

# IBM

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**Saturn Instrument Unit**

LVDC Equation Defining Document (EDD)

for the Saturn IB Flight Program

Parts I and II

Revision C

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loop, navigation data are required for the second (active) stage guidance and navigation calculations must begin at GRR and continue throughout the boost mission phase.

Since variations in acceleration are large during boost, the computation rate for navigation must be higher than during orbit. In determining position and velocity relative to the desired reference frame, gravitational effects are computed as part of the navigation scheme since the sensors cannot measure gravitational acceleration. A mathematical model of the earth's gravitational field, which was empirically derived from satellite measurements, has been selected for use in the gravitational computations. Position and velocity in the desired reference frame are obtained by differencing the integrated measured and gravitational accelerations. A computation rate, or integration interval, as low as once per two seconds is adequate for the boost phase. With this rate, and the smoothed acceleration function, a simple trapezoidal integration routine yields sufficient accuracy. A single navigation scheme is adequate throughout the boost phase.



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### 3.3.2.2 Repositioning

Repositioning of the ST-124M is accomplished by the RCA-110A azimuth laying fine positioning program executed in the Mobile Launch Computer (MLC). This program is called into execution at approximately T-10 minutes by the RCA-110A PTL test. The fine positioning program ensures positioning of the platform according to the latest computed position. The program continuously monitors GMT and countdown time for any change in  $T'_L$  until GRRA.

The predicted liftoff time ( $T'_L$ ) is loaded into the LVDC from the RCA-110A after the LVDC has been commanded to Prepare to Launch. The LVDC PTL routine computes the difference between the predicted time of GRR and the nominal time of GRR ( $T_{GRR0}$ ) using Eq. 3.2.1. The resulting time differential ( $T_D$ ) is used in Eq. 3.2.2 to compute  $\lambda$ , the longitude of the descending node measured from the launch meridian. The longitude of the descending node and the inclination are used in Eq. 3.2.3 to compute the platform azimuth ( $A_z$ ). The computed platform azimuth is transmitted back to the RCA-110A in true form and complemented form where it is used to align the platform.

Any holds greater than 5 seconds, occurring between the beginning of Prepare to Launch and 187 seconds prior to liftoff, require that a revised predicted liftoff time ( $T'_L$ ) be transmitted to the LVDC. In response to the new value of  $T'_L$ , the LVDC will calculate a new platform azimuth and transmit this to the RCA-110A for platform realignment. If it is necessary to recycle to the beginning of Prepare to Launch Mode, a new  $T'_L$  must be loaded into the LVDC and the sequence started again.

The platform may be realigned at times other than when  $T'_L$  changes. The capability to monitor platform gimbal angles exists at the MLC until GRR. Any drift of the azimuth encoder



greater than two binary bits (10 arcseconds) will be corrected automatically by executing the Azimuth Laying Fine Positioning program. Corrections will be made up until 152 seconds before liftoff. Any encoder drift after this time will result only in an error message indicating that repositioning is required.

### 3.3.3 Variable Data Tape

The flight program must provide the capability to accept a data load from a variable data tape. The use of this tape assures optimum launch date dependent and performance dependent data if late changes in the launch date or time becomes necessary. The day of launch in days past January 1 (where January 1 is day zero) must be included on the tape when defined. In addition, the following parameters must be provided; (1) constant acceleration bias terms for X, Y, and Z axes ( $B_{X0}$ ,  $B_{Y0}$ ,  $B_{Z0}$ ); (2) performance factor biases along  $X_B$ ,  $Y_B$ ,  $Z_B$  axes, for backup acceleration computations ( $P_{bx}$ ,  $P_{by}$ ,  $P_{bz}$ ); (3) times to begin using thrust misalignment angles (vectors) 1 through 4 ( $T_{TMA1}$  -  $T_{TMA4}$ ); (4) X component of thrust misalignment vector ( $C\alpha 1$  -  $C\alpha 4$ ); (5) Y component of thrust misalignment vector ( $S\alpha C\beta 1$  -  $S\alpha C\beta 4$ ); and (6) Z component of thrust misalignment vector ( $S\alpha S\beta 1$  -  $S\alpha S\beta 4$ ). The above parameters are utilized for the backup accelerometer scheme. The day of launch parameter is utilized in the M415 experiment calculations for SA-206 only.

Refer to Table 3-1 (Variable Data Tape Items) for LVDC locations and scaling of the parameters and to Part II Table 1-7, Data Required On Variable Data Tape, for the nominal presetting values.

The description, format, and absolute LVDC address assignments for the parameters required for the variable data tape are given in the Variable Data Tape Items, Table 3-1. This data must be supplied in the card format specified in Table 3-2 with the card deck sequenced in ascending order according to the LVDC address. The flight program must be capable of accessing these quantities



from the locations and with the units and scaling specified in Table 3-2. A launch day header card and launch day end card are required for each launch date on the Variable Data Tape and an end of deck card is required. The contents of these cards are not transferred to LVDC memory but are used to control the ground processing of the data cards. Their description is included here for completeness.

- The format of the launch day header card must be as follows:

CARD COLUMN	CONTENTS
1 - 6	VEHICLE NUMBER (e.g., SA-206)
11 & 12	DAY OF MONTH (right-justified)
14, 15, 16	MONTH (first three letters of name, e.g., MAY)
18 & 19	YEAR (e.g. 73)
25 - 27	DAY OF YEAR (number of days past January 1, right-justified)

The day of the year must also appear on the data card for location 0,16,300, scaled 10.

- The format of the launch day end card must be as follows:

CARD COLUMN	CONTENTS
1 - 3	END

- The end of an entire input deck (one or more launch days) must be signified by an end-of-deck card immediately following the END card of the last launch day unit. The format of the card shall consist of EØD in card columns 1-3.



TABLE 3-1 VARIABLE DATA TAPE ITEMS

\*

Variable Data Tape Item Description	EDD Symbol	Tape Symbol	LVDC Location	LVDC Scaling
Days past January 1 (where Jan. 1 is day zero) referenced to GMT	T <sub>DAY</sub>	TDAY	0,16,300	10
Constant accelera- tion bias terms for X, Y, and Z axis (m/sec <sup>2</sup> )	B <sub>X0</sub> B <sub>Y0</sub> B <sub>Z0</sub>	BX0 BY0 BZ0	0,16,301 0,16,302 0,16,303	0 0 0
Performance factor biases along X <sub>B</sub> , Y <sub>B</sub> , and Z <sub>B</sub> axes for backup accelera- tion computations	P <sub>bx</sub> P <sub>by</sub> P <sub>bz</sub>	PBX PBY PBZ	0,16,304 0,16,305 0,16,306	1 1 1
Times to begin using thrust misalignment angles (vectors) 1 through 4 (seconds)	T <sub>TMA1</sub> T <sub>TMA2</sub> T <sub>TMA3</sub> T <sub>TMA4</sub>	TTMA1 TTMA2 TTMA3 TTMA4	0,16,307 0,16,310 0,16,311 0,16,312	15 15 15 15
X component of thrust misalign- ment vector	Cα1 Cα2 Cα3 Cα4	CA1 CA2 CA3 CA4	0,16,313 0,16,314 0,16,315 0,16,316	0 0 0 0
Y component of thrust misalign- ment vector	SαCβ1 SαCβ2 SαCβ3 SαCβ4	SACB1 SACB2 SACB3 SACB4	0,16,317 0,16,320 0,16,321 0,16,322	0 0 0 0
Z component of thrust misalign- ment vector	SαSβ1 SαSβ2 SαSβ3 SαSβ4	SASB1 SASB2 SASB3 SASB4	0,16,323 0,16,324 0,16,325 0,16,326	0 0 0 0
Checksum Constant	CKSMIB	CKSMIB	0,16,327	-

\*

The time from GRR of occurrence of the following events must be recorded as  $T_{EVNT}$ .

- Liftoff
- S-IB Inboard Engines Cutoff
- S-IB Outboard Engines Cutoff
- Predicted Time of S-IVB Mainstage (90% thrust)
- S-IVB EMRC
- S-IVB Cutoff

The time  $T_{EVNT}$  is used to adjust the  $(F/M)_c$  computations. On the first boost major loop pass after the occurrence of one of the above events, the  $(F/M)_c$  acceleration must be computed using Eq. 4.2.17 through 4.2.22. In order to satisfy these equations the program must save the values of  $\dot{M}$ ,  $F_{EO}$ ,  $PF$ , and  $F_b$  prior to the event and store these values as  $\dot{M}'$ ,  $F'_{EO}$ ,  $PF'$ , and  $F'_b$  respectively.

The parameter  $M'_{c1}$  used in Eqs. 4.2.20 and 4.2.21 must be set equal to  $M'_c$  as computed by Eq. 4.2.17 except at places where the accelerometer processing mass constants change, i.e. at  $T1 + 0.0$  and  $T3 + 0.0$ . During the computation cycle in which  $TB1$  and  $TB3$  start,  $M'_{c1}$  must be set as defined in the Event Sequence Timeline of Part II.

The point in the current boost major loop where the event occurred is determined by Eq. 4.2.16, where  $T_{asp}$  is the time of accelerometer read prior to the event,  $T_{asc}$  is the time of accelerometer read following the event used in Eq. 4.2.19.

The parameters  $\Delta V_x$ ,  $\Delta V_y$ , and  $\Delta V_z$ , used in the performance factor calculation Eq. 4.2.34, must be the accelerometer change if the accelerometer change was reasonable for the current BML. If the X, Y, or Z channel accelerometer change is determined to be unreasonable, the corresponding velocity change computed by Eq. 4.2.26, 4.2.28, or 4.2.30 must be used in Eq. 4.2.34 to compute the performance factor.



The backup acceleration  $(F/M)_c$  is adjusted by the performance factor computed during the second previous boost major loop (Eq. 4.2.36); however, if an accelerometer failure has been detected, the performance factor computed during the first previous boost major loop (Eq. 4.2.35) must be used in Eq. 4.2.13, 4.2.15, 4.2.20, 4.2.22, and 4.2.34. This factor must be set to one at S-IB Outboard Engines Cutoff until the predicted time of S-IVB mainstage thrust, plus the nominal BML time during this time frame,  $(T_3 + T_{3_{FMC}} + \Delta T_{N2})$  at which time Eq. 4.2.34 must be used to compute the performance factor. During the time interval from S-IVB Engine Cutoff to the start of orbital navigation the performance factor must be set equal to one.

The parameter  $F_{EO}$  used in the  $(F/M)_c$  calculations is nominally set to one during Time Base 1. However, from the time of detection of the first engine failure in Time Base 1 until the start of Time Base 2,  $F_{EO}$  must be set equal to SIBEOB.

The values of force, mass and mass flow rate are initially set from values taken from a table. These values must be changed several times during the mission to represent all levels of performance. The times at which these values are changed are defined in the Event Sequence Timeline defined in Part II.

### 4.3 BOOST NAVIGATION

The flight program must determine the vehicle position, velocity, and gravitational acceleration relative to the plumblane coordinate system. During boost, a trapezoidal integration scheme is used to compute position and velocity components, and a gravitational acceleration model is used to compute the components of gravitational acceleration.

#### 4.3.1 Integration

The trapezoidal integration scheme determines the vehicle position and velocity from initial conditions, accelerometer data, and earth gravitation.

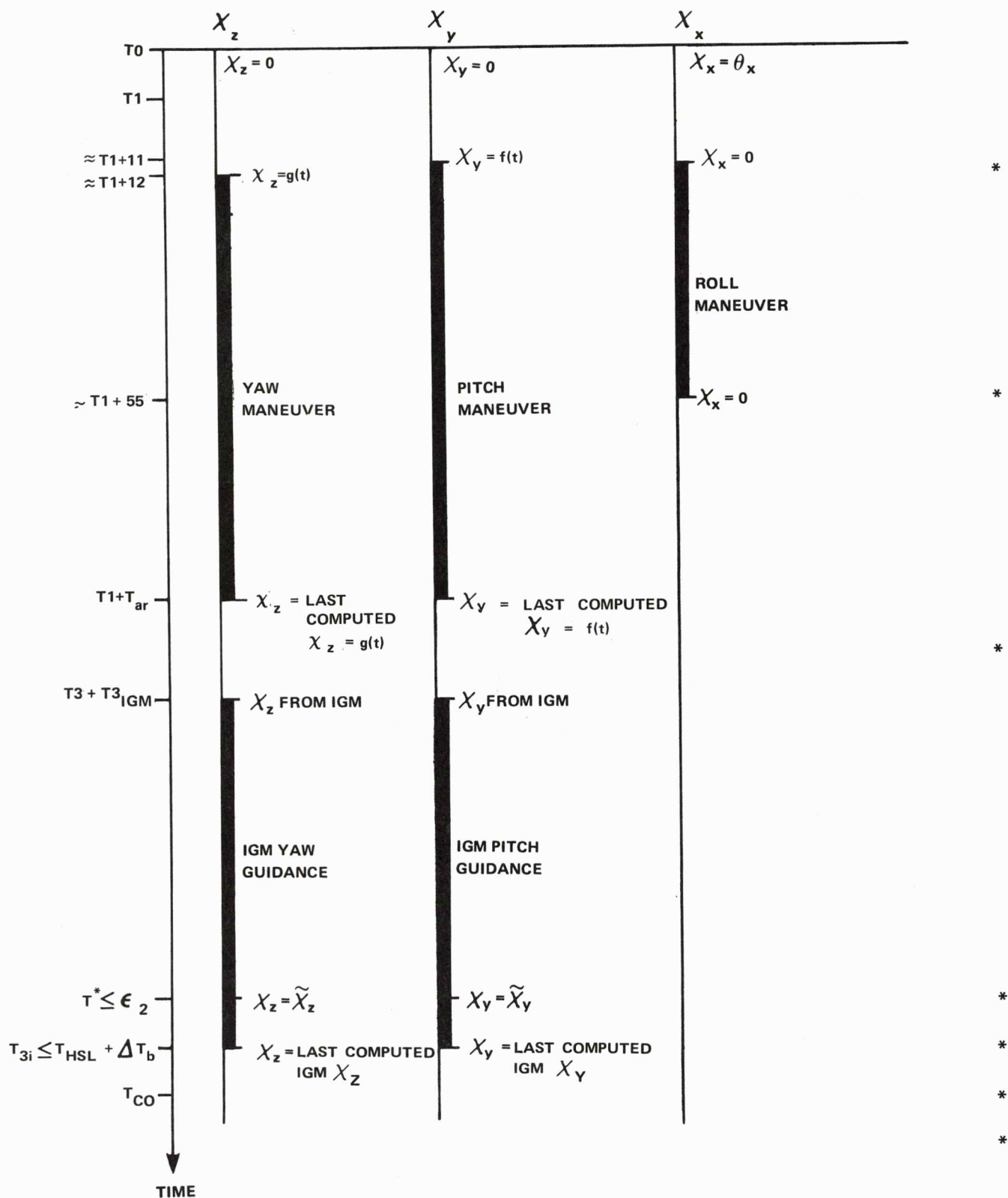


Figure 4-2 Boost Guidance Timeline



#### 4.4.1 First Stage Guidance

From GRR to  $T_3 + 0.0$  the flight program must generate guidance commands to insure that the launch vehicle aligns along the platform azimuth, and flies a preprogrammed time tilt profile along the specified azimuth.

##### 4.4.1.1 Roll Maneuver

At GRR, the inertial platform Z axis is aligned with the platform azimuth (see Section 3); the vehicle  $Z_B$  axis is aligned 90 degrees East of North. To maintain these relationships, the  $\chi_x$  guidance command is initialized and maintained at the last roll gimbal angle  $\theta_x$  read in the Prepare to Launch (PTL) program. \*

When the vehicle has cleared the LUT (when  $(X_S - \text{initial } X_S) \geq \text{GANTRY}$ ) (primary requirement), or alternatively when  $T_c \geq T_{S0}$  (backup requirement), the roll maneuver begins. The  $\chi_x$  guidance command is set to zero to align the vehicle to the proper flight azimuth and bit 2 of MC25 is set. The parameter  $T_c$  is the time from  $T_1$  biased by the constant  $T_d$  to compensate for delays between computing and commanding the attitude, Eq. 4.4.1. When  $|\theta_x| \leq 0.5$  degrees the roll maneuver is considered to be complete and bit 3 of MC25 is set.

##### 4.4.1.2 Time Tilt Pitch Guidance

The time tilt pitch maneuver is begun under the same criteria as those for the roll maneuver. When the vehicle has cleared the LUT (when  $X_S - (\text{initial } X_S) \geq \text{GANTRY}$ ), or alternatively when  $T_c \geq T_{S0}$ , computations of  $\chi_y$  begin.

The  $\chi_y$  guidance commands are computed as a function of time ( $T_c$ ) by a third-degree polynomial. The time profile for the pitch program is divided into three segments and Eq. 4.4.2 is used to compute the time tilt pitch commands during the indicated segments.



# S-IB CONTINGENCY ENGINE FAILURE CAPABILITY

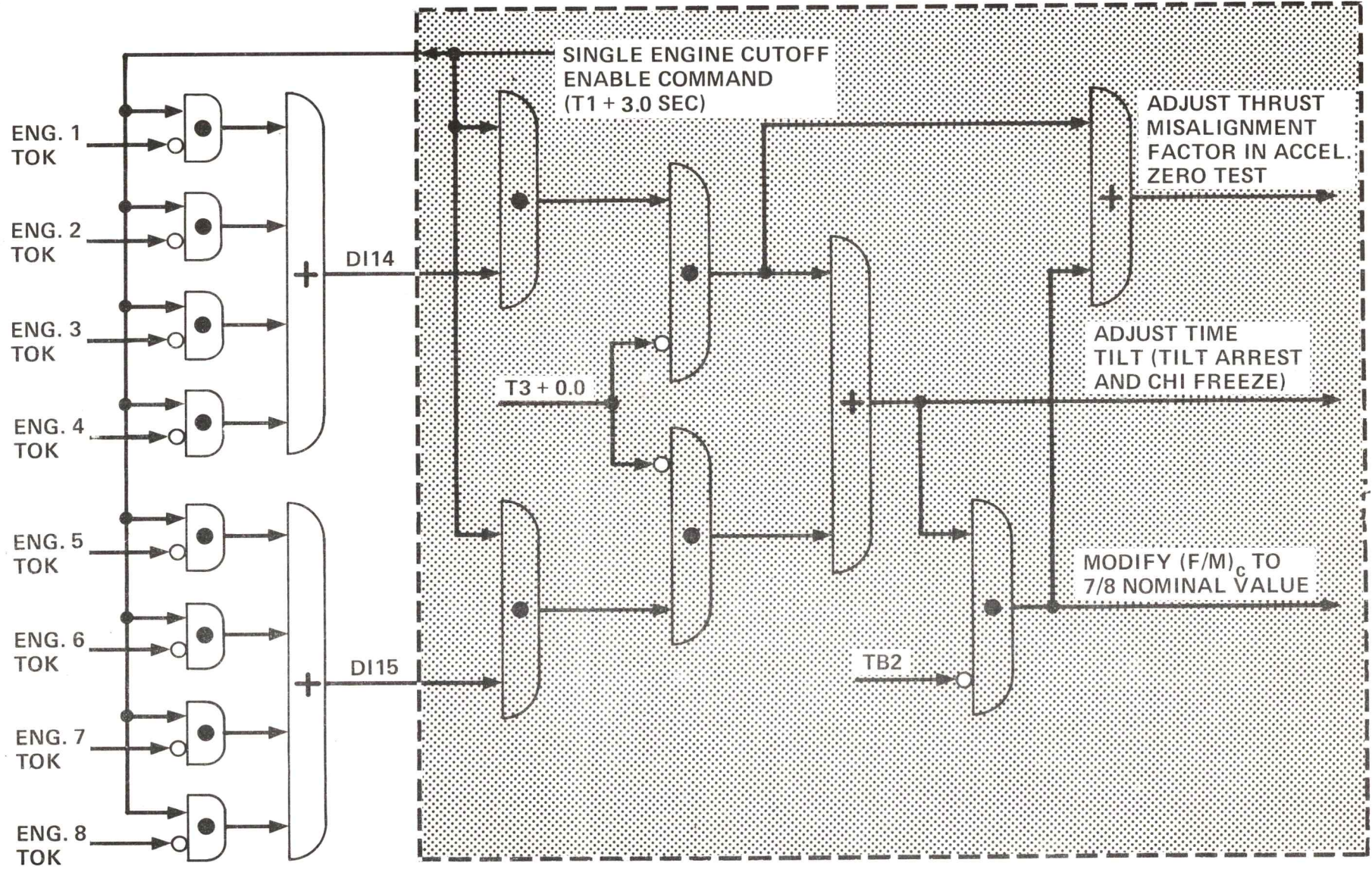


Figure 4-3 S-IB Contingency Engine Failure Capability

used as the current guidance command. All  $\chi_y$  guidance command \*  
freezes due to S-IB engine failures are delayed until  $T_c \geq T_{T2}$ .  
When the freeze period is completed,  $T_c \geq T_{MEFRZ}$ , the time tilt  
profile resumes. The time to end the  $\chi_y$  freeze,  $T_{MEFRZ}$ , is  
computed in Eq. 4.4.5. The time to arrest the guidance commands,  
 $T_{ar}$ , is modified by  $\Delta T_f$  and  $C_{ar1}$  (Eq. 4.4.6) for the first S-IB  
engine failure detected.

