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GEORGE C. MARSHALL **SPACE
FLIGHT
CENTER**

**INTERFACE CONTROL DOCUMENT
DEFINITION OF SATURN SA-513/SKYLAB 1
AND SA-515/SKYLAB BACKUP
FLIGHT SEQUENCE PROGRAM**

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



EFFECTIVE ON: SA-513/Skylab
1 and SA-515/Skylab Backup

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DEFINITION OF SATURN SA-513/SKYLAB I AND SA-515/SKYLAB
BACKUP FLIGHT SEQUENCE PROGRAM

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PREPARED FOR: ELECTRICAL WORKING GROUP

**SATURN INTERFACE
CONTROL DOCUMENT**

**SATURN INTERFACE CONTROL DOCUMENT
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GEORGE C. MARSHALL SPACE FLIGHT CENTER

DEFINITION OF SATURN SA-513/SKYLAB 1 & SA-515/SKYLAB BACKUP
FLIGHT SEQUENCE PROGRAM

I. INTRODUCTION

The purpose of this document is to define the flight sequence events, time bases, stage switch selector channel assignments, LVDA Discrete Outputs, Inputs and Interrupts for the Saturn SA-513/Skylab 1 & SA-515 vehicles. Special requirements and restrictions defined in this document will be imposed on the Marshall Space Flight Center and its contractors as applicable, to insure the proper functioning of the equipment in the various stages for required vehicle timing and sequencing to occur as outlined in this Interface Control Document (ICD).

II. DEFINITION OF TIME BASES FOR THE TIME SEQUENCING OF SA-513 & SA-515

A. General

Five (5) primary time bases are used in the SA-513 & SA-515 Flight Sequence Program in order to achieve an optimum vehicle mission with suitable sequential operation and timing of flight vehicle events. One (1) alternate time base is also programmed.

Safeguards are used where necessary to prevent premature initiation of time bases.

Proper establishment of time bases provides a safe and reliable vehicle on the pad and throughout the flight. Each time base will be established by the normal method when the required criteria, as outlined in this ICD, has been received by the Launch Vehicle Digital Computer (LVDC).

If a time base is not established, subsequent time bases cannot be started and the vehicle mission cannot be completed. Therefore, to further increase mission reliability in the absence of the normal time base signals, backup methods are used for establishing time bases.

Both the normal and backup methods for starting each time base are explained in the following paragraphs.

B. Time Base #1 (T_1)

Time Base #1 (T_1) is initiated by either of the liftoff signals (DI 24 or DI 7) provided by the deactuation of the liftoff relays in the IU at the umbilical disconnect. However, as a safety measure, the Launch Vehicle Digital Computer (LVDC) will not recognize the liftoff signals and start T_1 prior to Guidance Reference Release plus 17.4 seconds. If the LVDC has not detected either of these DI's prior to GRR plus 150 seconds, the program will go into a one instruction loop.

No "Negative Backup" (i.e., provisions for the LVDC to return to prelaunch conditions) is provided because the Saturn V vehicle can safely complete T_1 on the pad without catastrophic results, in the event T_1 began by error.

C. Time Base #2 (T_2)

The S-IC inboard engine shall be cutoff by the LVDC through the S-IC switch selector on Time Base #1 at $T_1 + 141.7$ seconds. At $T_1 + 141.8$ seconds the LVDC shall monitor the downrange accelerometer. If sufficient downrange velocity exists, the LVDC shall start Time Base #2 (T_2).

However, if Guidance Reference Failure (GRF) has occurred the LVDC shall bypass the velocity test and initiate Time Base #2.

Use of the downrange velocity reading provides a safeguard against starting T_2 on the pad should T_1 be started without liftoff. Furthermore if T_2 is not established, no subsequent time bases can be started. This insures a safe vehicle requiring at least one additional failure to render the vehicle unsafe on the pad.

D. Time Base #3 (T_3)

After arming the S-IC outboard engines propellant depletion cutoff sensors through the S-IC switch selector, the LVDC shall initiate Time Base #3 (T_3) upon receiving either of two redundant outboard engines cutoff signals. The S-IC Outboard Engines Cutoff "A" signal (INT 5) from the S-IC depletion circuitry is the primary signal for starting T_3 . The S-IC Outboard Engines Cutoff "B" signal (DIN 18) from the backup depletion circuitry is a backup signal.

E. Time Base #4 (T_4)

After a predetermined time on T_3 ($T_3 + 10.0$ Sec.) sufficient to allow the S-II stage engines to establish thrust OK, the LVDC shall start time base #4 after receiving any two of four functions monitored by the LVDC. The functions are (1) S-II engines out interrupt. (2) S-II engines out discrete. (3) S-II velocity cutoff which is issued by the LVDC through the S-II switch selector. (4) Loss of thrust determined by LVDC using accelerometer readings.

Redundant S-II engines cutoff commands are issued at the start of T_4 ($T_4 + 0.1$ and $T_4 + 0.2$ seconds) as a safeguard against starting T_4 with the thrust of the S-II stage engines present.

F. Time Base #4a (T_{4a})

Time Base #4a shall be initiated by the LVDC program upon achieving the Gravity Gradient Attitude $\pm 10^\circ$.

Also, the LVDC shall provide the capability to initiate Time Base #4a by CCS command during Time Base #4.

Program commands in Time Base #4 shall have priority over commands in Time Base #4a.

G. Alternate Time Base #4b (T_{4b})

In the event of a Guidance Reference Failure after activation of the ATM attitude pointing and control system (APCS), the LVDC shall initiate T_{4b} and transfer control to the ATM APCS. The LVDC shall also provide the capability to initiate T_{4b} by DCS command.

H. Additional SA-513 and SA-515 Sequence Requirements

a. IU Orbital TM Calibrations

The IU telemetry shall be calibrated after orbital insertion by using a special sequence. This special sequence of events consists of IU 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.

b. S-II Stage EMR Shift

The mixture ratio shift, for the S-II stage, from 5.5 to 4.8 shall be initiated inflight by the LVDC as a function of velocity. However, for the guidance failure case, the LVDC shall initiate the mixture ratio shift when $T_{2i}+0$, plus one (1) comp cycle, minus zero (0) seconds. The time shown in this ICD is nominal for this function, since the actual inflight time (Time Base No. 3 Time) is a function of initiation of IGM, T_{1i} , T_{2i} , and the LVDC computation cycle.

c. Orbital Water Coolant Valve Cycling

After liftoff plus 650 seconds the water coolant valve shall be switched open or closed by the LVDC through the IU switch selector. The LVDC shall be programmed to open the coolant valve when either of two thermal switches mounted in the coolant system close and to close the valve when both of the switches are open. This shall not interfere with other events in the flight sequence.

d. S-II Stage Inboard Engine Cutoff

The S-II Stage Inboard Engine shall be cutoff inflight by the LVDC through the S-II switch selector as a function of velocity. Using this method will provide additional engine out capability for the Skylab missions.

However, in the event of a Guidance Reference Failure (GRF), the LVDC shall initiate the S-II inboard engine cutoff when $T_{1i}=0$ plus one (1) comp cycle minus zero seconds. The time shown in the ICD is nominal for this function, since the actual inflight time (time base #3 time) is a function of IGM, T_{1i} and the LVDC computation cycle.

III. LVDA DISCRETE OUTPUTS, INPUTS AND INTERRUPTS

The following tables list the LVDA Discrete Outputs, Discrete Inputs and Interrupts used on this vehicle to accomplish the flight sequencing program as defined in this Interface Control Document.

