNB - CLOSED
7. OPTICS-MNA - CLOSED
8. OPTICS-MNB - CLOSED
9. G&N AC POWER-AC 1 - CLOSED
10. G&N AC POWER-AC 2 - CLOSED
11. G&N AC POWER-AC 1

LEB NAV STATION SWITCHES

1. FLOODLIGHT CONTROL PRIMARY - ADJUST AS REQUIRED
2. FLOODLIGHT CONTROL SECONDARY - AS REQUIRED
3. PANEL BRIGHTNESS CONTROL - ADJUST AS REQUIRED
4. AGC BRIGHTNESS CONTROL - ADJUST AS REQUIRED
5. IMU TRANSFER - COMPUTER
6. OPTICS SLAVE TELESCOPE - STAR LOS
7. OPTICS MODE - ZERO OPTICS
8. OPTICS HOLD - OFF
9. OPTICS CONTROLLER SPEED - HIGH
10. OPTICS CONTROLLER MODE - DIRECT
11. IMU TEMP. MODE - AUTO OVERRIDE
12. AGC MODE - ON
13. ATTITUDE IMPULSE ENABLE - OFF
14. CONDITION LAMPS - ON

10.35.2 Set up LEB as required to perform this procedure.

10.35.3 Select from the onboard charts the lunar landmark and proper star chart.

10.35.4 On LEB DSKY PRESS V37E23E.

10.35.5 Verify PROGRAM 23 is DISPLAYED on DSKY.

10.35.6 V51, Please MARK, will begin to Flash. Flash will continue until MARK is performed.

10.35.7 Recognize lunar landmark in Sextant. If required, center landmark as follows:

a. ENABLE THE ATTITUDE IMPULSE CONTROL.

b. Using the MINIMUM IMPULSE CONTROL adjust vehicle attitude until the lunar landmark is centered.

c. Place ENABLE Switch to OFF.

10.35.8 Place optics mode switch to the MANUAL position.

10.35.9 Perform one of the following:

a. If usable star is in Telescope's field of view do:

1. Place star on R line by driving the Optics in Shaft.

2. Center star in field of view by driving Optics in Trunnion.

b. If no usable star is in Telescope's field of view do:

1. Place TELESCOPE SLAVE SWITCH TO OFFSET 25 degrees.

2. Drive Shaft axis to place star on R line.

3. Place TELESCOPE SLAVE SWITCH to STAR LOS.

4. Drive Trunnion axis to center star.

5. Star charts may be used to make star selection.

10.35.10 Check landmark and star are in Sextant's field of view.

10.35.11 Place OPTICS CONTROLLER MODE Switch at RESOLVED.

10.35.12 ENABLE the ATTITUDE IMPULSE CONTROL.

10.35.13 Superimpose star and landmark by using OPTICS HAND CONTROLLER to move the star and the MINIMUM IMPULSE CONTROL to move the landmark.

NOTE: The star and landmark must be superimposed near or on the center of the field of view or the R line.

10.35.14 PRESS MARK button when alignment is exact.

10.35.15 Respond to V06N57 Flash by:

a. Recording in Flight Log the Displayed Shaft and Trunnion angles.

R1 - SHAFT ANGLE (0.01 DEG)

R2 - TRUNNION ANGLE (.001 DEG)

Confirm with MSFN if possible or hold data until next MSFN contact.

b. When completed with Display PRESS V33E on DSKY.

10.35.16 Respond to V06N34 Flash by:

a. Recording in Flight Log the Displayed GMT

R1 - TIME OF MARK - HOURS

R2 - TIME OF MARK - MINUTES

R3 - TIME OF MARK - 0.01 SECOND

Confirm with MSFN if possible or hold data until next MSFN contact.

b. When completed with Display PRESS V33E on DSKY.

10.35.17 Verify PROGRAM on DSKY is 00.

10.35.18 Close out LEB as required, depends on next mission task.

10.36 Earth Orbit Landmark Navigation.

10.36.1 This procedure should be performed within __ minutes after an IMU Fine Alignment. In this procedure it is assumed that the vehicle is initially in an G&N attitude hold and at a constant attitude relative to the local vertical. Procedure 10.41, G&N Local Vertical, would be used to establish this attitude using a pitch angle of 340 degrees (head up).

10.36.1.1 The navigator would delay calling the G&N Landmark Tracking Program until all presighting tasks have been performed and the vehicle attitude rates have reduced to approximately minimum impulse level. Once the Landmark Tracking Program is called, the vehicle will be placed under SCS attitude hold with free drift in pitch. The pitch rate will be approximately equal to earth rate. The vehicle attitude will remain satisfactory for Landmark Sightings for a minimum of ten minutes.

10.36.1.2 The proper attitude could be prolonged by using the minimum impulse controller to reduce the observed horizon rate in the telescope. This type of attitude control is not recommended unless time or attitude becomes a problem.

10.36.2 Confirm or select the following switch conditions:

MDC-8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - ON
3. ATTITUDE DEADBAND - MAXIMUM
4. 0.05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - OFF
7. G&N/SCS - G&N
8. ATTITUDE/MONITOR/ENTRY - ATTITUDE
9. A&C ROLL CHANNEL - } ONE OFF, ONE ON (SWITCH FOR
10. B&D ROLL CHANNEL - } FULLEST QUAD LEFT ON)
11. PITCH CHANNEL - ON
12. YAW CHANNEL - ON
13. ROLL RATE GYRO - NORMAL
14. PITCH RATE GYRO - BMAG
15. YAW RATE GYRO - NORMAL

MDC-25

1. FDAI LTG - AC 1
2. GROUP 1 - AC 1 - CLOSED
3. GROUP 1 - AC 2 - CLOSED
4. GROUP 2 - AC 1 - CLOSED
5. GROUP 2 - AC 2 - CLOSED
6. GROUP 1 - MNA - CLOSED
7. GROUP 1 - MNB - CLOSED
8. GROUP 2 - MNA - CLOSED
9. GROUP 2 - MNB - CLOSED

10. DIRECT CONTROL - MNA - CLOSED
11. DIRECT CONTROL - MNB - CLOSED
12. A&C ROLL - MNA -
13. A&C ROLL - MNB - } ONE CIRCUIT BREAKER CLOSED FOR
14. B&D ROLL - MNA - } FULLEST QUAD, OTHERS OPEN:
15. B&D ROLL - MNB -

A QUAD - A&C MNA
B QUAD - B&D MNA
C QUAD - A&C MNB
D QUAD - B&D MNB

16. PITCH - MNA - } ONE OPEN -
17. PITCH - MNB - } ONE CLOSED
18. YAW - MNA - } ONE OPEN -
19. YAW - MNB - } ONE CLOSED
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL - PITCH - BAT A - OPEN
22. GIMBAL MOTOR CONTROL - YAW - BAT A - OPEN

MDC-24

1. SCS POWER - AC 1
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC-3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC-6

ATTITUDE SET - OFF

MDC-7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - PINNED
TRANSLATION CONTROLS - LOCKED

MDC-14

1. PROGRAM - 00
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - ADJUST AS REQUIRED

MDC-2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - ADJUST AS REQUIRED
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

MDC-22

1. IMU HTR - MNA - CLOSED
2. IMU HTR - MNB - CLOSED
3. IMU - MNA - CLOSED
4. IMU - MNB - CLOSED
5. COMPUTER - MNA - CLOSED
6. COMPUTER - MNB - CLOSED
7. OPTICS - MNA - CLOSED
8. OPTICS - MNB - CLOSED
9. G&N AC POWER - AC 1 - CLOSED
10. G&N AC POWER - AC 2 - CLOSED
11. G&N AC POWER - AC 1

LEB NAV STATION SWITCHES

1. FLOODLIGHT CONTROL PRIMARY - ADJUST AS REQUIRED
2. FLOODLIGHT CONTROL SECONDARY - ADJUST AS REQUIRED
3. PANEL BRIGHTNESS CONTROL - ADJUST AS REQUIRED
4. AGC BRIGHTNESS CONTROL - ADJUST AS REQUIRED
5. IMU TRANSFER - COMPUTER
6. OPTICS SLAVE TELESCOPE - STAR LOS
7. OPTICS MODE - ZERO OPTICS
8. OPTICS HOLD - OFF
9. OPTICS CONTROLLER SPEED - HIGH
10. OPTICS CONTROLLER MODE - RESOLVED
11. IMU TEMP MODE - AUTO OVERRIDE
12. AGC MODE - ON
13. ATTITUDE IMPULSE ENABLE - OFF
14. CONDITION LAMPS - ON

10.36.3 Select from the onboard charts the proper earth track chart for this landmark sighting. Procedure 10.32 Ground Track Determination may be used to help select the proper earth track chart. Select three landmarks from the earth track charts. These landmarks should be at least ten degrees (16 NM) off the orbital track.