#### 4.4.1.4.1 Engine Out Responses In Time Base 1

The flight program responses to S-IB engine failures in Time  
Base 1 are as follows:

- The time tilt computations are modified as described above for the first engine out only.
- $F_{EO}$  must be set to SIBEOB.
- The  $\sin(6^\circ)$  is substituted for  $\sin(2^\circ)$  in the zero test computation, Eq. 4.2.3, until  $T3 + 0.0$ .
- Bit 8 of MC25 is set upon detection of DI15, and bit 9 of MC25 is set upon detection of DI14.



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 corrections 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
- An indication of an unreasonable accelerometer reading exists
- An indication of an unacceptable accelerometer zero reading exists

- One or more minor loop guidance command is rate limited \*
- The yaw guidance command is magnitude limited. \*

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 plumbline 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 plumbline 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.

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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 corrections 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
- An indication of an unreasonable accelerometer reading exists
- An indication of an unacceptable accelerometer zero reading exists



- One or more minor loop guidance command is rate limited \*
- The yaw guidance command is magnitude limited. \*

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.

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- Guidance Reference Failure Tests
- Issuance of the S-IVB cutoff switch selector commands.

The HSL calculations are initiated when the predicted time-to-go  $T_{3i}$  (Eq. 4.4.17) becomes less than the preset time ( $T_{HSL}$ ) plus a computed time bias ( $\Delta T_b$ ) and the velocity-to-be-gained is less than a velocity guard ( $V_{GRD}$ ).

On the first pass through the HSL, IGM guidance commands must be frozen to their last computed values and the predicted  $T_{3i}$  is decreased by the last computed value of the time bias ( $\Delta T_b$ ) which compensates for a velocity bias, Eq. 4.4.89. On all subsequent passes, the predicted  $T_{3i}$  is decremented by the length of the BML,  $\Delta T$ , Eq. 4.4.90.

The prediction of the S-IVB cutoff time is performed with Eq. 4.4.91 through 4.4.94. This cutoff prediction uses a second-degree polynomial which expresses velocity as a function of time. This polynomial is constructed using the current and two previous BML durations and velocity values. The polynomial is then evaluated to give the time at which the cutoff velocity will be achieved. The cutoff velocity is biased by the preset  $\Delta V_b$  to compensate for thrust tailoff and system delays which cause velocity gain after the S-IVB cutoff command is issued.

Beginning with the initial calculation of the predicted cutoff time in the HSL, the most recent  $T_{3i}$  value will be decremented and tested every 40 ms (a function of minor loop execution). When  $T_{3i}$  is determined to be less than 60 ms, the program must inhibit interrupts (except INT9 and INT12), continuously compare the time to S-IVB cutoff switch selector read issuance, and issue the S-IVB cutoff switch selector command sequence when the real time clock reading becomes greater than or equal to  $T_{CO}$ . Upon issuing the first S-IVB cutoff switch selector, minor loops must be enabled and INT4 and INT11 must be enabled.

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Any time that the predicted cutoff time calculation in Eq. 4.4.94 indicates that the time-to-go is less than 20 ms, the cutoff commands must be issued immediately.

When the read command for the S-IVB Engine Cutoff No. 1 ON switch selector is issued, bit 23 of MC25 must be set.

If guidance reference failure occurs, entrance to the high speed loop (HSL) shall be inhibited. If the HSL has already been entered when GRF is recognized, the HSL shall continue until cutoff.

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#### 4.4.3 Guidance Reference Failure (GRF)

If GRF is detected anytime during the mission, the S/C control of Saturn capability is provided by hardware logic in response to the guidance reference failure discrete outputs (D04 or D06). This capability is never disabled once enabled. Checks for DI9 begin immediately upon detection of GRF and continue to be made once per BML during boost until DI9 is detected. Once DI9 is detected, bit 15 of MC27 is set. This bit is never reset.

Upon detection of GRF, all attitude error commands originating from the flight program are maintained at their current value until DI9 is detected. When DI9 is detected, all attitude error commands are set and maintained at zero for the remainder of the mission.



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 at the time the accelerometers are read.

Steering misalignment correction terms are first computed at  $T3 + T_{SMC}$ . The SMC terms are set to zero at  $T4 + 0.0$ . Calculations of new SMC corrections 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
- An indication of an unreasonable accelerometer reading exists
- An indication of an unacceptable accelerometer zero reading exists

- One or more minor loop guidance command is rate limited \*
- The yaw guidance command is magnitude limited. \*

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 plumbline 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 plumbline 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.

#### 5.5.5.1 Inertial Attitude Hold Maneuver After S/C Control

To command an inertial attitude hold upon the return of control to the IU, the program must set the inertial platform gimbal angle guidance commands equal to the gimbal angles calculated in the last minor loop before maneuver initiation, Eq. 5.5.7. Bit 17 of MC27 must be set for the duration of this maneuver. Bits 10, 11, 12, and 16 of MC27 must be reset.

#### 5.5.5.2 Track Local Reference Maneuver After S/C Control

To command a track local reference maneuver upon the return of control to the IU, the following processing must be done:

- Set the desired roll command equal to the roll gimbal angle calculated in the last minor loop before maneuver initiation, Eq. 5.5.8.
- Compute the sine and cosine of the pitch and yaw gimbal angles calculated in the last minor loop before maneuver initiation and calculate the vehicle's attitude in the plumbline coordinate system, Eq. 5.5.9.
- Compute the components of the vehicle's attitude in the target plane coordinate system, Eq. 5.5.10.
- Compute the components of the vehicle's out-of-plane attitude, Eq. 5.5.11.
- Compute the vehicle's in-plane attitude with respect to the local horizontal, Eq. 5.5.12.

The results of the above computations will be substituted for the nominal track local reference parameters, Eq. 5.5.13, and the local reference computations described in Section 5.5.3



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 (D04 or D06). This 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 EOM or until DI9 is detected. 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 and



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

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## SECTION 7

### TIME BASES, DISCRETES, AND INTERRUPTS

#### 7.1 INTRODUCTION

Most of the time-dependent events in the flight program are referenced to important occurrences in the flight to prevent perturbations in one stage from impacting the timing in subsequent stages. To facilitate this timing, time bases must be started upon recognition of these events.

Most discrete outputs (DO) from the LVDC/LVDA to the rest of the Saturn IB system are generated through the stage switch selectors. Each switch selector allows the LVDC to command up to 112 different discrete outputs to each vehicle stage. A detailed explanation of switch selector command processing is contained in Section 9. Thirteen additional discrete output signals can be generated by the LVDC.

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Two means are available for sending discrete information into the LVDC from the Saturn IB/CSM system and supporting ground equipment: (1) discrete inputs, and (2) interrupts. Three interrupts are controlled internally by the LVDC. (Note: Times marked with an asterisk (\*) are mission-dependent; for exact value, see Event Sequence Timeline in the individual mission requirements, Part II.)

#### 7.2 TIME BASES

Time bases are used to reference program events to some key mission event. A time base must be started within 2 ms of the flight program's recognition that the required conditions have been met. When a time base is started, the flight program must execute the following functions:

1. Read the real-time clock to establish the time at which the time base began
2. Telemeter the real-time clock reading
3. Begin accumulating time in the time base
4. Set the required mode code bit
5. Stop issuing switch selector commands from the previous time base
6. Begin issuing switch selector commands from the new time base.

Six primary time bases are required for the Saturn IB flight program and are described below. Backup methods are required for Time Bases 1 through 4. To complement the time base start requirements descriptions, logic diagrams are provided by Figures 7-1 through 7-5. In each figure flight program functions are shown in the shaded area within the broken line while hardware functions are shown outside the broken line. The symbol "•" is used to represent a logical AND gate, giving an output if and only if all inputs to the gate are present. The symbol "+" is used to represent a logical OR gate, giving an output if one or more inputs to the gate is present. A double line input to an OR gate is used to indicate the primary input expected on a nominal mission. A circle in an input line to a logic gate indicates that the complement of the input signal must be used.

#### 7.2.1 Time Base 0 (Guidance Reference Release)

Time Base 0 (TBO) must be initiated when the program recognizes the guidance reference release (GRR) interrupt (INT7). When TBO is started, the sign bit of Mode Code 25 (MC25) must be set; this bit must never be reset.

#### 7.2.2 Time Base 1 (Liftoff)

Time Base 1 (TB1) must start upon detecting either DI7 (Liftoff "B") or DI24 (Liftoff "A"). These DIs are generated by the

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"

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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; 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

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.

#### 7.4.10 DI10: Coolant Thermal Switch #1

This DI indicates that the temperature of the environmental control system (ECS) coolant is above the selected control temperature. This input must be checked once every 300 seconds, beginning at  $T_{GRR} + T_M$  seconds, for use in maintaining the coolant temperature by controlling the water supply to the sublimator. Bit 18 of MC27 is initially set to indicate that the Water Control Valve Logic Inhibit DCS command has not been received.

If the water valve is closed and either DI10 or DI11 is on, the program must issue the switch selector command to open the water valve. This is a class 1 alternate switch selector sequence. If the water valve is closed and both DI10 and DI11 are off, no action is taken. \*

If the water valve is open and both DI10 and DI11 are off, the program must issue the switch selector command to close the valve. This is a class 1 alternate switch selector sequence. If the water valve is open and either DI10 or DI11 is on, no action is taken. \*

If the Water Control Valve Logic Inhibit DCS command has been accepted, DI10 and DI11 are ignored by the program. Bit 18 of MC27 must be reset.

#### 7.4.11 DI11: Coolant Thermal Switch #2

See DI10.

7.4.12 DI12: S-IB/S-IVB Separation

This DI indicates that the S-IB and S-IVB have separated. This DI is on, logic 1, until separation occurs, at which time it goes off, logic 0. There is no requirement to monitor this DI.

7.4.13 DI13: Spare (206, 207, 208), Spare (Wired to Control Distributor) (209 and Subs)

7.4.14 DI14: S-IB Outboard Engine Out

This DI indicates that at least one S-IB outboard engine is out. This DI must be checked once per BML from  $T_1 + T_{S1EO}$  until it is detected or until TB3. A detailed description of the required program response is found in the Engine Out Guidance Modifications discussion in Section 4. When this DI is recognized, bit 9 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 discrete is activated when at least two of the three "thrust OK" pressure switches in any one of S-IB engines 1 through 4 (outboard 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 outboard engines are burning. At S-IB/S-IVB separation, this DI will become a logic 0 and will remain in that state until EOM.

7.4.15 DI15: S-IB Inboard Engine Out

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DI15 indicates that at least one of the S-IB inboard engines is out. This DI must be checked once per BML from  $T_1 + T_{S1EO}$  until it is detected or until TB3. A detailed description of the criteria under which this DI must be checked, and the required



## SECTION 8

### LAUNCH VEHICLE ATTITUDE CONTROL

#### 8.1 INTRODUCTION

The flight program functions as a part of the attitude control system by generating vehicle attitude error signals. The launch vehicle attitude, in the form of angular displacements measured by inertial platform gimbal resolvers, is read into the LVDC through LVDA hardware. The attitude error is then computed by differencing the attitude angles with the desired angles computed by the guidance equations. The resulting attitude error is transformed to the body reference frame, limited in magnitude and rate of change, and issued to the flight control system.

The control functions of determining vehicle attitude and computing and issuing attitude error commands are called the minor loop. These functions must be performed approximately twenty-five times per second during boost and approximately ten times per second during orbit. The supporting control functions of computing attitude change increments and coefficients for the gimbal-to-body transformation required for attitude error command computations are called minor loop support functions. These functions are performed once per boost major loop (BML) during boost and once per second during orbit.

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#### 8.2 MINOR LOOP

The minor loop reads platform gimbal data, evaluates these data, and computes and issues attitude error commands. The gimbal angles are processed in the following order: yaw, pitch, and roll.

The minor loop samples the yaw gimbal resolver, evaluates the yaw gimbal resolver data, computes the yaw attitude angle, and computes and issues the yaw attitude error command. This process is then repeated for the pitch and roll gimbals.

Minor loop functions must be performed every 40 ms during boost and every 100 ms during orbit. However, the start of a minor loop may be delayed while processing of any of the following interrupt-protected program functions is under way. During boost, occasional delays of up to 8 ms may result from interference by switch selector processing. A delay of up to 21 ms may result while processing interrupt protected data output multiplexer (DOM) telemetry. A delay of up to 60 ms may occur just prior to S-IVB cutoff. In orbit, minor loops may be delayed up to 12 ms by command decoder interrupt processing.

#### 8.2.1 Gimbal Angle Data

The vehicle attitude angles are sensed by inertial platform resolvers which measure the angles between the three platform gimbals and the mounting frame. Primary, or fine, and backup resolvers are provided for each gimbal.

The fine resolvers are initially selected for attitude determination and are used unless repeated fine resolver errors are detected. A backup resolver is selected for attitude determination only if its corresponding fine resolver shows repeated errors.

The resolver outputs are converted to digital form in the LVDA by a combination of crossover detectors (COD) and redundant eleven bit counters. The resolver data word contains the redundant counter readings and a disagreement bit in the following format: DAAAAAAAAAASSBBBBBBBBBB, where A

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## SECTION 9

### SWITCH SELECTOR PROCESSING

#### 9.1 INTRODUCTION

The initiation of time dependent hardware events in the Saturn IB is accomplished by switch selector commands issued by the LVDC/LVDA. A switch selector in each launch vehicle stage, including the Instrument Unit, decodes the commanded address and activates one of 112 possible output circuits in that stage.

Switch selector processing performs the following flight program functions:

- Actuation of the switch selector command, including the necessary tests, verifications, and issuances
- Proper timing, as specified in the Flight Sequencing Table in Part II
- Adherence to the hierarchy of priorities when alternate flight sequences are requested.

#### 9.2 COMMAND EXECUTION OPERATIONS

The flight program action required to execute switch selector commands consists of the following sequence of program operations: test for hung stage (as necessary), issue the stage and address, verify the address, issue the read command, and issue the read reset.



### 9.2.1 Sequence of Operations

Figure 9-1 shows the sequence of operations required to issue a switch selector command and the minimum elapsed time which must be allowed between software operations for the corresponding hardware functions to be correctly executed. The minimum times shown in Figure 9-1 result from the hardware reaction times shown in Figure 9-2.

#### 9.2.1.1 Hung Stage Test

If the switch selector stage select circuitry does not reset after a switch selector command has been issued, a hung stage condition exists. Since the eight command address lines from the LVDA are common to all stage switch selectors, a hung stage condition will activate the switch selector circuitry on the hung stage for all subsequent switch selector commands. A hung stage results in erroneous outputs only when the currently selected stage differs from the stage selected by the previous switch selector command.

To test for a hung stage, the program must read the feedback lines. If the feedback bits are zero, there is no hung stage and the stage and address will be issued. If the feedback bits are not zero, a hung stage exists and a forced reset must be issued. Thirteen milliseconds must elapse between the forced reset and the issuance of the stage and address of the next switch selector command.

Prior to issuing certain switch selector commands, the flight  
program must test for a hung stage. These switch selector  
commands must include, at a minimum, the first switch selector  
command after GRR and any switch selector command in which the  
selected stage differs from that of the previous command. \*

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#### 9.2.1.2 Stage and Address

The flight program must issue the stage and address after the hung stage test. However, if the hung stage test is not necessary for the present switch selector command, the stage and address must be issued immediately. Table 9-1 indicates the stage and address bit format of the Switch Selector Command Word required for the issuance of all Switch Selector commands. Only one stage will be selected by each switch selector command.

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TABLE 9-1 SWITCH SELECTOR COMMAND WORD

Bit Position	Function
S	Read Command
1	Force Reset of Switch Selector Relays
2	IU Stage Selected
3	Spare
4	S-IVB Stage Selected
5	Spare
6	S-IB Stage Selected
7-14	Stage Address
15-25	Spares

The 8-bit coded address is transmitted in parallel via eight output lines from the LVDA to all switch selectors. At the same time, the corresponding stage select lines (two lines from each stage select bit to the corresponding stage switch selector) are activated to enable the desired stage to receive the coded command.

After issuing the stage and address, DOM telemetry of the discrete output register and switch selector register must be issued while the stage and address are in the LVDA switch selector register.

In the nominal sequence (no hung stage detected), 18 ms must elapse between the stage and address issuance and the next operation, that of verifying the address. If a hung stage were detected, 26 ms must elapse before verifying the address. The additional 8 ms is required because of the necessary forced reset.

#### 9.2.1.3 Address Verification

After receiving the address and prior to the actuation of the stage circuitry, the stage switch selector returns the one's complement of the received address to the LVDA via eight feedback lines.

The flight program must sample the eight feedback bits to determine if the commanded transfer is correct. If the command has been correctly interpreted by the switch selector, the eight feedback bits will be the one's complement of the commanded address and the read command must be issued immediately.

A feedback which is not the one's complement of the commanded address is an erroneous feedback word. Erroneous feedback words must be tested to determine if they are zero or non-zero.



All erroneous feedback words which are zero must be further tested for a zero simplex malfunction in the switch selector. If the commanded address contains more than one zero, the feedback mechanism is assumed to have failed (zero simplex malfunction) and nominal processing will be resumed as if the feedback were correct.

All other erroneous feedback words will disagree by one or more bits from the one's complement of the commanded address.

If the erroneous feedback word disagrees by only one bit from the one's complement of the commanded address (which includes the case when the commanded address of a zero feedback word contained only one zero), then the program must issue a forced reset. Thirteen milliseconds later the program must issue the stage and one's complement address. Twenty-three milliseconds must elapse between the issuance of the stage and complement address and the issuance of the read command. DOM telemetry of the complement address must also be issued.

If the feedback work disagrees by more than one bit from the address complement and Channel A (normal operation) is in use, then the following sequence of events must be initiated with the time delays specified above:

1. The program must issue a forced reset
2. Channel B must be selected
3. The stage and complement of the commanded address must be issued
4. The read command must be issued.

Bit 12 of the internal control register (ICR) must be set to zero. Bit 17 of Mode Code 24 must be set, this bit must never be reset; and the feedback address must be telemetered. After the program switches to Channel B, Channel A must never be used again. Instead, Channel B will be used for the rest of the mission. Nominal processing of the commanded address, including verification, will be continued using Channel B.

#### 9.2.1.4 Read Command

After an acceptable switch selector stage and address, or complement address, has been issued, the program must issue the read command. This command activates the selected circuitry in the switch selector to produce the command output.

After the read command is issued to the switch selector, the flight program must telemeter the stage, the commanded address, and the real time clock reading when the read command was issued. During the orbital mode when the vehicle is out of electromagnetic view of a telemetry dump station, switch selector commands must be compressed. See Section 11.5 for data compression requirements. The maximum allowable error between the clock value and the actual time the read command is issued is 1.0 ms. The time error must be kept constant for all switch selectors by keeping the number of instructions between the PIOs constant.

The stage must be reloaded in the switch selector register when the read command is issued to provide positive stage identification for real time monitoring (ground support) of the sequencing system.

#### 9.4.5 Class 4 Alternate Sequence

An alternate sequence consisting of one or more switch selector commands, which are to be issued intermittently and concurrently with the switch selector sequence in progress, will be considered a Class 4 sequence. Commands from the Class 4 alternate sequence will be issued when the time until the next switch selector command in the current sequence is greater than 500 ms. This requirement must be enforced until the alternate sequence is completed.

A Class 4 sequence can run concurrently with any other alternate sequence or the current nominal sequence. Furthermore, the starting of a new sequence (nominal or alternate Class 1, 2, or 3) does not cancel a Class 4 sequence that is being issued intermittently. The Class 4 sequence will continue to be issued in the new sequence whenever time permits. However, if a Class 4 sequence is requested while another Class 4 sequence is in progress, the new request must be honored and the new sequence will replace the former Class 4 sequence. (An example of a Class 4 sequence is the telemetry station acquisition sequence.)

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#### 11.4.1.1.6 Special Telemetry

The time at which the current time base started must be telemetered to allow an accurate determination of switch selector command times. This information must be telemetered once every BML during boost mode and once per second during orbital mode, but will change only when a new time base begins.

The special codes shown in Table 11-2 are necessary to adequately mark the end of the telemetry during each computation cycle and to mark the beginning of the telemetry for the next cycle.

TABLE 11-2 ETC/BTC TELEMETRY

Symbol	Data Word
ETC (end of telemetry cycle)	7 0 7 0 7 0 7 0 6
BTC (begin telemetry cycle)	Computation cycle counter

The ETC word must be telemetered immediately after all LVDC telemetry is completed in each BML in boost mode or in each one second interval in orbital mode; the BTC word must be telemetered just prior to the beginning of the telemetry cycle. The redundancy is necessary since interrupts can destroy these LVDC words.

The discrete input register (DIR), the internal control register (ICR), and the discrete output register (DOR), must be telemetered once during each BML in boost mode and once per second during orbital mode.

The error monitor register (EMR) will be read into the LVDC each time it is PIOed. All readings of the EMR within each BML in boost mode must be ORed together into a single word

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 a dump station loss is processed it must be reset.

#### 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.



#### 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.

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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, of at least 8.334 ms since the last LVDC telemetry PIO or the last LVDA PIO, must be provided 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 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.

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#### 11.5.1 General Data Compression Requirements

The following requirement 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 1.1 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 Backup gimbal angles Accelerometer outputs
B	{ Discrete outputs TLC HOP constants Switch selector stages and addresses
C	{ Error monitor register contents Mode code 24 Discrete inputs

TABLE 11-13 MODE CODE DESCRIPTION (CONTINUED)

Mode Code 25		
<u>Bit No.</u>	<u>Bit Set Indication</u>	<u>Reset Bit</u>
25	TLC (INT9), simultaneous memory error	This bit must never be reset after it has been set.