A. LVDA DISCRETE OUTPUTS

<u>LVDA Connector & Pin Number</u>	<u>Discrete Output Number</u>	<u>Function</u>
J17h	D01	Reset Command Decoder
J13J	D01	Reset RCA 110A
J13e	D02	RCA 110A Interrupt
J4AA	D03	Spare (Wired to Control Distributor)
J2EE	D04	Guidance Failure "A"
J2u	D05	Spare (Wired to Control Distributor)
J2c	D06	Guidance Failure "B"
J2G	D07	Spare (Wired to Control Distributor)
J4m	D08	Spare (Wired to Control Distributor)
J4a	D09	Spare (Wired to Control Distributor)
J4d	D010	Spare (Wired to Control Distributor)
J4e	D011	Spare (Wired to Control Distributor)
J4f	D012	LVDA/LVDC Firing Commit Enable
J4S	D013	LVDA/LVDC Firing Commit Inhibit
J4C		Switch Selector Address First Digit
J4B		Switch Selector Address Second Digit
J4A		Switch Selector Address Third Digit
J4D		Switch Selector Address Fourth Digit
J4Y		Switch Selector Address Fifth Digit
J4X		Switch Selector Address Sixth Digit
J4W		Switch Selector Address Seventh Digit

A. LVDA DISCRETE OUTPUTS (continued)

<u>LVDA Connector & Pin Number</u>	<u>Discrete Output Number</u>	<u>Function</u>
J4V		Switch Selector Address Eighth Digit
J4p		Switch Selector Read
J4n		Switch Selector Read
J4U		Switch Selector Register Reset
J4T		Switch Selector Register Reset
J4r		S-IC Switch Selector Enable
J4q		S-IC Switch Selector Enable
J4Z		S-II Switch Selector Enable
J4E		S-II Switch Selector Enable
J4J		SWS Switch Selector Enable
J4F		SWS Switch Selector Enable
J4CC		IU Switch Selector Enable
J4BB		IU Switch Selector Enable
J4K		Spare (Switch Selector Enable, SS-12D)
J4s		Spare (Switch Selector Enable, SS-12)

B. LVDC DISCRETE INPUTS

<u>LVDA Connector & Pin Number</u>	<u>Discrete Input Number</u>	<u>Function</u>
J13h	DIN1	RCA 110A Sync
J17X	DIN2A	Command Decoder OM/D "A"
J17Y	DIN2B	Command Decoder OM/D "B"

B. LVDA DISCRETE INPUTS (continued)

<u>LVDA Connector & Pin Number</u>	<u>Discrete Input Number</u>	<u>Function</u>
J2BB	DIN3	S-IC Engine No. 2 Out
J2CC	DIN4	Spare (Wired to EDS Distributor)
J2e	DIN5	S-IC Engine No. 3 Out
J2a	DIN6	Spare (Wired to EDS Distributor)
J8i	DIN7	Liftoff "B"
J8N	DIN8	Spare (Wired to ESE)
J2F	DIN9	Spare (Wired to EDS Distributor)
J2t	DIN10	S-II/SWS Separation
J2n	DIN11	S-IC Inboard Engine Out "B"
J2p	DIN12	S-IC/S-II Separation
J2q	DIN13	S-II Inboard Engine Out
J2r	DIN14	S-IC Engine No. 1 Out
J2Z	DIN15	S-II AFT Interstage Separation
J2E	DIN16	Prepare for Guidance Reference Release
J2U	DIN17	S-IC Inboard Engine Out "A"
J2X	DIN18	S-IC Outboard Engine Cutoff "B"
J2V	DIN19	S-II Engines Out "B"
J2W	DIN20	Spare (Wired to EDS Distributor)
J4N	DIN21	S-II Outboard Engine Out
J4M	DIN22	S-IC Engine No. 4 Out

B. LVDA DISCRETE INPUTS (Continued)

<u>LVDA Connector & Pin Number</u>	<u>Discrete Input Number</u>	<u>Function</u>
J4L	DIN23	Spare (Wired to Control Distributor)
J2s	DIN24	Liftoff "A"
J4b		Switch Selector Address Verification First Digit
J4t		Switch Selector Address Verification Second Digit
J4DD		Switch Selector Address Verification Third Digit
J4EE		Switch Selector Address Verification Fourth Digit
J4u		Switch Selector Address Verification Fifth Digit
J4c		Switch Selector Address Verification Sixth Digit
J4G		Switch Selector Address Verification Seventh Digit
J4H		Switch Selector Address Verification Eighth Digit
J2AA	DIS1	Coolant Thermal Switch #1
J2m	DIS2	Coolant Thermal Switch #2

C. LVDA INTERRUPTS

<u>LVDA Connector & Pin Number</u>	<u>Interrupt Number</u>	<u>Function</u>
J8BB	INT1	Command LVDA/RCA 110A Interrupt
J2B	INT2	Spare (Wired to EDS Distributor)
J8q	INT3	RCA 110A Interrupt
J2C	INT4	S-II Engines Out "A"
J2A	INT5	S-IC Outboard Engines Cutoff "A"
J2D	INT6	Spare (Wired to Control Distributor)
J2Y	INT7	Guidance Reference Release
J17A	INT11	Command Decoder Interrupt "A"

<u>LVDA Connector & Pin Number</u>	<u>Interrupt Number</u>	<u>Function</u>
J17B	INT12	Command Decoder Interrupt "B"
Internal		TLC - Simultaneous Memory Error
J18G	OC INT	Data Ready from C.I.U.
Internal		LVDC Timer II
Internal		LVDC Timer I

IV. ABBREVIATIONS

C.B.R.M.	Charging Battery Regulator Modules
OWS	Orbital Workshop
APCS	Attitude Pointing Control System
EDS	Emergency Detection System
FM	Frequency Modulation
ICD	Interface Control Document
IU	Instrument Unit
LH ₂	Liquid Hydrogen
LOX	Liquid Oxygen
LVDC	Launch Vehicle Digital Computer
PAM	Pulse Amplitude Modulation
P.U.	Propellant Utilization
TBD	To Be Determined
MR	Mixture Ratio
F.U.	Firing Unit

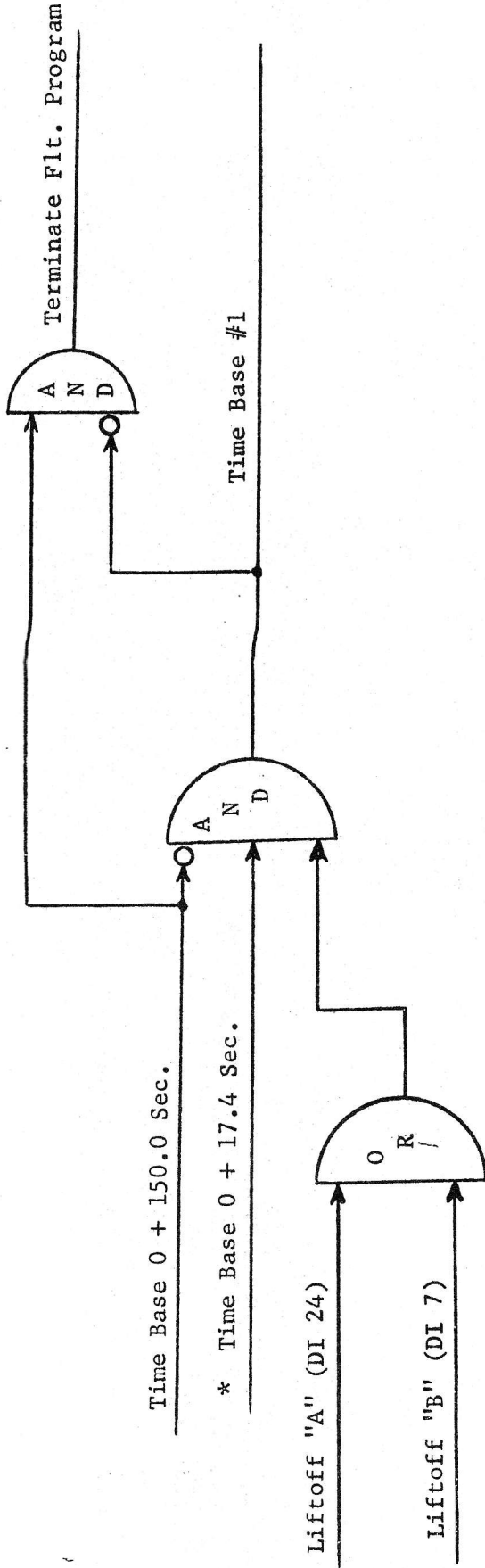
V. CHANGES

As requirements change and as the need arises, changes will be approved and released against this document and revisions to incorporate these changes will follow. Questions and requests for changes by all parties concerned should be put in writing and directed to S&E-CSE-LI, Marshall Space Flight Center, Alabama 35812. The telephone number for S&E-CSE-LI is 453-5494.