10.36.4 On MDC-8 place the G&N/SCS Switch to the SCS Position.

10.36.5 On the LEB DSKY PRESS V37E22E.

10.36.6 Verify PROGRAM number changes from 21 to 22 on DSKY.

10.36.7 Verify the ISS FINE ALIGN MODE light ON.

10.36.8 Respond to V50N25 Flash with R1 code 00011 as follows:

a. If automatic optics positioning is desired PRESS V33E on the DSKY.

1. Respond to V06N44 Flash by entering the following (Five digits must be entered after the sign with zeros being entered first if necessary).

PRESS V25N44E on DSKY

R1 - Landmark Latitude (0.01 degree)

R2 - Landmark Longitude (0.01 degree)

Rw - Landmark Altitude (0.1 NM)

Verify valves in register before PRESSING ENTER last time on DSKY.

2. Respond to V50N25 Flash with R1 code 00013 by placing OPTICS MODE Switch to COMPUTER position and PRESS ENTER pushbutton on DSKY.

3. Monitor drive of optics to Shaft and Trunnion value displayed on DSKY.

R1 - Shaft Angle (0.01 degree)

R2 - Trunnion Angle (0.01 degree)

b. If manual optics positioning is desired PRESS ENTER on DSKY.

1. Set OPTICS MODE Switch to MANUAL.

2. Drive the optics in Trunnion until the horizon is just tangent to the Telescope's field of view.

NOTE: V51, please MARK, will begin to Flash on the DSKY. The Flash will continue until _____ MARKS have been made.

10.36.9 Recognize the landmark. If selected landmarks are not visable pick an unknown landmark.

10.36.10 Verify or set OPTICS MODE Switch to MANUAL.

10.36.11 Set OPTICS CONTROLLER SPEED as required.

10.36.12 Perform one of following:

a. Center desired landmark in Telescope and track.

b. Center unknown landmark in Telescope and switch attention to SXT. Track unknown landmark with SXT.

10.36.13 Place ATTITUDE ENABLE Switch ON.

10.36.14 Press the MARK button whenever the landmark is centered in optics. Repeat MARK at least _____ times or more.

NOTE: Any MARK may be rejected immediately after its performance by PRESSING V52E on the DSKY.

10.36.15 Place ATTITUDE ENABLE Switch OFF.

10.36.16 On MDC-8 place Pitch Rate Gyro - Normal

10.36.17 After the landmark passes out of range enter one of the following:

NOTE: If program alarm comes on due to TOO MANY MARKS, PRESS ERROR RESET ENTER on DSKY. V25N44, Load Landmark Data will normally be Flashing.

a. If known landmark used enter on DSKY: (Five digits must be entered after the sign with zeros being entered first if necessary).

R1 - Landmark Latitude (0.01 degree)

R2 - Landmark Longitude (0.01 degree)

R3 - Landmark Altitude (0.1 NM)

Verify values in registers before PRESSING ENTER last time on DSKY.

b. If unknown landmark used enter zeros in all registers.

10.36.18 Monitor V06N75 Flash and Display of orbital parameter changes as a result of the sighting.

R1 - DELTA POSITION (FEET)

R2 - DELTA VELOCITY (FPS)

Record above in Flight Log.

10.36.19 * If data acceptable PRESS V33E on DSKY.

10.36.20 * If data not acceptable PRESS V34E on DSKY.

* The limits to which the Display in 10.36.17 must be compared with have not been defined.

10.36.21 Verify DSKY PROGRAM goes to 00.

10.36.22 If additional sightings are to be performed, set the OPTICS CONTROLLER SPEED Switch to high and perform Procedure 10.41, G&N Local Vertical, using a pitch angle of 340 degrees (heads up) and repeat this procedure.

10.36.23 If no additional sightings are to be performed proceed to the next mission task.

10.37 AGC Clock Update.

10.37.1 This procedure requires only that the AGC be ON.

10.37.2 Verify with ground that AGC clock update will be performed.

10.37.3 If UPDATE is to be performed manually proceed to step 10.37.5.

10.37.4 On MDC-14 PLACE UPTEL Switch to ACCEPT POSITION. Proceed to step 10.37.9.

10.37.5 Record from MSFN, the following:

±00XXX (Hours)

±000XX (Minutes)

±0XXXX (0.01 Seconds)

The above represents the amount of change that must be made to the AGC clock to make it correct.

10.37.6 PRESS V55E on DSKY.

10.37.7 ENTER following in sequence

± 00XXX (Hours)

± 000XX (Minutes)

± 0XXXX (0.01 Seconds)

PRESS ENTER button after each value is verified on the DSKY.

NOTE: All signs must be positive to increase clock value, or all negative to decrease clock value.

10.37.8 PRESS KEY RELEASE on DSKY and exit this procedure.

10.37.9 When UPTL light goes out PLACE UPTEL switch to BLOCK position.

10.38 CSM/S-IVB Separation and SLA Photography Attitude Orientation.

10.38.1 Confirm or select the following initial switch positions.

NOTE: The SCS has been in a power down configuration. The G&N System is on, and the IMU has been aligned. The IMU is in fine align and the computer is in idle, i.e. program 00.

MDC 8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - OFF
3. ATTITUDE DEADBAND - MAXIMUM
4. .05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - OFF
7. G&N/SCS - SCS
8. ATTITUDE/MONITOR/ENTRY - MONITOR
9. A&C ROLL CHANNEL - OFF
10. B&D ROLL CHANNEL - OFF
11. PITCH CHANNEL - OFF
12. YAW CHANNEL - OFF
13. ROLL RATE GYRO - BMAG
14. PITCH RATE GYRO - BMAG
15. YAW RATE GYRO - BMAG

MDC 25

1. FDAI LTG - AC 1
2. GROUP 1-AC 1 - CLOSED
3. GROUP 1-AC 2 - CLOSED
4. GROUP 2-AC 1 - CLOSED
5. GROUP 2-AC 2 - CLOSED
6. GROUP 1-MNA - CLOSED
7. GROUP 1-MNB - CLOSED
8. GROUP 2-MNA - CLOSED
9. GROUP 2-MNB - CLOSED
10. DIRECT CONTROL-MNA - CLOSED
11. DIRECT CONTROL-MNB - CLOSED
12. A&C ROLL-MNA - CLOSED
13. A&C ROLL-MNB - CLOSED
14. B&D ROLL-MNA - CLOSED
15. B&D ROLL-MNB - CLOSED
16. PITCH-MNA - CLOSED
17. PITCH-MNB - CLOSED
18. YAW-MNA - CLOSED
19. YAW-MNB - CLOSED
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL-PITCH-BAT A - OPEN
22. GIMBAL MOTOR CONTROL-YAW-BAT A - OPEN

MDC 24

1. SCS POWER - AC 1
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC 3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC 6

ATTITUDE SET - OFF

MDC 7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - PINNED
TRANSLATION CONTROLS - LOCKED

MDC 14

1. PROGRAM - 00
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - ADJUST AS REQUIRED

MDC 2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - ADJUST AS REQUIRED
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

MDC 22

1. IMU HTR-MNA - CLOSED
2. IMU HTR-MNB - CLOSED
3. IMU-MNA - CLOSED
4. IMU-MNB - CLOSED
5. COMPUTER-MNA - CLOSED
6. COMPUTER-MNB - CLOSED
7. OPTICS-MNA - OPEN
8. OPTICS-MNB - OPEN
9. G&N AC POWER-AC 1 - CLOSED
10. G&N AC POWER-AC 2 - CLOSED
11. G&N AC POWER-AC 1

LEB NAV STATION SWITCHES

1. IMU TRANSFER - COMPUTER
2. OPTICS SLAVE TELESCOPE - STAR LOS
3. OPTICS MODE - ZERO OPTICS
4. OPTICS HOLD - OFF
5. OPTICS CONTROLLER SPEED - HIGH
6. OPTICS CONTROLLER MODE - DIRECT
7. IMU TEMP. MODE - AUTO OVERRIDE
8. AGC MODE - ON
9. ATTITUDE IMPULSE ENABLE - OFF
10. CONDITION LAMPS - ON
11. FLOODLIGHT CONTROL PRIMARY - OFF
12. FLOODLIGHT CONTROL SECONDARY - OFF
13. PANEL BRIGHTNESS CONTROL - MAX. DIM.
14. AGC BRIGHTNESS CONTROL - MAX. DIM.