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	
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.

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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
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

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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
TLC	Temporary Loss of Control (LVDC simultaneous memory error)
TM	Telemetry
TOPS	Thrust OK Pressure Switch

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TABLE 15-2 DEFINITIONS

<u>Symbol</u>	<u>Definition and Comments</u>
$\bar{A} (\bar{A}_p)$	Vehicle acceleration vector (predicted) [m/sec <sup>2</sup> ]
$A'$	Intermediate parameter used in HSL time-to-go calculations [m/sec <sup>2</sup> ]
$A''$	Intermediate parameter used in HSL time-to-go calculations [m/sec <sup>3</sup> ]
$A_{c0}$	Estimated uncertainty in the expected velocity change computation [m/sec]
$\bar{A}_D (\bar{A}_{Dp})$	Drag acceleration vector (predicted) [m/sec <sup>2</sup> ]
$a_e$	Semi-major axis of the earth-model ellipsoid [m]
$A_z$	Platform azimuth, computed in Preflight routines [pirads]
$A_{zL}$	Position I azimuth at launch [pirads]
$A_{00}$	Constant term of variable azimuth polynomial, used by Preflight routines [deg]
$A_{01}$	Coefficient of inclination $i$ in variable azimuth polynomial, used by Preflight routines
$A_{10}$	Coefficient of descending node angle $\lambda$ in variable azimuth polynomial, used by Preflight routines



TABLE 15-2      DEFINITIONS (CONTINUED)

<u>Symbol</u>	<u>Definition and Comments</u>
$A_{11}$	Coefficient of product of inclination $i$ and descending node angle $\lambda$ in variable azimuth polynomial, used by Preflight routines [ $\text{deg}^{-1}$ ]
$A_1-A_6$	Coefficients used to compute pitch, yaw, and roll attitude correction commands

\*  
\*  
\*  
  
\*  
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TABLE 15-2 DEFINITIONS (CONTINUED)

<u>Symbol</u>	<u>Definition and Comments</u>	
<u><b>L</b></u>		
$L_p$	Component in the pitch plane of the total corrected velocity-to-be-gained by IGM, used in the calculation of position correction terms $K_1$ and $K_2$ [m/sec]	
$L_y$	Total corrected velocity-to-be-gained by IGM, used in calculation of position correction term [m/sec]	
$L'_y$	Total estimated velocity-to-be-gained by IGM, used in calculation of the predicted terminal range angle $\phi_T$ [m/sec]	
$L_1$	Velocity-to-be-gained in first phase IGM, used in calculation of the predicted terminal range angle $\phi_T$ [m/sec]	
$L_3$	Corrected velocity-to-be-gained in second phase IGM, used in calculation of the pitch guidance command $\chi_y$ [m/sec]	
$L'_3$	Estimated velocity-to-be-gained in second phase IGM, used in calculation of the predicted terminal range angle $\phi_T$ [m/sec]	
LML	Minimum value to be used for the pitch, yaw, and roll ladder magnitude limit if the loss of APS attitude control test determines the vehicle is out of control [deg]	* * * *



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) [deg]
MLKRC3	Gimbal angle RTC used after first pass on the backup gimbal (pitch and yaw channels) [deg/ML]
MLKRC5	Gimbal angle RTC used after first pass on the backup gimbal (roll channel) [deg/ML]
MLK2	Fine gimbal angle RTC (pitch and yaw channels) [deg/ML]
MLK12	Fine gimbal angle RTC (roll channel) [deg/ML]
MLR	Minor Loop rate [ $\text{sec}^{-1}$ ]
ML6HUN	Zero gimbal angle test constant (all channels) [deg]
[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) [deg/ML]
MSK6	Ladder magnitude limit (pitch and yaw channels) [deg]
MSK16	Ladder magnitude limit (roll channel) [deg]
MSLIM1	Attitude command ( $\chi$ ) rate limit (roll channel) [deg/ML]
MSLIM2	Attitude command ( $\chi$ ) rate limit (pitch and yaw channels) [deg/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>
<u>N</u>	
	*
NTSTB2	Nominal time in Time Base 1 to start Time Base 2 in repeatable flight simulation [sec]
NTSTB3	Nominal time in Time Base 2 to start Time Base 3 in repeatable flight simulation [sec]
NUPTIM	Time from GRR at which a DCS Navigation Update is to be implemented [sec]



TABLE 15-2 DEFINITIONS (CONTINUED)

<u>Symbol</u>	<u>Definition and Comments</u>	
<b><u>P</u></b>		*
P	Parameter used in calculation of gravitational acceleration vector	
P <sub>bx</sub>	Performance factor bias along X <sub>B</sub> axis for back-up acceleration computations	*
P <sub>by</sub>	Performance factor bias along Y <sub>B</sub> axis for back-up acceleration computations	*
P <sub>bz</sub>	Performance factor bias along Z <sub>B</sub> axis for back-up acceleration computations	*
P <sub>C</sub>	Elapsed time in artificial $\tau$ mode at EMRC [sec]	
P <sub>CMR</sub>	Preset length of artificial $\tau$ mode after EMRC [sec]	
		*
P <sub>1</sub>	IGM parameter used in calculation of range angle	
P <sub>3</sub>	IGM parameter used in calculation of pitch attitude correction term	
P <sub>34</sub>	Parameter in harmonic expansion of earth's gravitational potential	

TABLE 15-2      DEFINITIONS (CONTINUED)

<u>Symbol</u>	<u>Definition and Comments</u>	
<u><b>Q</b></u>		
$Q_p$	IGM parameter used in calculation of position correction term	*
$Q_y$	IGM parameter used in calculation of position correction term	
$Q_1$	IGM parameter used in calculation of position correction term	
$Q_3$	IGM parameter used in calculation of position correction term	

TABLE 15-2 DEFINITIONS (CONTINUED)

<u>Symbol</u>	<u>Definition and Comments</u>	
<u>R</u>		
$\overline{R} (\overline{R}_p)$	Vehicle geocentric radius vector (predicted) [m]	
$\overline{R}_L$	Geocentric radius to the center of the IU on the launch pad. Used to calculate initial conditions [m]	
$\overline{R}_{OG}$	Radius vector for use in orbital guidance [m]	
$R_{STA}$	Radius of telemetry station acquisition sphere, set to a value giving a two-degree elevation angle at the nominal orbit altitude [m]	* * *
$\overline{R}_T$	Terminal radius vector [m]	
$\overline{R}_1$	Unit vector along $\overline{R}$	
$RA_{M1} - RA_{M5}$	Roll angle for orbital guidance maneuvers 1-5 [pirads]	
ROLL	Roll attitude error correction command [ladder bits]	
ROLLA	Presetting for $\chi_x$ for orbital guidance [pirads]	
ROV	Constant used to bias terminal range angle prediction	
RTCX	Reasonableness test constant (RTC) for X accelerometer channel [m/sec <sup>2</sup> ]	

TABLE 15-2 DEFINITIONS (CONTINUED)

<u>Symbol</u>	<u>Definition and Comments</u>	
<u>Y</u>		
$Y_A$	Component of $\bar{R}$ along $Y_A$ axis [m]	
$Y_B$	Component of $\bar{R}$ along $Y_B$ axis [m]	
$\ddot{Y}_{DS}$	Component of $\bar{A}_D$ along $Y_S$ axis [m/sec <sup>2</sup> ]	
$Y_G$	Component of $\bar{R}$ along $Y_G$ axis [m]	
$\ddot{Y}_{Gg}$	Component of $\bar{G}$ along $Y_G$ axis [m/sec <sup>2</sup> ]	
$Y_{LS}$	Component of $\bar{R}_L$ along $Y_S$ axis [m]	
$\dot{Y}_m$	Measured platform velocity along $Y_S$ axis [m/sec]	
$\ddot{Y}_m$	Average platform acceleration along $Y_S$ axis [m/sec <sup>2</sup> ]	
$\dot{Y}_0$	Initial value of $\dot{Y}_S$ [m/sec]	
$Y_P$	Component of the non-orthogonal inertial platform gimbal system, identical to the $Y_S$ axis [m]	*
$Y_{ref}$	Y reference angle of execute generalized maneuver commanded attitude [pirads]	*
$Y_S$	Component of $\bar{R}$ along $Y_S$ axis [m]	
$\dot{Y}_S$	Component of $\bar{V}$ along $Y_S$ axis [m/sec]	
$\ddot{Y}_S$	Component of $\bar{A}$ along $Y_S$ axis [m/sec <sup>2</sup> ]	



TABLE 15-2 DEFINITIONS (CONTINUED)

<u>Symbol</u>	<u>Definition and Comments</u>	
$\dot{Y}_{Sg}$	Component of $\bar{V}$ along $Y_S$ axis due to gravitational acceleration [m/sec]	* *
$\ddot{Y}_{Sg}$	Component of $\bar{G}$ along $Y_S$ axis [m/sec <sup>2</sup> ]	
$Y_V$	Component of $\bar{R}$ along $X_V$ axis. This is identical to $Y_4$ [m]	
$\dot{Y}_V$	Component of $\bar{V}$ along $Y_V$ axis [m/sec]	
$\ddot{Y}_{Vg}^*$	Component of $\bar{G}^*$ along $Y_V$ axis [m/sec <sup>2</sup> ]	
$\ddot{Y}_{VgT}$	Component of $\bar{G}_T$ along $Y_V$ axis [m/sec <sup>2</sup> ]	
$Y_{VT}$	Component of $\bar{R}_T$ along $Y_V$ axis [m]	
$\dot{Y}_{VT}$	Component of $\bar{V}_T$ along $Y_V$ axis [m/sec]	
$Y_4$	Component of $\bar{R}$ along $Y_4$ axis. This is identical to $Y_V$ [m]	
$\dot{Y}_4$	Component of $\bar{V}$ along $Y_4$ axis [m]	*
YAW	Yaw attitude error command [ladder bits]	*
YAWC01-	Table of yaw commands for S-IB stage guidance	*
YAWC25	associated with times in table TYAW [deg]	*
YAWLIM	Yaw guidance command limit [pirads]	

TABLE 15-2 DEFINITIONS (CONTINUED)

<u>Symbol</u>	<u>Definition and Comments</u>	
<u>ALPHA</u>		
$\alpha$	Angle of attack [pirads]	
$\alpha_{ACTX}$	Attitude error comparison constant for the X channel loss of APS attitude control test [deg]	* *
$\alpha_{ACTZ}$	Attitude error comparison constant for the Z channel loss of APS attitude control test [deg]	*
$\alpha_f$	Weighting factor based on first phase IGM performance used in adjusting $\tau_3$ computations	
$\alpha_{LH}$	Angle between desired $\bar{P}$ and the local horizontal [pirads]	
<u>DELTA</u>		
$\delta_2$	Intermediate parameter used in terminal range angle prediction	
$\Delta A$	Measured velocity change from accelerometer optisyn A [pulses]	*
$\Delta B$	Measured velocity change from accelerometer optisyn B [pulses]	*
$\Delta L_3$	Correction to velocity-to-be-gained $L_3$ [m/sec]	
$\bar{\Delta R}$	Radius-to-be-gained vector [m]	
$\overline{\Delta R}_{SAV}$	Vector symbol for the low order bits of the com- puted position change during the past orbital navigation pass, saved to reduce truncation error [m/sec]	
$\Delta T$	Execution time of the last BML [sec]	

TABLE 15-2 DEFINITIONS (CONTINUED)

<u>Symbol</u>	<u>Definition and Comments</u>	
$\Delta T'$	Previous value of $\Delta T$ [sec]	
		*
$\Delta T_b$	Time bias to compensate for S-IVB engine thrust decay after cutoff [sec]	
$\Delta T'_E$	Fraction of a major loop prior to the occurrence of a thrust event, used in $(F/M)_c$ calculations for the next BML [sec]	*
		*
$\Delta T_{EVNT}$	Fraction of a major loop after the occurrence of a thrust event, used in $(F/M)_c$ calculation for the next BML [sec]	*
		*
$\Delta T_f$	Duration of S-IB guidance freeze [sec]	
$\Delta T_N$	Nominal value of $\Delta T$ [sec]	
$\Delta T_{N1}$	Nominal $\Delta T$ from $T_0 + 0.0$ until $T_1 + 0.0$ [sec]	
$\Delta T_{N2}$	Nominal $\Delta T$ from $T_1 + 0.0$ until $T_3 + T_{3IGM}$ [sec]	
$\Delta T_{N3}$	Nominal $\Delta T$ from $T_3 + T_{3IGM}$ until $T_4 - \epsilon_2$ [sec]	
$\Delta T_{N4}$	Nominal $\Delta T$ from $T_4 - \epsilon_2$ to $T_4 - T_{HSL}$ [sec]	
$\Delta T_{N5}$	Nominal $\Delta T$ from $T_4 + 0.0$ until $T_4 + BN_5$ [sec]	
$\Delta T_{N6}$	Nominal $\Delta T$ from $T_4 + BN_5$ to EOM [sec]	
$\Delta T'_3$	IGM time-to-go correction term based on vehicle performance during the past BML [sec]	*
$\Delta V$	Actual change in velocity in S-system [pulses]	

TABLE 15-2 DEFINITIONS (CONTINUED)

<u>Symbol</u>	<u>Definition and Comments</u>
$\overline{\Delta V}$	Velocity-to-be-gained vector [m/sec]
$\overline{\Delta V}'$	Approximation for $\overline{\Delta V}$ [m/sec]
$\Delta V_b$	Velocity bias to allow for engine thrust decay after cutoff [m/sec]
$\Delta V_{cx}$	Change in velocity along $X_S$ from velocity counter [m/sec]
$\Delta V_{cy}$	Change in velocity along $Y_S$ from velocity counter [m/sec]
$\Delta V_{cz}$	Change in velocity along $Z_S$ from velocity counter [m/sec]
$\Delta V_f$	Expected change in velocity in the S-coordinate system [pulses]
$\Delta V_{fx}$	Expected change in velocity along $X_S$ due to thrust [pulses]
$\Delta V_{fy}$	Expected change in velocity along $Y_S$ due to thrust [pulses]
$\Delta V_{fz}$	Expected change in velocity along $Z_S$ due to thrust [pulses]
$\Delta V_{gx}$	Change in velocity along $X_S$ due to gravity [m/sec]



TABLE 15-2      DEFINITIONS (CONTINUED)

<u>Symbol</u>	<u>Definition and Comments</u>	
$\Delta V_{gy}$	Change in velocity along $Y_S$ due to gravity [m/sec]	
$\Delta V_{gz}$	Change in velocity along $Z_S$ due to gravity [m/sec]	
$\overline{\Delta V}_{SAV}$	Vector symbol for the low order bits of the computed velocity change during the past orbital navigation pass, saved to reduce truncation error [m/sec]	
$\Delta V_x$	Change in velocity along $X_S$ [pulses]	*
$\Delta V_y$	Change in velocity along $Y_S$ [pulses]	*
$\Delta V_z$	Change in velocity along $Z_S$ [pulses]	*
$\Delta X$	Attitude error about roll gimbal axis [pirads]	
$\Delta X_{mf}$	Change in $X_S$ in $\Delta T$ seconds due to thrust [m]	
$\Delta X_{Sg}$	Change in radius vector along $X_S$ axis due to gravitational acceleration [m]	
$\Delta X_V$	Component of $\overline{\Delta R}$ along $X_V$ axis [m]	
$\dot{\Delta X}_V$	Component of $\overline{\Delta V}$ along $X_V$ axis [m/sec]	
$\dot{\Delta X}'_V$	Component of $\overline{\Delta V}'$ along $X_V$ axis [m/sec]	
$\Delta Y$	Attitude error about pitch gimbal axis [pirads]	

TABLE 15-2 DEFINITIONS (CONTINUED)

<u>Symbol</u>	<u>Definition and Comments</u>	
$\Delta Y_{mf}$	Change in $Y_S$ in $\Delta T$ seconds due to thrust [m]	
$\Delta Y_{Sg}$	Change in radius vector along $Y_S$ axis due to gravitational acceleration [m]	
$\Delta Y_V$	Component of $\overline{\Delta R}$ along $Y_V$ axis [m]	
$\Delta \dot{Y}_V$	Component of $\overline{\Delta V}$ along $Y_V$ axis [m/sec]	
$\Delta \dot{Y}'_V$	Component of $\overline{\Delta V'}$ along $Y_V$ axis [m/sec]	
$\Delta Z$	Attitude error about yaw gimbal axis [pirads]	*
$\Delta Z_{mf}$	Change in $Z_S$ in $\Delta T$ seconds due to thrust [m]	
$\Delta Z_{Sg}$	Change in radius vector along $Z_S$ axis due to gravitational acceleration [m]	
$\Delta Z_V$	Component of $\overline{\Delta R}$ along $Z_V$ axis [m]	
$\Delta \dot{Z}_V$	Component of $\overline{\Delta V}$ along $Z_V$ axis [m/sec]	
$\Delta \dot{Z}'_V$	Component of $\overline{\Delta V'}$ along $Z_V$ axis [m/sec]	*
$\Delta \theta_{xe}$	Expected change in $\theta_x$ [pirads]	
$\Delta \theta_{ye}$	Expected change in $\theta_y$ [pirads]	
$\Delta \theta_{ze}$	Expected change in $\theta_z$ [pirads]	

TABLE 15-2 DEFINITIONS (CONTINUED)

<u>Symbol</u>	<u>Definition and Comments</u>	
		*
$\Delta\chi'_x$	Computed $\chi_x$ guidance command increment for minor loop [pirads]	
		*
$\Delta\chi'_y$	Computed $\chi_y$ guidance command increment for minor loop [pirads]	
		*
$\Delta\chi'_z$	Computed $\chi_z$ guidance command increment for minor loop [pirads]	
<u>EPSILON</u>		
$\epsilon_2$	Time prior to S-IVB cutoff to begin $\tilde{\chi}$ -steering [sec] (see note 1)	
<u>THETA</u>		
$\theta_R$	Total angular rotation of earth since GRR [pirads]	*
$\theta_T$	Desired terminal flight path angle [pirads]	

TABLE 15-2 DEFINITIONS (CONTINUED)

<u>Symbol</u>	<u>Definition and Comments</u>
$\theta_x$	Platform gimbal angle about $X_p$ axis [pirads]
$\theta'_x$	Value of $\theta_x$ used in minor loop [pirads]
$\theta_{xa}$	Average value of $\theta_x$ during next major loop pass [pirads]
$\theta_{xac}$	Average value of $\theta_x$ during the past major loop pass, * used in backup acceleration computations [pirads] *
$\theta_{xe}$	Expected value of $\theta_x$ [pirads]
$\dot{\theta}_{xe}$	Expected rate of change of $\theta_x$ [pirads/sec]
$\theta_{xp}$	Value of $\theta_x$ in the past BML, used in the $\theta_{xac}$ * computations [pirads] *
$\theta_y$	Platform gimbal angle about $Y_p$ axis [pirads]
$\theta'_y$	Value of $\theta_y$ used in minor loop [pirads]
$\theta_{ya}$	Average value $\theta_y$ during next major loop pass [pirads]
$\theta_{yac}$	Average value of $\theta_y$ during the past major loop pass, * used in backup acceleration computations [pirads] *
$\theta_{ye}$	Expected value of $\theta_y$ [pirads]
$\dot{\theta}_{ye}$	Expected rate of change of $\theta_y$ [pirads/sec]
$\theta_{yp}$	Value of $\theta_y$ in the past BML, used in the $\theta_{yac}$ * computations [pirads] *
$\theta_z$	Platform gimbal angle about $Z_p$ axis [pirads]
$\theta'_z$	Value of $\theta_z$ used in minor loop [pirads]



TABLE 15-2 DEFINITIONS (CONTINUED)

<u>Symbol</u>	<u>Definition and Comments</u>	
$\theta_{za}$	Average value of $\theta_z$ during next major loop pass [pirads]	
$\theta_{zac}$	Average value of $\theta_z$ during the past major loop pass, used in the backup acceleration computations [pirads]	* * *
$\theta_{ze}$	Expected value of $\theta_z$ [pirads]	
$\dot{\theta}_{ze}$	Expected rate of change of $\theta_z$ [pirads/sec]	
$\theta_{zp}$	Value of $\theta_z$ in the past BML, used in the $\theta_{zac}$ computations [pirads]	* *

LAMBDA

$\lambda$	Angle from launch meridian to the descending node of the desired orbit computed as a function of $\lambda_0$ , $\dot{\lambda}$ , and $T_D$
$\lambda_0$	Value of $\lambda$ valid for a GRR time of $T_{GRR0}$ [pirads]
$\dot{\lambda}$	Time rate of change of $\lambda_0$ [pirads/sec]

MU

$\mu$	Product of the universal gravitational constant and the mass of the earth [ $m^3/sec^2$ ]
-------	--

PI

$\pi$	3.14159265
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$$\chi_{XSI} = \text{Arctan} \left[ \frac{\sin \chi_R'}{\cos \chi_R'} \right] + \beta_{usun} \quad (206.11)$$

#### 1.2.1.5 Definitions

The following definitions are unique to the M415 experiment:

