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22-184

LVDC Equation Defining Document (EDD)

for the Saturn IB Flight Program

Parts I and II

Revision D

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boost major loop sequence (Section 4.1) from  $T_4 + 0$  until  $T_4 + BN_5$ . After the flight program switches from boost mode to orbital mode at  $T_4 + BN_5$ , orbital guidance computations must be performed at once per second rate until EOM. During these periods the flight program must have the capability of commanding any one of the following four basic types of maneuvers:

- $\chi$  Freeze: maintain the inertial attitude defined by the gimbal angles calculated in the last minor loop before maneuver initiation
- Inertial Attitude Hold: orient the vehicle to a preset inertial attitude and maintain that attitude
- Track Local Reference: maintain a preset attitude with respect to local horizontal and the orbit plane
- Inertial Hold of Local Reference: calculate the desired attitude with respect to local horizontal at maneuver initiation time and hold it inertially.

(Note that inertial holds, as well as periods when rates are commanded, are considered to be maneuvers.)

In Time Base 4, the orbital guidance must have the capability to perform up to 5 preprogrammed maneuvers. The commanded attitudes must follow the preprogrammed attitude timeline unless altered by either S/C control or DCS commands. The preprogrammed attitude timeline is defined for each individual mission in the Orbital Attitude Timeline tables of Part II. The associated data, such as maneuver start times, types, and attitude data (when applicable), are contained in the Event Sequence Timeline and Presetting tables in the individual mission requirements in Part II.

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In Time Base 5, the orbital guidance must maintain the last  
TB4 maneuver (nominal or altered) being executed when TB5 is  
started.

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compressed data dumps. Each telemetry station must be tested for acquisition every eight seconds from  $T_4 + BN_5$  until  $T_5 + 0.0$  (see Telemetry Station Table 5-1); however, if it is determined that the vehicle is in range of a station which is both a calibrate and dump station, the program must not check the remaining stations during that eight second interval.

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#### 5.6.1 Acquisition and Loss Calculations

The determination of whether or not the vehicle is in range of a telemetry station will be made in the following manner.

The earth's rotation since  $T_{GRR}$  is calculated, Eq. 5.6.1, and a new [MGA] matrix is derived. This matrix is then used to transform the vehicle's position in the space-fixed gravitational coordinate system into the earth-fixed telemetry station coordinate system, Eq. 5.6.2. A telemetry station acquisition sphere with radius  $R_{STA}$  is used in computing station acquisition at a zero degree elevation angle from a point above each station. Each station acquisition reference point lies at the intersection of the acquisition sphere with a line passing from the center of the Earth through the station. The distance,  $d_A(i)$ , of the vehicle above or below the horizon of the acquisition reference point is calculated (Eq. 5.6.3 through 5.6.5). This is done by subtracting the radius,  $R_{STA}$ , of the telemetry station acquisition sphere from the dot product of the transformed vehicle's position vector and the unit station vector,  $\bar{C}_A(i)$ . If  $d_A(i)$  is found to be zero or positive for a station in the list, the vehicle is considered to be in acquisition of that station. The preset value of  $R_{STA}$  for each mission is selected to give approximately two degrees of elevation above the horizon of each station at the nominal orbit altitude. The components of  $\bar{C}_A$  for each station in the telemetry station coordinate system are preset for each mission. When a station acquisition or loss is computed, the time of acquisition, TBA, or the time of loss, TBL, in the prevailing time base must be updated.

TABLE 5-1 TELEMETRY STATION TABLE

| i  | Station        | Station Type       | $C_{Ax}(i)$ | $C_{Ay}(i)$ | $C_{Az}(i)$ |   |
|----|----------------|--------------------|-------------|-------------|-------------|---|
| 1  | MILA CIF       | Calibrate          | 0.87981     | -0.47532    | -0.00134    |   |
| 2  | Bermuda        | Calibrate          | 0.81395     | -0.53253    | 0.23214     |   |
| 3  | Newfoundland   | Calibrate          | 0.59676     | -0.73785    | 0.31537     | * |
| 4  | Canary Island  | Calibrate and Dump | 0.37533     | -0.46339    | 0.80275     | * |
| 5  | Ascension      | Calibrate          | 0.39895     | 0.13748     | 0.90661     | * |
| 6  | Madrid         | Calibrate and Dump | 0.17931     | -0.64631    | 0.74171     | * |
| 7  | Carnarvon      | Calibrate          | -0.87993    | 0.41883     | -0.22430    | * |
| 8  | Guam           | Calibrate          | -0.68462    | -0.22874    | -0.69208    | * |
| 9  | Honeysuckle    | Calibrate          | -0.52869    | 0.57948     | -0.62023    | * |
| 10 | Hawaii         | Calibrate          | 0.17552     | -0.37445    | -0.91048    | * |
| 11 | Goldstone      | Calibrate          | 0.65891     | -0.57586    | -0.48396    | * |
| 12 | Corpus Christi | Calibrate          | 0.84918     | -0.46168    | -0.25641    | * |

7.4.2 DI2: Command Decoder OM/D "A" and Command Decoder OM/D "B"

This DI indicates to the LVDC whether a DCS command is a mode or data command. A logic 1 indicates a mode command has been received, and a logic 0 indicates a data command has been received. This DI must be interrogated once upon receipt of each command decoder interrupt (INT8); see Section 10 for details of the required program response to this DI.

7.4.3 DI3: Spare (Wired to IU/S-IVB Interface on SA-206 and SA-207, wired to Control Distributor on SA-208 and Subs)

7.4.4 DI4: Spare (Wired to Control Distributor)

7.4.5 DI5: S-IVB Engine Out "A"

DI5 indicates that the S-IVB engine is out. This DI must be checked once per BML, until recognition, during the interval from  $T3 + S4IGTM$  until  $T4 + 0.0$ . DI5 is used as one of the inputs to initiate TB4 (see paragraph 7.2.5). Upon detection of DI5, the discrete's presence must be noted as satisfying one of the conditions for initiating TB4, and the check for the discrete must be discontinued.

This DI will be actuated when both of the two "thrust OK" switches in the S-IVB J2 engine indicate that the engine main LOX injection pressure is below operating level. There are no hardware inhibits of this DI, and it will be active during the entire mission.

7.4.6 DI6: Spare (SA-206, SA-207, SA-209 and Subs), Spacecraft Separation Indication (SA-208)

#### 7.4.7 DI7: Liftoff "B"

This DI, along with DI24, indicates that liftoff has occurred. These DIs are provided by the deactuation of the liftoff relays in the IU at umbilical disconnect and must be interrogated before and after every minor loop (twice every 40 ms) during the time from  $T0 + 17.4^*$  (-0, +40 ms) until detected or until  $T0 + BU3$ , whichever occurs earlier. These DIs are of equal priority and are used as indications to start TB1 (see Time Base 1 start logic).

#### 7.4.8 DI8: Spare (Wired to the ESE)

#### 7.4.9 DI9: S/C Control of Saturn

This discrete originates in the Spacecraft (S/C), and indicates to the LVDC that the S/C has taken control of the flight control computer (FCC) and that the LVDC outputs to the FCC are not being accepted. The program must check this DI once per BML from  $T4 + 5.0^*$  to  $T4 + BN_5$  and once per second from  $T4 + BN_5$  to EOM. A detailed description of the required program response to this DI is found in the Control Switchover Capability description in Section 5. When this DI is recognized, bit 12 of MC27 must be set except if guidance reference failure has previously occurred; \*  
this bit is reset when control is returned to the LVDC. \*

If a guidance reference failure (GRF) is detected, the program must check for this DI once per BML in the boost mode and once per second in orbit until detected. If DI9 is on after GRF, the attitude error commands must be set to zero for the remainder of the mission. Bit 15 of MC27 must also be set and remain set for the remainder of the mission. If DI9 is on when guidance reference failure is detected, bit 12 of MC27 must remain set as well as bit 15 of MC27. For a complete description of program responses to GRF, see Section 8.2.2.

If the S/C has taken control of the Saturn, this DI is a logic 1; otherwise, it will be a logic 0. The S/C Control of Saturn Enable switch selector command must be issued or D04 or D06

program response, is located in the Engine Out Guidance Modifications discussion in Section 4. When this DI is recognized, bit 8 of MC25 must be set; this bit must never be reset. After this DI has been detected, there is no further requirement to check it.

This DI is activated when at least two of the three "thrust OK" pressure switches in any one of S-IB engines 5 through 8 (inboard engines) indicate main fuel injection pressure has fallen below operating range. When one or more of the engines is not burning, this DI is a logic 1, and is a logic 0 while all the inboard engines are burning. At S-IB/S-IVB separation, this DI will become a logic 0 and will remain in that state until the EOM.

7.4.16 DI16: Prepare for Guidance Reference Release

This DI is used only by the ground routines. It occurs 5 seconds prior to guidance reference release (GRR) to warn the ground routine that GRR will be occurring soon. There is no requirement for this DI to be monitored by the LVDC flight program. This DI is also referred to as Guidance Reference Release Alert (GRRRA).

7.4.17 DI17: Spare

7.4.18 DI18: Spare

7.4.19 DI19: Spare (Wired to IU/S-IVB Interface on SA-206 and SA-207, wired to Control Distributor on SA-208 and Subs) \*

7.4.20 DI20: Spacecraft Initiation of S-IVB Engine Cutoff \*

The purpose of this DI is to give the S/C the capability to initiate S-IVB cutoff while the S/C has control of the flight

control computer. There is currently no requirement to check this DI.

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7.4.21 DI21: Spare (Wired to Control Distributor)

\*

7.4.22 DI22: Spare (Wired to Control Distributor)

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#### 9.2.1.5 Reset Read

The program will issue the reset of the read command no less than 25 ms after issuing the read command. Processing of the next switch selector command must not start until at least 19 ms after the reset has been issued.

#### 9.2.2 Termination of a Command Sequence

To terminate a switch selector command which is in progress, a forced reset must be issued. The hung stage test is invalidated by the forced reset and need not be performed for the next switch selector command issued. Thirteen milliseconds must elapse before initiating the next command.

### 9.3 TIMING

Timely execution of switch selector commands is a prime requirement of event sequencing. Most switch selector commands must be issued relative to a preset time in a time base. Others such as S-IVB cutoff and telemetry acquisition and loss sequences must be issued relative to calculated conditions. Some, such as ECS water valve command, are issued on the basis of elapsed time and vehicle conditions. Switch selector commands and their corresponding times are specified by the Flight Sequencing Table in Part II.

Where the commands are listed at intervals greater than 100 ms, the read command for each event must be issued within  $\pm 50$  ms of the assigned execution time unless higher priority switch selectors cause a delay. The following events may cause delays \*  
in the processing of switch selector functions: \*

- A delay of up to 21 ms may result while processing interrupt protected data output multiplexer telemetry \*
- A delay of up to 60 ms may occur just prior to S-IVB cutoff \*
- A delay of up to 12 ms may occur due to command decoder interrupt processing during orbit \*
- Delays due to minor loop processing may cause the following delays. \*

Nominal minor loop processing time, 20 ms \*

Minor loop processing time if GRF (guidance reference failure) has occurred in all three axes, 25 ms \*

Due to timing and the priority of interrupts a given switch selector may be delayed by a number of minor loop interrupts \*

- Additional switch selector error processing may cause the following delays. \*

Hung Stage Failure, 2 ms \*

Verify Address Failure, 8 ms \*

- A delay of up to 26 ms may occur due to a single TLC; however, if TLC's occur continuously it is conceivable that no switch selector function will be processed. \*

When switch selector commands are tabled at 100 ms intervals, the  $\pm 50$  ms tolerance may not be met due to the above delays and it is \*

#### 11.4.1.2.2. Special Time Base Start Telemetry

The real time clock reading associated with the initiation of TB0, TB1, TB2, TB3 and TB5 must be telemetered. The required format is defined in Figure 11-1 and the specific ID codes are given in the Telemetry Tags Table 11-8. If both DIs are received for TB1 initiation, the codes of the two DIs must be ORed together and used as the ID code for telemetry. If TB3 is initiated on the time backup, a special indication must be telemetered with an associated real time clock reading.

An indication of which two of the four possible conditions initiated TB4 must be telemetered at T4+0. The specific ID codes for each of the four possible conditions are defined in the Telemetry Tags Table 11-8. The codes of the two conditions that initiated TB4 must be ORed together and used as the ID code for telemetry. The required format is defined in Figure 11-1.

#### 11.4.2 LVDA Telemetry

LVDA telemetry data includes nominal minor loop data and information on LVDA registers and hardware interfaces. All LVDA telemetry is issued through the DOM to the telemetry system. The PIOs for all available LVDA telemetry are defined in the Telemetry Tags Table 11-8. The hardware-determined data formats are described in the LVDC/LVDA Programmers manual.<sup>1</sup>

Telemetry of certain LVDA data must be guaranteed at regular intervals or on occurrence. An interval since the last LVDC telemetry PIO or the last LVDA PIO must be provided sufficient to ensure that an empty DOM word is available.

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<sup>1</sup>IBM: Programmer's Operating Manual, Saturn V LVDC, LVDA, Programmable Test Controller, NAS8-11561 and NAS8-11562, June 1, 1968

#### 11.4.2.1 LVDA Regularly Scheduled Telemetry

From every minor loop, each of the three crossover detector (COD) counter readings (fine or backup, whichever is in use) combined with the respective ladder output must be telemetered.

The following hardware data must be telemetered at least once per BML during boost mode (except during the high speed cutoff loop) and once per second during orbital mode:

- Internal control register (ICR)
- Crossover detector and power supply word
- Error monitor register (EMR)
- Discrete input register (DIR)
- X, Y, and Z accelerometer readings
- X, Y, and Z backup gimbals.

#### 11.4.2.2 LVDA On-Occurrence Telemetry

A special PIO must be issued immediately after the switch selector stage and address have been loaded into the switch selector register to telemeter switch selector and discrete output register driver outputs.

### 11.5 DATA COMPRESSION

During orbital mode, significant time intervals will occur during which the vehicle will be out of electromagnetic view

of a telemetry dump station. During these intervals, data must be processed and stored in the LVDC for later transmission when the vehicle comes within the acquisition region of the next telemetry dump station. These data, with the exception of switch selector commands, must also be processed and stored while the vehicle is within the acquisition region of the telemetry dump station, to provide continuity of data. The processing and storing of these data is referred to as data compression. \*

#### 11.5.1 General Data Compression Requirements

The following requirements must apply for all compressed data: \*

- Data compression must be programmed for a minimum of nine hours. (A new compressed data time base may be initiated, if necessary.)
  - Storage requirements must be based on a maximum compression period of 5700 seconds.
  - If the maximum storage allocation in a particular table is exceeded between dump stations, the most recent data must be compressed over the oldest data in the affected table. This condition is called table wraparound.
  - Each data word or set of data words must have stored with it a word containing a unique identification (ID) code and an associated time accurate to 1.6 seconds. \*
- The ID code and time must be stored in the same relative locations for all data. The associated time must be the time at which the data is stored.