VI. LOGIC DIAGRAMS

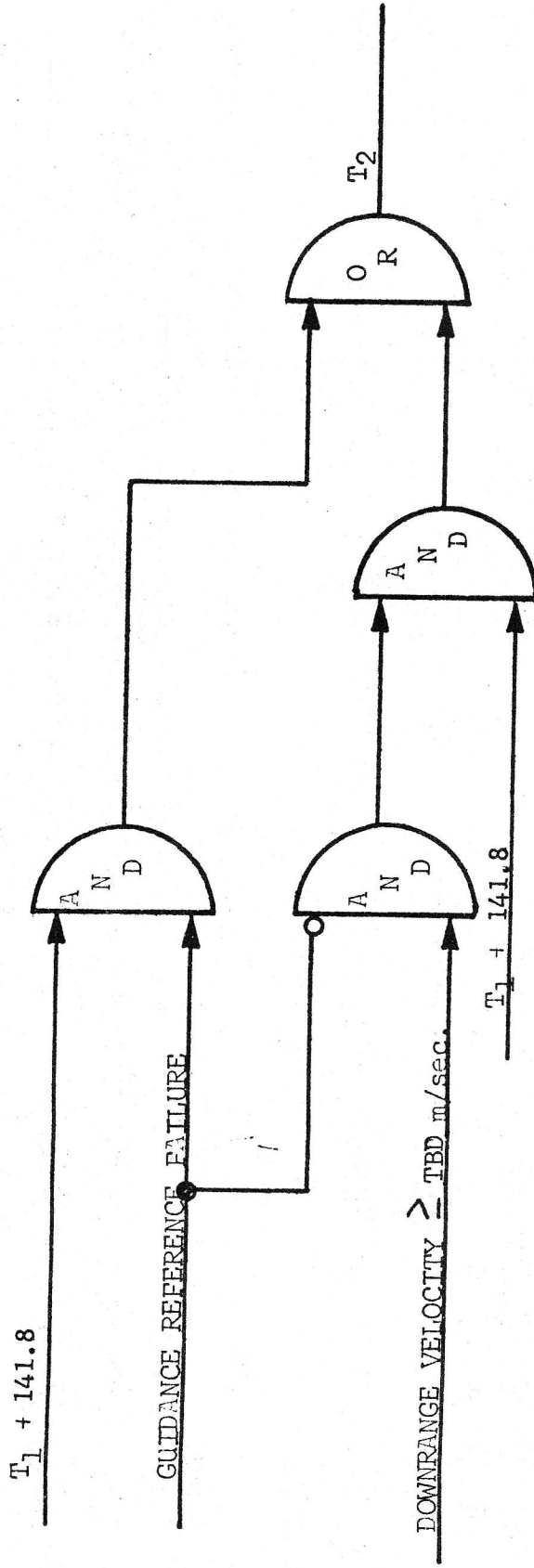
The logic diagrams, pages 11 through 16 indicate the conditions that must exist before initiation of each time base programmed for use on the SA-513/Skylab 1 and SA-515/Skylab backup missions. Logic Diagram, page 17 indicates conditions that must exist for water valve cycling.

VI. LOGIC DIAGRAMS



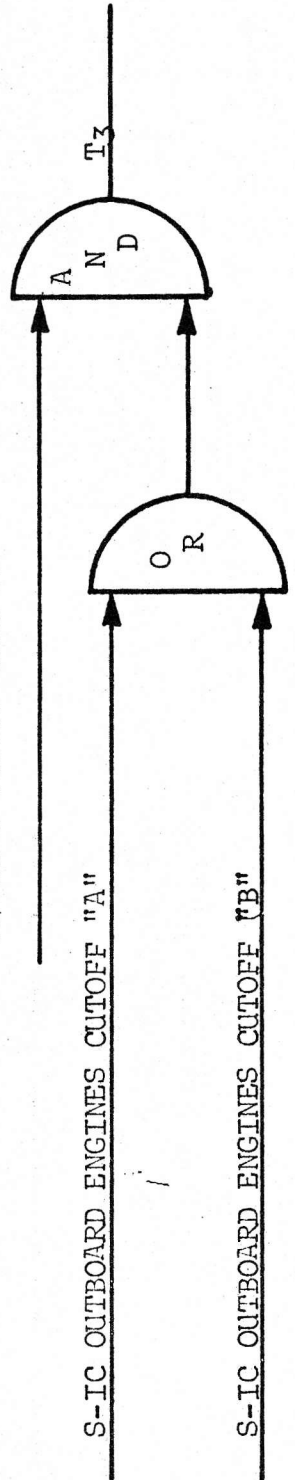
* Time Base 0 is initiated at guidance reference release.

TIME BASE #1

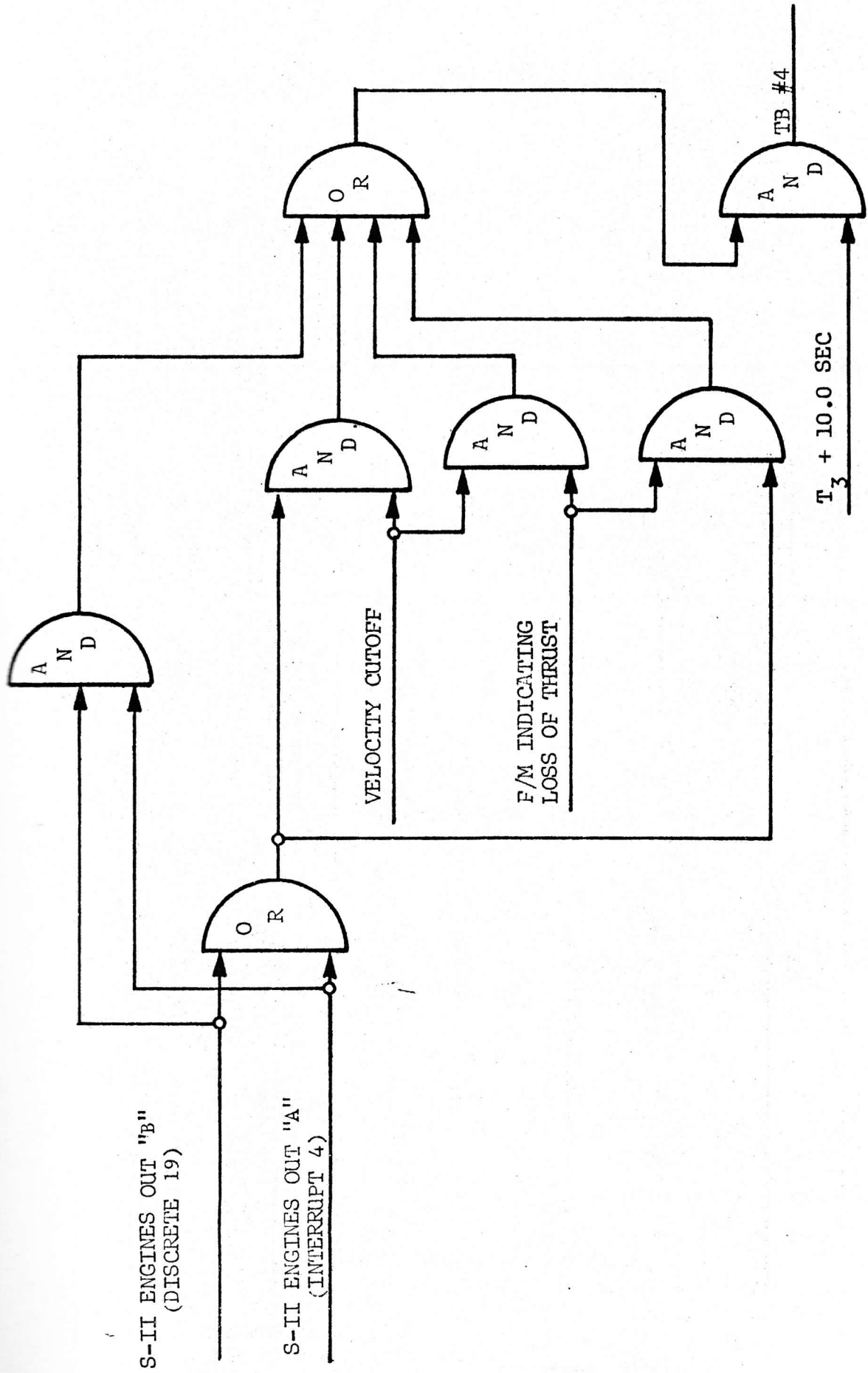


TIME BASE #2 (T2)