<u>Symbol</u>	<u>Definition and Comments</u>
$\overline{u}_{M415}$	Unit vector perpendicular to the $X_B$ axis and located midway between the M415 experiment panels
$\overline{u}_{sun}$	Unit vector parallel to earth-sun line and positive toward the sun
$\overline{u}_{sung}$	Unit solar vector in the Gravitational Coordinate System
$\overline{u}_{XB}$	Unit vector perpendicular to $\overline{u}_{sun}$ and lying in the orbital plane
$\overline{u}_{Y4}$	Unit vector parallel to the $Y_4$ axis transformed to the S-system
$X_{sun}$	Component of $\overline{u}_{sun}$ along $X_S$ axis
$X_{XB}$	Component of $\overline{u}_{XB}$ along $X_S$ axis
$Y_{sun}$	Component of $\overline{u}_{sun}$ along $Y_S$ axis
$Y_{XB}$	Component of $\overline{u}_{XB}$ along $Y_S$ axis



<u>Symbol</u>	<u>Definition and Comments</u>	
$z_{XB}$	Component of $\overline{u_{XB}}$ along $Z_S$ axis	
$z_{sun}$	Component of $\overline{u_{sun}}$ along $Z_S$ axis	
$\alpha_{sun}$	Angle between the launch meridian and the projection of the earth-sun line onto the equatorial plane, positive in an eastward direction from the launch meridian [pirads]	
$\beta_{usun}$	Angle between the $+Z_B$ axis and the $\overline{u_{M415}}$ vector [pirads]	*
$\lambda_L$	Longitude of launch meridian, positive east of the Greenwich Meridian [pirads]	
$\phi_{sun}$	Angle between the earth-sun line and the equatorial plane, positive when the sun vector is above the equatorial plane [pirads]	
$\chi_R'$	Intermediate roll gimbal angle used in M415 experiment attitude calculation [pirads]	
$\chi_{XSI}$	Roll guidance command required for the maneuver to solar inertial attitude [pirads]	
$\chi_{YSI}$	Pitch guidance command required for the maneuver to solar inertial attitude [pirads]	
$\chi_{ZSI}$	Yaw guidance command required for the maneuver to solar inertial attitude [pirads]	

TABLE 1-1 EVENT SEQUENCE TIMELINE (CONTINUED)

Time Reference	EDD Symbol	Presettings (Seconds)	Source Code	Events
T0	None	0		Set the backup gimbal angle RTC (MLKRC1) to 18.5 deg for first use in all channels. Set the backup gimbal angle RTC after first use to 0.6 deg per minor loop in pitch and yaw (MLKRC3) and 0.6 deg per minor loop in roll (MLKRC5).
T0	None	17.4 (-0,+40 ms)	D1	Start checking DI24 (Liftoff "A") and DI7 (Liftoff "B") for purpose of setting Time Base 1. These discretes must be checked before and after every minor loop (twice every 40 ms).
T0	BU3	150.0	D1	Enter a one instruction non-interruptible loop, preventing TB1 initiation, if lift-off (DI7 or DI24) has not been detected.
T0	TM	497.0	D1	Activate ECS Water Valve logic. The variable TM is incremented by 300 sec each time the logic is exercised.
T0	NUPTIM	Variable	E	Update position and velocity components via Navigation Update DCS command. This is a transmitted parameter and has meaning only if that command has been received and accepted.
T0	<sup>T</sup> TMA1- <sup>T</sup> TMA4	Variable	C4	Times to change thrust misalignment segments in accelerometer backup computations, given by the variable data tape.

\*  
\*  
\*

TABLE 1-1 EVENT SEQUENCE TIMELINE (CONTINUED)

Time Reference	EDD Symbol	Presettings (Seconds)	Source Code	Events
T1	None	0		<p>Initialize backup thrust, mass and mass flow rate to <math>F_1</math>, <math>M_1</math>, and <math>\dot{M}_1</math>, and start computing <math>(F/M)_c</math>.</p> <p>Stop looking for Liftoff Discretes, DI24 and DI7.</p> <p>Set <math>T_{EVNT} = T1</math> and compute <math>\Delta T'_E</math></p> <p>Start using <math>\Delta T_{N2}</math>.</p> <p>Set <math>BIAS = BIAS1</math></p> <p>Set <math>M'_{c1} = M_1</math></p>
T1	$T_{S1EO}$	3.0	D3	<p>Start computing acceleration (F/M) based on measured velocities, using the first guess <math>FM0</math> initialized at <math>T0+0</math>.</p> <p>Start checking DI14 and DI15 for S-IB engine out indications. If either discrete is detected, the <math>\sin(6^\circ)</math> will be used to compute <math>A_{c0}</math>, time tilt guidance will be modified, the backup accelerometer parameters will be modified, bit 18 of Mode Code 24 will be set, and either bit 8 (for DI15) or bit 9 (for DI14) of Mode Code 25 will be set.</p>
T1	$T_{f1}$	3.0	C3	<p>Change from first to second segment freeze time function for S-IB engine out.</p>

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TABLE 1-1 EVENT SEQUENCE TIMELINE (CONTINUED)

Time Reference	EDD Symbol	Presettings (Seconds)	Source Code	Events	
T1	T <sub>RTC</sub>	10.0	D3	Set the accelerometer RTCs to 6 m/sec <sup>2</sup> downrange (Z), vertical (X), and cross-range (Y). Begin computing performance factor (PF).	
T1	T <sub>f2</sub>	39.8	C3	End of second segment of engine failure freeze time function. (This is the latest time that an engine failure will result in a chi freeze.)	*
T1	T <sub>far</sub>	109.8	C3	Change from first segment to second segment of tilt arrest time bias function. Tilt arrest time will not be decreased for engine failures after this time.	*
T1	None	129.5	D1	Enable INT2 (S-IB Low Level Sensors Dry "A") and INT6 (S-IB Low Level Sensors Dry "B") for initiation of Time Base 2. This is keyed to the "Propellant Level Sensors Enable" switch selector command. If either signal is recognized after this time and downrange velocity is greater than or equal to 500 m/sec (bypass when GRF has occurred), Time Base 2 must be set.	*
T1	NTSTB2	134.5	D1	Nominal start time for Time Base 2 used in repeatable flight simulation.	*



TABLE 1-1 EVENT SEQUENCE TIMELINE (CONTINUED)

Time Reference	EDD Symbol	Presettings (Seconds)	Source Code	Events	
$T_c$	TMEFRZ	0	C3	End $\chi_y$ freeze following an S-IB engine out. TMEFRZ is recalculated at the engine out time $T_{EO}$ .	
$T_c$	$T_{S0}$	10.3	C3	Backup time for starting pitch and roll guidance (Guidance will nominally be started at tower clearance.)	
$T_c$	$T_{T2}$	30.0	C4	Earliest time for chi freeze initiation if an S-IB engine failure occurs.	
$T_c$	$T_{S1}$	47.8	C3	Begin using second segment Time Tilt (Pitch program) coefficients.	*
$T_c$	$T_{S2}$	89.8	C3	Begin using third segment Time Tilt (Pitch program) coefficients.	*
$T_c$	$T_{ar}$	131.05	C3	Nominal time to stop Time Tilt (Tilt Arrest). (This time can be extended by an S-IB engine out.)	
$T_c$	TYAW01	255.0	C3	Begin yaw guidance.	*
<p>Note: <math>T_c = T_{as} - T_l + T_d</math>, where <math>T_d</math> is the implementation delay. This causes the segment changes to be introduced into vehicle dynamics at the specified presetting times, referenced to Time Base 1 start.</p>					

TABLE 1-1 EVENT SEQUENCE TIMELINE (CONTINUED)

Time Reference	EDD Symbol	Presettings (Seconds)	Source Code	Events
T2	None	0		Inhibit INT2 and INT6 (S-IB Low Level Sense signals). If DI15 has not been previously detected, continue checking for it until detected. Do not modify accelerometer Zero test if DI15 is detected during Time Base 2.  Continue checking for DI14. Do not modify accelerometer backups if DI14 is detected during Time Base 2.
T2		2.9		Set vertical and downrange (X&Z) accelerometer RTCs to 50 m/sec <sup>2</sup> ; and leave the crossrange (Y) RTC unchanged at 6 m/sec <sup>2</sup> .  Disable accelerometer zero test.
T2	T2 <sub>IECO</sub>	3.0	D1	Stop computing acceleration, F/M, and set it to the preset constant FM2. (This is keyed to the inboard engines cutoff switch selector.)  Set $T_{EVNT} = T2_{IECO}$ , compute $\Delta T'_E$ and set $BIAS = BIAS2$ .  Adjust the S-IB accelerometer backup parameter $F_{EO}$ to 0.5.
T2	None	4.5	D1	Start checking for S-IB outboard engines cutoff signals (INT5 and DI23), initiated at propellant depletion cutoff, for the purpose of setting Time Base 3. (This is keyed to the LOX Depletion Cutoff Enable switch selector.)
T2	NTSTB3	6.0	D1	Nominal start time for Time Base 3 used in repeatable flight simulation.
T2	BU4	13.0	D1	Start Time Base 3 if not started previously.

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TABLE 1-1 EVENT SEQUENCE TIMELINE (CONTINUED)

Time Reference	EDD Symbol	Presettings (Seconds)	Source Code	Events
T3	None	0		<p>Reinitialize first guess at acceleration (F/M), to FM4.</p> <p>Reinitialize backup mass, mass flow rate and thrust to M<sub>2</sub>, zero and F<sub>2I</sub>, respectively, and begin using these values to compute backup acceleration (F/M)<sub>c</sub>.</p> <p>End Time Tilt guidance if tilt arrest has not already occurred.</p> <p>Stop checking DI14 and DI15 for S-IB engine failures. If either discrete was detected earlier, the checking of the recognized discrete stopped at that time.</p> <p>Resume using sin (2°) to compute A<sub>c0</sub> and reset bit 18 of Mode Code 24, if set.</p> <p>Stop checking DI23 and inhibit INT5 (S-IB Cutoff signals).</p> <p>Begin the X attitude error test using <math>\alpha_{ACTX} = 10.0</math> degrees.</p> <p>Set F<sub>E0</sub>=1, PF=1, PF<sub>0</sub>=1, PF<sub>1</sub>=1, BIAS=BIAS3, T<sub>EVNT</sub>=T3; compute <math>\Delta T'_E</math>, and stop computing the performance factor.</p> <p>Set M'<sub>c1</sub> = M<sub>2</sub>.</p> <p>Set B<sub>X01</sub> to zero and set B<sub>Z01</sub> to the preset value from the variable data tape.</p>

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TABLE 1-1 EVENT SEQUENCE TIMELINE (CONTINUED)

Time Reference	EDD Symbol	Presettings (Seconds)	Source Code	Events	
T3	None	0		Change the roll ladder magnitude limit (MSK16) to 3.5 degrees. Pitch and yaw limits remain unchanged.	*
T3	$T3_{FMC}$	6.08	C3	Start using mass flow rate, $\dot{M}_2$ , and backup thrust, $F_2$ , in computing backup acceleration, $(F/\dot{M})$ . (This is the predicted time of S-IVB 90% thrust.)	*
				Enable the accelerometer zero test and decrease vertical and downrange accelerometer RTCs to 6 m/sec <sup>2</sup> .	*
				Set $BIAS = BIAS_4$ , $T_{EVNT} = T3 + T3_{FMC}$ , and compute $\Delta T'_E$	*
T3	$T3_{FM}$	6.08	C3	Resume computing acceleration, $(F/\dot{M})$ , using first guess, $FM_4$ , initialized at $T3+0$ .	
				Start computing smoothed reciprocal acceleration, $(M/F)_S$ , using first guess, $(M/F)_0$ , initialized at $T0+0$ .	
T3	$T3_{FMC} + \Delta T_{N2}$	7.09	C3	Begin computing performance factor.	*
T3	S4IGTM	10.0	D1	Release inhibit on Time Base 4 and start checking for cutoff conditions. Flight Program response to INT4 is inhibited before this time. Start checking DI5. (After this time, the presence of any two of the four S-IVB cutoff indications will initiate Time Base 4.)	
T3	$T3_{IGM}$	35.0	C3	Start IGM.	*
				Start using $\Delta T_{N3}$ .	



TABLE 1-1 EVENT SEQUENCE TIMELINE (CONTINUED)

Time Reference	EDD Symbol	Presettings (Seconds)	Source Code	Events
T3	T <sub>SMC</sub>	59.3	C3	Enable SMC calculations
T3	T <sub>3PU</sub>	328.1	D1	Save the values of $\dot{M}$ , $F_{E0}$ , PF, and $F_b$ and store these values as $\dot{M}'$ , $F'_{E0}$ , PF', and $F'_b$ . Start using mass flow rate, $\dot{M}_3$ , and backup thrust, $F_3$ , in computation of backup acceleration, $(F/M)_c$ . Set $T_{EVNT} = T_{3PU}$ , compute $\Delta T'_E$ , and set $BIAS = BIAS5$ . (This event is keyed to the "Mixture Ratio Control Valve Open" switch selector command.)
T <sub>1i</sub>	None	0.0	C3	Start computing artificial $\tau_3$ and decrementing $T_{3i}$ . Set $T_{1i} = 0$ . Stop computing $\tau_1$ and $T_{1i}$ .
T <sub>1i</sub>	P <sub>C</sub>	0.0	C3	Start using $\tau_3$ computed from $(M/F)_S$ (end artificial $\tau_3$ guidance). This event must occur when P <sub>C</sub> , initially zero and recomputed on each BML after T <sub>1i</sub> becomes zero, exceeds the presetting P <sub>CMR</sub> .
IGM Time-to-go	$\epsilon_2$	25.0	D2	Start $\tilde{X}$ terminal steering guidance mode. Start using $\Delta T_{N4}$ .
IGM Time-to-go	BN <sub>1</sub>	14.4	B	Start building velocity history for S-IVB cutoff.

TABLE 1-1 EVENT SEQUENCE TIMELINE (CONTINUED)

Time Reference	EDD Symbol	Presettings (Seconds)	Source Code	Events
IGM Time-to- go	$T_{HSL} + \Delta T_b$	$5.0 + \Delta T_b$	D2	<p>Enter IGM high speed cutoff loop when the velocity-to-be-gained is less than a velocity guard, <math>V_{GRD}</math>. (If guidance reference failure has occurred, do not enter the high speed cutoff loop. If GRF occurs after entering, continue until cutoff.)</p> <p>Stop computing IGM guidance commands.</p> <p>Inhibit SMC calculations.</p> <p>Set up S-IVB Engine Cutoff On switch selector.</p>

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TABLE 1-1 EVENT SEQUENCE TIMELINE (CONTINUED)

Time Reference	EDD Symbol	Presettings (Seconds)	Source Code	Events
T4	None	0		<p>Set acceleration, (F/M), to zero.</p> <p>Increase vertical and downrange accelerometer RTCs to 50 m/sec<sup>2</sup> (crossrange RTC unchanged at 6 m/sec<sup>2</sup>).</p> <p>Disable accelerometer zero test. Set ladder magnitude limit to 2.5 degrees in pitch and yaw (MSK6). Roll remains unchanged.</p> <p>Set backup thrust and mass flow rate to zero.</p> <p>Reset the command decoder and the DCS error counter, reset INT8, and release inhibit on INT8.</p> <p>Enable the following DCS commands: Time Base Update, Generalized Switch Selector, Execute Generalized Maneuver, Return to Nominal Timeline, Terminate, Inhibit Water Control Valve Logic, Ladder Magnitude Limit, and S-IVB/IU De-orbit.</p> <p>Stop checking for S-IVB cutoff. (Disable INT4 and DI5.)</p> <p>Begin the Z attitude test using <math>\alpha_{ACTZ} = 48.0</math> degrees and change <math>\alpha_{ACTX} = 90.0</math> deg.</p> <p>Start using <math>\Delta T_{N5}</math>.</p> <p>Change the zero gimbal test constant, ML6HUN, to 1.4 deg.</p>

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TABLE 1-1 EVENT SEQUENCE TIMELINE (CONTINUED)

Time Reference	EDD Symbol	Presettings (Seconds)	Source Code	Events	
T5	None	0		Reset bit 7 of MC27. Inhibit the Time Base Update, Execute Generalized Maneuver, Return to Nominal Timeline, Ladder Magnitude Limit and S-IVB/IU De-orbit DCS commands. Disable the loss of APS Attitude Control test. Force a telemetry station loss and disable telemetry acquisition and loss calculations. Set the pitch and yaw ladder magnitude limit (MSK6) to 15.3 deg Reset the platform measured velocity components, $\dot{X}_m$ , $\dot{Y}_m$ and $\dot{Z}_m$ , to zero. Start monitoring velocity increments ( $\Delta V$ ).	*
T5+T <sub>SS</sub>	None	1.0	D1	Set the pitch and yaw Ladder Magnitude limit (MSK6) to 2.5 deg.	*
T5+T <sub>SS</sub>	None	2905.0	D1	Enable the Execute Generalized Maneuver DCS command.	*



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## 1.5 PRESETTINGS

Table 1-3 establishes the presettings to be used in the flight program. Program sequencing presettings are excluded since they are established in Section 1.3. For each presetting, the table gives:

- The symbol
- The required value and associated units
- The definition
- A source code.

Notice that the units of mass, force and angle presettings are not the same as those specified to be used in the flight program in Section 15 of Part I. The units used in the following table are consistent with those in other Apollo documentation while those in the flight program are dictated by programming constraints. For flight program implementation, all values given in degrees must be converted to pirads by dividing by 180. The forces, given in newtons, and masses, given in kilograms, must be converted to kilograms and  $\text{kg-sec}^2/\text{m}$ , respectively, by dividing each quantity by  $9.80665 \text{ m/sec}^2$ .

The source codes are inserted for information only and are not flight program requirements. The codes denote:

- A1 Constants established by the baseline requirements (mission-independent)
- A2 Launch pad dependent constants

- B Constants established by IBM
- C2 Constants established by the orbital  
timeline
- C3 Constants established by normal boost  
guidance requirements
- C4 Constants established by alternate  
mission requirements
- D2 Constants established by vehicle dynamics  
requirements
- D3 Constants established by other program  
requirements.

TABLE 1-4 SWITCH SELECTOR SEQUENCING (CONTINUED)

ICD/IRN	COMMAND	SWITCH SELECTOR			TIME FROM BASE 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 or Spacecraft initiated S-IVB 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  $T5 + T_{LDD} + 33.9$ . This is a Class 4 alternate switch selector sequence.

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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  $T_5 + T_{LDD} + T_{HDD} + 63.9$ . This is a Class 4 alternate switch selector sequence.

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## 1.9 VARIABLE DATA TAPE DATA

Table 1-6 establishes the Variable Data Tape Data which must be assembled in the SA-206 flight program. The values presently assigned to the listed items are for checkout purposes only. This table provides the LVDC address, symbolic name, decimal value, and scaling factor for each of the Variable Data Tape data items. \*

Table 1-7 establishes the data that is required and must be contained on the Variable Data Tape. \*



TABLE 1-6 VARIABLE DATA TAPE DATA

Address	Name	Decimal Value/Scaling	
016300	TDAY	1.200000D 02	10
016301	BXO	-4.100000D-01	0
016302	BYO	0.0	0
016303	BZO	-1.730000D-01	0
016304	PBX	0.0	1
016305	PBY	0.0	1
016306	PBZ	0.0	1
016307	TTMA1	0.0	15
016310	TTMA2	1.880000D 02	15
016311	TTMA3	1.900000D 02	15
016312	TTMA4	5.970000D 02	15
016313	CA1	9.999999D-01	0
016314	CA2	9.999999D-01	0
016315	CA3	9.999930D-01	0
016316	CA4	9.999770D-01	0
016317	SACB1	0.0	0
016320	SACB2	0.0	0
016321	SACB3	-3.835000D-03	0
016322	SACB4	-6.856000D-03	0
016323	SASB1	0.0	0
016324	SASB2	0.0	0
016325	SASB3	1.54000D-04	0
016326	SASB4	1.96000D-04	0
016327	CKSMIB		

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TABLE 1-7 DATA REQUIRED ON VARIABLE DATA TAPE

Address/Octal Value	Name	Decimal Value/Scaling	
016300 036000000	TDAY	1.200000D 02	10
016301 627024364	BX0	-4.100000D-01	0
016302 000000000	BY0	0.0	0
016303 723554426	BZ0	-1.730000D-01	0
016304 000000000	PBX	0.0	1
016305 000000000	PBY	0.0	1
016306 000000000	PBZ	0.0	1
016307 001360000	TTMA1	1.880000D 02	15
016310 002244000	TTMA2	2.970000D 02	15
016311 003320000	TTMA3	4.360000D 02	15
016312 003754000	TTMA4	5.070000D 02	15
016313 377776644	CA1	9.999910D-01	0
016314 377776166	CA2	9.999865D-01	0
016315 377775510	CA3	9.999820D-01	0
016316 377775072	CA4	9.999780D-01	0
016317 776724202	SACB1	-4.240000D-03	0
016320 776532266	SACB2	-5.170000D-03	0
016321 776362636	SACB3	-5.960000D-03	0
016322 776250062	SACB4	-6.530000D-03	0
016323 000024552	SASB1	1.58000D-04	0
016324 000026220	SASB2	1.70000D-04	0
016325 000027770	SASB3	1.83000D-04	0
016326 000031230	SASB4	1.93000D-04	0
016327 434146562	CKSMIB		

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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).