10.38.2 Set the Digital Event Timer to reach 00-00 at S-IVB Separation (03:18:00 Mission Elasped Time).

10.38.3 Check SM RCS pressure and propellant quantities by quad.

10.38.4 On MDC 25 Turn TVC 1 POWER SWITCH TO AC-1.

10.38.5 Adjust the delta V remaining counter on MDC 7 down to read 00010 feet per second using the delta V set switch on the same panel.

10.38.6 Momentarily deflect the FDAI self test switch on MDC 2 to the self test position and confirm that the rate meters deflect 2/3 full scale in the directions indicated: Roll, right; Pitch, up; and Yaw, right on MDC 4.

10.38.7 Place the Pitch, Yaw, and Roll Rate gyro switches on MDC 8 to Normal.

10.38.8 Adjust the attitude set dials on MDC 6 to the following settings: Roll - 0 degree; Pitch; Approximately 8 degrees of negative pitch ahead of the value currently under the entry (⊕) symbol on the FDAI; Yaw - 0 degree.

10.38.9 The navigator should now select program 47 on MDC 14 by pressing V37E47E and confirm that program 00 display ceases and 47 appears in the program display block. (Disregard flash of V50N25, R1 00035 until ready to ullage).

10.38.10 The pilot should depress the FDAI Align pushbutton on MDC 6 releasing it as the pitch value set on the dial is the same as the reading under the entry (⊕) symbol.

10.38.11 At 03:15:00 confirm S-IVB attitude hold establishment by the cessation of the pitching motion on the FDAI. Note the pitch angle reading.

10.38.12 Place the Attitude/Monitor/Entry switch (MDC 8) to Attitude.

10.38.13 The A&C Roll, B&D Roll, Pitch, and Yaw channel enable switches on MDC 8 should now be placed on.

10.38.14 Unlock and unpin the rotation and translation controls.

10.38.15 At 00-15 on the digital event timer the pilot should place his right index finger on the Direct Ullage Pushbutton on MDC 7 and his left hand on the translation control. At the same time the navigator should unlock the switches on MDC 5 and prepare to press ADPT SEP with his left hand on MDC 5 and Enter with his right hand on MDC 14.

10.38.16 At 00-02 the pilot should initiate Direct Ullage and the navigator should press enter (the Verb noun display should switch to V16N13 flashing and the velocity change assumulated will be displayed in R1).

10.38.17 At 00-00 the navigator should press ADPT SEP.

10.38.18 The navigator should momentarily move the RCS SMD switch on MDC 16 to on after pushing ADPT SEP.

10.38.19 At 59-58 the direct ullage command should be terminated and normal ullage (+ X) initiated and continued until the delta V remaining counter reads 00000. (The delta V displayed value on MDC 7 may be cross checked against the R1 display which should read +00010 at this time).

10.38.20 When + X is terminated, the navigator should, after noting the final reading in Register 1, press V33E to allow the computer to go back to program 00.

10.38.21 At the time the delta V remaining counter reaches 00000 and he terminates the $\pm$ X command, the pilot should initiate a plus pitch rate command of 0.5 degrees per second. The rate should be continued until nearing a pitch change of 150 degrees with respect to the pitch angle READING OF STEP 10.38.11 the rotation control should be eased back to neutral at the desired pitch attitude.

10.38.22 Place the limit cycle switch on MDC 8 to ON.

10.38.23 The SLA photography task may now be accomplished.

10.39 Display of IMU Gimbal Angles. The following procedure should only be performed if no major program is in progress in the AGC and the IMU is inertially stabilized.

10.39.1 If the vehicle is under G&N Attitude Hold and the IMU Gimbal Angles are desired without removing G&N Attitude Hold perform the following:

a. PRESS V16N20 on DSKY.

b. Monitor DSKY DISPLAY of IMU Gimbal Angles (these angles will represent the IMU gimbal angle when the FDAI Attitude Error Needles go through null for each axis).

R1 - ROLL (.01 DEG.)

R2 - PITCH (.01 DEG.)

R3 - YAW (.01 DEG.)

c. PRESS V34E on the DSKY, when complete with DSKY Display.

10.39.2 If the vehicle is in free drift, SCS Attitude Hold or G&N Attitude Hold and the IMU Gimbal Angles are desired when no G&N Attitude Hold requirement exists, perform the following:

a. Verify AGC Program is 00. If not perform the following:

1. PRESS V37E00E on DSKY.

2. Verify Program 00 is Displayed on DSKY.

3. Verify the ISS FINE ALIGN MODE light ON.

b. PRESS V16N20E on DSKY.

c. Monitor DSKY DISPLAY of IMU Gimbal Angles.

d. When complete with the Display PRESS V34E on the DSKY.

10.40 Commanding G&N Attitude Hold. The following procedure should only be performed if no major program is in the AGC and the IMU is inertially stabilized.

10.40.1 Verify AGC Program is 00. If not perform the following:

a. PRESS V37E00E on DSKY.

b. Verify Program 00 is Displayed on DSKY.

c. Verify the ISS FINE ALIGN MODE light ON.

10.40.2 Confirm or select the following switch positions.

MDC 8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - ON
3. ATTITUDE DEADBAND - MAXIMUM
4. .05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - OFF
7. G&N/SCS - AS IS
8. ATTITUDE/MONITOR/ENTRY - AS IS
9. A&C ROLL CHANNEL } ONE ON - ONE OFF
10. B&D ROLL CHANNEL } ON FOR FULLEST QUAD ON
11. PITCH CHANNEL - ON
12. YAW CHANNEL - ON
13. ROLL RATE GYRO - AS IS
14. PITCH RATE GYRO - AS IS
15. YAW RATE GYRO - AS IS

MDC 25

1. FDAI LTG - AC 1
2. GROUP 1-AC 1 - CLOSED
3. GROUP 1-AC 2 - CLOSED
4. GROUP 2-AC 1 - CLOSED
5. GROUP 2-AC 2 - CLOSED
6. GROUP 1-MNA - CLOSED
7. GROUP 1-MNB - CLOSED
8. GROUP 2-MNA - CLOSED
9. GROUP 2-MNB - CLOSED
10. DIRECT CONTROL-MNA - CLOSED
11. DIRECT CONTROL-MNB - CLOSED
12. A&C ROLL-MNA - } ONE CIRCUIT BREAKER CLOSED FOR
13. A&C ROLL-MNB - } FULLEST QUAD, OTHERS OPEN:
14. B&D ROLL-MNA - }
15. B&D ROLL-MNB - }

A QUAD - A&C MNA
B QUAD - B&D MNA
C QUAD - A&C MNB
D QUAD - B&D MNB

16. PITCH-MNA - } ONE OPEN -
17. PITCH-MNB - } ONE CLOSED
18. YAW-MNA - } ONE OPEN -
19. YAW-MNB - } ONE CLOSED
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL-PITCH-BAT A - OPEN
22. GIMBAL MOTOR CONTROL-YAW-BAT A - OPEN

MDC 24

1. SCS POWER - AC 1
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC 3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC 6

ATTITUDE SET - OFF

MDC 7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - PINNED
TRANSLATION CONTROLS - LOCKED

MDC 14

1. PROGRAM - 00
2. UPTEL - ACCEPT/BLOCK - BLOCK
3. DSKY BRIGHTNESS - ADJUST AS REQUIRED

MDC 2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - ADJUST AS REQUIRED
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

MDC 22

1. IMU HTR-MNA - CLOSED
2. IMU HTR-MNB - CLOSED
3. IMU-MNA - CLOSED
4. IMU-MNB - CLOSED
5. COMPUTER-MNA - CLOSED
6. COMPUTER-MNB - CLOSED
7. OPTICS-MNA - OPEN
8. OPTICS-MNB - OPEN
9. G&N AC POWER-AC 1 - CLOSED
10. G&N AC POWER-AC 2 - CLOSED
11. G&N AC POWER-AC 1

LEB NAV STATION SWITCHES

1. FLOODLIGHT CONTROL PRIMARY - ADJUST AS REQUIRED
2. FLOODLIGHT CONTROL SECONDARY - ADJUST AS REQUIRED
3. PANEL BRIGHTNESS CONTROL - ADJUST AS REQUIRED
4. AGC BRIGHTNESS CONTROL - ADJUST AS REQUIRED
5. IMU TRANSFER - COMPUTER
6. OPTICS SLAVE TELESCOPE - STAR LOS
7. OPTICS MODE - ZERO OPTICS
8. OPTICS HOLD - OFF
9. OPTICS CONTROLLER SPEED - HIGH
10. OPTICS CONTROLLER MODE - DIRECT
11. IMU TEMP. MODE - AUTO OVERRIDE
12. AGC MODE - ON
13. ATTITUDE IMPULSE ENABLE - OFF
14. CONDITION LAMPS - ON

10.40.3 On MDC PLACE G&N/SCS switch to G&N POSITION.

10.40.4 ON MDC PLACE ATTITUDE/MONITOR/ENTRY switch to ATTITUDE POSITION.

10.40.5 PRESS V44E on DSKY.

10.40.6 Verify the ISS ATT CONT MODE light ON.

10.40.7 Confirm Attitude Hold by monitoring the FDAI or external references.

10.40.8 A maneuver may not be performed with the above switch configuration. Reference procedures 10.12, 10.13, and 10.18 for maneuvers. Repeat this procedure after the maneuver if necessary.