### 11.5.2 Data to be Compressed

Compressed data can be conveniently divided into three groups:

- Group A: time compressed data, in which quantities are sampled and stored at regular intervals
- Group B: occurrence compressed data, in which data describing certain events are stored when the events occur
- Group C: amplitude compressed data, in which regularly sampled quantities are stored only when a change is detected.

A summary of the compressed data is given in Table 11-6. The Compressed Data Table 11-14 defines the required data, the ID codes, and the data formats.

TABLE 11-6 COMPRESSED DATA SUMMARY

| Group | Data  |
|-------|---|
| A     | { Fine gimbal angles<br>Backup gimbal angles<br>Accelerometer outputs           |
| B     | { Discrete outputs<br>TLC HOP constants<br>Switch selector stages and addresses |
| C     | { Error monitor register contents<br>Mode code 24<br>Discrete inputs            |

TABLE 11-8 TELEMETRY TAGS (CONTINUED)

| LVDC DATA            |            |            |               |   |                             |              |       |      |                      |      |       |              |       |      |                      |      |       |      |     |      |     |  |  |  |
|----------------------|------------|------------|---------------|---|-----------------------------|--------------|-------|------|----------------------|------|-------|--------------|-------|------|----------------------|------|-------|------|-----|------|-----|--|--|--|
| Mode<br>Reg.         | PIO<br>Tag | PCM<br>Tag | EDD<br>Symbol | Description   | Frequency<br>(Segments)     | Scal-<br>ing | Units |      |                      |      |       |              |       |      |                      |      |       |      |     |      |     |  |  |  |
| 0                    | 441        | 1520       | INT           | System interrupt indication:  | $0_1(1-6)$                  | N/A          | N/A   |      |                      |      |       |              |       |      |                      |      |       |      |     |      |     |  |  |  |
|                      |            |            |               | <table><tr><th>Octal</th><th>Interrupt</th></tr><tr><td>00000</td><td>INT7</td></tr><tr><td>20200</td><td>INT2</td></tr><tr><td>30300</td><td>INT5</td></tr><tr><td>01010</td><td>INT6</td></tr><tr><td>40400</td><td>INT4</td></tr><tr><td>35774</td><td>INT9</td></tr></table>  | Octal                       | Interrupt    | 00000 | INT7 | 20200                | INT2 | 30300 | INT5         | 01010 | INT6 | 40400                | INT4 | 35774 | INT9 |     |      |     |  |  |  |
| Octal                | Interrupt  |            |               |   |                             |              |       |      |                      |      |       |              |       |      |                      |      |       |      |     |      |     |  |  |  |
| 00000                | INT7       |            |               |   |                             |              |       |      |                      |      |       |              |       |      |                      |      |       |      |     |      |     |  |  |  |
| 20200                | INT2       |            |               |   |                             |              |       |      |                      |      |       |              |       |      |                      |      |       |      |     |      |     |  |  |  |
| 30300                | INT5       |            |               |   |                             |              |       |      |                      |      |       |              |       |      |                      |      |       |      |     |      |     |  |  |  |
| 01010                | INT6       |            |               |   |                             |              |       |      |                      |      |       |              |       |      |                      |      |       |      |     |      |     |  |  |  |
| 40400                | INT4       |            |               |   |                             |              |       |      |                      |      |       |              |       |      |                      |      |       |      |     |      |     |  |  |  |
| 35774                | INT9       |            |               |   |                             |              |       |      |                      |      |       |              |       |      |                      |      |       |      |     |      |     |  |  |  |
| 0                    | 444        | 0522       | $X_4$         | $X_4$ component of radius vector $\bar{R}$  | $C_1(3-6)$                  | 23           | m     |      |                      |      |       |              |       |      |                      |      |       |      |     |      |     |  |  |  |
| 0                    | 445        | 1522       | DIR           | Discrete input register status  | $RS_{ML}(1-5)$<br>$RS_1(6)$ | N/A          | N/A   |      |                      |      |       |              |       |      |                      |      |       |      |     |      |     |  |  |  |
| 0                    | 450        | 0524       | $Y_V$         | $Y_V$ component of radius vector $\bar{R}$  | $C_1(3-4)$                  | 23           | m     |      |                      |      |       |              |       |      |                      |      |       |      |     |      |     |  |  |  |
| 0                    | 455        | 1526       | TBi           | Time base start:  | $0_1(1-5)$                  | N/A          | N/A   |      |                      |      |       |              |       |      |                      |      |       |      |     |      |     |  |  |  |
|                      |            |            |               | <table><tr><th>Octal Code</th><th>Time Base</th></tr><tr><td>0000</td><td>TB0</td></tr><tr><td rowspan="2">{ 0020<br/>or<br/>4000</td><td rowspan="2">TB1</td></tr><tr><td></td></tr><tr><td rowspan="2">{ or<br/>4020</td><td rowspan="2"></td></tr><tr><td></td></tr><tr><td rowspan="2">{ 2020<br/>or<br/>0101</td><td rowspan="2">TB2</td></tr><tr><td></td></tr><tr><td>3030</td><td>TB3</td></tr><tr><td>5050</td><td>TB5</td></tr></table> | Octal Code                  | Time Base    | 0000  | TB0  | { 0020<br>or<br>4000 | TB1  |       | { or<br>4020 |       |      | { 2020<br>or<br>0101 | TB2  |       | 3030 | TB3 | 5050 | TB5 |  |  |  |
| Octal Code           | Time Base  |            |               |   |                             |              |       |      |                      |      |       |              |       |      |                      |      |       |      |     |      |     |  |  |  |
| 0000                 | TB0        |            |               |   |                             |              |       |      |                      |      |       |              |       |      |                      |      |       |      |     |      |     |  |  |  |
| { 0020<br>or<br>4000 | TB1        |            |               |   |                             |              |       |      |                      |      |       |              |       |      |                      |      |       |      |     |      |     |  |  |  |
|                      |            |            |               |   |                             |              |       |      |                      |      |       |              |       |      |                      |      |       |      |     |      |     |  |  |  |
| { or<br>4020         |            |            |               |   |                             |              |       |      |                      |      |       |              |       |      |                      |      |       |      |     |      |     |  |  |  |
|                      |            |            |               |   |                             |              |       |      |                      |      |       |              |       |      |                      |      |       |      |     |      |     |  |  |  |
| { 2020<br>or<br>0101 | TB2        |            |               |   |                             |              |       |      |                      |      |       |              |       |      |                      |      |       |      |     |      |     |  |  |  |
|                      |            |            |               |   |                             |              |       |      |                      |      |       |              |       |      |                      |      |       |      |     |      |     |  |  |  |
| 3030                 | TB3        |            |               |   |                             |              |       |      |                      |      |       |              |       |      |                      |      |       |      |     |      |     |  |  |  |
| 5050                 | TB5        |            |               |   |                             |              |       |      |                      |      |       |              |       |      |                      |      |       |      |     |      |     |  |  |  |

TABLE 11-8 TELEMETRY TAGS (CONTINUED)

| LVDC DATA  |                                |      |                 |                                 |                         |              |       |            |           |      |                             |      |                            |      |                                |      |                        |      |      |      |     |
|--|--------------------------------|------|-----------------|---------------------------------|-------------------------|--------------|-------|------------|-----------|------|-----------------------------|------|----------------------------|------|--------------------------------|------|------------------------|------|------|------|-----|
| Mode   | PIO                            | PCM  | EDD             | Description                     | Frequency<br>(Segments) | Scal-<br>ing | Units |            |           |      |                             |      |                            |      |                                |      |                        |      |      |      |     |
| Reg.   | Tag                            | Tag  | Symbol          |                                 |                         |              |       |            |           |      |                             |      |                            |      |                                |      |                        |      |      |      |     |
| The two conditions on which TB4 was initiated must be indicated by <u>OR</u> ing the associated codes:   |                                |      |                 |                                 |                         |              |       |            |           |      |                             |      |                            |      |                                |      |                        |      |      |      |     |
| <table><tr><th>Octal Code</th><th>Condition</th></tr><tr><td>1000</td><td>INT4 (S-IVB Engine Out "B")</td></tr><tr><td>0200</td><td>DI5 (S-IVB Engine Out "A")</td></tr><tr><td>0030</td><td>Low accelerometer pulse counts</td></tr><tr><td>0004</td><td>Guidance cutoff issued</td></tr></table> |                                |      |                 |                                 |                         |              |       | Octal Code | Condition | 1000 | INT4 (S-IVB Engine Out "B") | 0200 | DI5 (S-IVB Engine Out "A") | 0030 | Low accelerometer pulse counts | 0004 | Guidance cutoff issued |      |      |      |     |
| Octal Code   | Condition                      |      |                 |                                 |                         |              |       |            |           |      |                             |      |                            |      |                                |      |                        |      |      |      |     |
| 1000   | INT4 (S-IVB Engine Out "B")    |      |                 |                                 |                         |              |       |            |           |      |                             |      |                            |      |                                |      |                        |      |      |      |     |
| 0200   | DI5 (S-IVB Engine Out "A")     |      |                 |                                 |                         |              |       |            |           |      |                             |      |                            |      |                                |      |                        |      |      |      |     |
| 0030   | Low accelerometer pulse counts |      |                 |                                 |                         |              |       |            |           |      |                             |      |                            |      |                                |      |                        |      |      |      |     |
| 0004   | Guidance cutoff issued         |      |                 |                                 |                         |              |       |            |           |      |                             |      |                            |      |                                |      |                        |      |      |      |     |
| 0  | 460                            | 0530 | T*              | Time-to-go to S-IVB cutoff      | C <sub>1</sub> (3-4)    | 10           | sec   |            |           |      |                             |      |                            |      |                                |      |                        |      |      |      |     |
| 0  | 461                            | 1530 | N/A             | HOP save of TLC interrupt       | O <sub>1</sub> (1-6)    | N/A          | N/A   |            |           |      |                             |      |                            |      |                                |      |                        |      |      |      |     |
| 0  | 464                            | 0532 | T <sub>3i</sub> | S-IVB IGM time-to-go after EMRC | C <sub>1</sub> (3-4)    | 10           | sec   |            |           |      |                             |      |                            |      |                                |      |                        |      |      |      |     |
| 0  | 465                            | 1532 | DI              | Discrete input indication:      | O <sub>1</sub> (1-4)    | N/A          | N/A   |            |           |      |                             |      |                            |      |                                |      |                        |      |      |      |     |
| <table><tr><th>Octal Code</th><th>Discrete</th></tr><tr><td>0002</td><td>DI14</td></tr><tr><td>0004</td><td>DI15</td></tr><tr><td>0020</td><td>DI7</td></tr><tr><td>4000</td><td>DI24</td></tr><tr><td>3030</td><td>DI23</td></tr><tr><td>4040</td><td>DI5</td></tr></table>                       |                                |      |                 |                                 |                         |              |       | Octal Code | Discrete  | 0002 | DI14                        | 0004 | DI15                       | 0020 | DI7                            | 4000 | DI24                   | 3030 | DI23 | 4040 | DI5 |
| Octal Code   | Discrete                       |      |                 |                                 |                         |              |       |            |           |      |                             |      |                            |      |                                |      |                        |      |      |      |     |
| 0002   | DI14                           |      |                 |                                 |                         |              |       |            |           |      |                             |      |                            |      |                                |      |                        |      |      |      |     |
| 0004   | DI15                           |      |                 |                                 |                         |              |       |            |           |      |                             |      |                            |      |                                |      |                        |      |      |      |     |
| 0020   | DI7                            |      |                 |                                 |                         |              |       |            |           |      |                             |      |                            |      |                                |      |                        |      |      |      |     |
| 4000   | DI24                           |      |                 |                                 |                         |              |       |            |           |      |                             |      |                            |      |                                |      |                        |      |      |      |     |
| 3030   | DI23                           |      |                 |                                 |                         |              |       |            |           |      |                             |      |                            |      |                                |      |                        |      |      |      |     |
| 4040   | DI5                            |      |                 |                                 |                         |              |       |            |           |      |                             |      |                            |      |                                |      |                        |      |      |      |     |

TABLE 15-2 DEFINITIONS (CONTINUED)

| <u>Symbol</u> | <u>Definition and Comments</u>   |   |
|---------------|--|---|
| [MES]         | Transformation matrix from E-system to S-system  |   |
| MFK1-MFK8     | (M/F) <sub>S</sub> filter coefficients   |   |
| [MGA]         | Transformation matrix from G-system to A-system  |   |
| [MG4]         | Transformation matrix from G-system to 4-system  |   |
| MLKRC1        | Gimbal angle RTC used on first pass on the backup gimbal only (all channels) [pirads]            | * |
| MLKRC3        | Gimbal angle RTC used after first pass on the backup gimbal (pitch and yaw channels) [pirads/ML] | * |
| MLKRC5        | Gimbal angle RTC used after first pass on the backup gimbal (roll channel) [pirads/ML]           | * |
| MLK2          | Fine gimbal angle RTC (pitch and yaw channels) [pirads/ML]                                       | * |
| MLK12         | Fine gimbal angle RTC (roll channel) [pirads/ML]   | * |
| MLR           | Minor Loop rate [ $\text{sec}^{-1}$ ]  |   |
| ML6HUN        | Zero gimbal angle test constant (all channels) [pirads]  | * |
| [MSG]         | Transformation matrix from S-system to G-system  |   |
| [MSG]         | Transformation matrix from S-system to G-system  |   |

TABLE 15-2 DEFINITIONS (CONTINUED)

| <u>Symbol</u> | <u>Definition and Comments</u>   |   |
|---------------|--|---|
| MSK5          | Ladder rate limit (all channels) [ladder bits/ML]  | * |
| MSK6          | Ladder magnitude limit (pitch and yaw channels)<br>[ladder/bits]   | * |
| MSK16         | Ladder magnitude limit (roll channel) [ladder bits]  | * |
| MSLIM1        | Attitude command ( $\chi$ ) rate limit (roll channel)<br>[pirads/ML]   | * |
| MSLIM2        | Attitude command ( $\chi$ ) rate limit (pitch and yaw<br>channels) [pirads/ML]                               | * |
| [MSV]         | Transformation matrix from S-system to V-system  |   |
| MS04DT        | The reciprocal of MS25DT   |   |
| MS15DT        | Number of permissible unreasonable backup resolver readings per computation cycle before setting D04 and D06 |   |
| MS25DT        | Number of minor loops per $\Delta T_N$ through minor loop support  |   |
| [MS4]         | Transformation matrix from S-system to 4-system  |   |
| [M4V]         | Transformation matrix from 4-system to V-system  |   |