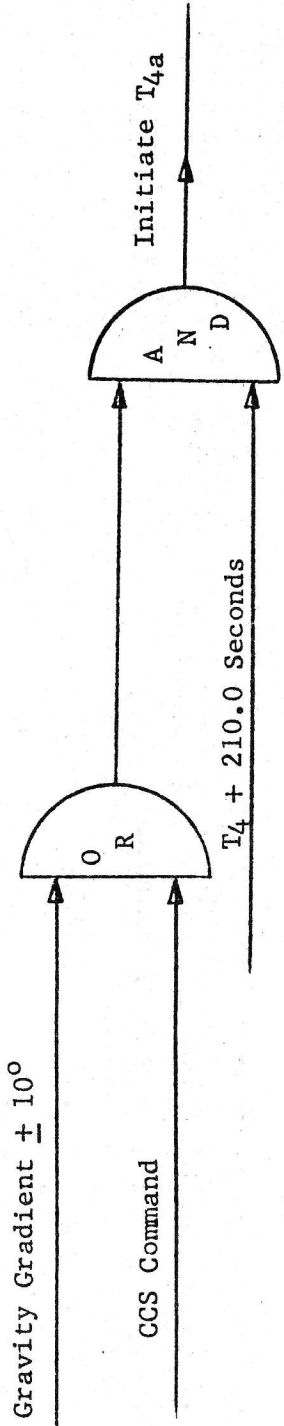
T₂ = ENABLE OUTBOARD
ENGINES CUTOFF COMMAND



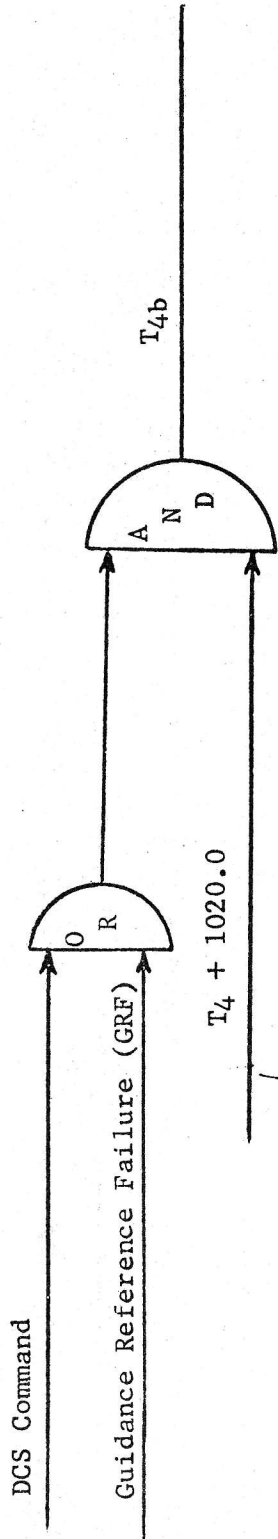
TIME BASE #3 (T₃)



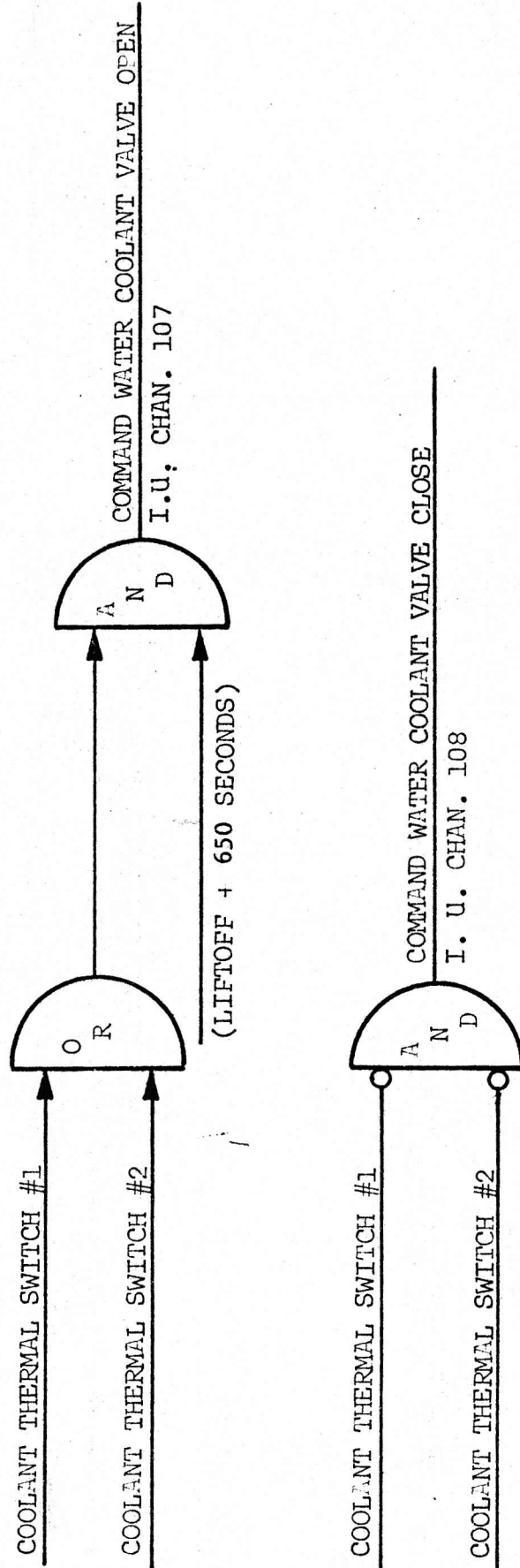
TIME BASE #4 (T₄)



Time Base #4a (T_{4a})



Alternate Time Base # 4b (T_{4b})



ECS WATER COOLANT VALVE LOGIC

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VII. FLIGHT SEQUENCE PROGRAM

NOMINAL FLIGHT TIME HR MIN SEC	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS
		CODE	STAGE	CHN	
00:00:00.0	LIFTOFF - START OF TIME BASE NO. 1 (T1)				T1 + .0
00:00:14.0	MULTIPLE ENGINE CUTOFF ENABLE	0110 0010	S-IC	3	T1 + 14.0
00:00:19.8	S-IC OUTBOARD ENGINES CANT 0N 'B'	0110 1001	IU	83	T1 + 19.8
00:00:20.0	S-IC OUTBOARD ENGINES CANT 0N 'A'	0101 1001	IU	84	T1 + 20.0
00:00:20.2	S-IC OUTBOARD ENGINES CANT 0N 'C'	0110 0111	IU	85	T1 + 20.2
00:00:24.0	TELEMETER CALIBRATE 0N	0101 1111	S-IC	2	T1 + 24.0
00:00:27.0	TELEMETRY CALIBRATOR IN-FLIGHT CALIBRATE 0N	0010 0010	IU	23	T1 + 27.0
00:00:29.0	TELEMETER CALIBRATE 0FF	0111 1111	S-IC	1	T1 + 29.0
00:00:30.0	LAUNCH VEHICLE ENGINES EDS CUTOFF ENABLE	0011 0001	IU	38	T1 + 30.0
00:00:32.0	TELEMETRY CALIBRATOR IN-FLIGHT CALIBRATE 0FF	0001 0010	IU	24	T1 + 32.0
00:00:49.5	FUEL PRESSURIZING VALVE NO.2 0PEN	0000 0010	S-IC	5	T1 + 49.5
00:01:30.0	TELEMETRY CALIBRATOR IN-FLIGHT CALIBRATE 0N	0010 0010	IU	23	T1 + 90.0
00:01:35.0	TELEMETRY CALIBRATOR IN-FLIGHT CALIBRATE 0FF	0001 0010	IU	24	T1 + 95.0
00:01:35.3	FUEL PRESSURIZING VALVE NO. 3 0PEN	0010 1101	S-IC	6	T1 + 95.3