10.41 G&N Local Vertical. This procedure can only be performed if the IMU is on and the AGC knows the inertial orientation of the IMU.

10.41.1 If G&N Attitude Hold is present proceed to Step 10.41.2. If not, Verify AGC is in Program 00. If not, perform the following:

NOTE: Program 00 would not normally be selected if there is another program in progress.

a. PRESS V37E00E ON DSKY.

b. Verify the ISS FINE ALIGN MODE light ON.

c. Verify Program 00 is DISPLAYED on DSKY.

10.41.2 Confirm or select the following switch conditions:

MDC 8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - OFF
3. ATTITUDE DEADBAND - MAXIMUM
4. .05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - OFF
7. G&N/SCS - AS IS
8. ATTITUDE/MONITOR/ENTRY - AS IS
9. A&C ROLL CHANNEL - } ONE OFF, ONE ON (SWITCH
10. B&D ROLL CHANNEL - } FOR FULLEST QUAD LEFT ON)
11. PITCH CHANNEL - ON
12. YAW CHANNEL - ON
13. ROLL RATE GYRO - AS IS
14. PITCH RATE GYRO - AS IS
15. YAW RATE GYRO - AS IS

MDC 25

1. FDAI LTG - AC 1
2. GROUP 1-AC 1 - CLOSED
3. GROUP 1-AC 2 - CLOSED
4. GROUP 2-AC 1 - CLOSED
5. GROUP 2-AC 2 - CLOSED
6. GROUP 1-MNA - CLOSED
7. GROUP 1-MNB - CLOSED
8. GROUP 2-MNA - CLOSED
9. GROUP 2-MNB - CLOSED
10. DIRECT CONTROL-MNA - CLOSED
11. DIRECT CONTROL-MNB - CLOSED
12. A&C ROLL-MNA - CLOSED
13. A&C ROLL-MNB - CLOSED

14. B&D ROLL-MNA - CLOSED
15. B&D ROLL-MNB - CLOSED
16. PITCH-MNA - CLOSED
17. PITCH-MNB - CLOSED
18. YAW-MNA - CLOSED
19. YAW-MNB - CLOSED
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL-PITCH-BAT A - OPEN
22. GIMBAL MOTOR CONTROL-YAW-BAT A - OPEN

MDC 24

1. SCS POWER -AC 1
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC 3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC 6

ATTITUDE SET - OFF

MDC 7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - PINNED
TRANSLATION CONTROLS - LOCKED

MDC 14

1. UPTEL - ACCEPT/BLOCK - BLOCK
2. DSKY BRIGHTNESS - ADJUST AS REQUIRED

MDC 2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - ADJUST AS REQUIRED
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

MDC 22

1. IMU HTR-MNA - CLOSED
2. IMU HTR-MNB - CLOSED
3. IMU-MNA - CLOSED
4. IMU-MNB - CLOSED
5. COMPUTER-MNA - CLOSED
6. COMPUTER-MNB - CLOSED
7. OPTICS-MNA - OPEN
8. OPTICS-MNB - OPEN
9. G&N AC POWER-AC 1 - CLOSED
10. G&N AC POWER-AC 2 - CLOSED
11. G&N AC POWER-AC 1

LEB NAV STATION SWITCHES

1. FLOODLIGHT CONTROL PRIMARY - ADJUST AS REQUIRED
2. FLOODLIGHT CONTROL SECONDARY - ADJUST AS REQUIRED
3. PANEL BRIGHTNESS CONTROL - ADJUST AS REQUIRED
4. AGC BRIGHTNESS CONTROL - ADJUST AS REQUIRED
5. IMU TRANSFER - COMPUTER
6. OPTICS SLAVE TELESCOPE - STAR LOS
7. OPTICS MODE - ZERO OPTICS
8. OPTICS HOLD - OFF
9. OPTICS CONTROLLER SPEED - HIGH
10. OPTICS CONTROLLER MODE - DIRECT
11. IMU TEMP. MODE - AUTO OVERRIDE
12. AGC MODE - ON
13. ATTITUDE IMPULSE ENABLE - OFF
14. CONDITION LAMPS - ON

10.41.3 PRESS V37E21E ON DSKY.

10.41.4 Verify Program 21 is DISPLAYED on DSKY.

10.41.5 Respond to V25N06 Flash by Entering desired local vertical vehicle attitude as follows:

a. ENTER PITCH ANGLE - Angle measured positively going up from forward local horizontal to spacecraft + X axis (.01 DEG). (Enter must be five digits with zeros entered first, if necessary).

R1 - PITCH ANGLE (.01 DEG)

b. ENTER HEADS UP OR DOWN

R2 - + 00001 (HEADS UP)

- - 00001 (HEADS DOWN)

Verify data in R1 and R2 before ENTER button is pushed during R2 load.

10.41.6 Respond to V16N36 Flash with time to gimbal lock DISPLAY in R1 as follows:

R1 - TIME TO GIMBAL LOCK (MIN - SEC)

a. If R1 Display is 00000 gimbal lock is not a problem. PRESS V33E on DSKY.

b. If local vertical is not desired if gimbal lock is possible, select another Program (V36E E).

c. If local vertical is desired for period greater than R1 Display, perform Procedure 10.45, IMU ALIGNMENT.

d. If local vertical is desired for period shorter than R1 Display, PRESS V33E on DSKY. (The DET may be set if desired and the FDAI must be monitored to prevent gimbal lock).

10.41.7 If G&N Attitude Control is not present, respond to V50N25 Flash with R1 code 00001 by PRESSING V33E on DSKY and selecting the following:

a. G&N/SCS Switch to G&N

b. ATTITUDE/MONITOR/ENTRY to ATTITUDE

10.41.8 Respond to V16N20 Flash and DSKY DISPLAY OF PRESENT CDU GIMBAL ANGLES by PRESSING V33E on DSKY.

R1 - OG ROLL (.01 DEG)

R2 - IG PITCH (.01 DEG)

R3 - MG YAW (.01 DEG)

10.41.9 Respond to V06N17 Flash and DSKY DISPLAY of Gimbal Angles desired at the end of the maneuver as follows:

R1 - OG ROLL(.01 DEG)

R2 - IG PITCH (.01 DEG)

R3 - MG YAW(.01 DEG)

a. Limit Cycle Switch - OFF.

b. PRESS V33E on the DSKY.

c. Monitor FDAI to check that maneuver is toward the ICDU values displayed on DSKY and gimbal lock is avoided.

d. Monitor Rate Needles indicate $\approx$ .5 degrees per second maneuver rate.

e. When final attitude is obtained place Limit Cycle Switch ON.

10.41.10 Monitor Pitch rate on the attitude ball of the FDAI (approximately 4 degrees per minute).

10.41.11 Select the following switch positions.

MDC 25

1. A&C ROLL-MNA -
2. A&C ROLL-MNB -
3. B&D ROLL-MNA -
4. B&D ROLL-MNB -

} ONE CIRCUIT BREAKER CLOSED FOR FULLEST QUAD, OTHERS OPEN.

A QUAD - A&C MNA
B QUAD - B&D MNA
C QUAD - A&C MNB
D QUAD - B&D MNB

5. PITCH-MNA - } ONE OPEN -
6. PITCH-MNB - } ONE CLOSED
7. YAW-MNA - } ONE OPEN -
8. YAW-MNB - } ONE CLOSED

10.41.12 When complete with local vertical requirement, change Program by Pressing V37E_ _ E on DSKY.

10.42 Orbit Change and SPS Minimum Impulse Prethrusting. This procedure will be performed at least twice for each thrusting maneuver. Once after the initial MSFN UPDATE of thrusting parameters and once prior to the burn while in contact with MSFN for final confirmation of thrusting parameters. AGC is required ON to perform the following.