TABLE 15-2 DEFINITIONS (CONTINUED)

| <u>Symbol</u>     | <u>Definition and Comments</u>   |   |
|-------------------|--|---|
| $T_{EVNT}$        | Intermediate storage location used to store the time of occurrence of a thrust change point at which an accelerometer backup change must occur. This variable must be reset at each designated thrust change point [sec] |   |
| $T_{far}$         | Partition time constant used to determine a time bias for $T_{ar}$ in case of an S-IB engine failure [sec]   |   |
| $T_{f1} - T_{f2}$ | Partition times for time tilt freeze polynomial [sec]  |   |
| $T_{GMT}$         | Universal time or Greenwich mean time (GMT) [sec]  |   |
| $T_{GRR}$         | Time of GRR in universal time ( $T_{GMT}$ ) [sec]  |   |
| $T_{GRR0}$        | Nominal value of $T_{GRR}$ [sec]   |   |
| $T_{HDD}$         | Length of time for hydrogen dump duration, sent in S-IVB/IU de-orbit DCS command [sec]   | * |
| $T_{HSL}$         | Time (referenced to $T^*$ ) to begin HSL calculations [sec]  | * |
| $T'_L$            | Predicted time of liftoff (in GMT) as transmitted to the LVDC from the RCA-110A [sec]  | * |
| $T_{LDD}$         | Length of time for LOX dump duration sent in S-IVB/IU de-orbit DCS command [sec]   | * |

TABLE 15-2 DEFINITIONS (CONTINUED)

| <u>Symbol</u> | <u>Definition and Comments</u>   |        |
|---------------|--|--------|
| $T_{LS}$      | Time in Time Base 5 for LOX dump close and hydrogen dump open sequence start [sec] (see note 1)  | *<br>* |
| $T_{LWC}$     | Liftoff time of launch window closing in terms of $T_{GMT}$ [sec]  |        |
| $T_{RNTL}$    | Time in current time base to implement the DCS return to nominal timeline [sec] (see note 1)   |        |
| $T_{RTC}$     | Time in TB1 to change accelerometer RTC's [sec]  |        |
| $T_{SEQ}$     | Time in current time base to start a DCS alternate sequence; referenced to TBB, the current time base time biased by any time base updates received [sec] (see note 1) |        |
| $T_{SMC}$     | Time in TB3 to enable SMC calculations [sec] (see note 1)  |        |
| $T_{SOM}$     | Time in current time base to start the DCS generalized maneuver or DCS special maneuver [sec] (see note 1)   |        |
| $T_{SON}$     | Time since last orbital navigation pass [sec]  |        |
| $T_{SO}$      | Backup time (based on $T_c$ ) to start roll maneuver and begin using first segment of time tilt coefficients [sec] (see note 1)  |        |
| $T_{SS}$      | Time in Time Base 5 for hydrogen dump close and safing sequence start [sec] (see note 1)   | *<br>* |
| $T_{S1}$      | Time (based on $T_c$ ) to begin using second segment of time tilt coefficients [sec] (see note 1)  |        |
| $T_{S1EO}$    | Time in TB1 to enable DI14 and DI15 check for S-IB engine out [sec] (see note 1)   |        |

TABLE 15-2      DEFINITIONS (CONTINUED)

| <u>Symbol</u> | <u>Definition and Comments</u>                                |
|---------------|---|
| <u>U</u>      |   |
| $U_1$         | IGM parameter used in calculation of position correction term |
| $U_3$         | IGM parameter used in calculation of position correction term |

TABLE 15-2 DEFINITIONS (CONTINUED)

| <u>Symbol</u>                              | <u>Definition and Comments</u>  |   |
|--|---|---|
| <u><b>V</b></u>                            |   |   |
| V  | Total space-fixed velocity [m/sec]  | * |
| $\bar{V}$ ( $\bar{V}_p$ )                  | Vehicle velocity vector (predicted) [m/sec]   |   |
| V'   | Velocity at end of past computation cycle, used in HSL time-to-go calculations [m/sec]        |   |
| V''  | Velocity at end of second past computation cycle, used in HSL time-to-go calculations [m/sec] |   |
| V <sub>ex1</sub>                           | Engine exhaust velocity during first IGM phase [m/sec]  |   |
| V <sub>ex3</sub>                           | Engine exhaust velocity during second IGM phase [m/sec]                                       |   |
| V <sub>GRD</sub>                           | Velocity guard for HSL [m/sec]  |   |
| $\bar{V}_r$                                | Velocity vector relative to the earth's atmosphere [m/sec]                                    |   |
| $\bar{V}_T$                                | Terminal velocity vector [m/sec]  |   |
| VENT <sub>1A</sub> -<br>VENT <sub>8A</sub> | First through eighth vent accelerations [m/sec <sup>2</sup> ]                                 |   |
| VENTNO                                     | Number of vent accelerations  |   |
| VTIM2-<br>VTIM8                            | Time (from T4) to start using second through eighth vent acceleration [sec]                   |   |

TABLE 1-1 EVENT SEQUENCE TIMELINE (CONTINUED)

| Time Reference | EDD Symbol | Presettings (Seconds) | Source Code | Events   |   |
|----------------|------------|-----------------------|-------------|--|---|
| T5             | None       | 0                     |             | <p>Reset bit 7 of MC27.</p> <p>Inhibit the Time Base Update, Execute Generalized Maneuver, Return to Nominal Timeline, Ladder Magnitude Limit and S-IVB/IU De-orbit DCS commands.</p> <p>Disable the loss of APS Attitude Control test.</p> <p>Terminate any Class 4 alternate switch selector sequence in progress, or scheduled.</p> <p>Force a telemetry station loss and disable telemetry acquisition and loss calculations.</p> <p>Set the pitch and yaw ladder magnitude limit (MSK6) to 15.3 deg.</p> <p>Reset the platform measured velocity components, <math>X_m</math>, <math>Y_m</math> and <math>Z_m</math>, to zero.</p> <p>Start monitoring velocity increments (<math>\Delta V</math>).</p> |   |
| T5             | $T_{LS}$   | Variable              | E           | Initiate sequence for LOX depletion dump stop and LH2 depletion dump start. (See Note 4 of Table 1-4).   | * |
| T5             | $T_{SS}$   | Variable              | E           | Initiate sequence for LH2 depletion dump stop and safing. (See Note 5 of Table 1-4).   | * |
| $T5+T_{SS}$    | None       | 1.0                   | D1          | Set the pitch and yaw Ladder Magnitude limit (MSK6) to 2.5 deg.  | * |
| $T5+T_{SS}$    | None       | 2905.0                | D1          | Enable the Execute Generalized Maneuver DCS command.   | * |

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TABLE 1-4 SWITCH SELECTOR SEQUENCING (CONTINUED)

| ICD/IRN   | COMMAND                            | SWITCH SELECTOR |       |     | TIME<br>FROM BASE<br>SECONDS |
|-----------|------------------------------------|-----------------|-------|-----|------------------------------|
|           |                                    | CODE            | STAGE | CHN |                              |
|           | S-IVB CUTOFF SEQUENCE (SEE NOTE 3) |                 |       |     |                              |
| 68M00001A | SIVB ENGINE CUTOFF NO. 1 ON        | 0100 1101       | SIVB  | 12  |                              |
| 68M00001A | SIVB ENGINE CUTOFF NO. 2 ON        | 0010 1100       | SIVB  | 48  |                              |

## Notes on Table 1-4:

### Note 1:

Each of these switch selector commands must be programmed as an alternate switch selector sequence. These are Class 3 alternate switch selector sequences. Requirements for issuance of these alternate sequences are detailed in Section 7.4.10.

### Note 2:

The IU telemetry and S-IVB telemetry shall be calibrated after orbital insertion by using a special sequence. This special sequence of events consists of IU and S-IVB telemetry calibration commands and shall be initiated by the LVDC using special tracking station acquisition logic. The first telemetry calibrate command shall be issued 60.0 seconds after station acquisition as determined by the LVDC. This is a Class 4 alternate switch selector sequence.

### Note 3:

This switch selector sequence must be issued in response to S-IVB velocity cutoff. It should be noted that if Time Base 4 is initiated prior to the completion of this sequence, the sequence must be terminated. The second command of this sequence must be scheduled immediately after the first command. This is a Class 1 alternate switch selector sequence.

### Note 4:

This sequence must be issued to stop the LOX depletion dump and to initiate the hydrogen depletion dump. This sequence must be issued at  $T_5 + T_{LDD} + 33.9$ . The start of this sequence may be delayed by as much as the amount of time required to process the once per 8 second orbital navigation pass. This is a Class 4 alternate switch selector sequence.

Notes on Table 1-4 (Continued)

Note 5:

This switch selector sequence is issued to stop the hydrogen depletion dump and provide safing sequences. This sequence must be issued at  $T_5 + T_{LDD} + T_{HDD} + 63.9$ . The start of this sequence may be delayed by as much as the amount of time required to process the once per eight second orbital navigation pass. This is a Class 4 alternate switch selector sequence.

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## SECTION 2

### SA-207 DATA AND REQUIREMENTS

#### 2.1 INTRODUCTION

The requirements for the SA-207 Flight Program consist of the baseline defined in Part I and this Section of Part II. Wherever the SA-207 program functions must differ from the baseline, the requirements of this Section supersede the baseline requirements of Part I.

The Skylab SL-3 mission has been assigned to the SA-207 vehicle. This mission will be the second manned mission of the Skylab A mission. A general description of the Skylab A mission can be found in Section 1.2 of Part I and Section 1.1 of Part II. \*

The SL-3 mission has the following configuration:

- |                   |           |
|-------------------|-----------|
| • Launch Vehicle  | SA-207    |
| - First Stage     | S-IB-7    |
| - Second Stage    | S-IVB-207 |
| - Instrument Unit | S-IU-207  |
| • Spacecraft      | CSM-117   |

The nominal SL-3 mission will have the following flight profile (See Figure 2-1):

1. The orbital workshop or Skylab-1 (SL-1) will be in an approximately 233.8 NM circular orbit with a 50 degree inclination. The SL-1 will be launched several months earlier and will be visited by the SL-2 mission for up to 28 days.
2. The SA-207/SL-3 vehicle will be launched Northeasterly from KSC Launch Complex 39, Pad B (LC-39B).

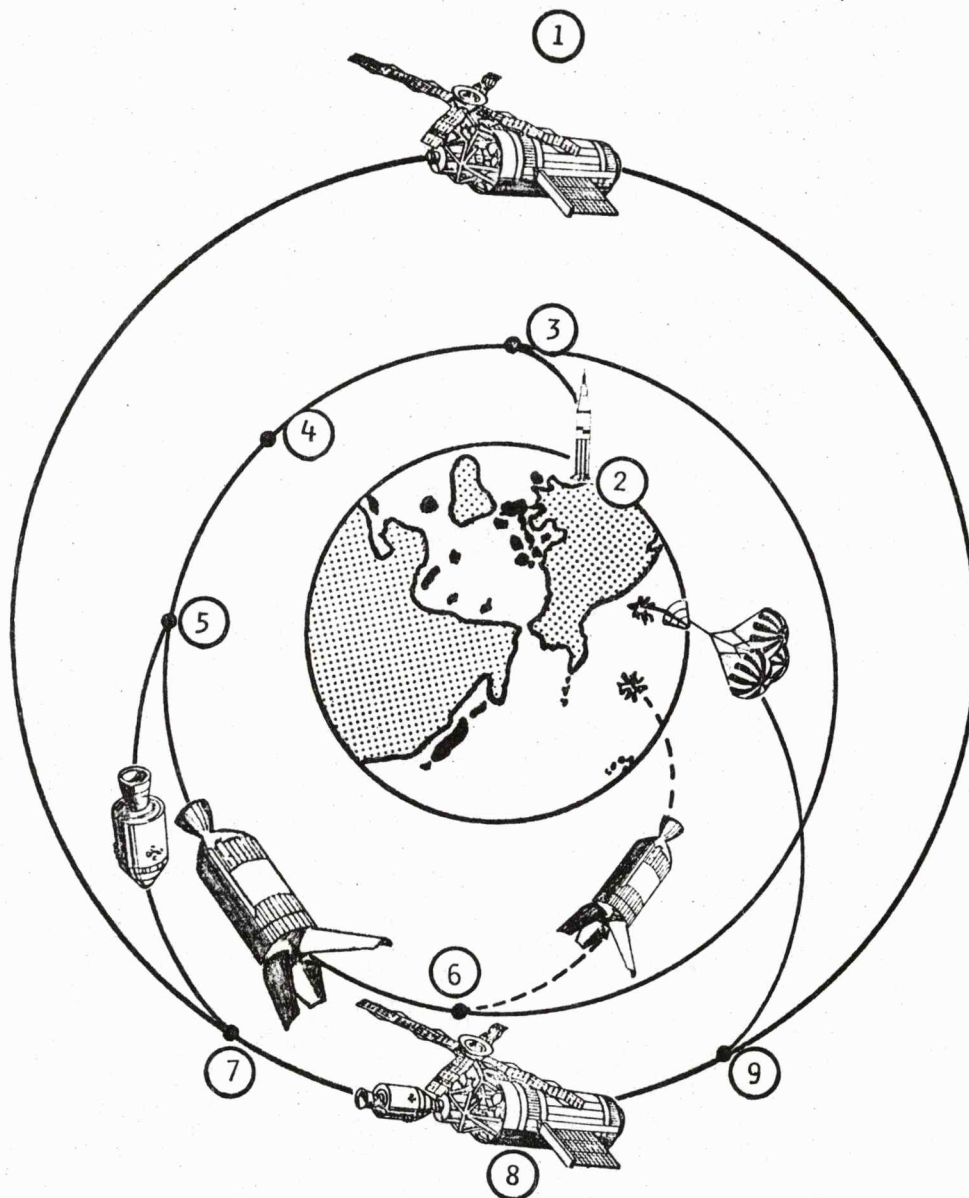


FIGURE 2-1 NOMINAL SA-207/SL-3 MISSION PROFILE.

## 2.2 LOGIC DIFFERENCES BETWEEN THE SA-207/SL-3 MISSION AND THE BASELINE REQUIREMENTS

This section contains the logic differences between the baseline requirements given in Part I and the SA-207/SL-3 mission requirements.

There are six logic differences presently defined for the SA-207/SL-3 mission; these are: \*

- Issue the compressed data dump as a function of a DCS command in lieu of the dump initiated via the acquisition and loss calculations
- Reference the segments of the accelerometer back-up thrust misalignment compensation to time from Time Base 3 (TB3) start instead of time from Time Base 0 (TB0) start
- Stop checking DI9 (Spacecraft Control of Saturn) and reset Bits 1 and 19 of MC27 at T5+0.0 \*
- Delete the requirement to process scheduled INT12 functions if no bit is set in the Interrupt Storage Register (ISR) when the program is interrupted \*
- Reschedule INT11 and INT12 and return to the beginning of the Boost Major Loop (BML) if INT9 is processed during the processing of any interrupt \*
- Inhibit the next two computations of steering misalignment corrections (SMC) terms if an accelerometer failure is detected. \*

Details of these changes are given in the following sections.

### 2.2.1 Compressed Data Dump DCS Command

In the SA-207/SL-3 mission, the compressed data must be telemetered when the compressed data dump DCS command is received. The baseline requirements in Part I specify that the compressed data dumps must be done as a function of the acquisition and loss calculations; this requirement must be deleted. Details of the changes to the baseline required to implement this change are given in the following sections and tables. These sections and tables must replace the corresponding sections and tables in Part I; Section 10.4.14 must be added.