NOMINAL FLIGHT TIME HR MIN SEC	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS
		CODE	STAGE	CHN	
00:01:45.0	FLIGHT CONTROL COMPUTER SWITCH POINT NO. 1	0111 1101	IU	26	T1 + 105.0
00:01:55.1	TELEMETER CALIBRATE ON	0101 1111	S-IC	2	T1 + 115.1
00:01:59.8	EXCESS RATE (P,Y,R) AUTO-ABORT INHIBIT ENABLE	0110 1111	IU	15	T1 + 119.8
00:02:00.0	EXCESS RATE (P,Y,R) AUTO-ABORT INHIBIT AND SWITCH RATE GYRO SC INDICATION 'A'	0101 1111	IU	2	T1 + 120.0
00:02:00.1	TELEMETER CALIBRATE OFF	0111 1111	S-IC	1	T1 + 120.1
00:02:10.0	FLIGHT CONTROL COMPUTER SWITCH POINT NO. 2	0100 0001	IU	21	T1 + 130.0
00:02:12.4	FUEL PRESSURIZING VALVE NO. 4 OPEN	0001 1101	S-IC	7	T1 + 132.4
00:02:18.4	S-IC TWO ENGINES OUT AUTO-ABORT INHIBIT ENABLE	0000 1110	IU	51	T1 + 138.4
00:02:18.6	S-IC TWO ENGINES OUT AUTO-ABORT INHIBIT	0001 1110	IU	35	T1 + 138.6
00:02:21.5	TWO ADJACENT OUTBOARD ENGINES OUT CUTOFF ENABLE	0001 1111	S-IC	17	T1 + 141.5
00:02:21.7	INBOARD ENGINE CUTOFF	0011 1111	S-IC	8	T1 + 141.7

NOMINAL FLIGHT TIME HR MIN SEC	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS
		CODE	STAGE	CHN	
00:02:21.8	START OF TIME BASE NO. 2 (T2)				T2 + .0
00:02:22.0	INBOARD ENGINE CUTOFF BACKUP	0001 0001	SIC	16	T2 + .2
00:02:22.2	START FIRST PAM-FM/FM CALIBRATION	0000 0011	S-II	30	T2 + .4
00:02:27.2	STOP FIRST PAM-FM/FM CALIBRATION	0001 0011	S-II	9	T2 + 5.4
00:02:29.7	SEPARATION AND RETRO NO. 1 EBW FIRING UNITS ARM	0110 0011	S-IC	10	T2 + 7.9
00:02:29.9	SEPARATION AND RETRO NO. 2 EBW FIRING UNITS ARM	0110 1110	S-IC	20	T2 + 8.1
00:02:32.3	OUTBOARD ENGINES CUTOFF ENABLE	0001 0011	S-IC	9	T2 + 10.5
00:02:32.5	OUTBOARD ENGINES CUTOFF BACKUP ENABLE	0000 1101	S-IC	14	T2 + 10.7

NOMINAL FLIGHT TIME HR MIN SEC	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS
		CODE	STAGE	CHN	
00:02:37.8	OUTBOARD ENGINES CUTOFF - START OF TIME BASE NO.3 (T3)				T3 + .0
00:02:37.9	LH2 TANK HIGH PRESSURE VENT MODE	0011 0001	S-II	38	T3 + .1
00:02:38.0	S-II LH2 RECIRCULATION PUMPS OFF	0010 1100	S-II	48	T3 + .2
00:02:39.1	S-IC OUTBOARD ENGINES CANT OFF 'B'	0101 0111	IU	86	T3 + 1.3
00:02:39.2	ACCUMULATOR BLEED VALVE CLOSE	0111 0110	S-II	78	T3 + 1.4
00:02:39.3	FLIGHT CONTROL COMPUTER SWITCH POINT NO. 8 INHIBIT	0110 1101	IU	47	T3 + 1.5
00:02:39.5	S-IC/S-II SEPARATION (NO.1)	0110 1111	S-IC	15	T3 + 1.7
00:02:39.6	S-IC/S-II SEPARATION (NO. 2)	0101 0010	S-IC	19	T3 + 1.8
00:02:39.7	SWITCH ENGINE CONTROL TO S-II MODE 'A' AND S-IC OUTBOARD ENGINES CANT OFF 'A'	0001 1100	IU	33	T3 + 1.9
00:02:39.8	SWITCH ENGINE CONTROL TO S-II MODE 'B'	0011 1110	IU	36	T3 + 2.0
00:02:39.9	S-II ENGINES CUTOFF NO. 1 RESET	0010 0011	S-II	31	T3 + 2.1

NOMINAL FLIGHT TIME HR MIN SEC	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS
		CODE	STAGE	CHN	
00:02:40.0	S-II ENGINES CUTOFF NO. 2 RESET	0000 0110	S-II	97	T3 + 2.2
00:02:40.1	ENGINES READY BYPASS	0110 1110	S-II	20	T3 + 2.3
00:02:40.2	S-II ENGINES START NO. 1	0001 1100	S-II	33	T3 + 2.4
00:02:40.3	S-II ENGINES START NO. 2	0000 0111	S-II	63	T3 + 2.5
00:02:40.4	S-II ENGINE OUT INDICATION 'A' ENABLE; S-II AFT INTERSTAGE SEPARATION INDICATION 'A' ENABLE	0111 1100	IJ	28	T3 + 2.6
00:02:40.5	S-II ENGINE OUT INDICATION 'B' ENABLE; S-II AFT INTERSTAGE SEPARATION INDICATION 'B' ENABLE	0010 1100	IJ	48	T3 + 2.7
00:02:40.7	ENGINES READY BYPASS RESET	0000 1100	S-II	49	T3 + 2.9
00:02:41.8	S-II HYDRAULIC ACCUMULATORS UNLOCK	0100 1101	S-II	12	T3 + 4.0
00:02:43.1	CHILDDOWN VALVES CLOSE	0101 1100	S-II	88	T3 + 5.3
00:02:44.1	CENTER ENGINE BACKUP CUTOFF SYSTEM ARM 1	0000 0101	S-II	81	T3 + 6.3
00:02:44.2	CENTER ENGINE BACKUP CUTOFF SYSTEM ARM 2	0101 1101	S-II	27	T3 + 6.4
00:02:44.3	ACCUMULATOR HE SUPPLY NO. 1 ON	0110 1010	S-II	79	T3 + 6.5
00:02:44.5	ACCUMULATOR HE SUPPLY NO. 2 ON	0110 0110	S-II	77	T3 + 6.7

NOMINAL FLIGHT TIME HR MIN SEC	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS
		CODE	STAGE	CHN	
00:02:45.5	S-II START PHASE LIMITER CUTOFF ARM	0011 1101	S-II	25	T3 + 7.7
00:02:45.7	HIGH [5.5] ENGINE MIXTURE RATIO NO. 1 ON	0110 1011	S-II	59	T3 + 7.9
00:02:45.9	HIGH [5.5] ENGINE MIXTURE RATIO NO. 2 ON	0011 1001	S-II	58	T3 + 8.1
00:02:46.4	PREVALVES LOCKOUT RESET	0101 0010	S-II	19	T3 + 8.6
00:02:46.5	S-II START PHASE LIMITER CUTOFF ARM RESET	0010 1101	S-II	6	T3 + 8.7
00:02:46.6	PREVALVES CLOSE ARM	0101 0110	S-II	99	T3 + 8.8
00:03:02.8	S-II AFT INTERSTAGE SEPARATION ARM NO. 1	0111 0011	S-II	11	T3 + 25.0
00:03:02.9	S-II AFT INTERSTAGE SEPARATION ARM NO. 2	0101 1001	S-II	84	T3 + 25.1
00:03:09.5	S-II AFT INTERSTAGE SEPARATION NO. 1	0010 0010	S-II	23	T3 + 31.7
00:03:09.6	S-II AFT INTERSTAGE SEPARATION NO. 2	0001 0110	S-II	82	T3 + 31.8
00:03:40.2	FLIGHT CONTROL COMPUTER SWITCH POINT NO. 3	0101 0001	IU	22	T3 + 62.4
00:04:29.8	MDA VENT VALVE 1 CLOSE ENABLE	0100 1001	SWS	66	T3 + 112.0
00:04:30.0	MDA VENT VALVE 2 CLOSE ENABLE	0100 0001	SWS	21	T3 + 112.2
00:04:31.8	MDA VENT VALVE 1 OPEN OR CLOSE EXECUTE ON	0011 0111	SWS	67	T3 + 114.0
00:04:32.0	MDA VENT VALVE 2 OPEN OR CLOSE EXECUTE ON	0101 0001	SWS	22	T3 + 114.2