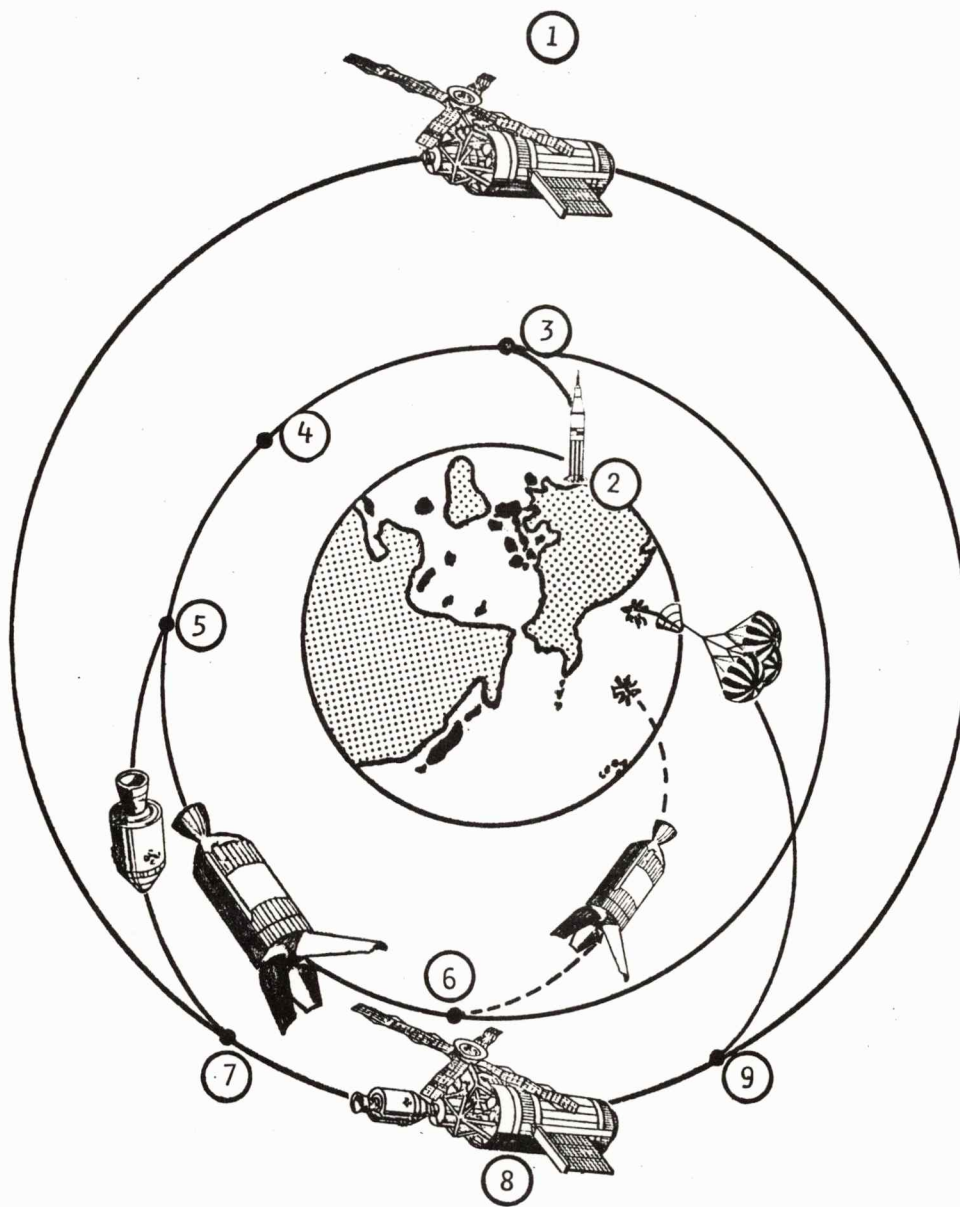


FIGURE 2-1 NOMINAL SA-207/SL-3 MISSION PROFILE.



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. After approximately four orbits the S-IVB/IU will be turned to a retrograde attitude and the residual S-IVB propellants will be dumped through the engine, causing the S-IVB/IU to deorbit into the Pacific.
7. The CSM will rendezvous and dock with the workshop.
8. The crew will transfer from the CSM and activate the workshop. The crew will stay with the workshop for up to 56 days.
9. 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 recovery.

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

This section contains any SA-207/SL-3 Flight Program requirements which require logic changes from the baseline requirements. As presently defined, the only SA-207 program logic requirements, which are different from those presented in Part I, are to delete the compressed data dump as a function of the acquisition and loss calculation and implement the Compressed Data Dump DCS command. The implementation of these changes is detailed in the following Sections and Tables. These Sections and Tables must replace the corresponding Sections 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).

### 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 for  $R_{STA}$  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.

#### 5.6.2 Acquisition and Loss Sequence

The capability to start an alternate Class 4 switch selector sequence (see Section 9.4.5) when the vehicle goes from a dark period into acquisition of at least one telemetry station must be provided. If more than one station is acquired without a loss between stations, only one acquisition sequence will be issued.

#### 5.6.3 Telemetry Dumps

(This Section must be deleted.)

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	0.37533	-0.46339	0.80275
5	Ascension	Calibrate	0.39895	0.13748	0.90661
6	Madrid	Calibrate	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



### 10.3.1 DCS Mode Command Verification

When a mode command is received, the following tests must be conducted, in the order listed, before the command will be accepted.

1. True-complement test: The 14 information bits transferred from the command decoder to the LVDC accumulator contain redundant information. LVDC bits 5 through 6 represent the command in true form. LVDC bits 7 through 13 must be the 1's complement of bits 5-6. If they are not, the command must not be accepted and DCS error code 10 must be issued.
2. Sequence bit test: LVDC bit 6 is designated as the sequence bit. This bit must be 0 for DCS mode commands. If this bit is 1, the command must not be accepted and DCS error code 24 must be issued.
3. Terminate command test: If the DCS mode command is the terminate command, then the mode expected test, DCS in progress test, mission acceptance test, and time acceptance test are omitted. The terminate command must be accepted whenever any other DCS command is acceptable.
4. Mode expected test: If a DCS mode command is received when a data command is required to complete the requirements of a previous mode command, the mode command must be rejected and DCS error code 20 must be telemetered.
5. DCS in progress test: If another DCS routine is presently being processed (e.g., performing a



memory dump or a compressed data dump), then the present mode command must not be accepted and DCS error code 64 must be issued.

6. Mission acceptance test: If the DCS mode command is not defined for this mission, it must not be accepted and DCS error code 14 must be issued.
7. Time acceptance test: If the DCS mode command is not acceptable at the time it is received, it must be rejected and DCS error code 74 must be issued. It should be noted that if a mode command is received during a period when the mode is valid and the related data words are received outside this period, the command may be erroneously accepted.

If all these conditions are satisfied, the flight program must: issue Discrete Output 1 (D01), which generates a Computer Reset Pulse (CRP); telemeter the proper mode status word twice; either prepare to receive DCS data commands or perform the commanded function, if no data is required; and reset D01. The format for the mode status word is defined in Table 10-2.

TABLE 10-2 MODE STATUS WORD FORMAT

LVDC Bit Position	S-5	6-25 (Octal)
Data	DCS mode command information bits 14-9	0000000

If any test fails, the program must telemeter the appropriate DCS error message twice, monitor the number of consecutive verification failures, and ignore the mode command. A CRP must not be issued. The absence of the CRP indicates to the ground station that the command is not accepted by the program. If seven consecutive verification failures occur, an automatic program initiated terminate must be performed, as defined in Section 10.4.5.

#### 10.4 DCS COMMANDS

The flight program must accept and process the following DCS commands:

- Time base update
- Navigation update
- Generalized switch selector
- Memory dump
- Terminate
- ECS water control valve logic inhibit
- Execute generalized maneuver
- Return to nominal timeline
- Execute alternate sequence
- Execute special maneuvers
- Targeting load
- Ladder magnitude limit
- S-IVB/IU de-orbit
- Compressed data dump.

Table 10-6 lists the current DCS mode command assignments, the LVDC 14-bit position format, and the DCS data command requirements. Some of these DCS mode commands may not be required for every mission. The required DCS mode commands and their acceptance times for a particular mission, and any additional commands required for that mission only, will be defined in the Digital Command System commands table in the individual mission requirements, Part II.

TABLE 10-6 DCS MODE COMMANDS

Octal Rep. of LVDC Bit Position S-5	Binary Rep. of LVDC Bit Position		Definition (General)	Data Words Req'd.
	S-6	7-13		
10	0010000	1's complement of LVDC bits S-6	Time base update	1
11	0010010		Navigation update	35
12	0010100		Generalized switch selector	2
13	0010110		Memory dump	6
20	0100000		Terminate	0
21	0100010		Execute alternate sequence	5
32	0110100		Targeting load	45
33	0110110		Execute maneuver A	5
34	0111000		Execute maneuver B	5
35	0111010		Execute generalized maneuver	20
36	0111100		Return to nominal timeline	5
41	1000010		Ladder magnitude limit	1
43	1000110		Compressed data dump	0
44	1001000		S-IVB/IU de-orbit	6
45	1001010		Water control valve logic inhibit	0

#### 10.4.5 Terminate

This DCS command will cause the flight program to terminate the receipt of multiple word commands or terminate a memory dump in progress. Upon receipt of this command, the flight program must do the following:

- Terminate any multiple-word DCS commands prior to the receipt of the last valid data word
- Terminate any commands which have failed to be validated by the LVDC
- Terminate a memory dump prior to the telemetry of the last block of data
- Terminate a compressed data dump
- Return to the configuration required to accept a new mode command.

The terminate command will have no effect on the execution of a DCS routine whose data requirements have been met and validated, except for the memory dump routine. The terminate command must be enabled whenever the command decoder interrupt is enabled.

Under certain specified conditions, an automatic program initiated terminate must be performed. These specific conditions are detailed within each applicable DCS command description section. A program initiated terminate must provide all the functions of the DCS terminate command except early memory dump termination and early compressed data dump termination.



#### 10.4.14 Compressed Data Dump

This DCS command must provide the capability to dump the compressed data tables. No data words are required for this DCS command.

Upon acceptance of this DCS command the flight program must dump the compressed data tables in their entirety three times. Details of the compressed data tables and their telemetry are given in Section 11.5. Once a compressed data dump has been started only a terminate command will be accepted by the program until the dump is completed. Other mode commands received during a dump must be rejected and DCS error code 64 must be issued. Receipt of a terminate command any time before the dump is completed must stop the dump.

### 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 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 requirement 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 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 accurate to 1.1 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.

#### 11.5.3 Telemetry of Compressed Data

Although the compressed data must be telemetered when the compressed data dump DCS command is received, it has the lowest priority of all orbital functions. Real time telemetry and processing of interrupts will consume about 25 percent of the duty cycle. The remaining time can be devoted to telemetering compressed data. This will allow all compressed data tables (1650 items) to be telemetered once in about 36 seconds.

Table 11-7 shows the storage allocation requirements of each compressed data table. The duplex storage requirement defines the minimum size required for each table in order to contain at least the maximum specified number of samples.

The following ground rules apply to compressed data telemetry:

- The three low order bits of the mode register must be used to distinguish compressed data from other telemetry. The mode register setting for compressed data must be octal 3.

- Compressed data must only be dumped when the compressed data dump DCS command is received.
- Each table must be telemetered three times, unless the Terminate DCS command is received.
- Since it is possible that the compressed data dump will have to be terminated before all data is telemetered, the program must telemeter the compressed data in such a way as to ensure that each table is at least partially emptied. The first item in each table must be telemetered and the second in each table, etc, until each table has been telemetered once.
- After all the tables have been telemetered the first time a second and third telemetry of all tables must be performed in the same manner as the first telemetry.
- Each compressed data table must be telemetered with a different telemetry PIO tag. (The specific PIO tags are defined in the Telemetry Tags Table 11-8.)
- All items in any one table must be telemetered with the same telemetry PIO tag. In every case, one complete entry must be telemetered before the next is processed.
- A special code must be telemetered to indicate the start and end of each table. (The specific PIO codes are defined in the Telemetry Tags Table 11-8.)

TABLE 11-7 COMPRESSED DATA STORAGE REQUIREMENTS

Table	Locations per Sample	Maximum No. of Samples	Storage Require- ment (Duplex Locations)
2    Gimbal angles	8	59	472
3    Composite EMR word	2	101	202
4    Discrete in- puts, dis- crete out- puts, switch selectors, TLC, and MC24	2	---	512
5    Accelerome- ters	4	116	464
Total			1650

TABLE 11-8

## TELEMETRY TAGS

LVDC DATA							
Mod. Reg.	PIO Tag	PCM Tag	EDD Symbol	Description	Frequency (Segments)	Scal- ing	Units
2	530	4554	K <sub>3</sub>	Altitude correction in yaw guidance angle	C <sub>1</sub> (3-4)	1	rad
2	534	4556	K <sub>4</sub>	IGM yaw rate correction	C <sub>1</sub> (3-4)	-2	rad/sec
2	550	4564	X <sub>z4</sub>	Yaw guidance command in target plane system	C <sub>1</sub> (3-4)	0	pirads
2	554	4566	X <sub>y4</sub>	Pitch guidance command in target plane system	C <sub>1</sub> (3-4)	0	pirads
2	560	4570	SMCZ	Yaw steering misalignment cor- rection	C <sub>1</sub> (3-4)	0	pirads
2	564	4572	SMCY	Pitch steering misalignment correction	C <sub>1</sub> (3-4)	0	pirads
3	011	7404	N/A	Start of Compressed Data Table 2	Telem- etered as speci- fied in Section 11.5.3	N/A	N/A
3	014	6406	N/A	Start of Compressed Data Table 3		N/A	N/A
3	015	7406	N/A	Start of Compressed Data Table 4		N/A	N/A
3	020	6410	N/A	Start of Compressed Data Table 5		N/A	N/A
3	021	7410	N/A	End of Compressed Data Table 2		N/A	N/A
3	024	6412	N/A	End of Compressed Data Table 3		N/A	N/A
3	025	7412	N/A	End of Compressed Data Table 4		N/A	N/A
3	030	6414	N/A	End of Compressed Data Table 5		N/A	N/A

TABLE 11-8

## TELEMETRY TAGS

LVDC DATA							
Mod. Reg.	PIO Tag	PCM Tag	EDD Symbol	Description	Frequency (Segments)	Scal- ing	Units
3	041	7420	N/A	Compressed Data Table 4	Telem- etered as speci- fied in Section 11.5.3	N/A	N/A
3	404	6502	N/A	Compressed Data Table 2		N/A	N/A
3	410	6504	N/A	Compressed Data Table 5		N/A	N/A
3	414	6506	N/A	Compressed Data Table 3		N/A	N/A



### 2.3 EVENT SEQUENCING TIMELINE

The following table describes the requirements for flight program sequencing. For each timed event, the table gives:

- A definition of the event
- The time at which the event must occur
- The time base or other occurrence to which the event is referenced
- The name of the time presetting.

During boost mode, the events must occur at the times specified in the table with a minus zero, plus one boost major loop tolerance (unless a closer tolerance is defined). During orbital mode, the tolerance is minus zero, plus one second (unless a closer tolerance is defined). Events specified to occur at a time base plus zero ( $T_j+0$ ) must be performed after the essential functions of starting the time base, but before any other functions except switch selector functions and minor loops.

Events that are defined with different presetting names must not be initiated by common logic, even though the times of occurrence may be the same. Common logic may be used for all events that are specified with the same presetting name.

The table contains a source code that is not a program requirement. It indicates the source and character of certain pre-settings and is included for convenience only. The meanings of the source codes are:

- A1 Times established by the baseline requirements (mission-independent)
- B Times established by IBM
- C2 Times established by the orbital timeline
- C3 Times established by normal boost guidance requirements
- C4 Times established by alternate mission requirements
- D1 Times established by the Flight Sequence ICD
- D2 Times established by vehicle dynamics requirements
- D3 Times established by other program requirements
- E Times established by DCS transmitted data.

TABLE 2-1 EVENT SEQUENCE TIMELINE

Time Reference	EDD Symbol	Presettings (Seconds)	Source Code	Events
T0	None	0		<p>Initialize acceleration, (F/M), to FM0</p> <p>Set backup acceleration (F/M)<sub>c</sub>, to the negative of the computed value of <math>G_{Sx}</math>.</p> <p>Set the accelerometer RTCs to 3 m/sec<sup>2</sup> vertical (X), 2 m/sec<sup>2</sup> crossrange (Y) and downrange (Z).</p> <p>Initialize backup force, mass, and mass flow rate to <math>F_0</math>, <math>M_0</math>, and <math>\dot{M}_0</math> respectively.</p> <p>Enable accelerometer zero test, using <math>\sin(2^\circ)</math> to compute <math>A_{c0}</math>.</p> <p>Initialize all values of reciprocal acceleration to <math>(M/F)_0</math> for use in S-IVB stage IGM.</p> <p>Reset all interrupts.</p> <p>Release Inhibit on INT9, TLC Interrupt.</p> <p>Set the number of permissible unreasonable backup resolver readings (MS15DT) to 12 per 0.8 sec. The guidance reference failure discrettes (D04 and D06) will be set on detecting 13 unreasonable backup resolver readings in 0.8 sec.</p> <p>Set the zero gimbal test constant ML6HUN to 0.06 deg (all channels).</p> <p>Set MS25DT to <math>25 \cdot \Delta T_{N1}</math>.</p> <p>Set <math>F_{E0}</math> equal to 1; initialize the 3 values of the performance factor to .93 (PF, PF<sub>1</sub> and PF<sub>0</sub>.)</p>

TABLE 2-1 EVENT SEQUENCE TIMELINE (CONTINUED)

Time Reference	EDD Symbol	Presettings (Seconds)	Source Code	Events
T0	None	0		<p>Set MS04DT to <math>0.04/\Delta T_{N1}</math>.</p> <p>Start performing tests for guidance reference failure. If that condition is detected, set D04 and D06 and the appropriate mode code bits. These tests must be performed during all phases of flight.</p> <p>Set ladder rate limits (MSK5) to 0.48 deg per minor loop, all channels.</p> <p>Set ladder magnitude limits to 15.3 deg in pitch and yaw (MSK6) and roll (MSK16).</p> <p>Set attitude command (<math>\chi</math>) rate limits to 1.0 deg per sec. (MSLIM1=0.04 deg per minor loop in roll, MSLIM2=0.04 deg per minor loop in pitch and yaw.)</p> <p>Set the fine gimbal angle RTCs, (MLK2) and (MLK12) to 1.4 deg per minor loop in the pitch, yaw and roll channels for the initial reading only. After the initial reading, set the fine gimbal angle RTCs to 0.4 deg per minor loop in pitch and yaw (MLK2) and 0.4 deg per minor loop in roll (MLK12).</p> <p>Initialize <math>B_{X01}</math> to the preset value from the variable data tape and set <math>B_{Z01}</math> to zero.</p> <p>Initialize the parameters <math>C\alpha</math>, <math>S\alpha C\beta</math>, and <math>S\alpha S\beta</math> to 1,0,0 respectively.</p>



TABLE 2-1 EVENT SEQUENCE TIMELINE (CONTINUED)

Time Reference	EDD Symbol	Presettings (Seconds)	Source Code	Events
T0	None	0		Set the backup gimbal angle RTC (MLKRC1) to 18.5 deg for first use in all channels. Set the backup gimbal angle RTC after first use to 0.6 deg per minor loop in pitch and yaw (MLKRC3) and 0.6 deg per minor loop in roll (MLKRC5).
T0	None	17.4 (-0,+40 ms)	D1	Start checking DI24 (Liftoff "A") and DI7 (Liftoff "B") for purpose of setting Time Base 1. These discretes must be checked before and after every minor loop (twice every 40 ms).
T0	BU3	150.0	D1	Enter a one instruction non-interruptible loop, preventing TB1 initiation, if lift-off (DI7 or DI24) has not been detected.
T0	TM	497.0	D1	Activate ECS Water Valve logic. The variable TM is incremented by 300 sec each time the logic is exercised.
T0	NUPTIM	Variable	E	Update position and velocity components via Navigation Update DCS command. This is a transmitted parameter and has meaning only if that command has been received and accepted.
T0	<sup>T</sup> TMA1- <sup>T</sup> TMA4	Variable	C4	Times to change thrust misalignment segments in accelerometer backup computations, given by the variable data tape.