## 5.6 TELEMETRY ACQUISITION AND LOSS

The determination of whether the vehicle is in range of a telemetry station will be done as a function of the vehicle's position with respect to the active telemetry stations. The knowledge that the vehicle is in range of a station will be used to start alternate Class 4 switch selector sequences. Each telemetry station must be tested for acquisition every eight seconds from  $T_4 + BN_5$  until  $T_5 + 0.0$  (see Telemetry Station Table 5-1); however, if it is determined that the vehicle is in range of a telemetry station, the program must not check the remaining stations during that eight second interval.

\*  
\*  
\*

### 5.6.1 Acquisition and Loss Calculations

The determination of whether or not the vehicle is in range of a telemetry station will be made in the following manner.

The earth's rotation since  $T_{GRR}$  is calculated, Eq. 5.6.1, and a new [MGA] matrix is derived. This matrix is then used to transform the vehicle's position in the space-fixed gravitational coordinate system into the earth-fixed telemetry station coordinate system, Eq. 5.6.2. A telemetry station acquisition

value must be the constant which will force the summation of the octal data supplied for that sector to be equal to octal 252525252. This constant has no meaningful decimal equivalent; columns 27 through 39 of this data card must be blank. These data cards must be used to generate a multi-file magnetic tape for input to an RCA-110A program. The tape must be used to load the LVDC with the data requirements for the specified launch opportunity.

TABLE 3-1 VARIABLE DATA TAPE ITEMS

| Variable Data<br>Tape Item Description  | EDD<br>Symbol  | Tape<br>Symbol                   | LVDC<br>Location                             | LVDC<br>Scaling      |
|---|--|----------------------------------|--|----------------------|
| Days past January 1<br>(where Jan. 1 is<br>day zero)<br>referenced to GMT at<br>launch window opening             | $T_{DAY}$  | TDAY                             | 0,16,300                                     | 10                   |
| Constant accelera-<br>tion bias terms for<br>X, Y, and Z axis<br>(m/sec <sup>2</sup> )                            | $B_{XO}$<br>$B_{YO}$<br>$B_{ZO}$   | BXO<br>BYO<br>BZO                | 0,16,301<br>0,16,302<br>0,16,303             | 0<br>0<br>0          |
| Performance factor<br>biases along $X_B$ ,<br>$Y_B$ , and $Z_B$ axes<br>for backup accelera-<br>tion computations | $P_{bx}$<br>$P_{by}$<br>$P_{bz}$   | PBX<br>PBY<br>PBZ                | 0,16,304<br>0,16,305<br>0,16,306             | 1<br>1<br>1          |
| Times in Time Base 3<br>(TB3) to begin using<br>thrust misalignment<br>angles (vectors)<br>1 through 4 (seconds)  | $T_{TMA1}$<br>$T_{TMA2}$<br>$T_{TMA3}$<br>$T_{TMA4}$                                 | TTMA1<br>TTMA2<br>TTMA3<br>TTMA4 | 0,16,307<br>0,16,310<br>0,16,311<br>0,16,312 | 15<br>15<br>15<br>15 |
| X component of<br>thrust misalign-<br>ment vector   | $C\alpha_1$<br>$C\alpha_2$<br>$C\alpha_3$<br>$C\alpha_4$                             | CA1<br>CA2<br>CA3<br>CA4         | 0,16,313<br>0,16,314<br>0,16,315<br>0,16,316 | 0<br>0<br>0<br>0     |
| Y component of<br>thrust misalign-<br>ment vector   | $S\alpha C\beta_1$<br>$S\alpha C\beta_2$<br>$S\alpha C\beta_3$<br>$S\alpha C\beta_4$ | SACB1<br>SACB2<br>SACB3<br>SACB4 | 0,16,317<br>0,16,320<br>0,16,321<br>0,16,322 | 0<br>0<br>0<br>0     |
| Z component of<br>thrust misalign-<br>ment vector   | $S\alpha S\beta_1$<br>$S\alpha S\beta_2$<br>$S\alpha S\beta_3$<br>$S\alpha S\beta_4$ | SASB1<br>SASB2<br>SASB3<br>SASB4 | 0,16,323<br>0,16,324<br>0,16,325<br>0,16,326 | 0<br>0<br>0<br>0     |
| Checksum Constant   | CKSMIB   | CKSMIB                           | 0,16,327                                     | -                    |

\*  
\*

TABLE 15-2 DEFINITIONS (CONTINUED)

| <u>Symbol</u>             | <u>Definition and Comments</u>   |
|---------------------------|--|
| $T_{S2}$                  | Time (based on $T_c$ ) to begin using third segment of time tilt coefficients [sec] (see note 1)                           |
| $T_{TMA1-}$<br>$T_{TMA4}$ | Times (referenced to $T3$ ) to begin using thrust misalignment angles (vectors) in backup accelerometer calculations [sec] |
| $T_{T2}$                  | Earliest time (based on $T_c$ ) for $\chi$ freeze initiation if S-IB engine failure is detected [sec] (see note 1)         |
| $T_{1i}$                  | Time-to-go in first phase of IGM [sec]   |
| $T_{10}$                  | Nominal duration of first phase IGM [sec]  |
| $T_{3i}$                  | Time-to-go in second phase of IGM [sec]  |
| $T_{4M2-}$<br>$T_{4M5}$   | Preset times in TB4 to execute maneuver 2-5 [sec] (see note 1)   |
| TB                        | Elapsed time in prevailing time base [sec]   |
| TBA                       | Time of station acquisition in TB4 [sec]   |
| TBB                       | Value of TB biased by any time base updates received [sec]   |
| TBL                       | Time of station loss in TB4 [sec]  |
| TI                        | Time (from $T_{GRR}$ ) of initiation of the current time base [sec]  |
| TLCK                      | Target load checksum factor set to the two's complement of the sum of the other eight target load variables                |

#### 7.4.9 DI9: S/C Control of Saturn

This discrete originates in the Spacecraft (S/C), and indicates to the LVDC that the S/C has taken control of the flight control computer (FCC) and that the LVDC outputs to the FCC are not being accepted. The program must check this DI once per BML from  $T4 + 5.0^*$  to  $T4 + BN_5$  and once per second from  $T4 + BN_5$  to  $T5 + 0.0$ . A detailed description of the required program response to this DI is found in the Control Switchover Capability description in Section 5. When this DI is recognized, bit 12 of MC27 must be set; this bit is reset when control is returned to the LVDC. \*

If a guidance reference failure (GRF) is detected, the program must check for this DI once per BML in the boost mode and once per second in orbit until detected, until  $T5 + 0.0$ , or until EOM, whichever occurs first. If DI9 is on after GRF, the attitude error commands must be set to zero for the remainder of the mission. Bit 15 of MC27 must also be set and remain set for the remainder of the mission. If DI9 is on when guidance reference failure is detected, bit 12 of MC27 must remain set as well as bit 15 of MC27. For a complete description of program responses to GRF, see Section 8.2.2. \*

If the S/C has taken control of the Saturn, this DI is a logic 1; otherwise, it will be a logic 0. The S/C Control of Saturn Enable switch selector command must be issued or D04 or D06 must be set in order for the S/C commands to be accepted by the FCC. The S/C Control of Saturn Disable switch selector command disables the S/C commands from being accepted by the FCC unless D04 or D06 is on. Although the S/C cannot control the FCC unless the above conditions are met, the discrete input register will recognize this DI during all periods of flight up to S/C separation, at which time this DI becomes zero and remains in that state until EOM.

#### 10.4.6 Execute Generalized Maneuver

This DCS mode command will provide the capability to initiate either an inertial attitude hold or a track local reference orbital maneuver with any attitude within the limitations defined in Section 8.3.2. The five data quantities required by this mode command, their units and scaling, are described in Table 10-12.

These parameters will be contained in 20 DCS data commands. Since only six true information bits are transmitted with each DCS data command, five transmissions are required to form each 26-bit LVDC word. Since the GOMTYP parameter only requires two bit locations, it is transmitted in the spare location of the fifth data word of  $T_{SOM}$ . The most significant bit of each LVDC word must be transmitted first, and negative quantities must be in two's complement form. The five parameters must be transmitted in the order  $T_{SOM}$ , GOMTYP,  $Y_{ref}$ ,  $Z_{ref}$ ,  $X_{ref}$ . The information bit format for the first 5 data commands containing

TABLE 10-12 EXECUTE GENERALIZED MANEUVER PARAMETERS

| Parameter | Definition  | Units  | Scaling |
|-----------|---|--------|---------|
| $T_{SOM}$ | Time in current time base to start the generalized orbital maneuver           | sec    | 15      |
| GOMTYP    | Type of generalized orbital maneuver (Inertial hold or track local reference) | N/A    | N/A     |
| $Y_{ref}$ | Y reference angle   | pirads | 0       |
| $Z_{ref}$ | Z reference angle   | pirads | 0       |
| $X_{ref}$ | X reference angle   | pirads | 0       |

At present, no preprogrammed DCS alternate sequences are defined. Switch selector alternate sequence classes, telemetry mode code bits, and other specific details of implementation will be defined when requirements for individual DCS alternate sequences are defined.

TABLE 11-13 MODE CODE DESCRIPTION (CONTINUED)

| Mode Code 27 |  |   |
|--------------|--|---|
| Bit No.      | Bit Set Indication   | Reset Bit   |
| 5            | Powered flight~DCS inhibit removed   | This bit must be reset each time the DCS is inhibited.  |
| 1            | Execute Alternate Sequence DCS command accepted  | This bit must be reset after the corresponding alternate sequence command has been implemented.                       |
| 2-6          | Spares   | This bit must be reset at T5+0.0. *   |
| 7            | S-IVB/IU De-orbit DCS command accepted   | This bit must be reset at TB5 start.  |
| 8            | Navigation Update DCS command accepted   | This bit must be reset after the update is incorporated.  |
| 9            | Time Base Update DCS command accepted  | The state of this bit will initially be zero and must be changed each time an update is accepted.                     |
| 10           | Local reference maneuver in progress   | This bit must be reset when bit 11, 12, 16 or 17 of MC27 is set.  |
| 11           | Inertial attitude hold in progress   | This bit must be reset when bit 10, 12, 16 or 17 of MC27 is set.  |
| 12           | S/C in control (DI9 recognized)  | This bit must be reset when control is returned to the LVDC. If GRF occurs while this bit is set, it must remain set. |
| 13           | Spare  |   |
| 14           | Guidance Reference Failure discretes (DO4/DO6) are set.  | This bit must never be reset after it has been set.   |
| 15           | S/C has assumed control of the Saturn after GRF detection (DI9 recognized after DO4 and DO6 set.)          | This bit must never be reset after it has been set.   |
| 16           | Tracking local reference after S/C control (This bit remains set until time for next programmed maneuver.) | This bit must be reset when bit 10, 11, 12 or 17 of MC27 is set.  |

TABLE 11-13 MODE CODE DESCRIPTION (CONTINUED)

| Mode Code 27 |   |   |
|--------------|---|---|
| Bit No.      | Bit Set Indication  | Reset Bit   |
| 17           | Inertial attitude hold maneuver after S/C control (This bit remains set until time for next programmed maneuver.) | This bit must be reset when bit 10, 11, 12 or 16 of MC27 is set.  |
| 18           | Water Control Valve Logic Inhibit DCS command not accepted (This bit is nominally set.)                           | This bit must be reset upon acceptance of the Water Control Valve Logic Inhibit DCS command. This bit will never be set after it has been reset.                      |
| 19           | Execute Generalized Maneuver DCS command accepted   | This bit must be reset upon acceptance of a Return to Nominal Timeline DCS command or Execute Special Maneuver command or when the generalized maneuver is initiated. |
| 20-25        | Spares  | This bit must be reset at T5+0.0.   |

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\*

#### 2.2.4 Response to Interrupts when No Bit is Set in the ISR

The baseline requirements of Part I specify in Section 7.5.11 that, if an interrupt occurs and no bit is set in the interrupt storage register, the program must check the INT12 scheduler. If the scheduler indicates that an INT12 should have been generated, the program must process the function called for by the scheduler. If the scheduler indicates that INT12 functions are not required, control must be returned to the interrupted program.

Since the interrupt circuitry in the LVDA is triple modular redundant (TMR), there is no need for this special processing. Details of the changes to the baseline required to delete this requirement are given in the following Sections 7.5 and 7.5.11. Changes from the baseline requirements are marked by an \* in the right-hand margin.

### 7.5 INTERRUPTS

Twelve interrupts have been provided in the LVDC in order to permit the interruption of the normal program to free the computer for priority tasks. The LVDC must respond to the interrupt upon completion of the instruction being executed when the interrupt is received, or after interrupts are enabled following interrupt protected logic.

Of the twelve interrupts, nine are external and inform the LVDC of the occurrence of an event which requires immediate action. Three interrupts are provided for functions internal to the LVDC. These are the simultaneous memory error (TLC) and two interrupts whose use is determined by the implementation of the flight program. See Table 7-3.

TABLE 2-1 EVENT SEQUENCE TIMELINE (CONTINUED)

| Time Reference | EDD Symbol | Presettings (Seconds) | Source Code | Events   |
|----------------|------------|-----------------------|-------------|--|
| T5             | None       | 0                     |             | Reset Bits 1, 7, and 19 of MC27.<br>Inhibit the Time Base Update, Execute Generalized Maneuver, Return to Nominal Timeline, Ladder Magnitude Limit and S-IVB/IU De-orbit DCS commands.<br>Disable the loss of APS Attitude Control test.<br>Terminate any Class 4 alternate switch selector sequence in progress, or scheduled.<br>Disable telemetry acquisition and loss calculations and force a station loss.<br>Stop checking DI9, S/C Control of Saturn.<br>Set the pitch and yaw ladder magnitude limit (MSK6) to 15.3 deg.<br>Reset the platform measured velocity components, $\dot{X}_m$ , $\dot{Y}_m$ and $\dot{Z}_m$ , to zero.<br>Start monitoring velocity increments ( $\Delta V$ ). |
| T5             | $T_{LS}$   | Variable              | E           | Initiate sequence for LOX depletion dump stop and hydrogen depletion dump start. (See Note 4 of Table 2-4).  |
| T5             | $T_{SS}$   | Variable              | E           | Initiate sequence for hydrogen depletion dump stop and safing. (See Note 5 of Table 2-4).  |
| $T5+T_{SS}$    | None       | 1.0                   | D1          | Set the pitch and yaw Ladder Magnitude limit (MSK6) to 2.5 deg.  |
| $T5+T_{SS}$    | None       | 2905.0                | D1          | Enable the Execute Generalized Maneuver DCS command.   |

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Notes on Table 2-4:

Note 1:

Each of these switch selector commands must be programmed as an alternate switch selector sequence. These are Class 3 alternate switch selector sequences. Requirements for issuance of these alternate sequences are detailed in Section 7.4.10.