NOMINAL FLIGHT TIME HR MIN SEC	COMMAND	SWITCH SELECTOR			TIME FRM BASE SECONDS
		CODE	STAGE	CHN	
00:04:42.8	START SECOND PAM-FM/FM CALIBRATION	0000 0011	S-II	30	T3 + 125.0
00:04:47.8	STOP SECOND PAM-FM/FM CALIBRATION	0001 0011	S-II	9	T3 + 130.0
00:04:48.2	MDA VENT VALVE 1 OPEN OR CLOSE EXECUTE OFF	0000 1010	SWS	111	T3 + 130.4
00:04:48.4	MDA VENT VALVE 2 OPEN OR CLOSE EXECUTE OFF	0110 1110	SWS	20	T3 + 130.6
00:05:50.0	WATER COOLANT VALVE OPEN	0110 0101	IU	107	T3 + 192.2
00:05:50.2	FLIGHT CONTROL COMPUTER SWITCH POINT NO. 4	0110 0001	IU	4	T3 + 192.4
00:06:00.5	TELEMETRY CALIBRATOR IN-FLIGHT CALIBRATE ON	0010 0010	IU	23	T3 + 202.7
00:06:05.5	TELEMETRY CALIBRATOR IN-FLIGHT CALIBRATE OFF	0001 0010	IU	24	T3 + 207.7
00:06:22.8	START THIRD PAM-FM/FM CALIBRATION	0000 0011	S-II	30	T3 + 225.0
00:06:27.8	STOP THIRD PAM-FM/FM CALIBRATION	0001 0011	S-II	9	T3 + 230.0
00:07:28.7	TELEMETRY CALIBRATOR IN-FLIGHT CALIBRATE ON	0010 0010	IU	23	T3 + 290.9
00:07:33.7	TELEMETRY CALIBRATOR IN-FLIGHT CALIBRATE OFF	0001 0010	IU	24	T3 + 295.9
TBD	S-II LOX DEPLETION SENSORS CUTOFF ARM	0110 0010	S-II	3	T3 + TBD
TBD	S-II LH2 DEPLETION SENSORS CUTOFF ARM	0101 1110	S-II	42	T3 + TBD
00:09:37.7	S-II ENGINES CUTOFF NO. 1 ON	0011 0011	S-II	18	T4 - .2

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NOMINAL FLIGHT TIME HR MIN SEC	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS
	CODE	STAGE	CHN		
00:09:37.8	S-II ENGINES CUTOFF NO. 2 6N	0100 0100 S-II	98	T4 -01	

NOMINAL FLIGHT TIME HR MIN SEC	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS
		CODE	STAGE	CHN	
00:09:37.9	START OF TIME BASE NO. 4 (T4)				T4 + .0
00:09:38.0	S-II ENGINES CUTOFF NO. 1 ON	0011 0011	S-II	18	T4 + .1
00:09:38.1	S-II ENGINES CUTOFF NO. 2 ON	0100 0100	S-II	98	T4 + .2
00:09:38.2	S-II SEPARATION AND RETRO ORDNANCE ARM NO. 1	0011 1111	S-II	8	T4 + .3
00:09:38.3	S-II SEPARATION AND RETRO ORDNANCE ARM NO. 2	0011 0101	S-II	92	T4 + .4
00:09:39.9	S-II/SWS SEPARATION ON NO. 1	0000 0010	S-II	5	T4 + 2.0
00:09:40.0	S-II/SWS SEPARATION ON NO. 2	0011 1011	S-II	95	T4 + 2.1
00:09:42.9	AM SEQUENTIAL BUSES PRIMARY ON	0101 1100	SWS	88	T4 + 5.0
00:09:43.1	AM SEQUENTIAL BUSES SECONDARY ON	0000 1111	SWS	39	T4 + 5.2
00:09:45.9	RS RADIATOR PROTECTIVE SHIELD JETTISON	0100 0101	SWS	108	T4 + 8.0
00:09:49.9	RS RADIATOR PROTECTIVE SHIELD RESET	0001 0101	SWS	109	T4 + 12.0
00:09:57.9	RS PRIMARY LOOP ENABLE	0111 0101	SWS	106	T4 + 20.0
00:09:59.4	RS SECONDARY LOOP ENABLE	0111 0001	SWS	50	T4 + 21.5
00:10:07.9	PCS WASTE TANK VENT PRIMARY OPEN ON	0111 0100	SWS	54	T4 + 30.0

NOMINAL FLIGHT TIME HR MIN SEC	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS
		CODE	STAGE	CHN	
00:10:08.1	PCS WASTE TANK VENT SECONDARY OPEN ON	0111 1111	SWS	1	T4 + 30.2
00:10:08.3	PCS HABITATION AREA VENT VALVE OPEN	0000 0010	SWS	5	T4 + 30.4
00:10:08.5	PCS HABITATION AREA LATCHING VENT VALVE OPEN ON	0011 1001	SWS	58	T4 + 30.6
00:11:07.9	PCS WASTE TANK VENT PRIMARY OPEN OFF	0110 0100	SWS	55	T4 + 30.0
00:11:08.1	PCS WASTE TANK VENT SECONDARY OPEN OFF	0101 1111	SWS	2	T4 + 30.2
00:13:01.3	PAYLOAD SHROUD ENABLE 1	0000 1001	SWS	87	T4 + 203.4
00:13:01.5	PAYLOAD SHROUD ENABLE 2	0101 1110	SWS	42	T4 + 203.6
00:13:01.7	PAYLOAD SHROUD LATCH CHARGE 1	0101 0111	SWS	86	T4 + 203.8
00:13:01.9	PAYLOAD SHROUD LATCH CHARGE 2	0100 1110	SWS	41	T4 + 204.0
00:13:04.7	PAYLOAD SHROUD LATCH TRIGGER 1	0110 1001	SWS	83	T4 + 209.0
00:13:04.9	PAYLOAD SHROUD LATCH TRIGGER 2	0011 0001	SWS	38	T4 + 209.2
00:15:22.9	AM DEPLOY BUSES ON	0010 1100	SWS	48	T4 + 345.0
00:16:07.9	ATM DA ENABLE	0101 1001	SWS	84	T4 + 390.0
00:16:08.9	ATM DA LATCH RELEASE CHARGE	0001 1001	SWS	68	T4 + 391.0
00:16:11.9	ATM DA LATCH RELEASE TRIGGER 1	0110 0111	SWS	85	T4 + 394.0