TABLE 2-1 EVENT SEQUENCE TIMELINE (CONTINUED)

Time Reference	EDD Symbol	Presettings (Seconds)	Source Code	Events
T1	None	0		<p>Initialize backup thrust, mass and mass flow rate to <math>F_1</math>, <math>M_1</math>, and <math>M_1</math>, and start computing <math>(F/M)_c</math>.</p> <p>Stop looking for Liftoff Discretes, DI24 and DI7.</p> <p>Set <math>T_{EVNT} = T1</math> and compute <math>\Delta T'_E</math></p> <p>Start using <math>\Delta T_{N2}</math>.</p> <p>Set <math>BIAS = BIAS1</math></p> <p>Set <math>M'_{c1} = M_1</math></p>
T1	$T_{S1EO}$	3.0	D3	<p>Start computing acceleration <math>(F/M)</math> based on measured velocities, using the first guess <math>FM0</math> initialized at <math>T0+0</math>.</p> <p>Start checking DI14 and DI15 for S-IB engine out indications. If either discrete is detected, the <math>\sin(6^\circ)</math> will be used to compute <math>A_{c0}</math>, time tilt guidance will be modified, the backup accelerometer parameters will be modified, bit 18 of Mode Code 24 will be set, and either bit 8 (for DI15) or bit 9 (for DI14) of Mode Code 25 will be set.</p>
T1	$T_{f1}$	3.0	C3	<p>Change from first to second segment freeze time function for S-IB engine out.</p>

TABLE 2-1 EVENT SEQUENCE TIMELINE (CONTINUED)

Time Reference	EDD Symbol	Presettings (Seconds)	Source Code	Events
T1	T <sub>RTC</sub>	10.0	D3	Set the accelerometer RTCs to 6 m/sec <sup>2</sup> downrange (Z), vertical (X), and cross-range (Y).  Begin computing performance factor (PF).
T1	T <sub>f2</sub>	39.8	C3	End of second segment of engine failure freeze time function. (This is the latest time that an engine failure will result in a chi freeze.)
T1	T <sub>far</sub>	109.8	C3	Change from first segment to second segment of tilt arrest time bias function. Tilt arrest time will not be decreased for engine failures after this time.
T1	None	129.5	D1	Enable INT2 (S-IB Low Level Sensors Dry "A") and INT6 (S-ID Low Level Sensors Dry "B") for initiation of Time Base 2. This is keyed to the "Propellant Level Sensors Enable" switch selector command. If either signal is recognized after this time and downrange velocity is greater than or equal to 500 m/sec (bypass when GRF has occurred), Time Base 2 must be set.
T1	NTSTB2	134.5	D1	Nominal start time for Time Base 2 used in repeatable flight simulation.

TABLE 2-1 EVENT SEQUENCE TIMELINE (CONTINUED)

Time Reference	EDD Symbol	Presettings (Seconds)	Source Code	Events
$T_c$	TMEFRZ	0	C3	End $\chi_y$ freeze following an S-IB engine out. $T_{MEFRZ}$ is recalculated at the engine out time $T_{EO}$ .
$T_c$	$T_{SO}$	10.3	C3	Backup time for starting pitch and roll guidance (Guidance will nominally be started at tower clearance.)
$T_c$	$T_{T2}$	30.0	C4	Earliest time for chi freeze initiation if an S-IB engine failure occurs.
$T_c$	$T_{S1}$	47.8	C3	Begin using second segment Time Tilt (Pitch program) coefficients.
$T_c$	$T_{S2}$	89.8	C3	Begin using third segment Time Tilt (Pitch program) coefficients.
$T_c$	$T_{ar}$	131.05	C3	Nominal time to stop Time Tilt (Tilt Arrest). (This time can be extended by an S-IB engine out.)
$T_c$	TYAW01	255.0	C3	Begin yaw guidance.
<p>Note: <math>T_c = T_{as} - T_1 + T_d</math>, where <math>T_d</math> is the implementation delay. This causes the segment changes to be introduced into vehicle dynamics at the specified presetting times, referenced to Time Base 1 start.</p>				

TABLE 2-1 EVENT SEQUENCE TIMELINE (CONTINUED)

Time Reference	EDD Symbol	Presettings (Seconds)	Source Code	Events
T2	None	0		Inhibit INT2 and INT6 (S-IB Low Level Sense signals). If DI15 has not been previously detected, continue checking for it until detected. Do not modify accelerometer Zero test if DI15 is detected during Time Base 2.  Continue checking for DI14. Do not modify accelerometer backups if DI14 is detected during Time Base 2.
T2		2.9		Set vertical and downrange (X&Z) accelerometer RTCs to $50 \text{ m/sec}^2$ ; and leave the crossrange (Y) RTC unchanged at $6 \text{ m/sec}^2$ .  Disable accelerometer zero test.
T2	T2 <sub>IECO</sub>	3.0	D1	Stop computing acceleration, F/M, and set it to the preset constant FM2. (This is keyed to the inboard engines cutoff switch selector.)  Set $T_{\text{EVENT}} = T2_{\text{IECO}}$ , compute $\Delta T'_E$ and set $\text{BIAS} = \text{BIAS2}$ .  Adjust the S-IB accelerometer backup parameter $F_{EO}$ to 0.5.
T2	None	4.5	D1	Start checking for S-IB outboard engines cutoff signals (INT5 and DI23), initiated at propellant depletion cutoff, for the purpose of setting Time Base 3. (This is keyed to the LOX Depletion Cutoff Enable switch selector.)
T2	NTSTB3	6.0	D1	Nominal start time for Time Base 3 used in repeatable flight simulation.
T2	BU4	13.0	D1	Start Time Base 3 if not started previously.



TABLE 2-1 EVENT SEQUENCE TIMELINE (CONTINUED)

Time Reference	EDD Symbol	Presettings (Seconds)	Source Code	Events
T3	None	0		<p>Reinitialize first guess at acceleration (F/M), to FM4.</p> <p>Reinitialize backup mass, mass flow rate and thrust to M<sub>2</sub>, zero and F<sub>2I</sub>, respectively, and begin using these values to compute backup acceleration (F/M)<sub>c</sub>.</p> <p>End Time Tilt guidance if tilt arrest has not already occurred.</p> <p>Stop checking DI14 and DI15 for S-IB engine failures. If either discrete was detected earlier, the checking of the recognized discrete stopped at that time.</p> <p>Resume using sin (2°) to compute A<sub>c0</sub> and reset bit 18 of Mode Code 24, if set.</p> <p>Stop checking DI23 and inhibit INT5 (S-IB Cutoff signals).</p> <p>Begin the X attitude error test using <math>\alpha_{ACTX} = 10.0</math> degrees.</p> <p>Set F<sub>E0</sub>=1, PF=1, PF<sub>0</sub>=1, PF<sub>1</sub>=1, BIAS=BIAS3, T<sub>EVNT</sub>=T3; compute <math>\Delta T'_E</math>, and stop computing the performance factor.</p> <p>Set M'<sub>c1</sub> = M<sub>2</sub>.</p> <p>Set Bx01 to zero and set Bz01 to the preset value from the variable data tape.</p>



TABLE 2-1 EVENT SEQUENCE TIMELINE (CONTINUED)

Time Reference	EDD Symbol	Presettings (Seconds)	Source Code	Events
T3	None	0		Change the roll ladder magnitude limit (MSK16) to 3.5 degrees. Pitch and yaw limits remain unchanged.
T3	$T3_{FMC}$	6.08	C3	Start using mass flow rate, $\dot{M}_2$ , and backup thrust, $F_2$ , in computing backup acceleration, $(F/\dot{M})$ . (This is the predicted time of S-IVB 90% thrust.)  Enable the accelerometer zero test and decrease vertical and downrange accelerometer RTCs to 6 m/sec <sup>2</sup> . Set $BIAS = BIAS_4$ , $T_{EVNT} = T3 + T3_{FMC}$ , and compute $\Delta T'_E$ .
T3	$T3_{FM}$	6.08	C3	Resume computing acceleration, $(F/\dot{M})$ , using first guess, FM4, initialized at $T3+0$ .  Start computing smoothed reciprocal acceleration, $(M/F)_S$ , using first guess, $(M/F)_0$ , initialized at $T0+0$ .
T3	$T3_{FMC} + \Delta T_{N2}$	7.09	C3	Begin computing performance factor.
T3	S4IGTM	10.0	D1	Release inhibit on Time Base 4 and start checking for cutoff conditions. Flight Program response to INT4 is inhibited before this time. Start checking DI5. (After this time, the presence of any two of the four S-IVB cutoff indications will initiate Time Base 4.)
T3	$T3_{IGM}$	35.0	C3	Start IGM. Start using $\Delta T_{N3}$ .

TABLE 2-1 EVENT SEQUENCE TIMELINE (CONTINUED)

Time Reference	EDD Symbol	Presettings (Seconds)	Source Code	Events
T3	TSMC	59.3	C3	Enable SMC calculations
T3	T3PU	328.1	D1	Save the values of $\dot{M}$ , $F_{EO}$ , PF, and $F_b$ and store these values as $\dot{M}'$ , $F'_{EO}$ , PF', and $F'_b$ . Start using mass flow rate, $\dot{M}_3$ , and backup thrust, $F_3$ , in computation of backup acceleration, $(F/M)_c$ . Set TEVNT = T3PU, compute $\Delta T'_E$ , and set BIAS = BIAS5. (This event is keyed to the "Mixture Ratio Control Valve Open" switch selector command.)
T <sub>1i</sub>	None	0.0	C3	Start computing artificial $\tau_3$ and decrementing T <sub>3i</sub> . Set T <sub>1i</sub> = 0. Stop computing $\tau_1$ and T <sub>1i</sub> .
T <sub>1i</sub>	P <sub>C</sub>	0.0	C3	Start using $\tau_3$ computed from $(M/F)_s$ (end artificial $\tau_3$ guidance). This event must occur when P <sub>C</sub> , initially zero and recomputed on each BML after T <sub>1i</sub> becomes zero, exceeds the presetting P <sub>CMR</sub> .
IGM Time-to-go	$\epsilon_2$	25.0	D2	Start $\bar{x}$ terminal steering guidance mode. Start using $\Delta T_{N4}$ .
IGM Time-to-go	BN <sub>1</sub>	14.4	B	Start building velocity history for S-IVB cutoff.

TABLE 2-1 EVENT SEQUENCE TIMELINE (CONTINUED)

Time Reference	EDD Symbol	Presettings (Seconds)	Source Code	Events
IGM Time-to-go	$T_{HSL} + \Delta T_b$	$5.0 + \Delta T_b$	D2	<p>Enter IGM high speed cutoff loop when the velocity-to-be-gained is less than a velocity guard, <math>V_{GRD}</math>. (If guidance reference failure has occurred, do not enter the high speed cutoff loop. If GRF occurs after entering, continue until cutoff.)</p> <p>Stop computing IGM guidance commands.</p> <p>Inhibit SMC calculations.</p> <p>Set up S-IVB Engine Cutoff On switch selector.</p>

TABLE 2-1 EVENT SEQUENCE TIMELINE (CONTINUED)

Time Reference	EDD Symbol	Presettings (Seconds)	Source Code	Events
T4	None	0		<p>Set acceleration, (F/M), to zero.</p> <p>Increase vertical and downrange accelerometer RTCs to 50 m/sec<sup>2</sup> (crossrange RTC unchanged at 6 m/sec<sup>2</sup>).</p> <p>Disable accelerometer zero test.</p> <p>Set ladder magnitude limit to 2.5 degrees in pitch and yaw (MSK6). Roll remains unchanged.</p> <p>Set backup thrust and mass flow rate to zero.</p> <p>Reset the command decoder and the DCS error counter, reset INT8, and release inhibit on INT8.</p> <p>Enable the following DCS commands: Time Base Update, Generalized Switch Selector, Execute Generalized Maneuver, Return to Nominal Timeline, Terminate, Inhibit Water Control Valve Logic, Ladder Magnitude Limit, and S-IVB/IU De-orbit.</p> <p>Stop checking for S-IVB cutoff. (Disable INT4 and DI5.)</p> <p>Begin the Z attitude test using <math>\alpha_{ACTZ} = 48.0</math> degrees and change <math>\alpha_{ACTX} = 90.0</math> deg.</p> <p>Start using <math>\Delta T_{N5}</math>.</p> <p>Change the zero gimbal test constant, ML6HUN, to 1.4 deg.</p>



TABLE 2-1 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	BN <sub>5</sub>	15.0	D3	<p>Enter orbit initialize and begin orbit navigation.</p> <p>Enable the following DCS commands: Memory Dump, Navigation Update, and Compressed Data Dump.</p>



TABLE 2-1 EVENT SEQUENCE TIMELINE (CONTINUED)

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

TABLE 2-1 EVENT SEQUENCE TIMELINE (CONTINUED)

Time Reference	EDD Symbol	Presettings (Seconds)	Source Code	Events
T4	BN <sub>5</sub>	15.0	D3	<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	T <sub>5GRD</sub>	5000.0	D1	Enable TB5 start.
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.

TABLE 2-1 EVENT SEQUENCE TIMELINE (CONTINUED)

Time Reference	EDD Symbol	Presettings (Seconds)	Source Code	Events
T4+TBB-TB	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	D1	Start Time Base 5. This is a transmitted parameter and has meaning only if the corresponding DCS command has been received and accepted.

TABLE 2-1 EVENT SEQUENCE TIMELINE (CONTINUED)

Time Reference	EDD Symbol	Presettings (Seconds)	Source Code	Events
T5	None	0		Reset bit 7 of MC27. Inhibit the Time Base Update, Execute Generalized Maneuver, Return to Nominal Timeline, Ladder Magnitude Limit and S-IVB/IU De-orbit DCS commands. Disable the loss of APS Attitude Control test. Disable telemetry acquisition and loss calculations. Set the pitch and yaw ladder magnitude limit (MSK6) to 15.3 deg Reset the platform measured velocity components, $\dot{X}_m$ , $\dot{Y}_m$ and $\dot{Z}_m$ , to zero. Start monitoring velocity increments ( $\Delta V$ ).
$T5+T_{SS}^*$	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.

\*See note 5 to Table 2-4 for definition of  $T_{SS}$

## 2.4 ORBITAL ATTITUDE TIMELINE

The following table (Table 2-2) 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 2-2 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
6	T5+0.0	Continue TB4 Maneuver in progress when TB5 is started	Variable

## 2.5 PRESETTINGS

Table 2-3 establishes the presettings to be used in the flight program. Program sequencing presettings are excluded since they are established in Section 1.3. For each presetting, the table gives:

- The symbol
- The required value and associated units
- The definition
- A source code.

Notice that the units of mass, force and angle presettings are not the same as those specified to be used in the flight program in Section 15 of Part I. The units used in the following table are consistent with those in other Apollo documentation while those in the flight program are dictated by programming constraints. For flight program implementation, all values given in degrees must be converted to pirads by dividing by 180. The forces, given in newtons, and masses, given in kilograms, must be converted to kilograms and  $\text{kg-sec}^2/\text{m}$ , respectively, by dividing each quantity by  $9.80665 \text{ m/sec}^2$ .

The source codes are inserted for information only and are not flight program requirements. The codes denote:

- A1 Constants established by the baseline requirements (mission-independent)
- A2 Launch pad dependent constants

- B Constants established by IBM
- C2 Constants established by the orbital  
timeline
- C3 Constants established by normal boost  
guidance requirements
- C4 Constants established by alternate  
mission requirements
- D2 Constants established by vehicle dynamics  
requirements
- D3 Constants established by other program  
requirements.

TABLE 2-3 PRESETTINGS

PAD 39B

EDD Symbol	Presetting	Units	Source Code	Definition
$\cos(\phi'_L)$	0.87910194		A2	Cosine of geocentric latitude of launch pad
$R_L$	6373402.3	m	A2	Geocentric radius to the center of the IU on the launch pad, used to calculate initial conditions
$\sin(\phi_L - \phi'_L)$	0.0028191516		A2	Sine of geodetic latitude minus geocentric latitude of the launch pad
$\cos(\phi_L)$	0.87775474		A2	Cosine of the geodetic latitude of the launch pad
$\sin(\phi_L)$	0.47911023		A2	Sine of the geodetic latitude of the launch pad
$X_{LS}$	6373377.0	m	A2	Initial radius component along $X_S$ -axis
Note: $\phi_L = 28.6273060$ $\phi'_L = 28.4657803$				

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TABLE 2-3 PRESETTINGS (CONTINUED)

## PREFLIGHT PTL SPECIAL DATA

EDD Symbol	Presetting	Units	Source Code	Definition
A <sub>00</sub>	467.766	deg	D3	Coefficients of the variable azimuth polynomial, included in flight routines for use by preflight routines
A <sub>01</sub>	-19.43775		D3	
A <sub>10</sub>	-1.1165417		D3	
A <sub>11</sub>	0.0934375	deg <sup>-1</sup>	D3	



TABLE 2-3 PRESETTINGS (CONTINUED)  
BOOST INITIALIZATION

EDD Symbol	Presetting	Units	Source Code	Definition
$A_{zL}$	90.0	deg	A1	Position I Azimuth
$G_H$	9.7972155	m/sec <sup>2</sup>	A1	Huntsville gravity used for flight simulation
$\phi_H$	34.7166666	deg	A1	Huntsville geodetic latitude used for flight simulation
$G_L$	9.791855	m/sec <sup>2</sup>	A1	Cape Kennedy gravity used for flight simulation
$\dot{x}_0$	0.0	m/sec	A1	Initial velocity component along $X_S$ axis

TABLE 2-3 PRESETTINGS (CONTINUED)  
ACCELEROMETER PROCESSING

EDD Symbol	Presetting	Units	Source Code	Definition
SIBEOB	0.875		C4	Engine out bias used to modify the back-up force and mass flow rate presettings during Time Base 1.
BIAS1	0	m/sec	C4	Velocity bias used in $(F/M)_c$ calculations during the BML in which liftoff occurs.
BIAS2	0	m/sec	C4	Velocity bias used in $(F/M)_c$ calculations during the BML in which S-IB IECO occurs.
BIAS3	0	m/sec	C4	Velocity bias used in $(F/M)_c$ calculations during the BML in which S-IB OECO occurs.
BIAS4	0	m/sec	C4	Velocity bias used in $(F/M)_c$ calculations during the BML in which mainstage is achieved (i.e., at $T3+T3_{FMC}$ ).
BIAS5	0	m/sec	C4	Velocity bias used in $(F/M)_c$ calculations during the BML in which S-IVB EMRC occurs.
BIAS6	0	m/sec	C4	Velocity bias used in $(F/M)_c$ calculations during the BML in which S-IVB cutoff occurs.

TABLE 2-3 PRESETTINGS (CONTINUED)  
ACCELEROMETER PROCESSING

EDD Symbol	Presetting	Units	Source Code	Definition
$F_0$	5742146.0	n	C4	Backup force used for computing $(F/M)_c$ for first portion of BML in which liftoff occurs.
$F_1$	7957634.0	n	C4	Predicted average S-IB thrust used to compute $(F/M)_c$
$F_{2I}$	299973.0	n	C4	Predicted average S-IVB buildup thrust used to compute $(F/M)_c$
$F_2$	1022822.0	n	C4	Predicted average S-IVB thrust used to compute $(F/M)_c$ before EMRC
$F_3$	861540.0	n	C4	Predicted average S-IVB thrust used to compute $(F/M)_c$ after EMRC
$\dot{M}_0$	0.0	kg/sec	C4	Backup mass flow rate used for computing $(F/M)_c$ for first portion of BML in which liftoff occurs.
$\dot{M}_1$	2882.72	kg/sec	C4	S-IB backup mass flow rate used to compute $(F/M)_c$
$\dot{M}_2$	246.441	kg/sec	C4	S-IVB backup mass flow rate prior to EMRC used to compute $(F/M)_c$
$\dot{M}_3$	205.420	kg/sec	C4	S-IVB backup mass flow rate after EMRC used to compute $(F/M)_c$
$M_0$	586420.64	kg	C4	Mass of the vehicle used for computing $(F/M)_c$ in the first portion of the BML in which liftoff occurs.
$M_1$	586420.64	kg	C4	Mass of the vehicle at liftoff used to compute $(F/M)_c$

TABLE 2-3 PRESETTINGS (CONTINUED)  
ACCELEROMETER PROCESSING

EDD Symbol	Presetting	Units	Source Code	Definition
$M_2$	132885.60	kg	C4	Mass of the vehicle (not including LES) at $T3+T3_{FMC}$ used to compute $(F/M)_c$
$\sin (2^\circ)$	.0348994967		A1	$\sin (2^\circ)$ used to compute the estimated thrust (F/M) misalignment uncertainty term
$\sin (6^\circ)$	.1045284633		A1	$\sin (6^\circ)$ used to compute the estimated thrust (F/M) misalignment uncertainty term if an S-IB engine out occurs

TABLE 2-3 PRESETTINGS (CONTINUED)  
BOOST NAVIGATION

EDD Symbol	Presetting	Units	Source Code	Definition
MFK1	0.32157638		D2	(M/F) <sub>S</sub> filter coefficients for S-IVB stage
MFK2	-0.2687668			
MFK3	0.0			
MFK4	0.0			
MFK5	1.6504718			
MFK6	-0.70328021			
MFK7	0.0			
MFK8	0.0			
FM0	12.8	m/sec <sup>2</sup>	B	Initial (F/M) for S-IB burn (This pre-setting is valid at T1+T <sub>S1EO</sub> and is also used to initialize the S-IB engine out acceleration decrease table.)
FM2	23.5	m/sec <sup>2</sup>	B	Constant (F/M) from S-IB IEEO to T3+0.0
FM4	5.9	m/sec <sup>2</sup>	B	Initial (F/M) for S-IVB burn
(M/F) <sub>0</sub>	0.169	sec <sup>2</sup> /m	B	M/F at T3+T <sub>3FM</sub> used to initialize the S-IVB smoothing filter at T0+0
μ	3.986032E+14	m <sup>3</sup> /sec <sup>2</sup>	A1	Product of universal gravity constant and mass of the earth



TABLE 2-3 PRESETTINGS (CONTINUED)  
FIRST STAGE GUIDANCE

EDD Symbol	Presetting	Units	Source Code	Definition
B <sub>11</sub>	0.0		C4	Coefficient used to calculate delta freeze time ( $\Delta T_f$ ) for S-IB engine out during first S-IB engine failure interval
B <sub>12</sub>	15.0	sec	C4	Coefficient used to calculate delta freeze time ( $\Delta T_f$ ) for S-IB engine out during first S-IB engine failure interval
B <sub>21</sub>	-.375		C4	Coefficient used to calculate delta freeze time ( $\Delta T_f$ ) for S-IB engine out during second S-IB engine failure interval
B <sub>22</sub>	15.0	sec	C4	Coefficient used to calculate delta freeze time ( $\Delta T_f$ ) for S-IB engine out during second S-IB engine failure interval
C <sub>ar1</sub>	20.0	sec	C4	Constant time bias used to modify $T_{ar}$ in case of an S-IB engine failure prior to $T_{far}$ .