Note 2:

The IU telemetry and S-IVB telemetry shall be calibrated after orbital insertion by using a special sequence. This special sequence of events consists of IU and S-IVB telemetry calibrate commands and shall be initiated by the LVDC using special tracking station acquisition logic. The first telemetry calibrate command shall be issued 60.0 seconds after station acquisition as determined by the LVDC. This is a Class 4 alternate switch selector sequence. \*

Note 3:

This switch selector sequence must be issued in response to S-IVB velocity cutoff. It should be noted that if Time Base 4 is initiated prior to the completion of this sequence, the sequence must be terminated. The second command of this sequence must be scheduled immediately after the first command. This is a Class 1 alternate switch selector sequence. \*

Notes on Table 2-4 (Continued)

Note 4:

This sequence must be issued to stop the LOX depletion dump and to initiate the hydrogen depletion dump. This sequence must be issued at  $T5 + T_{LDD} + 33.9$ . The start of this sequence may be delayed by as much as the amount of time required to process the once per eight second orbital navigation pass. This is a Class 4 alternate switch selector sequence.

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Note 5:

This switch selector sequence is issued to stop the hydrogen depletion dump and provide safing sequences. This sequence must be issued at  $T5 + T_{LDD} + T_{HDD} + 63.9$ . The start of this sequence may be delayed by as much as the amount of time required to process the once per eight second orbital navigation pass. This is a Class 4 alternate switch selector sequence.

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SECTION 3  
SA-207A DATA AND REQUIREMENTS

3.1 INTRODUCTION

The requirements for the SA-207A Flight Program consist of the baseline defined in Part I and this Section of Part II. Wherever the SA-207A program functions must differ from the baseline, the requirements of this Section supersede the baseline requirements of Part I.

The Skylab SL-3A mission has been assigned to the SA-207 vehicle. This mission will be the second manned mission of the Skylab A mission. A general description of the Skylab A mission can be found in Section 1.2 of Part I and Section 1.1 of Part II.

The SL-3A mission has the following configuration;

- |                   |           |
|-------------------|-----------|
| • Launch Vehicle  | SA-207    |
| - First Stage     | S-IB-7    |
| - Second Stage    | S-IVB-207 |
| - Instrument Unit | S-IU-208  |
| • Spacecraft      | CSM-117   |

The nominal SL-3A mission will have the following flight profile (See Figure 3-1):

1. The orbital workshop or Skylab-1 (SL-1) will be in an approximately 233.8 NM circular orbit with a 50 degree inclination. SL-1 will be launched several months earlier and will be visited by the SL-2 mission for up to 28 days.

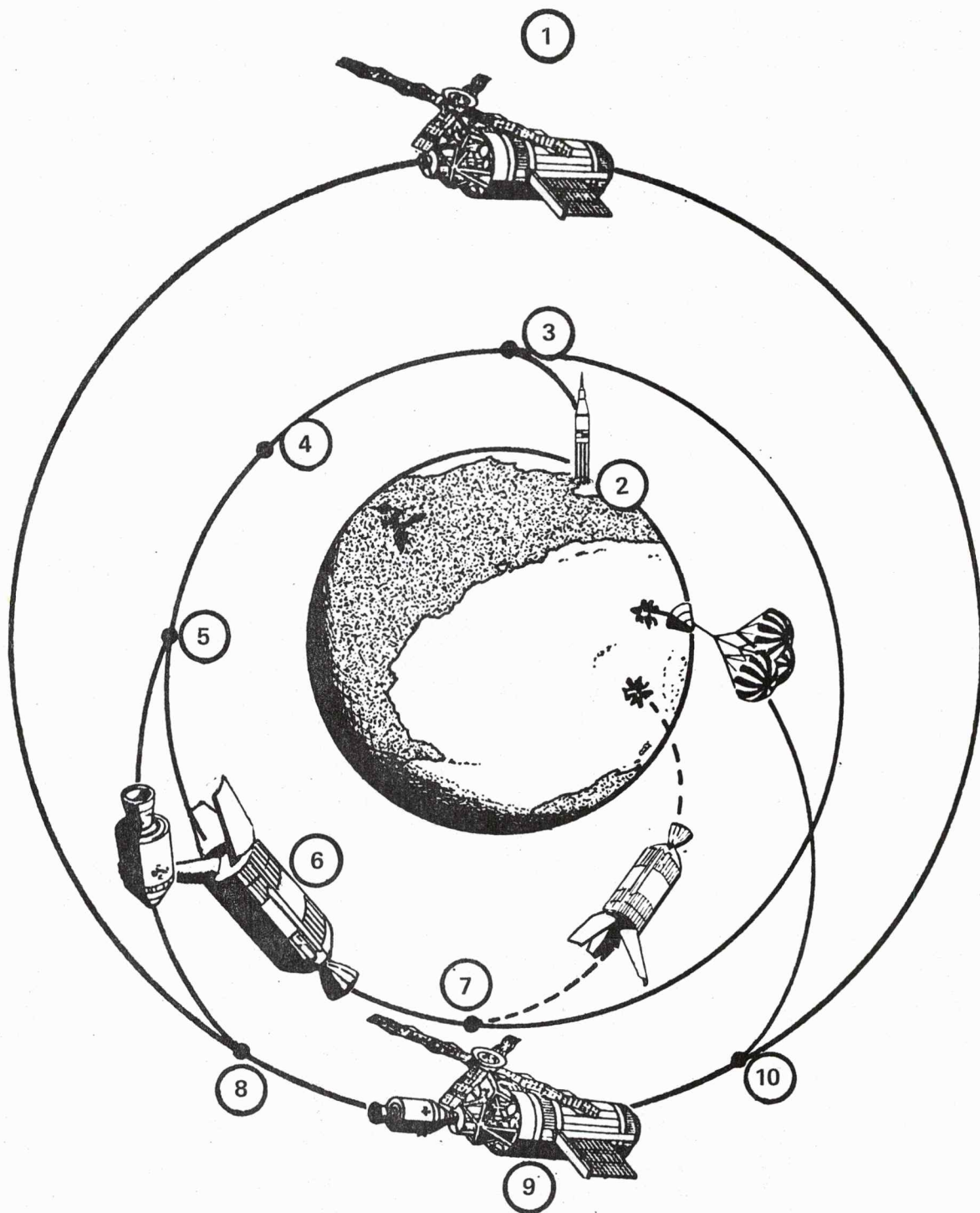


FIGURE 3-1 NOMINAL SA-207A/SL-3A MISSION PROFILE

2. The SA-207/SL-3 launch vehicle will transport the second crew to the orbital workshop for a visit of up to 56 days. The SA-207/SL-3 vehicle will be launched northeasterly from KSC Launch Complex 39, Pad B (LC-39B).
3. The S-IVB/IU and CSM will be inserted into an 81 by 120 NM orbit.
4. The spacecraft will initiate separation of the S-IVB/IU and the CSM.
5. The CSM will use the Service Propulsion System (SPS) to begin rendezvous with the workshop leaving the S-IVB/IU in the 81 by 120 NM orbit.
6. The S-IVB/IU will be rotated through a negative pitch angle to a retrograde attitude 190 seconds after spacecraft separation to permit operation of the S150 Galactic X-Ray Experiment. Orbital Maneuvers will be executed to reorient the experiment sensor in the celestial sphere.
7. After approximately four orbits the residual S-IVB propellants will be dumped through the engine, on ground command, causing the S-IVB/IU to de-orbit.
8. The CSM will rendezvous and dock with the workshop.
9. The crew will transfer from the CSM and activate the workshop. The crew will stay with the workshop for up to 56 days.
10. After the mission is complete the crew will prepare the workshop for orbital storage, and transfer to the CSM. The CSM will undock and de-orbit for an Earth re-entry and mid-Pacific recovery.

### 3.2 LOGIC DIFFERENCES BETWEEN THE SA-207A/SL-3A MISSION AND THE BASELINE REQUIREMENTS

This section contains the logic differences between the baseline requirements given in Part I and the SA-207A/SL-3A mission requirements. Differences from the baseline requirements of Part I are indicated by asterisks in the right margin opposite the changes. The corresponding page numbers from Part I are given in parentheses following each page number of this section.

The following sources of logic differences are presently defined for the SA-207A/SL-3A mission:

- Issue the compressed data dump as a function of a DCS command in lieu of the dump initiated via the acquisition and loss calculations.
- Reference the segments of the accelerometer backup thrust misalignment compensation to time from Time Base 3 (TB3) start instead of time from Time Base 0 (TB0) start.
- Stop checking DI9 (Spacecraft Control of Saturn) at initiation of alternate sequence T4a and reset Bits 1 and 19 of MC27 at T5+0.0.
- Maneuver the S-IVB/IU to the orbital attitudes required to perform the S150 Galactic X-Ray Experiment; issue commands to sequence functions of this experiment; and collect, store, and telemeter vehicle gimbal angle data for experiment evaluation.
- Delete the requirement to process scheduled INT12 functions if no bit is set in the Interrupt Storage Register (ISR) when the program is interrupted. \*  
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order of their appearance in Part I, since the requirements of the change areas overlap. Thus, each Part I page will appear only once in this section. Unchanged pages of Part I are not reprinted in Part II.

#### 3.2.1 Compressed Data Dump DCS Command

In the SA-207A/SL-3A mission, the compressed data must be telemetered when the compressed data dump DCS command is received. The baseline requirements in Part I specify that the compressed data dumps must be done as a function of the acquisition and loss calculations; this requirement must be deleted.

#### 3.2.2 Accelerometer Backup Thrust Misalignment Time Reference

The baseline requirements of Part I specify that the accelerometer backup thrust misalignments must be segmented as a function of time from GRR. In the SA-207A/SL-3A mission these segments must be referenced to time in Time Base 3 (TB3).

#### 3.2.3 Reset Bits 1 and 19 of MC27 at Time Base 5 Start

The baseline requirements of Part I specify that if an execute alternate sequence command or an execute generalized maneuver command is pending when a new orbital primary time base is started, the pending command must be cancelled. Bits 1 and 19 of MC27 are specified to indicate, respectively, that an execute alternate sequence and an execute generalized maneuver is pending and the corresponding bit must be reset when the pending command is implemented. For the SA-207A mission these bits must also be reset at Time Base 5 start to indicate that the command is no longer pending, since it is cancelled by the start of the new time base.

#### 3.2.4 S150 Galactic X-Ray Experiment

The SA-207A/SL-3A LVDC flight program must perform the following operations as a part of the S150 Galactic X-Ray Experiment:

- Initiate events and switch selector command sequences for experiment activation and calibration
- Compress gimbal angle data and associated mission time for experiment evaluation
- Provide DCS alternate sequence commands for dumping the Auxiliary Storage and Playback (ASAP) recorder and as a backup for initial activation of the experiment
- Maneuver the launch vehicle to various orbital viewing positions for collection of experiment data.

In order to properly reference the required S150 experiment operations, four additional Class 4 alternate switch selector command sequences have been defined for execution at specified times during Time Base 4, as follows:

- Initial activation of S150 experiment at Spacecraft Separation or upon receipt of the proper DCS command, designated as alternate sequence T4a (one time only)
- Initiate ASAP data dump sequence, upon receipt of proper DCS command, designated as alternate sequence T4b (repetitive)

If GRF occurs prior to the start of TB2, the downrange velocity guard on TB2 must be bypassed.

If GRF occurs prior to HSL entrance, HSL entrance is inhibited and DI9 tests are enabled.

For further details on required program responses to GRF, see Section 8.2.2.

#### 4.4.4 Steering Misalignment Correction (SMC)

Because of thrust vector misalignment and center of mass offset, it is possible that the thrust direction achieved in response to IGM guidance commands is in error. The steering misalignment correction (SMC) compensates for this error and achieves the desired thrust direction. To accomplish this, SMC terms in both pitch and yaw planes are calculated by determining the relative position of the acceleration vector with respect to the vehicle longitudinal axis. Eq. 4.4.83 and 4.4.84 are used to calculate the pitch and yaw SMC terms, respectively.

The values of  $\chi_y$  and  $\chi_z$  used in Eq. 4.4.83 and 4.4.84 are the minor loop  $\chi$ 's read within two minor loops following the read of the accelerometers.

Steering misalignment correction term are first computed at  $T3 + T_{SMC}$ . The SMC terms are set to zero at  $T4 + 0.0$ . Calculations of new SMC terms are inhibited during HSL and during periods when one or more of the following failure conditions exists:

- An indication of an unreasonable gimbal angle exists in the first past BML \*
- An indication of an unreasonable accelerometer reading exists in the current or first past BML \*

- An indication of an unacceptable accelerometer zero change exists in the current or first past BML \*
- One or more minor loop guidance command is rate limited in the first past BML \*
- The yaw guidance command is magnitude limited in the first past BML. \*

During periods when SMC terms are being computed, bit 10 of MC25 is set; it is reset when SMC calculations are inhibited. The SMC terms are held at their last computed values while the calculations are inhibited.

#### 4.4.5 Chi Computations

Steering commands computed in IGM and orbital guidance are converted into plumblane coordinate system guidance commands. The steering commands  $\chi_{y4}$  and  $\chi_{z4}$  are used to form the desired unit thrust vector relative to the target plane coordinate system. This unit thrust vector is then transformed into the plumblane coordinate system, Eq. 4.4.85. The inertial pitch and yaw guidance commands are then computed from the components of the unit thrust vector, Eq. 4.4.86 and 4.4.87. The SMC terms are added to the guidance commands. After the inertial pitch and yaw guidance commands are computed, the yaw command is limited to a maximum magnitude of 45 degrees. This limit is required to prevent the tumbling of the three gimbal platform by approaching the physical limitations in the middle (yaw) gimbal.

must be performed. Bit 16 of MC27 must be set for the duration of this maneuver. Bits 10, 11, 12, and 17 of MC27 must be reset.

#### 5.5.6 Guidance Reference Failure (GRF)

If guidance reference failure (GRF) is detected at any time during the mission, the S/C control of Saturn capability will be provided by hardware logic in response to the GRF discrete outputs (DO4 or DO6). This hardware capability can never be disabled once enabled. Checks for DI9 must begin immediately upon detection of GRF and must continue to be made once per BML during boost mode or once per second during orbital mode, until initiation of alternate sequence T4a, until DI9 is detected, or until EOM, whichever occurs first. Once DI9 is detected, bit 15 of Mode Code 27 must be set. This bit must never be reset. \*

Upon detection of GRF, all attitude error commands originating from the flight program must be frozen at their current value until DI9 is detected. When DI9 is detected, all attitude error commands will be frozen at zero for the remainder of the mission. \*

#### 5.5.7 DCS Commanded Functions

The preprogrammed attitude timeline can be altered by acceptance of a Generalized Execute Maneuver DCS command. Return will be made to the preprogrammed timeline upon acceptance of the Return to Nominal Timeline DCS command. (See Sections 10.4.7 and 10.4.8.) \*

### 5.6 TELEMETRY ACQUISITION AND LOSS

The determination of whether the vehicle is in range of a telemetry station will be done as a function of the vehicle's position with respect to the active telemetry stations. The knowledge that the vehicle is in range of a station will be used to start alternate Class 4 switch selector sequences.

Each telemetry station must be tested for acquisition every eight seconds from  $T_4 + BN_5$  until  $T_5 + 0.0$ . (See Telemetry Station Table 5-1); however, if it is determined that the vehicle is in range of a telemetry station, the program must not check the remaining stations during that eight second interval.

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#### 5.6.1 Acquisition and Loss Calculations

The determination of whether or not the vehicle is in range of a telemetry station will be made in the following manner.