10.42.1 On the DSKY PRESS V37E *E.

10.42.2 Verify PROGRAM * is Displayed on DSKY.

* 31 if data load for orbit change.

33 if data load for SPS minimum impulse.

10.42.3 Monitor V06N34 Flash and DSKY Display:

R1 - TIG (HRS) (GMT)

R2 - TIG (MIN) (GMT)

R3 - TIG (.01 SEC) (GMT)

Compare Display with onboard recording of MSFN data and perform the following:

a. If Display is correct PRESS V33E on the DSKY.

b. If Display is not correct PRESS V25N34 on DSKY and ENTER correct data: (Five digits must be entered after the sign with zeros being entered first).

R1 - TIG (HRS) (GMT)

R2 - TIG (MIN) (GMT)

R3 - TIG (.01 SEC) (GMT)

Verify values in registers before PRESSING ENTER last time on DSKY.

10.42.4 Monitor V06N44 Flash and DSKY Display:

R1 - LATITUDE (.01 DEG)

R2 - LONGITUDE (.01 DEG)

R3 - ALTITUDE (.01 NM)

(+ is east or north)

Compare Display with onboard recording of MSFN data and perform the following:

a. If Display is correct PRESS V33E on the DSKY.

b. If Display is not correct PRESS V25N44 on DSKY and ENTER correct data: (Five digits must be entered after the sign with zeros being entered first; if necessary).

R1 - LATITUDE (.01 DEG)

R2 - LONGITUDE (.01 DEG)

R3 - ALTITUDE (0.1 NM)

(+ is east or north)

Verify values in registers before PRESSING ENTER last time on DSKY.

10.42.5 Monitor V06N45 Flash and DSKY Display of desired orbit period.

R1 - HR

R2 - MINS

R3 - SECS (.01 SEC)

Compare Display with onboard recording of MSFN data and perform the following:

a. If Display is correct PRESS V33E on the DSKY.

b. If Display is not correct PRESS V25N45 on DSKY and ENTER correct data: (Five digits must be entered after the sign with zeros being entered first).

R1 - HR

R2 - MINS

R3 - SECS (.01 SEC)

Verify values in registers before PRESSING ENTER last time on DSKY.

10.42.6 Monitor V06N70 Flash and DSKY Display:

R1 - PITCH TRIM (0.01 DEG)

R2 - YAW TRIM (0.01 DEG)

R3 - DELTA V TAILOFF (FT/SEC)

Compare Display with onboard recording of MSFN data and perform the following:

a. If Display is correct PRESS V33E on the DSKY.

b. If Display is not correct, PRESS V25N70 on DSKY and ENTER correct data: (Five digits must be entered after the sign with zeros being entered first).

R1 - PITCH TRIM (0.01 DEG)

R2 - YAW TRIM (0.01 DEG)

R3 - DELTA V TAILOFF (FT/SEC)

Verify values in registers before PRESSING ENTER last time on DSKY.

10.42.7 (Only for Program 33, SPS Minimum Impulse Prethrusting Data Load)

Monitor V06N35 Flash and DSKY Display:

R1 - DELTA T BURN (HRS)

R2 - DELTA T BURN (MINS)

R3 - DELTA T BURN (.01 SECS)

Compare Display with onboard recording of MSFN data and perform the following:

a. If Display is correct PRESS V33E on the DSKY.

b. If Display is not correct PRESS V25N35 on DSKY and ENTER correct data. (Five digits must be entered after the sign with zeros being entered first).

R1 - DELTA T BURN (HRS)

R2 - DELTA T BURN (MINS)

R3 - DELTA T BURN (.01 SECS)

Verify values in registers before PRESSING ENTER last time on DSKY.

NOTE: If the data in steps 10.42.4, 5, 6, 7, or 8 was found to be incorrect after on AGC update by the MSFN UPLINK, this fact should be noted and passed on to the ground as soon as possible.

10.42.8 Monitor V06N45 Flash and DSKY Display.

R1 - Perigee Altitude (0.1 NM)

R2 - Apogee Altitude (0.1 NM)

R3 - Delta V Required (FT/SEC)

Confirm above with MSFN if contact is available or with MSFN data recorded during a previous contact.

NOTE: Verification of the unit thrust vector and earth centered radius vector direction at ignition will also be made at this time. The magitude of plane change that will result from this burn must also be displayed for verification. At present the MIT program does not provide a display of the above information to the operation, but displays are being requested.

10.42.9 Perform one of the following:

a. If data Displayed in 10.42.8 is acceptable PRESS V33E on the DSKY.

b. If data Displayed in 10.42.8 is not in agreement with MSFN Data, contact MSFN for evaluation of the G&N computations. Perform thrusting as directed by MSFN. Continue procedure if MSFN contact is not presently available, noting additional errors.

10.42.10 Monitor V06N35 Flash and DSKY Display:

R1 - TTI - (HRS)

R2 - TTI - (MINS)

R3 - TTI - (0.01 SECS)

10.42.11 Set TTE clock and DET using time Display in step 10.42.10.

PRESS V33E on DSKY when finished with Display in step 10.42.10.

NOTE: It may not be possible to set the DET due to Display being greater than 60 minutes. In this case there will be another TTI Display in Program 41 or 43 to allow setting of the DET.

10.42.12 Monitor V06N14 Flash and DSKT Display:

R1 - Delta V (SCS) (FT/SEC)

a. Record Delta V (SCS) value for use later to set Delta V Remaining Counter.

b. Compare Display with onboard recording of MSFN data.

c. When complete with Display PRESS V33E on DSKY.

10.42.13 Respond to V50N07 Flash with R1 code 00051 by PRESSING V37E00E on DSKY.

10.42.14 Verify Program 00 on DSKY.

10.42.15 Verify ISS FINE ALIGN MODE light is ON.

10.43 Deorbit Prethrusting. This procedure will be performed at least twice for the deorbit maneuver. Once after the initial MSFN UPDATE of thrusting parameters and once prior to the burn while in contact with MSFN for final confirmation of thrusting parameters. AGC is required ON to perform the following:

10.43.1 On the DSKY PRESS V37E32E.

10.43.2 Verify PROGRAM 32 is DISPLAYED on DSKY.

10.43.3 Monitor V06N44 Flash and DSKY Display of landing point.

R1 - LATITUDE (.01 DEG)

R2 - LONGITUDE (.01 DEG)

(+ is east or north)

Compare Display with onboard recording of MSFN data and perform the following:

a. If Display is correct PRESS V33E on the DSKY.

b. If Display is not correct PRESS V24N44 on DSKY and ENTER correct data: (Five digits must be entered after the sign with zeros being entered first).

R1 - LATITUDE (.01 DEG)

R2 - LONGITUDE (.01 DEG)

Verify values in registers before PRESSING ENTER last time on DSKY.

10.43.4 Monitor V06N12 Flash and DSKY Display:

R1 - Delta V ALLOW (FT/SEC)

Compare Display with onboard recording of MSFN data and perform the following:

a. If Display is correct PRESS V33E on the DSKY.

b. If Display is not correct PRESS V24N12 on DSKY and ENTER correct data: (Five digits must be entered after the sign with zeros being entered first).

R1 - Delta V ALLOW (FT/SEC)

Verify values in register before PRESSING ENTER last time on DSKY.

10.43.5 Monitor V06N70 Flash and DSKY Display:

R1 - PITCH TRIM (0.01 DEG)

R2 - YAW TRIM (0.01 DEG)

R3 - DELTA V TAILOFF (FT/SEC)

Compare Display with onboard recording of MSFN data and perform the following:

a. If Display is correct PRESS V33E on the DSKY.

b. If Display is not correct PRESS V24N70 on DSKY and ENTER correct data: (Five digits must be entered after the sign with zeros being entered first).

R1 - PITCH TRIM (0.01 DEG)

R2 - YAW TRIM (0.01 DEG)

R3 - DELTA V TAILOFF (FT/SEC)

Verify values in registers before PRESSING ENTER last time on DSKY.

10.43.6 Monitor V06N34 Flash and DSKY Display of earliest permissible time for SPS ignition.

R1 - TIG PERM (HRS)

R2 - TIG PERM (MINS)

R3 - TIG PERM (0.01 SECS)

Compare Display with onboard recording of MSFN data and perform the following:

a. If Display is correct PRESS V33E on the DSKY.

b. If Display is not correct PRESS V25N34 on DSKY and ENTER correct data: (Five digits must be entered after the sign with zeros being entered first).