TABLE 2-3 PRESETTINGS (CONTINUED)

TABULAR COMMANDED INERTIAL YAW ATTITUDE FOR  
OPEN LOOP GUIDANCE (TIME TILT YAW COMMANDS) (SOURCE CODE C3)

Biased Time Base 1 Time ( $T_c$ ) (Symbols)	Presetting (sec)	Inertial Yaw Command (Symbols)	Presetting (Deg)
TYAW01	255.0	YAWC01	0.0
TYAW02	0.0	YAWC02	0.0
TYAW03	0.0	YAWC03	0.0
TYAW04	0.0	YAWC04	0.0
TYAW05	0.0	YAWC05	0.0
TYAW06	0.0	YAWC06	0.0
TYAW07	0.0	YAWC07	0.0
TYAW08	0.0	YAWC08	0.0
TYAW09	0.0	YAWC09	0.0
TYAW10	0.0	YAWC10	0.0
TYAW11	0.0	YAWC11	0.0
TYAW12	0.0	YAWC12	0.0
TYAW13	0.0	YAWC13	0.0
TYAW14	0.0	YAWC14	0.0
TYAW15	0.0	YAWC15	0.0
TYAW16	0.0	YAWC16	0.0
TYAW17	0.0	YAWC17	0.0
TYAW18	0.0	YAWC18	0.0
TYAW19	0.0	YAWC19	0.0
TYAW20	0.0	YAWC20	0.0
TYAW21	0.0	YAWC21	0.0
TYAW22	0.0	YAWC22	0.0
TYAW23	0.0	YAWC23	0.0
TYAW24	0.0	YAWC24	0.0
TYAW25	0.0	YAWC25	0.0

Note:

$T_c = T_{as} - T_l + T_d$ , where  $T_d$  is the implementation delay. This causes the segment changes to be introduced into vehicle dynamics at the specified presetting times, referenced to Time Base 1 start.

TABLE 2-3      PRESETTINGS (CONTINUED)  
ATTITUDE CONTROL

EDD Symbol	Presetting	Units	Source Code	Definition
LML	12.0	Degrees	B	Ladder magnitude limit to be used after loss of APS attitude control test determines the vehicle is out of control.

TABLE 2-3 PRESETTINGS (CONTINUED)  
FIRST STAGE GUIDANCE

EDD Symbol	Presetting	Units	Source Code	Definition
F <sub>10</sub>	+0.160503E+1	deg	C3	Coefficients of first segment time tilt polynomial
F <sub>11</sub>	-0.113275E+0	deg/sec		
F <sub>12</sub>	-0.576848E-2	deg/sec <sup>2</sup>		
F <sub>13</sub>	+0.971731E-6	deg/sec <sup>3</sup>		
F <sub>20</sub>	+0.113283E+2	deg	C3	Coefficients of second segment time tilt polynomial
F <sub>21</sub>	-0.575758E+0	deg/sec		
F <sub>22</sub>	-0.231588E-3	deg/sec <sup>2</sup>		
F <sub>23</sub>	-0.146034E-5	deg/sec <sup>3</sup>		
F <sub>30</sub>	-0.288222E+2	deg	C3	Coefficients of third segment time tilt polynomial
F <sub>31</sub>	+0.396950E+0	deg/sec		
F <sub>32</sub>	-0.870892E-2	deg/sec <sup>2</sup>		
F <sub>33</sub>	+0.278457E-4	deg/sec <sup>3</sup>		
T <sub>d</sub>	1.6170	sec	B	Time tilt bias constant
GANTRY	162.0	m	A1	Three sigma altitude gain from liftoff to 10 seconds flight time

TABLE 2-3 PRESETTINGS (CONTINUED)  
NOMINAL COMPUTATION CYCLE LENGTHS

EDD Symbol	Presetting	Units	Source Code	Definition
$\Delta T_{N1}$	.83	sec	B	Nominal comp cycle length from T0+0 to T1+0
$\Delta T_{N2}$	1.01	sec	B	Nominal comp cycle length from T1+0 to T3+T3 <sub>IGM</sub>
$\Delta T_{N3}$	1.75	sec	B	Nominal comp cycle length from T3+T3 <sub>IGM</sub> to S-IVB $\tilde{\chi}$ steering
$\Delta T_{N4}$	1.55	sec	B	Nominal comp cycle length from start of S-IVB $\tilde{\chi}$ guidance until T4-T <sub>HSL</sub>
$\Delta T_{N5}$	.96	sec	B	Nominal comp cycle length from T4+0 to T4+BN <sub>5</sub>
$\Delta T_{N6}$	1.0	sec	B	Nominal comp cycle length from T4 + BN <sub>5</sub> to EOM



TABLE 2-3 PRESETTINGS (CONTINUED)  
BOOST IGM

EDD Symbol	Presetting	Units	Source Code	Definition
$V_{ex1}$	4160.9641	m/sec	C3	Exhaust velocity used in first phase for IGM computations
$T_{li}$	294.0	sec	C3	Nominal IGM time-to-go from $T3+T3_{IGM}$ to S-IVB EMRC
$T_{10}$	294.0	sec	C3	Nominal first phase burn time
$\tau_{10}$	512.215	sec	C3	Nominal value of $\tau_1$ used in artificial $\tau$ calculations
$M_{GR}$	125825.03	kg		Estimated mass of S-IVB at IGM initiation
$V_{ex3}$	4194.0352	m/sec	C3	Exhaust velocity used in second phase IGM computations
$\tau_3$	258.017	sec	C3	Initial $\tau_3$ for second phase IGM
$P_{CMR}$	35.0	sec	C3	Duration of artificial $\tau_3$ mode following EMRC
$T_{3i}$	109.5	sec	C3	Nominal IGM time-to-go from S-IVB EMRC to $T4+0$

TABLE 2-3 PRESETTINGS (CONTINUED)  
BOOST IGM

EDD Symbol	Presetting	Units	Source Code	Definition
ROV	1.0		C3	Bias constant for terminal range angle
$G_T$	-9.351	m/sec <sup>2</sup>	C3	Terminal gravity for S-IVB burn
$\ddot{X}_{VgT}$	-9.351	m/sec <sup>2</sup>	C3	Terminal X gravity component for S-IVB burn
$\ddot{Y}_{VgT}$	0.0	m/sec <sup>2</sup>	C3	Terminal Y gravity component for S-IVB burn
$\ddot{Z}_{VgT}$	0.0	m/sec <sup>2</sup>	C3	Terminal Z gravity component for S-IVB burn
SQ1	5818.0420	m/sec	B	First guess at sqrt ( $\dot{\Delta X}_V^2 + \dot{\Delta Z}_V^2$ ) for S-IVB burn
SQ2	0.99997756		B	First guess at sqrt ( $1 - (F'_{Sy})^2$ )
$\Delta V_b$	6.5727	m/sec	C3	Thrust decay velocity bias for S-IVB burn
YAWLIM	45.0	deg	B	Yaw guidance command limit
SMCG	0.03	rad/sec	D2	SMC gain for Time Base 3
$V_{GRD}$	150.0	m/sec	C3	Velocity guard for the high speed loop in S-IVB burn

TABLE 2-3 PRESETTINGS (CONTINUED)  
TYPICAL TARGETING LOAD DATA FOR USE BY FLIGHT SIMULATION

EDD Symbol	Presetting	Units	Source Code	Definition
$V_T$	7835.13	m/sec	C3	Desired insertion velocity for S-IVB burn
$R_T$	6528178.0	m	C3	Desired insertion radius for S-IVB burn
$\theta_T$	0.0	deg	C3	Desired insertion flight path angle
$i$	49.999	deg	C3	Inclination of parking orbit
$\lambda_0$	155.021	deg	C3	Longitude of descending node
$\dot{\lambda}$	-0.004237	deg/sec	C3	Time rate of change of the descending node (a negative preset value moves the node westward)
$T_{GRRO}$	61158.6	sec	D3	Nominal value of $T_{GRR}$ , referenced to $T_{GMT}$
$T_{LWC}$	61794.0	sec	D3	Liftoff time of launch window closing, referenced to $T_{GMT}$
$A_z$	47.035	deg	C3	Platform Azimuth

TABLE 2-3 PRESETTINGS (CONTINUED)  
ORBITAL GUIDANCE

EDD Symbol	Presetting	Units	Source Code	Definition	
SP <sub>M1</sub>	0.0		C2	Pitch	Attitude variables for Maneuver 1
CP <sub>M1</sub>	0.0			Yaw	
SY <sub>M1</sub>	0.0			Roll	
CY <sub>M1</sub>	0.0				
RA <sub>M1</sub>	0.0	deg			
TYP <sub>M1</sub> (NOTE*)	0.0		B	Type of maneuver indicator for Maneuver 1	
SP <sub>M2</sub>	0.0		C2	Pitch	Attitude variables for Maneuver 2
CP <sub>M2</sub>	1.0			Yaw	
SY <sub>M2</sub>	0.0			Roll	
CY <sub>M2</sub>	1.0				
RA <sub>M2</sub>	0.0	deg			
TYP <sub>M2</sub>	-1.0		B	Type of maneuver indicator for Maneuver 2	
*NOTE: TYP <sub>M1</sub> -TYP <sub>M3</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).					

TABLE 2-3 PRESETTINGS (CONTINUED)  
GRAVITY

EDD Symbol	Presetting	Units	Source Code	Definition
$a_e$	6378165.0	m	A1	Earth's semi-major axis
b	6356783.0	m	A1	Earth's semi-minor axis
D	0.7875E-5		C3	Fourth zonal harmonic coefficient used in the gravitational potential model
H	0.575E-5		C3	Third zonal harmonic coefficient used in the gravitational potential model
J	1.62345E-3		C3	Second zonal harmonic coefficient used in the gravitational potential model



TABLE 2-3 PRESETTINGS (CONTINUED)  
TELEMETRY ACQUISITION AND LOSS

EDD Symbol	Presetting	Units	Source Code	Definition
R <sub>STA</sub>	.6419879.7	m	D3	Mean radius of the telemetry stations
$\omega_E$	.000023211523	pirads/ sec	A1	Earth's rotational rate

TABLE 2-3      PRESETTINGS (CONTINUED)  
DRAG

EDD Symbol	Presetting	Units	Source Code	Definition
$\rho_0$	0.179142E-6	kg/m <sup>3</sup>	C3	Atmospheric density polynomial coefficients
$\rho_1$	-0.37213949E-11	kg/m <sup>4</sup>		
$\rho_2$	0.31057886E-16	kg/m <sup>5</sup>		
$\rho_3$	-0.12962178E-21	kg/m <sup>6</sup>		
$\rho_4$	0.26986419E-27	kg/m <sup>7</sup>		
$\rho_5$	-0.22388267E-33	kg/m <sup>8</sup>		
$K_D$	0.164311287E-2	m <sup>2</sup> /kg	C3	Orbital drag model constant
$C_{D1}$	11.079923		C3	Drag as a function of the cosine of the angle of attack polynomial coefficients
$C_{D2}$	0.17954281			
$C_{D3}$	-2.1771971			
$C_{D4}$	-0.28074902			
$C_{D5}$	-5.8764139			

TABLE 2-3      PRESETTINGS (CONTINUED)  
DRAG

EDD Symbol	Presetting	Units	Source Code	Definition
$h_1$	1.5E5	m	C3	Lower bound of atmospheric density polynomial
$h_2$	3.0E5	m	C3	Upper bound of atmospheric density polynomial
$\rho_c$	0.5E-7	kg/m <sup>3</sup>	C3	Constant atmospheric density used when the altitude of the vehicle is less than $h_1$

## 2.6 FLIGHT SEQUENCING

The flight sequencing requirements for SA-207 are established in Table VII of the current revision of the Flight Sequence Program ICD 68M00001 and the approved IRN's described in Table 2-4. 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 2-4 SWITCH SELECTOR SEQUENCING (CONTINUED)

ICD/IRN	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS		
		CODE	STAGE	CHN			
	LIFTOFF - START OF TIME BASE NO. 1 (T1)				T1		.0
68M00001A	SINGLE ENGINE CUTOFF ENABLE	0101 1010	S-IB	100	T1	+	3.0
28	LOX TANK PRESSURIZATION SHUTOFF VALVES CLOSE	0110 1010	SIVB	79	T1	+	6.0
68M00001A	MULTIPLE ENGINE CUTOFF ENABLE NO.1	0001 0001	S-IB	16	T1	+	10.0
68M00001A	MULTIPLE ENGINE CUTOFF ENABLE NO.2	0110 1111	S-IB	15	T1	+	10.1
68M00001A	TELEMETER CALIBRATION ON	0101 1111	S-IB	2	T1	+	20.0
68M00001A	TELEMETER CALIBRATION OFF	0000 1111	S-IB	39	T1	+	25.0
68M00001A	TELEMETRY CALIBRATOR IN-FLIGHT CALIBRATE ON	0010 0010	IU	23	T1	+	27.0
68M00001A	TELEMETRY CALIBRATOR IN-FLIGHT CALIBRATE OFF	0001 0010	IU	24	T1	+	32.0
68M00001A	LAUNCH VEHICLE ENGINES EDS CUTOFF ENABLE	0011 0001	IU	38	T1	+	40.0
68M00001A	TELEMETRY CALIBRATOR IN-FLIGHT CALIBRATE ON	0010 0010	IU	23	T1	+	90.2
68M00001A	TELEMETRY CALIBRATOR IN-FLIGHT CALIBRATE OFF	0001 0010	IU	24	T1	+	95.2
68M00001A	FLIGHT CONTROL COMPUTER SWITCH POINT NO. 1	0111 1110	IU	43	T1	+	100.0
68M00001A	FLIGHT CONTROL COMPUTER SWITCH POINT NO. 2	0100 0001	IU	21	T1	+	100.2



TABLE 2-4 SWITCH SELECTOR SEQUENCING (CONTINUED)

ICD/IRN	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS		
		CODE	STAGE	CHN			
68M00001A	TELEMETER CALIBRATION ON	0101 1111	S-IB	2	T1	+	119.8
68M00001A	FLIGHT CONTROL COMPUTER SWITCH POINT NO. 3	0101 0001	IU	22	T1	+	120.0
68M00001A	IU CONTROL ACCELEROMETER POWER OFF	0111 0101	IU	106	T1	+	120.2
68M00001A	TELEMETER CALIBRATION OFF	0000 1111	S-IB	39	T1	+	124.8
68M00001A	TM CALIBRATE ON	0100 1010	SIVB	62	T1	+	127.5
68M00001A	TM CALIBRATE OFF	0000 0111	SIVB	63	T1	+	128.5
68M00001A	EXCESS RATE (P,Y,R) AUTO-ABORT INHIBIT ENABLE	0110 1111	IU	15	T1	+	128.7
68M00001A	EXCESS RATE (P,Y,R) AUTO-ABORT INHIBIT AND SWITCH RATE GYROS SC INDICATION A	0101 1111	IU	2	T1	+	128.9
68M00001A	S-IB TWO ENGINES OUT AUTO-ABORT INHIBIT ENABLE	0000 1110	IU	51	T1	+	129.1
68M00001A	S-IB TWO ENGINES OUT AUTO-ABORT INHIBIT	0001 1110	IU	35	T1	+	129.3
68M00001A	PROPELLANT LEVEL SENSORS ENABLE	0111 0111	S-IB	104	T1	+	129.5

TABLE 2-4. SWITCH SELECTOR SEQUENCING (CONTINUED)

ICD/IRN	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS	
		CODE	STAGE	CHN		
	S-IB PROPELLANT LEVEL SENSOR ACTUATION-START OF TIME BASE NO. 2 (T2)		S-IB		T2	.0
68M00001A	EXCESS RATE (ROLL) AUTO-ABORT INHIBIT ENABLE	0100 1111	IU	34	T2 +	.2
68M00001A	EXCESS RATE (ROLL) AUTO-ABORT INHIBIT AND SWITCH RATE GYROS SC INDICATION B	0111 0001	IU	50	T2 +	.4
68M00001A	INBOARD ENGINES CUTOFF	0100 0100	S-IB	98	T2 +	3.0
68M00001A	AUTO-ABORT ENABLE RELAYS RESET	0001 0001	IU	16	T2 +	3.4
68M00001A	CHARGE ULLAGE IGNITION EBW FIRING UNITS	0111 0100	SIVB	54	T2 +	3.6
68M00001A	Q-BALL POWER OFF	0111 1111	IU	1	T2 +	4.0
68M00001A	PREVALVES OPEN	0110 1001	SIVB	83	T2 +	4.3
68M00001A	LOX DEPLETION CUTOFF ENABLE	0000 0110	S-IB	97	T2 +	4.5
68M00001A	FUEL DEPLETION CUTOFF ENABLE	0110 1010	S-IB	79	T2 +	5.0
30	S-IB OUTBOARD ENGINES CUTOFF	0011 0011	S-IB	18	T2 +	12.9

TABLE 2-4 SWITCH SELECTOR SEQUENCING (CONTINUED)

ICD/IRN	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS	
		CODE	STAGE	CHN		
	S-IB OUTBOARD ENGINES CUTOFF - START OF TIME BASE NO. 3 (T3)				T3	.0
68M00001A	S-IB OUTBOARD ENGINES CUTOFF	0011 0011	S-IB	18	T3 +	.1
28	LOX TANK PRESSURIZATION SHUTOFF VALVES OPEN	0111 1010	SIVB	80	T3 +	.2
68M00001A	LOX TANK FLIGHT PRESSURIZATION SYSTEM ON	0111 1001	SIVB	103	T3 +	.3
68M00001A	S-IVB ENGINE CUTOFF NO. 1 OFF	0111 0010	SIVB	13	T3 +	.4
68M00001A	S-IVB ENGINE CUTOFF NO. 2 OFF	0000 1100	SIVB	49	T3 +	.5
68M00001A	MIXTURE RATIO CONTROL VALVE OPEN	0000 0010	SIVB	5	T3 +	.8
68M00001A	MIXTURE RATIO CONTROL VALVE BACKUP OPEN	0100 1111	SIVB	34	T3 +	.9
68M00001A	ULLAGE ROCKETS IGNITION	0101 0100	SIVB	56	T3 +	1.1
68M00001A	S-IB/S-IVB SEPARATION ON	0010 0010	S-IB	23	T3 +	1.3
68M00001A	FLIGHT CONTROL COMPUTER S-IVB BURN MODE ON A	0010 0001	IU	53	T3 +	1.5
68M00001A	FLIGHT CONTROL COMPUTER S-IVB BURN MODE ON B	0010 1101	IU	6	T3 +	1.7
68M00001A	ENGINE READY BYPASS ON	0110 0011	SIVB	10	T3 +	1.9



TABLE 2-4 SWITCH SELECTOR SEQUENCING (CONTINUED)

ICD/IRN	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS		
		CODE	STAGE	CHN			
68M00001A	LH2 CHILLDOWN PUMP OFF	0110 1011	SIVB	59	T3	+	2.1
68M00001A	LOX CHILLDOWN PUMP OFF	0010 0010	SIVB	23	T3	+	2.3
68M00001A	S-IVB ENGINE OUT INDICATION A ENABLE	0001 0011	IU	9	T3	+	2.4
68M00001A	S-IVB ENGINE OUT INDICATION B ENABLE	0011 1100	IU	29	T3	+	2.6
68M00001A	ENGINE IGNITION SEQUENCE START	0001 0011	SIVB	9	T3	+	2.7
68M00001A	ENGINE IGNITION SEQUENCE START RELAY RESET	0101 1101	SIVB	27	T3	+	3.2
68M00001A	MAINSTAGE ENABLE ON	0111 0011	SIVB	11	T3	+	3.7
68M00001A	LH2 TANK PRESSURIZATION CONTROL SWITCH ENABLE	0001 1001	SIVB	68	T3	+	5.3
68M00001A	MIXTURE RATIO CONTROL VALVE CLOSE	0010 1101	SIVB	6	T3	+	8.7
68M00001A	MIXTURE RATIO CONTROL VALVE BACKUP CLOSE	0001 1110	SIVB	35	T3	+	8.9
68M00001A	CHARGE ULLAGE JETTISON EBW FIRING UNITS	0110 0100	SIVB	55	T3	+	10.2
68M00001A	ULLAGE ROCKETS JETTISON	0001 1010	SIVB	57	T3	+	13.3
28	MAINSTAGE ENABLE OFF	0001 0001	SIVB	16	T3	+	13.7
68M00001A	ULLAGE EBW FIRING UNITS CHARGE RELAYS RESET	0101 1100	SIVB	88	T3	+	19.3
68M00001A	ULLAGE ROCKETS IGNITION AND JETTISON RELAYS	0010 1011	SIVB	73	T3	+	19.5

TABLE 2-4 SWITCH SELECTOR SEQUENCING (CONTINUED)