The earth's rotation since  $T_{GRR}$  is calculated, Eq. 5.6.1, and a new [MGA] matrix is derived. This matrix is then used to transform the vehicle's position in the space-fixed gravitational coordinate system into the earth-fixed telemetry station coordinate system, Eq. 5.6.2. A telemetry station acquisition sphere with radius  $R_{STA}$  is used in computing station acquisition at a zero degree elevation angle from a point above each station. Each station acquisition reference point lies at the intersection of the acquisition sphere with a line passing from the center of the Earth through the station. The distance,  $d_A(i)$ , of the vehicle above or below the horizon of the acquisition reference point is calculated (Eq. 5.6.3 through 5.6.5). This is done by subtracting the radius,  $R_{STA}$ , of the telemetry station acquisition sphere from the dot product of the transformed vehicle's position vector and the unit station vector,  $\overline{C}_A(i)$ . If  $d_A(i)$  is found to be zero or positive for a station in the list, the vehicle is considered to be in acquisition of that station. The preset value of  $R_{STA}$  for each mission is selected to give approximately two degrees of elevation above the horizon of each station at the nominal orbit altitude. The components of  $\overline{C}_A$  for each station in the telemetry station coordinate system are preset for each mission (see Table 5-1). When a station acquisition or loss is computed, the time of acquisition, TBA, or the time of loss, TBL, in the prevailing time base must be updated.

\*

TABLE 7-2 DISCRETE INPUTS

| Discrete Input No. | LVDC Bit Position | Function                                     |
|--------------------|-------------------|--|
| 1                  | 23                | RCA-110A Sync                                |
| 2a                 | 22                | Command Decoder OM/D "A"                     |
| 2b                 | 22                | Command Decoder OM/D "B"                     |
| 3                  | 21                | Spare (See Section 7.4.3)                    |
| 4                  | 20                | Spare (wired to Control Distributor)         |
| 5                  | 19                | S-IVB Engine Out "A"                         |
| 6                  | 18                | Spacecraft Separation Indication             |
| 7                  | 17                | Liftoff "B"                                  |
| 8                  | 16                | Spare (wired to ESE)                         |
| 9                  | 15                | Spacecraft Control of Saturn                 |
| 10                 | 14                | Coolant Thermal Switch #1                    |
| 11                 | 13                | Coolant Thermal Switch #2                    |
| 12                 | 12                | S-IB/S-IVB Separation                        |
| 13                 | 11                | Spare (See Section 7.4.13)                   |
| 14                 | 10                | S-IB Outboard Engine Out                     |
| 15                 | 9                 | S-IB Inboard Engine Out                      |
| 16                 | 8                 | Prepare for Guidance Reference Release       |
| 17                 | 7                 | Spare  |
| 18                 | 6                 | Spare  |
| 19                 | 5                 | Spare (See Section 7.4.19)                   |
| 20                 | 4                 | Spacecraft Initiation of S-IVB Engine Cutoff |
| 21                 | 3                 | Spare (wired to Control Distributor)         |
| 22                 | 2                 | Spare (wired to Control Distributor)         |
| 23                 | 1                 | S-IB Outboard Engines Cutoff "B"             |
| 24                 | Sign              | Liftoff "A"                                  |
| DIS1               | 7                 | Spare (not wired)                            |
| DIS2               | 6                 | Spare (not wired)                            |
| DIS3               | 5                 | Spare (not wired)                            |
| DIS4               | 4                 | Spare (not wired)                            |
| DIS5               | 3                 | Spare (not wired)                            |
| DIS6               | 2                 | Spare (not wired)                            |
| DIS7               | 1                 | Spare (not wired)                            |
| DIS8               | Sign              | Spare (not wired)                            |

#### 7.4.2 DI2: Command Decoder OM/D "A" and Command Decoder OM/D "B"

This DI indicates to the LVDC whether a DCS command is a mode or data command. A logic 1 indicates a mode command has been received, and a logic 0 indicates a data command has been

received. This DI must be interrogated once upon receipt of each command decoder interrupt (INT8); see Section 10 for details of the required program response to this DI.

7.4.3 DI3: Spare (Wired to IU/S-IVB Interface on SA-206 and SA-207, wired to Control Distributor on SA-208 and Subs)

7.4.4 DI4: Spare (Wired to Control Distributor)

7.4.5 DI5: S-IVB Engine Out "A"

DI5 indicates that the S-IVB engine is out. This DI must be checked once per BML, until recognition, during the interval from  $T3 + S4IGTM$  until  $T4 + 0.0$ . DI5 is used as one of the inputs to initiate TB4 (see paragraph 7.2.5). Upon detection of DI5, the discrete's presence must be noted as satisfying one of the conditions for initiating TB4, and the check for the discrete must be discontinued.

This DI will be actuated when both of the two "thrust OK" switches in the S-IVB J2 engine indicate that the engine main LOX injection pressure is below operating level. There are no hardware inhibits of this DI, and it will be active during the entire mission.

7.4.6 DI6: Spare (IUs SA-206, SA-207, SA-209 and Subs),  
Spacecraft Separation Indication (IU SA-208)

This DI indicates that the spacecraft has separated from the S-IVB/IU. DI6 is a logic 0 until separation at which time it becomes a logic 1. DI6 must be monitored once per second from  $T4 + T4a_{GRD}$  seconds until recognized as a logic 1 at which time alternate sequence T4a must be initiated, referenced to T4. Bit 6 of MC27 must be set at the initiation of alternate sequence T4a.

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#### 7.4.7 DI7: Liftoff "B"

This DI, along with DI24, indicates that liftoff has occurred. These DIs are provided by the deactuation of the liftoff relays in the IU at umbilical disconnect and must be interrogated before and after every minor loop (twice every 40 ms) during the time from  $T_0 + 17.4^*$  (-0, +40 ms) until detected or until  $T_0 + BU3$ , whichever occurs earlier. These DIs are of equal priority and are used as indications to start TB1 (see Time Base 1 start logic).

#### 7.4.8 DI8: Spare (Wired to the ESE)

#### 7.4.9 DI9: S/C Control of Saturn

This discrete originates in the Spacecraft (S/C), and indicates to the LVDC that the S/C has taken control of the flight control computer (FCC) and that the LVDC outputs to the FCC are not being accepted. The program must check this DI once per BML from  $T_4 + 5.0^*$  to  $T_4 + BN_5$  and once per second from  $T_4 + BN_5$  until initiation of alternate sequence T4a. A detailed description of the required program response to this DI is found in the Control Switchover Capability description in Section 5. When this DI is recognized without guidance reference failure, bit 12 of MC27 must be set; this bit is reset when control is returned to the LVDC.

If a guidance reference failure (GRF) is detected, the program must check for this DI once per BML in the boost mode and once per second in orbit until detected, until initiation of alternate sequence T4a, or until EOM, whichever occurs first. If DI9 is on after GRF, the attitude error commands must be set to zero for the remainder of the mission. Bit 15 of MC27 must also be set and remain set for the remainder of the mission. If DI9 is on when guidance reference failure is detected, bit 12 of MC27 must remain set as well as bit 15 of MC27. For a complete description of program responses to GRF, see Section 8.2.2.

If the S/C has taken control of the Saturn, this DI is a logic 1; otherwise, it will be a logic 0. The S/C Control of Saturn Enable switch selector command must be issued or D04 or D06

3. Determine the source of the interrupt
4. Perform the functions required by the interrupt
5. Remove the inhibit of normally enabled interrupts unless the time is within 60 milliseconds (ms) of S-IVB cutoff, in which case only the inhibit on INT12 is removed to permit the S-IVB cutoff to occur at exactly the correct time
6. Return to the main program.

If more than one interrupt occurs at the same time, they must be processed in the following priority sequence: INT9, INT12, external, INT11 (external interrupts must be processed in descending order). \*

If an interrupt occurs and no bit is set in the interrupt storage register, the program must return to the interrupted program. \*

A brief description of these interrupts and the required response is provided below.

#### 7.5.1 INT1: Command LVDA/RCA-110A Interrupt

This signal is used in the Preflight routines and there is no requirement to process it by the flight program. A logic 1 indicates an interrupt from the RCA-110A. A logic 0 indicates no interrupt is present. The line from the RCA-110A breaks at L0, and this interrupt will remain a logic 0 until the EOM.

#### 7.5.2 INT2: S-IB Low Level Sensors Dry "A"

This interrupt indicates that the propellant level in either the S-IB fuel tanks or LOX tanks has dropped below a given level. This interrupt must be program inhibited until the time of issuance of the "Propellant Level Sensors Enable" switch selector command. This interrupt is used as one of the signals for starting Time Base 2 (see Section 7.2.3). Once this interrupt is received or when Time Base 2 is started, this interrupt must be inhibited for the remainder of the mission.

#### 10.4.10.1 Execute Alternate Sequence T4a

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Alternate sequence T4a must be initiated upon recognition of spacecraft separation (DI6 set to a logic 1). However, if DI6 fails to set to a logic 1, DCS command capability must be provided to allow a backup means for starting this alternate sequence. Upon receipt of an Execute Alternate Sequence command with SEQNUM=0001, the LVDC must, upon verification of the mode and data commands, execute alternate sequence T4a at the specified implementation time. Once T4a has been initiated, this specified implementation time must be recorded in the LVDC as a time reference for later sequencing of attitude pointing maneuvers, S150 Calibrate Commands, and S150 TM time correlation commands. Bit 6 of MC27 must be set at the initiation of alternate sequence T4a.

This alternate sequence must be enabled at  $T4 + T4a_{GRD}$  and will activate the S150 Galactic X-Ray Experiment. If this sequence is commanded via the DCS and accepted prior to  $T4 + T4a_{GRD}$  with  $T_{SEQ}$  less than  $T4a_{GRD}$ , it must be held and implemented at  $T4 + T4a_{GRD}$ . At the initiation of alternate sequence T4a, checks for DI6 and DI9 must be terminated. If an Execute Alternate Sequence Command with SEQNUM=0001 is received after alternate sequence T4a has been initiated, the command must be rejected and DCS error message 70 must be issued as defined in Section 10.3.

#### 10.4.10.2 Execute Alternate Sequence T4b

\*

Upon receipt of an Execute Alternate Sequence Command with SEQNUM=0010, the LVDC must, upon verification of the mode and data commands, execute alternate sequence T4b at the specified implementation time. Each transmission of this DCS command will initiate a dump of S150 Experiment sensor data stored on the Auxiliary Storage and Playback (ASAP) recorder. In addition

to initiating these dumps, alternate sequence T4b will terminate the dumps and reprogram the recorder to accept additional data. While the ASAP data dump initiated by alternate sequence T4b is in progress, telemetry of LVDC data will be hardware inhibited.

Alternate sequence T4b must be enabled at  $T4 + T4b_{GRD}$ . If this sequence is commanded via the DCS and accepted prior to  $T4 + T4b_{GRD}$  with  $T_{SEQ}$  less than  $T4b_{GRD}$ , it must be held and implemented at  $T4 + T4b_{GRD}$ .

and telemetered in the same BML, at which time the ORed word must be reset. In orbital mode, a one second accumulation and an eight second accumulation of ORed EMR readings must be telemetered at a regular once per second frequency and once per eight second frequency, respectively. The one second accumulated ORed word must be reset after the telemetry is issued. The eight second accumulation must continue to be ORed with subsequent EMR readings when the program is not doing a compressed data dump; and must be reset upon completing the dump.

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#### 11.4.1.2 LVDC On Occurrence Telemetry

Special telemetry is required when events significant to the flight sequence occur. The occurrence of these events is indicated by the setting of particular bits in discrete hardware registers as outputs from the LVDC (discrete output register or switch selector register) and as inputs to LVDC (discrete input register, interrupt storage register or switch selector feedback register).

In addition, the start time of each time base in conjunction with a special indication of whether the time base was initiated nominally or by the backup method must be telemetered.

##### 11.4.1.2.1 Discrete Register Inputs and Outputs

An indication of the discrete inputs (DIs) given in Table 11-3 must be telemetered when detected in the BML during boost mode.

of a telemetry dump station. During these intervals, data must be processed and stored in the LVDC for later transmission when the Compressed Data Dump DCS command is received. These data must also be processed and stored while the compressed data dump is being performed. The processing and storing of these data is referred to as data compression.

#### 11.5.1 General Data Compression Requirements

The following requirements must apply for all compressed data:

- Data compression must be programmed for a minimum of nine hours. (A new compressed data time base may be initiated, if necessary.)
- Storage requirements must be based on a maximum compression period of 6000 seconds for data table 1 and 5700 seconds for data tables 2 through 5 (see Compressed Data Table 11-14).
- If the maximum storage allocation in a particular table is exceeded between dumps, the most recent data must be compressed over the oldest data in the affected table. This condition is called table wraparound.
- Each data word or set of data words must have stored with it a word containing a unique identification (ID) code and an associated time. The time associated with data table 1 must be the time of the minor loop in which the data set was read, accurate to 0.04 seconds. The times associated with tables 2 through 5 must be the times at which the data was stored, accurate to 1.6 seconds. The ID code and time values must be stored in the relative locations specified in Table 11-14.