R1 - TIG PERM (HRS)

R2 - TIG PERM (MINS)

R3 - TIG PERM (0.01 SECS)

Verify values in registers before PRESSING ENTER last time on DSKY.

NOTE: If the data in steps 10.43.4, 5, 6, or 7 was found to be incorrect after an AGC update by the MSFN UPLINK, this fact should be noted and passed on to the ground as soon as possible.

10.43.7 Monitor V06N34 Flash and DSKY Display:

R1 - TIG (HRS)

R2 - TIG (MINS)

R3 - TIG (0.01 SECS)

Confirm above with MSFN if possible or record for confirmation later but prior to the burn.

10.43.8 PRESS V33E on DSKY.

10.43.9 Monitor V06N47 Flash and DSKY Display:

R1 - GAMMA I (0.01 DEG)

R2 - DELTA R (0.1 NM)

Confirm above with MSFN if contact is available or with MSFN DATA recorded during a previous contact.

NOTE: Verification of the unit thrust vector and earth centered radius vector direction at ignition will also be made at this time. At present the MIT program does not provide a display of this information to the operator, but displays are being requrested.

10.43.10 Perform one of the following:

a. If data Displayed in 10.43.7 and 9 is acceptable PRESS V33E on the DSKY.

c. If data Displayed in 10.43.7 and 9 is not in agreement with MSFN DATA, contact MSFN for evaluation of the G&N computations. Perform thrusting as directed by MSFN. Continue procedure if MSFN contact is not presently available, noting additional errors.

10.43.11 Monitor V06N35 Flash and DSKY Display:

R1 - TTI (HRS)

R2 - TTI (MINS)

R3 - TTI (0.01 SECS)

10.43.12 Set TTE clock and DET using time Display in step 10.43.11 PRESS V33E on DSKY when finished with Display in step 10.43.11.

NOTE: It may not be possible to set the DET due to Display being greater than 60 minutes. In this case there will be another TTI Display in P-41 to allow setting of the DET.

10.43.13 Monitor V06N14 Flash and DSKY Display:

R1 - Delta V (SCS) (FT/SEC)

a. Record Delta V (SCS) value for use later to set Delta V remaining counter.

b. Compare Display with onboard recording of MSFN data.

c. When complete with Display PRESS V33E on DSKY.

10.43.14 Respond to V50N07 Flash with R1 code 00051 by PRESSING V37E00E on DSKY.

10.43.15 Verify Program 00 on DSKY.

10.43.16 Verify ISS FINE ALIGN MODE light is ON.

10.44 IMU Orientation Determination. The vehicle attitude is already adjusted to allow two stars to be visable through the G&N Optics and the vehicle rates are below 0.2 degrees per second in each axis.

10.44.1 Confirm or select the following switch conditions:

MDC 8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - ON
3. ATTITUDE DEADBAND - MAXIMUM
4. .05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - OFF
7. G&N/SCS - SCS
8. ATTITUDE/MONITOR/ENTRY - MONITOR
9. A&C ROLL CHANNEL - OFF
10. B&D ROLL CHANNEL - OFF
11. PITCH CHANNEL - OFF
12. YAW CHANNEL - OFF
13. ROLL RATE GYRO - BMAG
14. PITCH RATE GYRO - BMAG
15. YAW RATE GYRO - BMAG

MDC 25

1. FDAI LTG - OFF
2. GROUP 1-AC 1 - CLOSED
3. GROUP 1-AC 2 - CLOSED
4. GROUP 2-AC 1 - CLOSED
5. GROUP 2-AC 2 - CLOSED
6. GROUP 1-MNA - CLOSED
7. GROUP 1-MNB - CLOSED
8. GROUP 2-MNA - CLOSED
9. GROUP 2-MNB - CLOSED
10. DIRECT CONTROL-MNA - CLOSED
11. DIRECT CONTROL-MNB - CLOSED
12. A&C ROLL-MNA - CLOSED
13. A&C ROLL-MNB - CLOSED
14. B&D ROLL-MNA - CLOSED
15. B&D ROLL-MNB - CLOSED
16. PITCH-MNA - CLOSED
17. PITCH-MNB - CLOSED
18. YAW-MNA - CLOSED
19. YAW-MNB - CLOSED
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL-PITCH-BAT A - OPEN
22. GIMBAL MOTOR CONTROL-YAW-BAT A - OPEN

MDC 24

1. SCS POWER - OFF
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC 3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC 6

ATTITUDE SET - OFF

MDC 7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - PINNED
TRANSLATION CONTROLS - LOCKED

MDC 14

1. UPTEL - ACCEPT/BLOCK - BLOCK
2. DSKY BRIGHTNESS - ADJUST AS REQUIRED

MDC 2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - ADJUST AS REQUIRED
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

MDC 22

1. IMU HTR-MNA - CLOSED
2. IMU HTR-MNB - CLOSED
3. IMU-MNA - CLOSED
4. IMU-MNB - CLOSED
5. COMPUTER-MNA - CLOSED
6. COMPUTER-MNB - CLOSED
7. OPTICS-MNA - CLOSED
8. OPTICS-MNB - CLOSED

9. G&N AC POWER-AC 1 - CLOSED
10. G&N AC POWER-AC 2 - CLOSED
11. G&N AC POWER-AC 1

LEB NAV STATION SWITCHES

1. FLOODLIGHT CONTROL PRIMARY - ADJUST AS REQUIRED
2. FLOODLIGHT CONTROL SECONDARY - ADJUST AS REQUIRED
3. PANEL BRIGHTNESS CONTROL - ADJUST AS REQUIRED
4. AGC BRIGHTNESS CONTROL - ADJUST AS REQUIRED
5. IMU TRANSFER - COMPUTER
6. OPTICS SLAVE TELESCOPE - STAR LOS
7. OPTICS MODE - ZERO OPTICS
8. OPTICS HOLD - OFF
9. OPTICS CONTROLLER SPEED - HIGH
10. OPTICS CONTROLLER MODE - DIRECT
11. IMU TEMP. MODE - AUTO OVERRIDE
12. AGC MODE - ON
13. ATTITUDE IMPULSE ENABLE - OFF
14. CONDITION LAMPS - ON

10.44.2 PRESS V37E51E on DSKY.

10.44.3 Verify Program 51 is Displayed on DSKY.

10.44.4 Verify the ISS FINE ALIGN MODE light is ON.

10.44.5 Respond to V50N25 Flash with R1 code 00001 by PRESSING V33E on DSKY.

10.44.6 Verify the ISS COARSE ALIGN MODE light comes ON.

10.44.7 Verify the ICDU'S DRIVE TO ZERO.

10.44.8 Respond to V50N25 Flash with R1 code 00015 by PRESSING ENTER on the DSKY.

10.44.9 Verify the ISS FINE ALIGN MODE light comes ON.

10.44.10 Respond to V51 Flash by performing the following:

a. Place OPTICS MODE switch to MANUAL POSITION.

b. If one star from star list is in telescope's field of view, center star in field of view with Optics Hand Controller by first driving Shaft axis to place star on R line and then driving Trunnion axis to center star.

c. If no star from star list is in telescope's field of view, place OPTICS SLAVE TELESCOPE switch to OFFSET 25 degrees position. Use the Optics Hand Controller to drive in Shaft until a star from the star list is on the R line. Place OPTICS SLAVE TELESCOPE switch to STAR LOS position. Drive the Optics in Trunnion until the star is centered.

d. Place OPTICS CONTROLLER SPEED switch as required.

e. When star is exactly centered PRESS MARK button.

NOTE: MARK may be rejected by PRESSING V52E on the DSKY. If so, repeat paragraph d. above.

10.44.11 Respond to V21N30 Flash by entering STAR CODE number into DSKY.

R1 - STAR CODE Number

If Display is correct PRESS ENTER on DSKY.

10.44.12 Perform second MARK on a different star by return to step 10.44.9.

10.44.13 Monitor one of the following:

*a. V06N05, Data Good and Display of differences between actual and measured angle between MARKED stars in R1 (.01 DEG). Record in Flight Log.

*b. V06N05, Data Bad Flash and Display of differences between actual and measured angle between MARKED stars in R1 (.01 DEG).

1. Record data in Flight Log.

2. To continue program with this data PRESS V33E on DSKY.

3. If Program should be stopped, change program and exit procedure.

* Acceptable Limits for data have not been defined.