ICD/IRN	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS		
		CODE	STAGE	CHN			
	RESET						
28	HEAT EXCHANGER BYPASS VALVE CONTROL ENABLE	0111 0001	SIVB	50	T3	+	24.0
68M00001A	TELEMETRY CALIBRATOR IN-FLIGHT CALIBRATE ON	0010 0010	IU	23	T3	+	25.4
68M00001A	TELEMETRY CALIBRATOR IN-FLIGHT CALIBRATE OFF	0001 0010	IU	24	T3	+	30.4
30	WATER COOLANT VALVE OPEN	0110 0101	IU	107	T3	+	39.5
68M00001A	FLIGHT CONTROL COMPUTER SWITCH POINT NO. 4	0110 0001	IU	4	T3	+	42.0
68M00001A	FLIGHT CONTROL COMPUTER SWITCH POINT NO. 5	0011 0010	IU	44	T3	+	203.7
68M00001A	TELEMETRY CALIBRATOR IN-FLIGHT CALIBRATE ON	0010 0010	IU	23	T3	+	205.4
68M00001A	TELEMETRY CALIBRATOR IN-FLIGHT CALIBRATE OFF	0001 0010	IU	24	T3	+	210.4
68M00001A	LH2 TANK PRESSURIZATION CONTROL SWITCH DISABLE	0010 1001	SIVB	69	T3	+	302.9
68M00001A	MIXTURE RATIO CONTROL VALVE OPEN	0000 0010	SIVB	5	T3	+	328.1
68M00001A	MIXTURE RATIO CONTROL VALVE BACKUP OPEN	0100 1111	SIVB	34	T3	+	328.3
68M00001A	TELEMETRY CALIBRATOR IN-FLIGHT CALIBRATE ON	0010 0010	IU	23	T3	+	355.4
68M00001A	TELEMETRY CALIBRATOR IN-FLIGHT CALIBRATE OFF	0001 0010	IU	24	T3	+	360.4
68M00001A	PROPELLANT DEPLETION CUTOFF ARM	0000 0110	SIVB	97	T3	+	400.0



TABLE 2-4 SWITCH SELECTOR SEQUENCING (CONTINUED)

ICD/IRN	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS	
		CODE	STAGE	CHN		
	S-IVB ENGINE CUTOFF - START OF TIME BASE 4 (T4)				T4	0.0
68M00001A	S-IVB ENGINE CUTOFF NO. 1 ON	0100 1101	SIVB	12	T4 +	.1
68M00001A	S-IVB ENGINE CUTOFF NO. 2 ON	0010 1100	SIVB	48	T4 +	.2
31	PREVALVES CLOSE	0001 0110	SIVB	82	T4 +	.3
34	LOX TANK NPV VALVE OPEN ON	0101 1110	SIVB	42	T4 +	.6
28	LOX TANK PRESSURIZATION SHUTOFF VALVES CLOSE	0110 1010	SIVB	79	T4 +	.8
68M00001A	LOX TANK FLIGHT PRESSURIZATION SYSTEM OFF	0111 0111	SIVB	104	T4 +	1.0
68M00001A	PROPELLANT DEPLETION CUTOFF DISARM	0100 0100	SIVB	98	T4 +	1.8
68M00001A	MIXTURE RATIO CONTROL VALVE CLOSE	0010 1101	SIVB	6	T4 +	2.2
68M00001A	MIXTURE RATIO CONTROL VALVE BACKUP CLOSE	0001 1110	SIVB	35	T4 +	2.4
68M00001A	FLIGHT CONTROL COMPUTER S-IVB BURN MODE OFF A	0100 1101	IU	12	T4 +	3.5
68M00001A	FLIGHT CONTROL COMPUTER S-IVB BURN MODE OFF B	0000 0010	IU	5	T4 +	3.7
68M00001A	AUX. HYDRAULIC PUMP FLIGHT MODE OFF	0011 1100	SIVB	29	T4 +	3.9
68M00001A	S/C CONTROL OF SATURN ENABLE	0011 0011	IU	18	T4 +	5.0

TABLE 2-4 SWITCH SELECTOR SEQUENCING (CONTINUED)

ICD/IRN	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS		
		CODE	STAGE	CHN			
68M00001A	RATE MEASUREMENTS SWITCH	0001 1111	IU	17	T4	+	6.0
68M00001A	S-IVB ENGINE EDS CUTOFFS DISABLE	0110 0010	IU	3	T4	+	10.0
34	LH2 TANK LATCHING RELIEF VALVE OPEN ON	0101 0110	SIVB	99	T4	+	10.4
34	LH2 TANK LATCHING RELIEF VALVE LATCH ON	0010 1110	SIVB	52	T4	+	12.4
34	LH2 TANK LATCHING RELIEF VALVE OPEN OFF	0101 1010	SIVB	100	T4	+	13.6
34	LH2 TANK LATCHING RELIEF VALVE LATCH OFF	0101 0010	SIVB	19	T4	+	14.8
33	CHILLDOWN SHUTOFF VALVES CLOSE	0101 0101	SIVB	91	T4	+	20.0
31	P.U. INVERTER AND DC POWER OFF	0011 1111	SIVB	8	T4	+	30.0
34	LOX TANK NPV VALVE OPEN OFF	0000 0001	SIVB	37	T4	+	30.6
34	LOX TANK VENT AND NPV VALVES BOOST CLOSE ON	0011 1011	SIVB	95	T4	+	33.6
34	LOX TANK VENT AND NPV VALVES BOOST CLOSE OFF	0001 1011	SIVB	96	T4	+	35.6
31	PREVALVES OPEN	0110 1001	SIVB	83	T4	+	680.0
31	CHILLDOWN SHUTOFF VALVES OPEN	0011 0101	SIVB	92	T4	+	680.2
34	LH2 TANK LATCHING RELIEF VALVE OPEN ON	0101 0110	SIVB	99	T4	+	680.4
34	LH2 TANK LATCHING RELIEF VALVE OPEN OFF	0101 1010	SIVB	100	T4	+	681.4

TABLE 2-4 SWITCH SELECTOR SEQUENCING (CONTINUED)

ICD/IRN	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS		
		CODE	STAGE	CHN			
34	LH2 TANK VENT AND LATCHING RELIEF VALVES BOOST CLOSE ON	0110 0110	SIVB	77	T4	+	684.4
34	LH2 TANK VENT AND LATCHING RELIEF VALVES BOOST CLOSE OFF	0111 0110	SIVB	78	T4	+	686.4
31	AUX. HYDRAULIC PUMP FLIGHT MODE ON	0111 1100	SIVB	28	T4	+	2120.0
31	AUX. HYDRAULIC PUMP FLIGHT MODE OFF	0011 1100	SIVB	29	T4	+	2600.0
31	S-IVB ENGINE EDS CUTOFF NO. 2 DISABLE	0010 0001	SIVB	53	T4	+	4990.0
31	PASSIVATION ENABLE	0110 0111	SIVB	85	T4	+	5000.0
31	AUX. HYDRAULIC PUMP FLIGHT MODE ON	0111 1100	SIVB	28	T4	+	5060.0
31	AUX. HYDRAULIC PUMP FLIGHT MODE OFF	0011 1100	SIVB	29	T4	+	5108.0
31	AUX. HYDRAULIC PUMP FLIGHT MODE ON	0111 1100	SIVB	28	T4	+	7520.0
31	AUX. HYDRAULIC PUMP FLIGHT MODE OFF	0011 1100	SIVB	29	T4	+	8000.0
31	AUX. HYDRAULIC PUMP FLIGHT MODE ON	0111 1100	SIVB	28	T4	+	10460.0
31	AUX. HYDRAULIC PUMP FLIGHT MODE OFF	0011 1100	SIVB	29	T4	+	10508.0
31	AUX. HYDRAULIC PUMP FLIGHT MODE ON	0111 1100	SIVB	28	T4	+	12620.0



TABLE 2-4 SWITCH SELECTOR SEQUENCING (CONTINUED)

ICD/IRN	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS	
		CODE	STAGE	CHN		
31	AUX. HYDRAULIC PUMP FLIGHT MODE OFF	0011 1100	SIVB	29	T4	+ 13100.0
31	AUX. HYDRAULIC PUMP FLIGHT MODE ON	0111 1100	SIVB	28	T4	+ 15050.0
31	AUX. HYDRAULIC PUMP FLIGHT MODE OFF	0011 1100	SIVB	29	T4	+ 15530.0
31	AUX. HYDRAULIC PUMP FLIGHT MODE ON	0111 1100	SIVB	28	T4	+ 18320.0
31	AUX. HYDRAULIC PUMP FLIGHT MODE OFF	0011 1100	SIVB	29	T4	+ 18800.0

TABLE 2-4 SWITCH SELECTOR SEQUENCING (CONTINUED)

ICD/IRN	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS	
		CODE	STAGE	CHN		
	START OF TIME BASE 5 (T5)-(T4+60TDSS)				T5	0.0
31	AUX. HYDRAULIC PUMP FLIGHT MODE ON	0111 1100	SIVB	28	T5 +	4.0
34	PREVALVES OPEN	0110 1001	SIVB	83	T5 +	31.0
34	CHILLDOWN SHUTOFF VALVES OPEN	0011 0101	SIVB	92	T5 +	32.0
31	ENGINE MAINSTAGE CONTROL VALVE OPEN ON	0000 0100	SIVB	74	T5 +	33.4
32	FLIGHT CONTROL COMPUTER S-IVB BURN MODE ON 'A'	0010 0001	IU	53	T5 +	33.6
32	FLIGHT CONTROL COMPUTER S-IVB BURN MODE ON 'B'	0010 1101	IU	6	T5 +	33.8
31	ENGINE HE CONTROL VALVE OPEN ON	0001 0101	SIVB	109	T5 +	34.0



TABLE 2-4 SWITCH SELECTOR SEQUENCING (CONTINUED)

ICD/IRN	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS	
		CODE	STAGE	CHN		
	SEQUENCE FOR LOX DEPLETION DUMP STOP AND LH2 DEPLETION DUMP START $TL5 = T5 + TLDD + 33.9$ (SEE NOTE 4)				TL5	0.0
31	ENGINE MAINSTAGE CONTROL VALVE OPEN OFF	0001 0100	SIVB	75	TL5 +	.1
31	ENGINE HE CONTROL VALVE OPEN OFF	0011 0100	SIVB	110	TL5 +	.3
31	ENGINE IGNITION PHASE CONTROL VALVE OPEN	0110 0010	SIVB	3	TL5 +	29.9
31	ENGINE HE CONTROL VALVE OPEN ON	0001 0101	SIVB	109	TL5 +	30.1

TABLE 2-4 SWITCH SELECTOR SEQUENCING (CONTINUED)

ICD/IRN	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS	
		CODE	STAGE	CHN		
	SEQUENCE FOR LH2 DEPLETION DUMP STOP AND SAFING - $TSS = T5 + TLDD + THDD + 63.9$ (SEE NOTE 5)				TSS	0.0
31	ENGINE IGNITION PHASE CONTROL VALVE CLOSE	0110 0001	SIVB	4	TSS +	.1
32	ENGINE HE CONTROL VALVE OPEN OFF	0011 0100	SIVB	110	TSS +	.3
32	FLIGHT CONTROL COMPUTER S-IVB BURN MODE OFF 'A'	0100 1101	IU	12	TSS +	.5
32	FLIGHT CONTROL COMPUTER S-IVB BURN MODE OFF 'B'	0000 0010	IU	5	TSS +	.7
31	AUX. HYDRAULIC PUMP FLIGHT MODE OFF	0011 1100	SIVB	29	TSS +	.9
31	LOX TANK NPV VALVE OPEN ON	0101 1110	SIVB	42	TSS +	1.1
31	LH2 TANK LATCHING RELIEF VALVE OPEN ON	0101 0110	SIVB	99	TSS +	1.3
34	PREVALVES CLOSE	0001 0110	SIVB	82	TSS +	2.1
34	CHILLDOWN SHUTOFF VALVES CLOSE	0101 0101	SIVB	91	TSS +	2.6

TABLE 2-4 SWITCH SELECTOR SEQUENCING (CONTINUED)

ICD/IRN	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS	
		CODE	STAGE	CHN		
31	LOX TANK NPV VALVE LATCH OPEN ON	0011 0110	SIVB	101	TSS +	3.1
31	LH2 TANK LATCHING RELIEF VALVE LATCH ON	0010 1110	SIVB	52	TSS +	3.3
31	LOX TANK NPV VALVE OPEN OFF	0000 0001	SIVB	37	TSS +	4.1
31	LH2 TANK LATCHING RELIEF VALVE OPEN OFF	0101 1010	SIVB	100	TSS +	4.3
31	LOX TANK NPV VALVE LATCH OPEN OFF	0010 0110	SIVB	102	TSS +	5.1
31	LH2 TANK LATCHING RELIEF VALVE LATCH OFF	0101 0010	SIVB	19	TSS +	5.3
31	ENGINE HE CONTROL VALVE OPEN ON	0001 0101	SIVB	109	TSS +	60.1
31	LOX TANK PRESSURIZATION SHUTOFF VALVES OPEN	0111 1010	SIVB	80	TSS +	100.1
31	LOX TANK PRESSURIZATION SHUTOFF VALVES CLOSE	0110 1010	SIVB	79	TSS +	2900.1

TABLE 2-4 SWITCH SELECTOR SEQUENCING (CONTINUED)

ICD/IRN	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS	
		CODE	STAGE	CHN		
	WATER COOLANT VALVE SWITCHING (SEE NOTE 1)					
68M00001A	WATER COOLANT VALVE OPEN	0110 0101	IU	107	+	
68M00001A	WATER COOLANT VALVE CLOSED	0100 0101	IU	108	+	
	SPECIAL SEQUENCE FOR VEHICLE TELEMETRY CALIBRATION (SEE NOTE 2)					
68M00001A	TELEMETRY CALIBRATOR IN-FLIGHT CALIBRATE ON	0010 0010	IU	23	ACQ +	60.0
68M00001A	TM CALIBRATE ON	0100 1010	SIVB	62	ACQ +	63.0
68M00001A	TM CALIBRATE OFF	0000 0111	SIVB	63	ACQ +	64.0
68M00001A	TELEMETRY CALIBRATOR IN-FLIGHT CALIBRATE OFF	0001 0010	IU	24	ACQ +	65.0



TABLE 2-4 SWITCH SELECTOR SEQUENCING (CONTINUED)

ICD/IRN	COMMAND	SWITCH SELECTOR			TIME FROM BASE 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 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 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 or Spacecraft initiated S-IVB 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  $T_5 + T_{LDD} + 33.9$ . This is a Class 4 alternate switch selector sequence.

Notes on Table 2-1 (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  $T_5 + T_{LDD} + T_{HDD} + 63.9$ . This is a Class 4 alternate switch selector sequence.

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## 2.7 DIGITAL COMMAND SYSTEM (DCS) MODE COMMAND SUMMARY

Table 2-5 defines the only DCS commands which are accepted by the AS-206 flight program and the interval during which each command is accepted. The required program response to each command is defined in Section 10 of Part I.

TABLE 2-5 DCS MODE COMMAND FORMAT

Octal Rep. of LVDC Bit Position S-5	Binary Rep. of LVDC Bit Position		Definition	Acceptance Times
	S-6	7-13		
10	0010000	Complement of Bits S-6	Time Base Update	T4+ 0→T5+0
11	0010010		Navigation Update	T4+ 15→End of Mission [EOM]
12	0010100		Generalized Switch Selector	T4+ 0→EOM
13	0010110		Memory Dump	Prelaunch Command Mode T4+ 15→EOM
20	0100000		Terminate	When any other DCS command is allowed
32	0110100		Targeting Load	Prelaunch Command Mode
35	0111010		Execute Generalized Maneuver	T4+ 0→T5+0 T5+T <sub>SS</sub> +2905.0→EOM
36	0111100		Return to Nominal Timeline	T4+ 0→T5+0
41	1000010		Ladder Magnitude Limit	T4+ 0→T5+0
43	1000110		Compressed Data Dump	T4+ 0→EOM
44	1001000		S-IVB/IU De-orbit	T4+ 0→T5+0
45	1001010		Inhibit Water Control Valve Logic	T4+ 0→EOM



## 2.8 FLIGHT SIMULATION LADDER PROFILES

Figure 2-2 depicts the signal profiles required on the ladder outputs during flight simulation tests. These ladder profiles must be issued as specified in Section 12.4.6 of Part I.

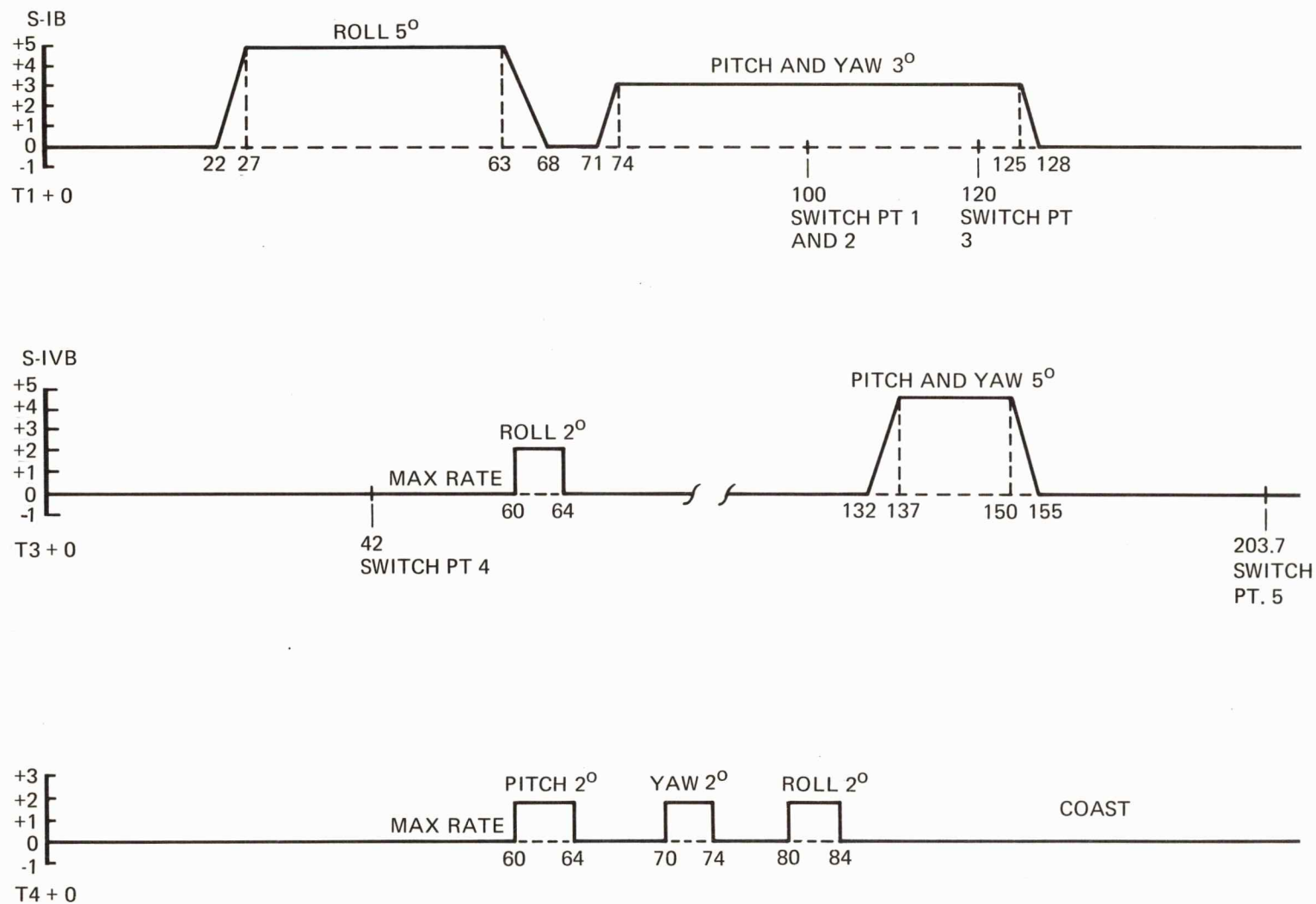


FIGURE 2-2 FLIGHT SIMULATION LADDER PROFILES

## 2.9 VARIABLE DATA TAPE DATA

Table 2-6 establishes the Variable Data Tape Data which must be assembled in the SA-207 flight program. The values presently assigned to the listed items are for checkout purposes only. This table provides the LVDC address, symbolic name, decimal value, and scaling factor for each of the Variable Data Tape data items.

TABLE 2-6 VARIABLE DATA TAPE DATA

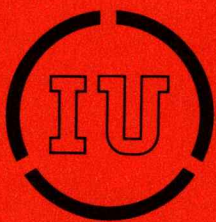
Address	Name	Decimal Value/Scaling	
016300	TDAY	1.200000D 02	10
016301	BXO	-4.100000D-01	0
016302	BYO	0.0	0
016303	BZO	-1.730000D-01	0
016304	PBX	0.0	1
016305	PBY	0.0	1
016306	PBZ	0.0	1
016307	TTMA1	0.0	15
016310	TTMA2	1.880000D 02	15
016311	TTMA3	1.900000D 02	15
016312	TTMA4	5.970000D 02	15
016313	CA1	9.999999D-01	0
016314	CA2	9.999999D-01	0
016315	CA3	9.999930D-01	0
016316	CA4	9.999770D-01	0
016317	SACB1	0.0	0
016320	SACB2	0.0	0
016321	SACB3	-3.835000D-03	0
016322	SACB4	-6.856000D-03	0
016323	SASB1	0.0	0
016324	SASB2	0.0	0
016325	SASB3	1.54000D-04	0
016326	SASB4	1.96000D-04	0
016327	CKSMIB		





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