TABLE 15-1 ABBREVIATIONS (CONTINUED)

|          |  |
|----------|--|
| ML       | Minor Loop   |
| MLC      | Mobile Launch Computer   |
| MLS      | Minor Loop Support   |
| MSB      | Most Significant Bit   |
| MSFC     | Marshall Space Flight Center (Huntsville, Alabama)             |
| NM       | Nautical Mile  |
| N.P.     | North Pole   |
| NPV      | Non-Propulsive Vent  |
| OA       | Output Axis  |
| OM/D     | Orbital Mode-Data Bit in DCS word transmitted from ground      |
| OML      | Orbital Major Loop   |
| ON       | Orbital Navigation   |
| PCM      | Pulse Code Modulation  |
| PIO      | Process Input-Output   |
| PTL      | Prepare to Launch  |
| PU       | Propellant Utilization   |
| QMS      | (qms) Quarter Milliseconds                                     |
| RCA-110A | Designation for ground computer used in checkout and prelaunch |
| RF       | Radio Frequency  |
| RTC      | Real Time Clock (as used in Parts III & IV)                    |
| RTC      | Reasonableness Test Constant (as used in Parts I & II)         |
| S-IB     | Designation for Saturn IB vehicle first stage                  |
| S-IVB    | Designation for Saturn IB vehicle second stage                 |
| S/C, SC  | Spacecraft   |
| SLA      | Spacecraft Lunar Module Adapter                                |
| SM       | Service Module   |
| SMC      | Steering Misalignment Correction                               |
| SRA      | Spin Reference Axis  |
| SS       | Switch Selector Command  |
| STDN     | Spaceflight Tracking and Data Network                          |
| ST-124M  | Designation for the launch vehicle inertial platform           |
| TBD      | To be determined   |

TABLE 15-1 ABBREVIATIONS (CONTINUED)

|      |   |
|------|---|
| TB0  | Time Base 0   |
| TB1  | Time Base 1   |
| TB2  | Time Base 2   |
| TB3  | Time Base 3   |
| TB4  | Time Base 4   |
| TB5  | Time Base 5   |
| TLC  | Temporary Loss of Control (LVDC simultaneous<br>memory error) |
| TM   | Telemetry   |
| TOPS | Thrust OK Pressure Switch                                     |

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TABLE 3-1 EVENT SEQUENCE TIMELINE (CONTINUED)

| Time Reference | EDD Symbol         | Presettings (Seconds) | Source Code | Events   |
|----------------|--------------------|-----------------------|-------------|--|
| T4             | None               | 0                     |             | <p>Set <math>T_{EVNT} = T4</math>, <math>BIAS = BIAS6</math>, compute <math>\Delta T'_E</math>, stop computing performance factor and set <math>PF=1</math>, <math>PF_0=1</math>, and <math>PF_1=1</math>; thereafter set <math>FE_0</math> equal to one.</p> <p>Change attitude command rate limits in all channels. <math>MSLIM1 = 0.024</math> deg per minor loop in roll (0.6 deg per sec). <math>MSLIM2 = 0.016</math> deg per minor loop in pitch and yaw (0.4 deg per sec).</p> <p>Change from IGM guidance to orbital guidance.</p> <p>Set SMC corrections to zero.</p> <p>Set guidance commands and minor loop guidance commands to the gimbal angles on the first pass only. Start a <math>\chi</math> freeze. Maintain constant <math>\chi</math> commands.</p> |
| T4             | None               | 5.0                   | D1          | <p>Start checking DI9, S/C control of Saturn. The start of this test is keyed to the switch selector command S/C Control of Saturn Enable. If guidance reference failure occurs, DI9 checks will be enabled at the time of failure, independent of programmed time guards.</p>   |
| T4             | T4a <sub>GRD</sub> | 10.0                  | D1          | <p>Enable alternate sequence T4a start, dependent on time base updates. Start checking DI6, S/C separation indication. Alternate sequence T4a must begin upon recognition of DI6 or DCS command. The DCS command is enabled earlier but T4a must not be started before this time.</p>  |

TABLE 3-1. EVENT SEQUENCE TIMELINE (CONTINUED)

| Time<br>Reference | EDD<br>Symbol   | Presettings<br>(Seconds) | Source<br>Code | Events   |
|-------------------|-----------------|--------------------------|----------------|--|
| T4                | BN <sub>5</sub> | 15.0                     | D3             | <p>Enter orbit initialize and begin orbit navigation.</p> <p>Enable the following DCS commands:<br/>Memory Dump, Navigation Update, and<br/>Compressed Data Dump.</p> <p>Change the minor loop rate from 25 per sec<br/>to 10 per sec.</p> <p>Continue using MSLIM1 = 0.6 deg per sec<br/>and MSLIM2 = 0.4 deg per sec.</p> <p>Start telemetry acquisition and loss<br/>calculations.</p> <p>Set the number of permissible unreasonable<br/>backup resolver readings (MS15DT)<br/>to 6 per sec. The guidance reference<br/>failure discretes (D04 and D06) will be<br/>set on detecting 7 unreasonable backup<br/>resolver readings in 1 sec.</p> <p>Set the gimbal angle RTC for first pass<br/>on the backup gimbal (MLKRC1) to 18.5 deg.</p> <p>Change the backup gimbal angle RTC after<br/>first use to 1.1 deg per minor loop in<br/>pitch and yaw (MLKRC3) and 1.1 deg per<br/>minor loop in roll (MLKRC5).</p> |

TABLE 3-1 EVENT SEQUENCE TIMELINE (CONTINUED)

| Time<br>Reference | EDD<br>Symbol      | Presettings<br>(Seconds) | Source<br>Code | Events   |
|-------------------|--------------------|--------------------------|----------------|--|
| T4                | BN <sub>5</sub>    | 15.0                     | D3             | <p>Start using <math>\Delta T_{N6}</math>.</p> <p>Change the fine gimbal angle RTC to 0.2 deg per minor loop in pitch and yaw (MLK2) and 0.2 deg per minor loop in roll (MLK12).</p> <p>Change ladder rate limit (MSK5) to 0.24 deg per minor loop, all channels, unless guidance reference failure has occurred. In that case, leave MSK5 unchanged at zero.</p> <p>Set MS04DT to <math>.1/\Delta T_{N6}</math>.</p> <p>Set MS25DT to <math>10*\Delta T_{N6}</math>.</p> <p>Continue using the zero gimbal test constant, ML6HUN, of 1.40 deg (all channels).</p> |
| T4                | T <sub>4M2</sub>   | 20.0                     | C2             | Start Local Reference Maneuver, Track Local Horizontal, Posigrade, Position I down.  |
| T4                | T4b <sub>GRD</sub> | 1800.0                   | D1             | Enable alternate sequence T4b start via DCS command, dependent on time base updates. The DCS command is enabled earlier but T4b must not be started before this time.  |
| T4                | T5 <sub>GRD</sub>  | 5000.0                   | D1             | Enable TB5 start.  |

TABLE 3-1 EVENT SEQUENCE TIMELINE (CONTINUED)

| Time Reference | EDD Symbol         | Presettings (Seconds) | Source Code | Events  |
|----------------|--------------------|-----------------------|-------------|---|
| T4             | T <sub>RNTL</sub>  | Variable              | E           | Implement the DCS return to nominal timeline. This is a transmitted parameter and has meaning only if that command has been received and accepted.                                      |
| T4             | T <sub>SOM</sub>   | Variable              | E           | Start a DCS generalized orbital maneuver or DCS specialized maneuver. This is a transmitted parameter and has meaning only if the corresponding command has been received and accepted. |
| T4+TB-TBB      | T <sub>SEQ</sub>   | Variable              | E           | Start a DCS generalized alternate sequence. This is a transmitted parameter and has meaning only if that command has been received and accepted.  |
| T4             | 60T <sub>DSS</sub> | Variable              | E           | Start Time Base 5. This is a transmitted parameter and has meaning only if the corresponding DCS command has been received and accepted.  |

TABLE 3-1 EVENT SEQUENCE TIMELINE (CONTINUED)

| Time Reference | EDD Symbol        | Presettings (Seconds) | Source Code | Events  |
|----------------|-------------------|-----------------------|-------------|---|
| T4a            | None              | 0                     |             | <p>Set Bit 6 of MC27.</p> <p>Stop checking DI6, S/C Separation Indication.</p> <p>Stop checking DI9, S/C Control of Saturn.</p> <p>Inhibit the alternate sequence T4a DCS command (SEQNUM=0001).</p> <p>Terminate any IU/S-IVB TM calibrate sequence in progress.</p> |
| T4a            | T <sub>4aM3</sub> | 190.0                 | C2          | Start S150 maneuver to place S-IVB/IU in retrograde attitude (-90° pitch).  |
| T4a            | T <sub>4aM4</sub> | 220.0                 | C2          | Complete retrograde maneuver (180° pitch).  |
| T4a            | T <sub>4aM5</sub> | 540.0                 | C2          | Start S150 maneuver (-90° roll), position IV down, retrograde.  |
| T4a            | T <sub>COR</sub>  | 1881.6                | D1          | Start S150 TM Time Correlation Alternate Sequence. (This sequence must be issued at this time and every 1800 seconds thereafter until T5+0.0.)  |
| T4a            | T <sub>CAL</sub>  | 2520.0                | D1          | Start S150 Calibrate Command Alternate Sequence. (This sequence must be issued every 1800 seconds thereafter until T5+0.0.)   |

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TABLE 3-1 EVENT SEQUENCE TIMELINE (CONTINUED)

| Time<br>Reference | EDD<br>Symbol     | Presettings<br>(Seconds) | Source<br>Code | Events   |
|-------------------|-------------------|--------------------------|----------------|--|
| T4a               | T <sub>4aM6</sub> | 5700.0                   | C2             | Start S150 maneuver (-135° roll),<br>retrograde.                             |
| T4a               | T <sub>4aM7</sub> | 11100.0                  | C2             | Start S150 maneuver (-180° roll),<br>Position I down, retrograde.            |
| T4a               | T <sub>4aM8</sub> | 16500.0                  | C2             | Start S150 maneuver (-27° yaw),<br>Position I down, retrograde.              |
| T4a               | T <sub>4aM9</sub> | 21900.0                  | C2             | Start S150 maneuver (+27° yaw, - 90° roll),<br>Position IV down, retrograde. |

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TABLE 3-1 EVENT SEQUENCE TIMELINE (CONTINUED)

| Time<br>Reference | EDD<br>Symbol | Presettings<br>(Seconds) | Source<br>Code | Events   |
|-------------------|---------------|--------------------------|----------------|--|
| T4b               | None          | 0                        |                | Terminate any IU/S-IVB TM calibrate<br>sequence in progress. |

TABLE 3-1 EVENT SEQUENCE TIMELINE (CONTINUED)

| Time Reference | EDD Symbol | Presettings (Seconds) | Source Code | Events   |
|----------------|------------|-----------------------|-------------|--|
| T5             | None       | 0                     |             | <p>Reset Bits 1, 7, and 19 of MC27.</p> <p>Inhibit the Time Base Update, Execute Generalized Maneuver, Return to Nominal Timeline, Execute alternate sequence, Ladder Magnitude Limit and S-IVB/IU De-orbit DCS commands.</p> <p>Inhibit the S150 TM time correlation Alternate Sequence and the S150 calibrate command Alternate Sequence.</p> <p>Disable the loss of APS Attitude Control test.</p> <p>Terminate any Class 4 alternate switch selector sequence in progress, or scheduled.</p> <p>Disable telemetry acquisition and loss calculations and force a station loss.</p> <p>Set the pitch and yaw ladder magnitude limit (MSK6) to 15.3 deg.</p> <p>Reset the platform measured velocity components, <math>X_m</math>, <math>Y_m</math> and <math>Z_m</math>, to zero.</p> <p>Start monitoring velocity increments (<math>\Delta V</math>).</p> |
| T5             | $T_{LS}$   | Variable              | E           | Initiate sequence for LOX depletion dump stop and LH2 depletion dump start. (See Note 4 of Table 3-4).   |
| T5             | $T_{SS}$   | Variable              | E           | Initiate sequence for LH2 depletion dump stop and safing. (See Note 5 of Table 3-4).   |
| $T5+T_{SS}$    | None       | 1.0                   | D1          | Set the pitch and yaw ladder magnitude limit (MSK6) to 2.5 deg.  |
| $T5+T_{SS}$    | None       | 2905.0                | D1          | Enable the Execute Generalized Maneuver DCS command.   |

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### 3.4 ORBITAL ATTITUDE TIMELINE

The following table (Table 3-2) describes the nominal attitude maneuver timeline from S-IVB cutoff until EOM. The following items are defined in the timeline for each maneuver:

- Maneuver number
- Description of the maneuver
- Nominal maneuver start time
- Maneuver type.

TABLE 3-2 ORBITAL ATTITUDE TIMELINE

| Maneuver Number | Nominal Maneuver Time Seconds | Description of Maneuver   | Maneuver Type           |
|-----------------|-------------------------------|---|-------------------------|
| 1               | T4+0.0                        | Maintain vehicle attitude   | X freeze                |
| 2               | T4+20.0                       | Track local horizontal - posigrade, Position I down               | Track local reference   |
| 3               | T4a+190.0                     | S150 maneuver (-90° pitch)  | Track local reference   |
| 4               | T4a+220.0                     | S150 maneuver (180° pitch), IU S-IVB to retrograde                | Track local reference   |
| 5               | T4a+540.0                     | S150 maneuver (-90° roll), Position IV down, retrograde           | Track local reference * |
| 6               | T4a+5700.0                    | S150 maneuver (-135° roll), retrograde                            | Track local reference * |
| 7               | T4a+11100.0                   | S150 maneuver (-180° roll), Position I down, retrograde           | Track local reference * |
| 8               | T4a+16500.0                   | S150 maneuver (-27° yaw), Position I down, retrograde             | Track local reference * |
| 9               | T4a+21900.0                   | S150 maneuver (+27° yaw, -90° roll), Position IV down, retrograde | Track local reference * |
| 10              | T5+0.0                        | Continue TB4 maneuver in progress when TB5 is started             | Variable                |

TABLE 3-3 PRESETTINGS (CONTINUED)  
ORBITAL GUIDANCE

| EDD<br>Symbol   | Presetting | Units | Source<br>Code | Definition                                |
|---|------------|-------|----------------|---|
| SP <sub>M3</sub>  | -1.0       |       | C2             | Pitch Attitude variables for              |
| CP <sub>M3</sub>  | 0.0        |       |                | Yaw Maneuver 3                            |
| SY <sub>M3</sub>  | 0.0        |       |                | Roll                                      |
| CY <sub>M3</sub>  | 1.0        |       |                |   |
| RA <sub>M3</sub>  | 0.0        | deg   |                |   |
| TYP <sub>M3</sub> (NOTE*)   | -1.0       |       | B              | Type of maneuver indicator for Maneuver 3 |
| SP <sub>M4</sub>  | 0.0        |       | C2             | Pitch Attitude variables for              |
| CP <sub>M4</sub>  | -1.0       |       |                | Yaw Maneuver 4                            |
| SY <sub>M4</sub>  | 0.0        |       |                | Roll                                      |
| CY <sub>M4</sub>  | 1.0        |       |                |   |
| RA <sub>M4</sub>  | 0.0        | deg   |                |   |
| TYP <sub>M4</sub>   | -1.0       |       | B              | Type of maneuver indicator for Maneuver 4 |
| *NOTE: TYP <sub>M1</sub> - TYP <sub>M9</sub> indicate whether a maneuver is an inertial reference (+1), chi freeze (0),<br>a local reference (-1), or an inertial hold of local reference (-2). |            |       |                |   |

TABLE 3-3 PRESETTINGS (CONTINUED)  
ORBITAL GUIDANCE

| EDD<br>Symbol   | Presetting | Units | Source<br>Code | Definition                                |                                      |
|---|------------|-------|----------------|---|--------------------------------------|
| SP <sub>M5</sub>  | 0.0        |       | C2             | Pitch                                     | Attitude variables for<br>Maneuver 5 |
| CP <sub>M5</sub>  | -1.0       |       |                | Yaw                                       |                                      |
| SY <sub>M5</sub>  | 0.0        |       |                | Roll                                      |                                      |
| CY <sub>M5</sub>  | 1.0        |       |                |   |                                      |
| RA <sub>M5</sub>  | -90.0      | deg   |                |   |                                      |
| TYP <sub>M5</sub> (NOTE*)   | -1.0       |       | B              | Type of maneuver indicator for Maneuver 5 |                                      |
| SP <sub>M6</sub>  | 0.0        |       | C2             | Pitch                                     | Attitude variables for<br>Maneuver 6 |
| CP <sub>M6</sub>  | -1.0       |       |                | Yaw                                       |                                      |
| SY <sub>M6</sub>  | 0.0        |       |                | Roll                                      |                                      |
| CY <sub>M6</sub>  | 1.0        |       |                |   |                                      |
| RA <sub>M6</sub>  | -135.0     | deg   |                |   |                                      |
| TYP <sub>M6</sub>   | -1.0       |       | B              | Type of maneuver indicator for Maneuver 6 |                                      |
| *NOTE: TYP <sub>M1</sub> - TYP <sub>M9</sub> indicate whether a maneuver is an inertial reference (+1), chi freeze (0),<br>a local reference (-1), or an inertial hold of local reference (-2). |            |       |                |   |                                      |