NOMINAL FLIGHT TIME HR MIN SEC	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS
		CODE	STAGE	CHN	
00:16:12.1	ATM DA LATCH RELEASE TRIGGER 2	0010 1111	SWS	40	T4 + 394.2
00:16:21.9	ATM DA MOTOR CONTROL ON	0010 1011	SWS	73	T4 + 404.0
00:16:57.9	ATM DA RESET 1	0010 0111	SWS	90	T4 + 440.0
00:16:58.1	ATM DA RESET 2	0111 1110	SWS	43	T4 + 440.2
00:20:02.9	ATM C.B.R.M. ALL ON	0100 0010	SWS	45	T4 + 625.0
00:24:37.9	PCS HABITATION AREA LATCHING VENT VALVE OPEN OFF	0110 1011	SWS	59	T4 + 900.0
00:24:38.1	ATM EBW SYSTEM A ARM	0110 1100	SWS	70	T4 + 900.2
00:24:41.1	ATM EBW SYSTEM A FIRE	0111 1011	SWS	72	T4 + 903.2
00:24:42.1	ATM EBW SYSTEM B ARM	0011 1101	SWS	25	T4 + 904.2
00:24:45.1	ATM EBW SYSTEM B FIRE	0101 1101	SWS	27	T4 + 907.2
00:24:57.9	ATM APCS ON (PRIMARY)	0111 1010	SWS	80	T4 + 920.0
00:24:58.9	ATM APCS ON (SECONDARY)	0001 1110	SWS	35	T4 + 921.0
00:25:14.9	ATM SOLAR WINGS 1 AND 3 DEPLOY (PRIMARY)	0000 0100	SWS	74	T4 + 937.0
00:25:15.1	ATM SOLAR WINGS 1 AND 3 DEPLOY (SECONDARY)	0011 1100	SWS	29	T4 + 937.2
00:25:24.9	ATM SOLAR WINGS 2 AND 4 DEPLOY (PRIMARY)	0100 0110	SWS	76	T4 + 947.0

NOMINAL FLIGHT TIME HR MIN SEC	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS
		CODE	STAGE	CHN	
00:25:25.1	ATM SOLAR WINGS 2 AND 4 DEPLOY (SECONDARY)	0010 0011	SWS	31	T4 + 947.2
00:36:37.9	ATM TELEMETRY 0N (PRIMARY)	0001 0110	SWS	82	T4 + 1620.0
00:36:38.1	ATM TELEMETRY 0N (SECONDARY)	0000 0001	SWS	37	T4 + 1620.2
00:36:54.9	ATM EBW SYSTEM A ARM AND SOLAR WINGS DEPLOY RESET NO. 2 (PRIMARY)	0001 0100	SWS	75	T4 + 1637.0
00:36:55.1	ATM EBW SYSTEM A ARM AND SOLAR WINGS DEPLOY RESET NO. 2 (SECONDARY)	0000 0011	SWS	30	T4 + 1637.2
00:37:04.9	ATM EBW SYSTEM B ARM AND SOLAR WINGS DEPLOY RESET NO. 1 (PRIMARY)	0110 0110	SWS	77	T4 + 1647.0
00:37:05.1	ATM EBW SYSTEM B ARM AND SOLAR WINGS DEPLOY RESET NO. 1 (SECONDARY)	0100 0011	SWS	32	T4 + 1647.2
00:39:17.9	PCS HABITATION AREA VENT VALVE CLOSE	0010 1101	SWS	6	T4 + 1780.0
00:41:59.9	SAS, FAIRINGS EBW FU 2 CHARGE	0001 0011	SWS	9	T4 + 1942.0
00:42:04.9	SAS, FAIRINGS EBW FU 2 FIRE	0010 0001	SWS	53	T4 + 1947.0
00:42:09.9	SAS, FAIRINGS EBW FU 2 RESET	0110 0011	SWS	10	T4 + 1952.0

NOMINAL FLIGHT TIME HR MIN SEC	COMMAND	SWITCH SELECTOR			TIME FROM BASE SEC9ND5
		CODE	STAGE	CHN	
00:49:59.9	SAS, WINGS EBW FU 2 CHARGE	0111 0011	SWS	11	T4 + 2422.0
00:50:04.9	SAS, WINGS EBW FU 2 FIRE	0000 1110	SWS	51	T4 + 2427.0
00:50:09.9	SAS, WINGS EBW FU 2 RESET	0100 1101	SWS	12	T4 + 2432.0
00:53:18.5	ATM THERMAL SYSTEM 0N (PRIMARY)	0111 0110	SWS	78	T4 + 2620.6
00:53:18.7	ATM THERMAL SYSTEM 0N (SECONDARY)	0001 1100	SWS	33	T4 + 2620.8
01:35:47.9	METEOROID SHIELD EBW FU 2 CHARGE	0101 0010	SWS	19	T4 + 5170.0
01:35:52.9	METEOROID SHIELD EBW FU 2 FIRE	0001 1111	SWS	17	T4 + 5175.0
01:35:57.9	METEOROID SHIELD EBW FU 2 RESET	0011 0011	SWS	18	T4 + 5180.0
01:39:37.9	AM DEPLOY BUSES OFF	0010 0010	SWS	23	T4 + 5400.0
03:09:37.9	PCS PNEUMATIC DUMP VALVE OPEN	0001 1101	SWS	7	T4 + 10800.0
04:39:59.2	TACS, COMMAND TRANSFER ENABLE NO. 1A 0N	0011 1010	SWS	64	T4 + 16221.3
04:39:59.4	TACS, COMMAND TRANSFER ENABLE NO. 1B 0N	0110 1111	SWS	15	T4 + 16221.5
04:39:59.6	TACS, COMMAND TRANSFER ENABLE NO. 2A 0N	0100 1010	SWS	62	T4 + 16221.7
04:39:59.8	TACS, COMMAND TRANSFER ENABLE NO. 2B 0N	0111 0010	SWS	13	T4 + 16221.9
04:40:00.0	TACS COMMAND TRANSFER 1 IU TO ATM	0011 0100	SWS	110	T4 + 16222.1

NOMINAL FLIGHT TIME HR MIN SEC	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS
		CODE	STAGE	CHN	
04:40:00.2	TACS COMMAND TRANSFER 2 IV TO ATM	0000 1100	SWS	49	T4 + 16222.3
04:40:00.4	TACS, COMMAND TRANSFER ENABLE NO. 1A OFF	0010 1010	SWS	65	T4 + 16222.5
04:40:00.6	TACS, COMMAND TRANSFER ENABLE NO. 1B OFF	0001 0001	SWS	16	T4 + 16222.7
04:40:00.8	TACS, COMMAND TRANSFER ENABLE NO. 2A OFF	0000 0111	SWS	63	T4 + 16222.9
04:40:01.0	TACS, COMMAND TRANSFER ENABLE NO. 2B OFF	0000 1101	SWS	14	T4 + 16223.1
06:54:37.9	PCS PNEUMATIC DUMP VALVE CLOSE	0011 1111	SWS	8	T4 + 24300.0
TBD	SWS SWITCH SELECTOR INHIBIT A	0011 1100	IU	29	T4 + TBD
TBD	SWS SWITCH SELECTOR INHIBIT B	0100 0110	IU	76	T4 + TBD

NOMINAL FLIGHT TIME HR MIN SEC	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS
		CODE	STAGE	CHN	
VARIABLE	START OF TIME BASE NO. 4A (T4A)				T4A + 0.0
VARIABLE	PAYLOAD SHROUD THRUSTING JOINT CHARGE 1	0000 0101	SWS	81	T4A + 0.2
VARIABLE	PAYLOAD SHROUD THRUSTING JOINT TRIGGER 1	0110 1010	SWS	79	T4A + 1.7
VARIABLE	PAYLOAD SHROUD THRUSTING JOINT CHARGE 2	0011 1110	SWS	36	T4A + 1.9
VARIABLE	PAYLOAD SHROUD THRUSTING JOINT TRIGGER 2	0100 1111	SWS	34	T4A + 3.4
VARIABLE	PAYLOAD SHROUD RESET 1	0100 0111	SWS	89	T4A + 4.4
VARIABLE	PAYLOAD SHROUD RESET 2	0111 1100	SWS	28	T4A + 4.6