10.44.14 Verify Program is 00.

10.44.15 Verify ISS FINE ALIGN MODE light is ON.

10.45 IMU Alignment.

10.45.1 Confirm or select the following initial switch positions.

MDC 8

1. DIRECT RCS - OFF
2. LIMIT CYCLE - ON
3. ATTITUDE DEADBAND - MAXIMUM
4. .05 G ENTRY - OFF
5. LOCAL VERTICAL - OFF
6. DELTA V - OFF
7. G&N/SCS - SCS
8. ATTITUDE/MONITOR/ENTRY - ATTITUDE
9. A&C ROLL CHANNEL - } ONE ON - ONE OFF (ONE
10. B&D ROLL CHANNEL - } FOR FULLEST QUAD ON)
11. PITCH CHANNEL - ON
12. YAW CHANNEL - ON
13. ROLL RATE GYRO - NORMAL
14. PITCH RATE GYRO - NORMAL
15. YAW RATE GYRO - NORMAL

MDC 25

1. FDAI LTG - AC 1
2. GROUP 1-AC 1 - CLOSED
3. GROUP 1-AC 2 - CLOSED
4. GROUP 2-AC 1 - CLOSED
5. GROUP 2-AC 2 - CLOSED
6. GROUP 1-MNA - CLOSED
7. GROUP 1-MNB - CLOSED
8. GROUP 2-MNA - CLOSED
9. GROUP 2-MNB - CLOSED
10. DIRECT CONTROL-MNA - CLOSED
11. DIRECT CONTROL-MNB - CLOSED
12. A&C ROLL-MNA - CLOSED
13. A&C ROLL-MNB - CLOSED
14. B&D ROLL-MNA - CLOSED
15. B&D ROLL-MNB - CLOSED
16. PITCH-MNA - CLOSED
17. PITCH-MNB - CLOSED
18. YAW-MNB - CLOSED
19. YAW-MNB - CLOSED
20. G&N SYNC - OFF
21. GIMBAL MOTOR CONTROL-PITCH-BAT A - OPEN
22. GIMBAL MOTOR CONTROL-YAW-BAT A - OPEN

MDC 24

1. SCS POWER - AC 1
2. RATE GYRO POWER - AC 1
3. ROTATION CONTROL POWER - AC 2
4. BMAG POWER - AC 2
5. TVC 1 POWER - OFF
6. TVC 2 POWER - OFF

MDC 3

1. PITCH GIMBAL MOTOR 1 - OFF
2. PITCH GIMBAL MOTOR 2 - OFF
3. YAW GIMBAL MOTOR 1 - OFF
4. YAW GIMBAL MOTOR 2 - OFF
5. INJECT PREVALVE A - OFF
6. INJECT PREVALVE B - OFF

MDC 6

ATTITUDE SET - OFF

MDC 7

NORMAL/OFF/DIRECT ON - OFF

ROTATION CONTROLS - PINNED
TRANSLATION CONTROLS - LOCKED

MDC 14

1. UPTEL - ACCEPT/BLOCK - BLOCK
2. DSKY BRIGHTNESS - ADJUST AS REQUIRED

MDC 2

1. FDAI SELF TEST - OFF
2. FDAI BRIGHTNESS - ADJUST AS REQUIRED
3. FCSM - ON/OFF/RESET - OFF
4. FCSM - AUTO/OVERRIDE - OVERRIDE

MDC 22

1. IMU HTR-MNA - CLOSED
2. IMU HTR-MNB - CLOSED
3. IMU-MNA - CLOSED
4. IMU-MNB - CLOSED
5. COMPUTER-MNA - CLOSED
6. COMPUTER-MNB - CLOSED
7. OPTICS-MNA - CLOSED
8. OPTICS-MNB - CLOSED

9. G&N AC POWER-AC 1 - CLOSED
10. G&N AC POWER-AC 2 - CLOSED
11. G&N AC POWER-AC 1

LEB NAV STATION SWITCHES

1. FLOODLIGHT CONTROL PRIMARY - AS REQUIRED
2. FLOODLIGHT CONTROL SECONDARY - AS REQUIRED
3. PANEL BRIGHTNESS CONTROL - ADJUST AS REQUIRED
4. AGC BRIGHTNESS CONTROL - ADJUST AS REQUIRED
5. IMU TRANSFER - COMPUTER
6. OPTICS SLAVE TELESCOPE - STAR LOS
7. OPTICS MODE - ZERO OPTICS
8. OPTICS HOLD - OFF
9. OPTICS CONTROLLER SPEED - HIGH
10. OPTICS CONTROLLER MODE - DIRECT
11. IMU TEMP. MODE - AUTO OVERRIDE
12. AGC MODE - ON
13. ATTITUDE IMPULSE ENABLE - OFF
14. CONDITION LAMPS - ON

10.45.2 PRESS V37E53E on DSKY.

10.45.3 Verify Program 53 is Displayed on DSKY.

10.45.4 A 20 second delay may occur if the ISS FINE ALIGN MODE light was not ON.

10.45.5 Respond to V50N25 Flash with F1 code 00001 as follows:

a. Place G&N/SCS switch to G&N.

b. PRESS V33E on DSKY.

10.45.6 Verify the ISS ATT CONT MODE light comes ON.

10.45.7 If the ISS FINE ALIGN MODE light comes ON, perform the following:

NOTE: A twenty second delay will occur at this point.

a. Verify the ISS COARSE ALIGN MODE light comes ON.

b. Verify IMU-CDU DIFFERENCE INDICATOR ZEROED ($\pm$ 1.5 DEG).

c. Verify the ISS FINE ALIGN MODE light comes ON. (Light will be on 20 seconds).

d. Verify the ISS ATT CONT MODE light comes ON.

10.45.8 Respond to V16N20 Flash with Display of present ICDU angles by PRESSING V33E on DSKY.

R1 - OG ROLL (.01 DEG)

R2 - IG PITCH (.01 DEG)

R3 - MG YAW (.01 DEG)

10.45.9 Respond to V06N17 Flash and DSKY Display of gimbal angles desired at the end of the maneuver as follows:

R1 - OG ROLL (.01 DEG)

R2 - IG PITCH (.01 DEG)

R3 - MG YAW (.01 DEG)

a. Limit Cycle Switch - OFF

b. PRESS V33E on the DSKY.

c. Monitor FDAI to check that maneuver is toward the ICDU valves displayed on DSKY and gimbal lock is avoided.

d. Monitor that Rate Needles on FDAI indicate 0.5 degree per second maneuver rate.

e. When final attitude is obtained, place Limit Cycle switch ON.

10.45.10 If the ISS FINE ALIGN MODE light come ON, perform the following:

NOTE: Light will be on twenty seconds.

a. Verify the ISS COARSE ALIGN MODE light comes ON.

b. Verify IMU-CDU DIFFERENCE INDICATOR ZEROED ($\pm$ 1.5 DEG).

c. Verify the ISS FINE ALIGN MODE light comes ON. (Light will be on 20 seconds).

d. Verify the ISS ATT CONT MODE light comes ON.

10.45.11 Monitor V06N30 Flash with Display of Star Code.

R1 - Star Code

a. If Star Code is satisfactory, identify star on star charts and PRESS V33E on DSKY.

b. If Star Code is not satisfactory, perform the following:

1. PRESS V21N30 on DSKY.

2. ENTER new Star Code on DSKY.

10.45.12 Respond to V50N25 Flash with R1 Code 00013 by performing one of the following:

a. If Automatic Optics Positioning is desired:

1. PLACE OPTICS MODE switch to COMPUTER position.

2. PRESS ENTER ON DSKY.

NOTE: If V05N31 Flash with R1 code - 00402 starts, proceed to b.

3. Monitor V16N57 and DSKY Display.

R1 - SHAFT (0.01 DEG)

R2 - TRUNNION (.001 DEG)

4. Verify Optics drive to Displayed values.

5. Place OPTICS MODE Switch to MANUAL position.

b. If Manual Positioning desired:

1. PRESS V33E on DSKY.

2. Place OPTICS MODE Switch to MANUAL Position.

3. Select two stars on star chart that can be MARKED from the present attitude.

10.45.13 Verify the ISS FINE ALIGN MODE light comes ON.

10.45.14 V51, Please MARK will begin to Flash. Flash will continue until MARK is performed.

10.45.15 Recognize star field in Telescope and perform one of the following:

a. If desired star is in the field of view, center star in field of view with Optics Hand Controller by first driving Shaft axis to place star on R line and then driving Trunnion axis to center star.

b. If the selected star is out of the field of view, place OPTICS SLAVE TELESCOPE switch to OFFSET 25 degrees position. Use the OPTICS Hand Controller to drive in Shaft until the star is on the R line. Place OPTICS SLAVE TELESCOPE Switch to STAR LOS position. Drive the Optics in Trunnion until the star is centered.