TABLE 3-3 PRESETTINGS (CONTINUED)  
ORBITAL GUIDANCE

| EDD<br>Symbol   | Presetting | Units | Source<br>Code | Definition                                |
|---|------------|-------|----------------|---|
| SP <sub>M7</sub>  | 0.0        |       | C2             | Pitch Attitude variables for              |
| CP <sub>M7</sub>  | -1.0       |       |                | Yaw Maneuver 7                            |
| SY <sub>M7</sub>  | 0.0        |       |                | Roll                                      |
| CY <sub>M7</sub>  | 1.0        |       |                |   |
| RA <sub>M7</sub>  | 180.0      | deg   |                |   |
| TYP <sub>M7</sub> (NOTE*)   | -1.0       |       | B              | Type of maneuver indicator for Maneuver 7 |
| SP <sub>M8</sub>  | 0.0        |       | C2             | Pitch Attitude variables for              |
| CP <sub>M8</sub>  | -1.0       |       |                | Yaw Maneuver 8                            |
| SY <sub>M8</sub>  | -.45399050 |       |                | Roll                                      |
| CY <sub>M8</sub>  | .89100652  |       |                |   |
| RA <sub>M8</sub>  | 180.0      | deg   |                |   |
| TYP <sub>M8</sub>   | -1.0       |       | B              | Type of maneuver indicator for Maneuver 8 |
| *NOTE: TYP <sub>M1</sub> - TYP <sub>M9</sub> indicate whether a maneuver is an inertial reference (+1), chi freeze (0),<br>a local reference (-1), or an inertial hold of local reference (-2). |            |       |                |   |

TABLE 3-3 PRESETTINGS (CONTINUED)  
ORBITAL GUIDANCE

| EDD<br>Symbol             | Presetting | Units | Source<br>Code | Definition                                |                                      |
|---------------------------|------------|-------|----------------|---|--------------------------------------|
| SP <sub>M9</sub>          | 0.0        |       | C2             | Pitch                                     | Attitude variables for<br>Maneuver 9 |
| CP <sub>M9</sub>          | -1.0       |       |                | Yaw                                       |                                      |
| SY <sub>M9</sub>          | .45399050  |       |                | Roll                                      |                                      |
| CY <sub>M9</sub>          | .89100652  |       |                |   |                                      |
| RA <sub>M9</sub>          | -90.0      | deg   |                |   |                                      |
| TYP <sub>M9</sub> (NOTE*) | -1.0       |       | B              | Type of maneuver indicator for Maneuver 9 |                                      |

\*NOTE: TYP<sub>M1</sub> - TYP<sub>M9</sub> indicate whether a maneuver is an inertial reference (+1), chi freeze (0), a local reference (-1), or an inertial hold of local reference (-2).

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### 3.6 FLIGHT SEQUENCING

The flight sequencing requirements for SA-207A are established in Table VII of the current revision of the Flight Sequence Program ICD 68M0001, Revision B, and the approved IRN's described in Table 3-4. The information to be obtained from the ICD are switch selector command title, stage, address, and time from base. No other information contained in the ICD is to be considered a program requirement.

TABLE 3-4 SWITCH SELECTOR SEQUENCING

| ICD/IRN   | COMMAND                                      | SWITCH SELECTOR |       |     | TIME FROM BASE SECONDS |      |
|-----------|--|-----------------|-------|-----|------------------------|------|
|           |  | CODE            | STAGE | CHN |                        |      |
|           | LIFTOFF - START OF TIME BASE NO. 1 (T1)      |                 |       |     | T1                     | .0   |
| 68M000018 | SINGLE ENGINE CUTOFF ENABLE                  | 0101 1010       | S-IB  | 100 | T1 +                   | 3.0  |
| 68M000018 | LDX TANK PRESSURIZATION SHUTOFF VALVES CLOSE | 0110 1010       | S-IB  | 79  | T1 +                   | 6.0  |
| 68M000018 | MULTIPLE ENGINE CUTOFF ENABLE NO.1           | 0001 0001       | S-IB  | 16  | T1 +                   | 10.0 |
| 68M000018 | MULTIPLE ENGINE CUTOFF ENABLE NO.2           | 0110 1111       | S-IB  | 15  | T1 +                   | 10.1 |
| 68M000018 | TELEMETRY CALIBRATION ON                     | 0101 1111       | S-IB  | 2   | T1 +                   | 20.0 |
| 68M000018 | TELEMETRY CALIBRATION OFF                    | 0000 1111       | S-IB  | 39  | T1 +                   | 25.0 |
| 68M000018 | TELEMETRY CALIBRATOR IN-FLIGHT CALIBRATE ON  | 0010 0010       | IU    | 23  | T1 +                   | 27.0 |
| 68M000018 | TELEMETRY CALIBRATOR IN-FLIGHT CALIBRATE OFF | 0001 0010       | IU    | 24  | T1 +                   | 32.0 |
| 38        | S150 VENT VALVE OPEN ON                      | 0111 0110       | IU    | 78  | T1 +                   | 35.0 |
| 38        | S150 VENT VALVE OPEN OFF                     | 0110 1010       | IU    | 79  | T1 +                   | 35.2 |
| 68M000018 | LAUNCH VEHICLE ENGINES FDS CUTOFF ENABLE     | 0011 0001       | IU    | 38  | T1 +                   | 40.0 |
| 68M000018 | TELEMETRY CALIBRATOR IN-FLIGHT CALIBRATE ON  | 0010 0010       | IU    | 23  | T1 +                   | 90.2 |
| 68M000018 | TELEMETRY CALIBRATOR IN-FLIGHT CALIBRATE OFF | 0001 0010       | IU    | 24  | T1 +                   | 95.2 |

TABLE 3-4 SWITCH SELECTOR SEQUENCING (CONTINUED)

| ICD/ISN   | COMMAND  | SWITCH SELECTOR |       |     | TIME FROM BASE SECONDS |   |         |
|-----------|--|-----------------|-------|-----|------------------------|---|---------|
|           |  | CODE            | STAGE | CHN |                        |   |         |
| 68M000018 | LH2 TANK VENT AND LATCHING RELIEF VALVES BOOST CLOSE ON  | 0110 0110       | SIVB  | 77  | T4                     | + | 684.4   |
| 68M000018 | LH2 TANK VENT AND LATCHING RELIEF VALVES BOOST CLOSE OFF | 0111 0110       | SIVB  | 78  | T4                     | + | 686.4   |
| 68M000018 | AUX. HYDRAULIC PUMP FLIGHT MODE ON                       | 0111 1100       | SIVB  | 28  | T4                     | + | 2120.0  |
| 68M000018 | AUX. HYDRAULIC PUMP FLIGHT MODE OFF                      | 0011 1100       | SIVB  | 29  | T4                     | + | 2600.0  |
| 68M000018 | S-IVB ENGINE EDS CUTOFF NO. 2 DISABLE                    | 0010 0001       | SIVB  | 53  | T4                     | + | 4900.0  |
| 68M000018 | PASSIVATION ENABLE                                       | 0110 0111       | SIVB  | 85  | T4                     | + | 5000.0  |
| 68M000018 | AUX. HYDRAULIC PUMP FLIGHT MODE ON                       | 0111 1100       | SIVB  | 28  | T4                     | + | 5060.0  |
| 68M000018 | AUX. HYDRAULIC PUMP FLIGHT MODE OFF                      | 0011 1100       | SIVB  | 29  | T4                     | + | 5103.0  |
| 68M000018 | AUX. HYDRAULIC PUMP FLIGHT MODE ON                       | 0111 1100       | SIVB  | 28  | T4                     | + | 7520.0  |
| 68M000018 | AUX. HYDRAULIC PUMP FLIGHT MODE OFF                      | 0011 1100       | SIVB  | 29  | T4                     | + | 8000.0  |
| 68M000018 | AUX. HYDRAULIC PUMP FLIGHT MODE ON                       | 0111 1100       | SIVB  | 28  | T4                     | + | 10460.0 |
| 68M000018 | AUX. HYDRAULIC PUMP FLIGHT MODE OFF                      | 0011 1100       | SIVB  | 29  | T4                     | + | 10503.0 |
| 68M000018 | AUX. HYDRAULIC PUMP FLIGHT MODE ON                       | 0111 1100       | SIVB  | 28  | T4                     | + | 12620.0 |

TABLE 3-4 SWITCH SELECTOR SEQUENCING (CONTINUED)

| ICD/IPM   | COMMAND                             | SWITCH SELECTOR |       |     | TIME<br>FROM BASE<br>SECONDS |           |
|-----------|-------------------------------------|-----------------|-------|-----|------------------------------|-----------|
|           |                                     | CODE            | STAGE | CHN |                              |           |
| 68M00001R | AUX. HYDRAULIC PUMP FLIGHT MODE OFF | 0011 1100       | SIVB  | 29  | T4                           | + 13100.0 |
| 68M00001R | AUX. HYDRAULIC PUMP FLIGHT MODE ON  | 0111 1100       | SIVB  | 28  | T4                           | + 15050.0 |
| 68M00001R | AUX. HYDRAULIC PUMP FLIGHT MODE OFF | 0011 1100       | SIVB  | 29  | T4                           | + 15530.0 |
| 68M00001R | AUX. HYDRAULIC PUMP FLIGHT MODE ON  | 0111 1100       | SIVB  | 28  | T4                           | + 18320.0 |
| 68M00001R | AUX. HYDRAULIC PUMP FLIGHT MODE OFF | 0011 1100       | SIVB  | 29  | T4                           | + 18800.0 |

TABLE 3-4 SWITCH SELECTOR SEQUENCING (CONTINUED)

| ICD/IRN | COMMAND  | SWITCH SELECTOR |       |     | TIME<br>FROM BASE<br>SECONDS |       |
|---------|--|-----------------|-------|-----|------------------------------|-------|
|         |  | CODE            | STAGE | CHN |                              |       |
|         | ALTERNATE SEQUENCE T4A - S-IVB/IU - SPACECRAFT<br>SEPARATION OR DCS COMMAND ( SEE NOTE 6 ) |                 |       |     | T4A                          | 0.0   |
| 38      | TM CALIBRATE OFF   | 0000 0111       | SIVB  | 63  | T4A +                        | 0.2   |
| 38      | TELEMETRY CALIBRATOR IN-FLIGHT CALIBRATE OFF   | 0001 0010       | IU    | 24  | T4A +                        | 0.4   |
| 38      | S150 ASAP CIU POWER ON   | 0101 0101       | IU    | 91  | T4A +                        | 75.0  |
| 38      | S150 AIU AND MEMORY POWER ON   | 0010 0100       | IU    | 61  | T4A +                        | 75.2  |
| 38      | S150 TAPE RECORDER POWER ON  | 0000 0110       | IU    | 97  | T4A +                        | 75.4  |
| 38      | S150 TM CLOCK, CTR SET ON  | 0010 0101       | IU    | 93  | T4A +                        | 81.2  |
| 38      | S150 TAPE RECORDER RECORD ON   | 0001 1011       | IU    | 96  | T4A +                        | 81.4  |
| 38      | S150 TM TIME CORRELATION ON  | 0111 1010       | IU    | 80  | T4A +                        | 81.6  |
| 38      | S150 TM TIME CORRELATION OFF   | 0000 0101       | IU    | 81  | T4A +                        | 82.6  |
| 38      | S150 P-10 SUPPLY SHUTOFF VALVE ON  | 0100 1010       | IU    | 62  | T4A +                        | 120.0 |
| 38      | S150 SENSOR POWER ON   | 0001 0100       | IU    | 75  | T4A +                        | 120.2 |
| 38      | S150 PYRO ARM  | 0111 1001       | IU    | 103 | T4A +                        | 160.0 |

TABLE 3-4 SWITCH SELECTOR SEQUENCING (CONTINUED)

| ICD/IRN | COMMAND                    | SWITCH SELECTOR |       |     | TIME<br>FROM BASE<br>SECONDS |
|---------|----------------------------|-----------------|-------|-----|------------------------------|
|         |                            | CODE            | STAGE | CHN |                              |
| 38      | S150 PYRO FIRE             | 0011 0110       | IU    | 101 | T4A + 160.2                  |
| 38      | S150 PYRO FIRE SAFE        | 0010 0110       | IU    | 102 | T4A + 160.3                  |
| 38      | S150 PYRO ARM SAFE         | 0101 1010       | IU    | 100 | T4A + 160.4                  |
| 38      | S150 CALIBRATE COMMAND ON  | 0000 0111       | IU    | 63  | T4A + 720.0                  |
| 38      | S150 CALIBRATE COMMAND OFF | 0100 0110       | IU    | 76  | T4A + 725.0                  |
| 38      | ASAP REPROGRAM ON/OFF      | 0101 0111       | IU    | 86  | T4A + 725.2                  |

Notes on Table 3-4:

Note 1:

Each of these switch selector commands must be programmed as an alternate switch selector sequence. These are Class 3 alternate switch selector sequences. Requirements for issuance of these alternate sequences are detailed in Section 7.4.10.

Note 2:

The IU telemetry and S-IVB telemetry shall be calibrated after orbital insertion by using a special sequence. This special sequence of events consists of IU and S-IVB telemetry calibration commands and shall be initiated by the LVDC using special tracking station acquisition logic. The first telemetry calibrate command shall be issued 60.0 seconds after station acquisition as determined by the LVDC. This is a Class 4 alternate switch selector sequence and may be terminated by the T4a and T4b alternate sequences.

Note 3:

This switch selector sequence must be issued in response to S-IVB velocity cutoff. It should be noted that if Time Base 4 is initiated prior to the completion of this sequence, the sequence must be terminated. The second command of this sequence must be scheduled immediately after the first command. This is a Class 1 alternate switch selector sequence.

Notes on Table 3-4 (Continued)

Note 4:

This sequence must be issued to stop the LOX depletion dump and to initiate the hydrogen depletion dump. This sequence must be issued at  $T5+T_{LDD}+33.9$  seconds. The start of this sequence may be delayed by as much as the amount of time required to process the once per eight second orbital navigation pass. This is a Class 4 alternate switch selector sequence.

Note 5:

This switch selector sequence must be issued to stop the hydrogen depletion dump and provide safing sequences. This sequence must be issued at  $T5+T_{LDD}+T_{HDD}+63.9$  seconds. The start of this sequence may be delayed by as much as the amount of time required to process the once per eight second orbital navigation pass. This is a Class 4 alternate switch selector sequence.

Note 6:

This switch selector sequence must be issued one time only to activate the S150 Galactic X-Ray Experiment. This sequence must be inhibited until  $T4+T4a_{GRD}$  (the enabling of this sequence must be dependent on time base updates). This sequence must be initiated by one of the following methods:

- Recognition of DI6 at Spacecraft Separation
- Receipt of the Execute alternate sequence T4a DCS command (This sequence must initiated at  $T4+T_{SEQ}$ , see Section 10.4.10 of Part I.)



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