NOMINAL FLIGHT TIME HR MIN SEC	COMMAND	SWITCH SELECTOR			— TIME FROM BASE SECONDS
		CODE	STAGE	CHN	
VARIABLE	START ALTERNATE SEQUENCE - T4B				T4B + 0.0
VARIABLE	TACS, COMMAND TRANSFER ENABLE NO. 1A ON	0011 1010	SWS	64	T4B + 10.0
VARIABLE	TACS, COMMAND TRANSFER ENABLE NO. 1B ON	0110 1111	SWS	15	T4B + 10.2
VARIABLE	TACS, COMMAND TRANSFER ENABLE NO. 2A ON	0100 1010	SWS	62	T4B + 11.2
VARIABLE	TACS, COMMAND TRANSFER ENABLE NO. 2B ON	0111 0010	SWS	13	T4B + 11.4
VARIABLE	TACS COMMAND TRANSFER 1 IU TO ATM	0011 0100	SWS	110	T4B + 11.6
VARIABLE	TACS COMMAND TRANSFER 2 IU TO ATM	0000 1100	SWS	49	T4B + 11.8
VARIABLE	TACS, COMMAND TRANSFER ENABLE NO. 1A OFF	0010 1010	SWS	65	T4B + 12.0
VARIABLE	TACS, COMMAND TRANSFER ENABLE NO. 1B OFF	0001 0001	SWS	16	T4B + 12.2
VARIABLE	TACS, COMMAND TRANSFER ENABLE NO. 2A OFF	0000 0111	SWS	63	T4B + 12.4
VARIABLE	TACS, COMMAND TRANSFER ENABLE NO. 2B OFF	0000 1101	SWS	14	T4B + 12.6

NOMINAL FLIGHT TIME HR MIN SEC	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS
		CODE	STAGE	CHN	
	SPECIAL SEQUENCE FOR ORBITAL VEHICLE TELEMETRY CALIBRATION (SEE PARA. II H, SUBPARA. a.)				
VARIABLE	TELEMETRY CALIBRATOR IN-FLIGHT CALIBRATE ON	0010 0010	I U	23	ACQ + 50.0
VARIABLE	TELEMETRY CALIBRATOR IN-FLIGHT CALIBRATE OFF	0001 0010	I U	24	ACQ + 65.0
	SPECIAL SEQUENCE FOR S-II P.U. SYSTEM MIXTURE RATIO SHIFT (SEE PARA. II H, SUBPARA. b.)				
VARIABLE	LOW (4.8) ENGINE MIXTURE RATIO NO. 1 ON	0101 0100	S-II	56	T3 + TBD
VARIABLE	LOW (4.8) ENGINE MIXTURE RATIO NO. 2 ON	0101 1011	S-II	60	T3 + TBD

NOMINAL FLIGHT TIME HR MIN SEC	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS
		CODE	STAGE	CHN	
	SPECIAL SEQUENCE FOR WATER COOLANT VALVE SWITCHING (SEE PARA. II H, SUBPARA. c.)				
VARIABLE	WATER COOLANT VALVE OPEN	0110 0101	IU	107	VARIABLE
VARIABLE	WATER COOLANT VALVE CLOSED	0100 0101	IU	108	VARIABLE
	SPECIAL SEQUENCE FOR S-II INBOARD ENGINE CUTOFF (SEE PARA. II H, SUBPARA. d.)				NOMINAL
VARIABLE	S-II INBOARD ENGINE CUTOFF	0110 1111	S-II	15 T3	+ 141.0

VIII. SWITCH SELECTOR CHANNELS WIRED IN
VEHICLE BUT NOT PROGRAMMED FOR USE
DURING FLIGHT

NOMINAL FLIGHT TIME HR MIN SEC	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS
		CODE	STAGE	CHN	
	ENGINE MIXTURE RATIO CHECKOUT NO. 1	0100 0011	S-II	32	
	ENGINE MIXTURE RATIO CHECKOUT NO. 2	0010 0100	S-II	61	
	SAFING STAGE CHECKOUT ENABLE NO. 1	0101 1010	S-II	100	
	SAFING STAGE CHECKOUT ENABLE RELAYS RESET	0011 0110	S-II	101	
	SAFING TIMER NO. 1 ENABLE	0010 0110	S-II	102	
	SAFING TIMER NO. 2 ENABLE	0111 1001	S-II	103	
	SAFING TIMER NO. 3 ENABLE	0111 0101	S-II	106	
	SAFING SOLENOID VALVE LOGIC NO. 1 DISABLE	0110 0101	S-II	107	
	SAFING SOLENOID VALVE LOGIC NO. 2 DISABLE	0100 0101	S-II	108	
	SAFING SOLENOID VALVE LOGIC NO. 3 DISABLE	0001 0101	S-II	109	
	SAFING ORDNANCE LOGIC NO. 1 DISABLE	0011 0100	S-II	110	
	SAFING ORDNANCE LOGIC NO. 2 DISABLE	0000 1010	S-II	111	
	SAFING ORDNANCE LOGIC NO. 3 DISABLE	0100 1011	S-II	112	
	FLIGHT CONTROL COMPUTER SWITCH POINT NO. 6	0000 0010	IU	5	
	FLIGHT CONTROL COMPUTER SWITCH POINT NO. 7	0001 1101	IU	7	

NOMINAL FLIGHT TIME HR MIN SEC	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS
		CODE	STAGE	CHN	
	----- EXCESS RATE (P,Y,R) AUTO-ABORT INHIBIT ENABLE RESET	0111 0010	IU	13	
	AUTO-ABORT ENABLE RELAYS RESET	0001 0001	IU	16	
	RATE MEASUREMENTS SWITCH	0001 1111	IU	17	
	EXCESS RATE (ROLL) AUTO-ABORT INHIBIT RESET	0110 1110	IU	20	
	FLIGHT CONTROL COMPUTER SWITCH POINT NO. 9	0101 1101	IU	27	
	EXCESS RATE (ROLL) AUTO-ABORT INHIBIT ENABLE	0100 1111	IU	34	
	FLIGHT CONTROL COMPUTER SWITCH POINT NO. 8 ENABLE	0000 0001	IU	37	
	EXCESS RATE (P,Y,R) AUTO-ABORT INHIBIT RESET	0100 1110	IU	41	
	EXCESS RATE (ROLL) AUTO-ABORT INHIBIT ENABLE RESET	0101 1110	IU	42	
	FLIGHT CONTROL COMPUTER SWITCH POINT NO. 5	0011 0010	IU	44	
	EXCESS RATE (ROLL) AUTO-ABORT INHIBIT AND SWITCH RATE GYRO SC INDICATION 'B'	0111 0001	IU	50	

NOMINAL FLIGHT TIME HR MIN SEC	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS
		CODE	STAGE	CHN	
	C-BAND TRANSPONDERS NO. 1 AND NO. 2 ON	0111 0100	IU	54	
	C-BAND TRANSPONDER NO. 1 OFF	0110 0100	IU	55	
	C-BAND TRANSPONDER NO. 2 OFF	0101 0100	IU	56	
	CCS TRANSMITTER INHIBIT ON	0011 1001	IU	58	
	CCS TRANSMITTER INHIBIT RESET	0110 1011	IU	59	
	FLIGHT CONTROL COMPUTER POWER OFF A	0101 1011	IU	60	
	FLIGHT CONTROL COMPUTER POWER OFF B	0010 0100	IU	61	
	CCS TM SUBCARRIER OSCILLATOR INHIBIT	0100 1010	IU	62	
	CCS TM SUBCARRIER OSCILLATOR INHIBIT RESET	0011 0111	IU	67	
	COOLANT PUMP NO. 1 ON AND PRESSURE SWITCH DEACTIVATE	0111 1011	IU	72	
	PRESSURE SWITCH ACTIVATE AND COOLANT PUMP NO. 1 ON RELAY RESET	0010 1011	IU	73	
	S-IC OUTBOARD ENGINES CANT OFF C	0000 1001	IU	87	
	AM SEQUENTIAL BUSES OFF	0111 1101	SWS	26	

NOMINAL FLIGHT TIME HR MIN SEC	COMMAND	SWITCH SELECTOR			TIME FROM BASE SECONDS
		CODE	STAGE	CHN	
	MDA VENT VALVE 2 OPEN ENABLE	0110 1101	SWS	47	
	PCS HABITATION AREA LATCHING VENT VALVE LATCH ON	0101 1011	SWS	60	
	PCS HABITATION AREA LATCHING VENT VALVE LATCH OFF	0010 0100	SWS	61	
	MDA VENT VALVE 1 OPEN ENABLE	0100 1011	SWS	112	