10.45.16 Recognize star in Sextant.

10.45.17 Place OPTICS CONTROLLER SPEED switch as required.

10.45.18 Place OPTICS CONTROLLER MODE switch to RESOLVED position.

10.45.19 Center star in Sextant using the Optics Hand Controller.

10.45.20 PRESS MARK button when the star is exactly centered.

NOTE: The MARK may be rejected by ENTERING V52 on the DSKY. If so, repeat step 10.45.40.

10.45.21 Respond to V21N30 Flash by ENTERING the STAR CODE number.

R1 - STAR CODE NUMBER

10.45.22 Verify the ISS ATT. CONT. MODE light comes ON.

10.45.23 Perform MARK on second STAR by setting the following switches and returning to step 10.45.11.

a. OPTICS CONTROLLER SPEED - HIGH

b. OPTICS CONTROLLER MODE - DIRECT

10.45.24 Monitor one of the following:

a. V06N05, DATA GOOD and Display of differences between actual and measured angle between MARKED stars in R1.

R1 - STAR ANGLE DIFF.

Record data in Flight Log.

*b. V06N05, DATA BAD Flash and Display of differences between actual and measured angle between MARKED stars in R1.

R1 - STAR ANGLE DIFF.

1. Record data in Flight Log.

2. To continue program with this data PRESS V33E ENTER on DSKY.

3. If program should be stopped, change program and exit procedure.

*Acceptable limits for data have not been defined.

10.45.25 Monitor one of the following:

a. V06N67, Data Good and Display of IMU Gyro torquing angles.

R1 - X GYRO

R2 - Y GYRO

R3 - Z GYRO

Record data in Flight Log.

*b. V06N67, Data Bad Flash and Display of IMU gyro torquing angles.

R1 - X GYRO

R2 - Y GYRO

R3 - Z GYRO

1. Record data in Flight Log.

2. To cintinue program with this data PRESS V33E on DSKY.

3. If program should be stopped, PRESS V34E on DSKY and exit procedure.

* Acceptable limits for data have not been defined.

10.45.26 Respond to V50N25 Flash and R1 code 00014 as follows:

a. If FINE ALIGN CHECK is desired PRESS ENTER on DSKY and return to step 10.45.11.

b. If FINE ALIGN CHECK will not be performed PRESS V33E on DSKY.

10.45.27 Respond to V16N20 Flash with Display of present ICDU angles by PRESSING V33E on DSKY.

R1 - OG ROLL (.01 DEG)

R2 - IG PITCH (.01 DEG)

R3 - MG YAW (.01 DEG)

10.45.28 Respond to V06N17 Flash and DSKY Display of gimbal angles desired at the end of the maneuver as follows:

R1 - OG ROLL (.01 DEG)

R2 - IG PITCH (.01 DEG)

R3 - MG YAW (.01 DEG)

a. Limit cycle switch - OFF

b. PRESS V33E on the DSKY.

c. Monitor FDAI to check that maneuver is toward the ICDU values displayed on the DSKY and gimbal lock is avoided.

d. Monitor Rate Needles on FDAI indicate .5 degree per second maneuver rate.

e. When final attitude is obtained place Limit Cycle Switch ON.

10.45.29 Select following switch positions:

MDC 25

a. A&C ROLL-MNA -
b. A&C ROLL-MNB -
c. B&D ROLL-MNA -
d. B&D ROLL-MNB -

} OPEN CIRCUIT BREAKER OF EMPTIEST QUAD OF QUAD ENABLED

A QUAD - A&C MNA
B QUAD - B&D MNA
C QUAD - A&C MNB
D QUAD - B&D MNB

e. PITCH-MNA -
f. PITCH-MNB -

} ONE OPEN - ONE CLOSED

g. YAW-MNA -
h. YAW-MNB -

} ONE OPEN - ONE CLOSED

10.45.30 Monitor one of the following:

a. If Program 21 is displayed on DSKY, return to Procedure 10.41, G&N Local Vertical.

b. If Program 31, 32, 33, or 53 are present with a Verb - Noun Flash select Program 00 by PRESSING V37E00E on DSKY. Verify Program 00 is displayed on DSKY.

10.46 AGC Update. This procedure requires only that the AGC be on.

10.46.1 Verify with ground which type of UPDATE will be performed.

10.46.2 If UPDATE is to be performed manually proceed to step 10.46.4.

10.46.3 On MDC 14 PLACE UPTEL switch to ACCEPT POSITION.

NOTE: If present AGC program will not allow an UPDATE, A V05N31 Flash will occur with a R1 code 00410. In this case, PRESS ALARM RESET and repeat this procedure when present AGC program is completed.

10.46.4 Record from MSFN, parameters required for verification. (All data must be in decimal form. The following data must be recorded even if the AGC is not operable).

*a. Aim parameters for a minimum impulse thrusting maneuver.

1. GMT - Time of ignition. (HRS-MINS-.01 SECS)
2. Latitude of aim point. (.01 DEG)
3. Longitude of aim point. (.01 DEG)
4. Altitude of aim point. (0.1 NM)
5. SPS gimbal trim - pitch. (.01 DEG)
6. SPS gimbal trim - yaw. (.01 DEG)
7. SPS tail off. (FT/SEC)
8. Period of new orbit. (HRS-MINS-.01 SECS)
9. SPS burn time. (.01 SECS)

*b. Aim parameters for a return to earth thrusting maneuver.

1. Latitude of aim point. (.01 DEG)
2. Longitude of aim point. (.01 DEG)
3. Delta velocity allowable. (FT/SEC)
4. GMT - Earliest possible ignition time. (HRS-MINS-.01 SECS)
5. SPS gimbal trim - pitch. (.01 DEG)
6. SPS gimbal trim - yaw (.01 DEG)
7. SPS tail off. (FT/SEC)

*c. Aim parameters for an orbit change thrusting maneuver.

1. GMT - Time of ignition. (HRS-MINS-.01 SECS)
2. Latitude of aim point. (.01 DEG)
3. Longitude of aim point. (.01 DEG)
4. Altitude of aim point. (0.1 DEG)
5. SPS gimbal trim - pitch. (.01 DEG)
6. SPS gimbal trim - yaw. (.01 DEG)
7. SPS tail off. (FT/SEC)
8. Period of new orbit. (HRS-MINS-.01 SECS)

*The unit thrust vector and earth centered radius vector direction at SPS ignition should be provided by MSFN at this time for verification of the AGC calculations. At present the MIT program does not provide a display of these calculations to the operator, but displays are being requested. The external window reference when at the proper thrusting attitude must also be provided at this time.

10.46.5 If UPDATE is automatic proceed to step 10.46.14.

10.46.6 Record vehicle position, velocity and time parameters from MSFN. (All data must be in octal form and in the following sequence).

a. Most sig. part of X position. (XXXXX)
b. Least sig. part of X position. (XXXXX)
c. Most sig. part of Y position. (XXXXX)
d. Least sig. part of Y position. (XXXXX)
e. Most sig. part of Z position. (XXXXX)
f. Least sig. part of Z position. (XXXXX)
g. Most sig. part of X velocity. (XXXXX)
h. Least sig. part of X velocity. (XXXXX)
i. Most sig. part of Y velocity. (XXXXX)

j. Least sig. part of Y velocity. (XXXXX)

k. Most sig. partof Z velocity. (XXXXX)

l. Least sig. part of Z velocity. (XXXXX)

m. Most sig. part of time from AGC clock zero. (XXXXX)

n. Least sig. part of time from AGC clock zero. (XXXXX)

10.46.7 PRESS V76E ON DSKY.

10.46.8 Verify Program 27 is Displayed and UPTEL light on DSKY is ON.

10.46.9 Monitor V20N01 Flash. A display of an erasable memory location will occur in R-3. Any data entered will be placed in this location.

10.46.10 ENTER data from 10.46.6 and verify in R1 before PRESSING ENTER button.

10.46.11 Repeat 10.46.10 and 11 for each parameter in 10.46.6. Data sequence given in 10.46.6 must be maintained.

10.46.12 Respond to V21N02 Flash by PRESSING V33E on DSKY. (Disregard R3 Display).

10.46.13 Verify UPTEL light goes out on DSKY.

10.46.14 Place or verify UPTEL Switch Block Position

10.46.15 Verify Program 27 terminations and AGC goes back to Program in progress prior to this procedure.

10.47 Manual G&N Entry.

10.47.1 At the 0.05 g switching point the translation control should be rotated clockwise into the stop and left there. The roll attitude commands from the G&N on the roll attitude error indicator should now be nulled manually with the rotation control.

1. REWORK LUM'S MATERIAL.