2-237. SUBPROGRAM U54 (MTDATA). MTDATA reads the required data from the Missile Trajectory (M/T) tape B7 and puts it on tape A5, or, when in TAA or MSS modes, puts the required data for one target in the appropriate Common locations. Tape A5 records include seven identity words including four or five blank words, as found on tape B7. These seven words precede the data words. Four or five are blank depending on whether the data is azimuth limits and delta matrices or missiles and M constants, respectively. The FORTRAN II reference statement is CALL MTDATA.

a. Inputs. The inputs are M/T data on tape B7 and the following:

COMMON TAG	DIMENSION	ITEM
AIPR(64)		Number of needed records per data type decrement - No. of missile models address - No. of complex-launcher combinations
GCMOD-GCMOD-{9}	10	Identification of missile data required for one to ten targets
GCAZL-GCAZL-{9}	10	Identification of azimuth limits data for one to ten targets
GCMC-GCMC-{9}	10	Identification of M constant data for one to ten targets
GCDM-GCDM-{9}	10	Identification of delta matrix data for one to ten targets
SW(77)		TAA Mode Indicator
SW(79)		SIM Mode Indicator

b. Outputs. The outputs are as follows:

A tape generated on unit A5 (in other than TAA or MSS modes) containing data for one to ten targets in each of four files. These four files contain missile data, azimuth limits data, M constants, and delta matrices, respectively.

In TAA and MSS modes, Common locations set in core for one target:

COMMON TAG	DIMENSION	ITEM
FKLMD-GFRRU	392	
VCOG-VBSCD	814	Missile data tables
GTAUC	20,11,1	
PAZLM	22	Azimuth limits table
XM	2,	M constants table
TLZTH-INRNG	2,6	Delta matrix tables
PMWID	2	Missile identification words
PAZID	3	Azimuth limits identification words
PMCID	2	M constant identification words
PDMID	3	Delta matrix identification words

In case of error in either mode, the following printed and written statements are also outputs:

a. REQUIRED (MISSL, AZLIM, M-CØN, or MATRX) DATA NØT ØN TAPE - IMPØSSIBLE TØ PRØCEED

b. ERRØR READING TAPE B7 AFTER 10 TRIES

c. Program Logic. FD U54

(1) Steps 1-2. Index registers are saved and SW(70), SW(120), parity, and end-of-file indicators are set ØFF. SW(77) and SW(79) are tested to see if operation is in TAA or MSS modes. If either switch is ØN, control is transferred to step 56.

(2) Steps 3-6. The number in the decrement of AIPR-64 is used to determine the number of missile records required. Step 97 is set to read missile data, and the end-of-file transfer (step 114) is set to transfer to the processing of the next type of data when missile data is completed. Control is then transferred to step 97.

(3) Steps 7-10. If the end-of-file indicator is on at this point, the required data is not on tape. U08 prints and writes statement a (modified for missile data). ITYER is set to two, and control is transferred to step 104.

(4) Steps 11-13. The checksum of the missile record now in core is computed and compared with the checksum from tape. If they do not agree, ITYER is set to one and control is transferred to step 104.

(5) Steps 14-16. The identification of the record from tape is compared with the identification of the required missile data. If no match is found, control is transferred to step 6, to read the next record from the file. When a match is found, WRTTP writes the record on output tape A5, and control is transferred to step 107 to

check the success of the writing and to see if the required number of records have been written. (If more records are required, the return is made to step 6 to read another record, otherwise, the return is made to step 17.)

(6) Step 17. An end-of-file is written after the missile data on tape A5.

(7) Steps 18-32. These steps repeat steps 3-17, processing azimuth data instead of missile data, and blanking the launcher digit of GCAZL before comparison, if this digit is blank, for handover, in the tape identification record.

(8) Steps 33-41. These steps repeat steps 3-15, processing M constant data, instead of missile data. The read command (step 97) needs no modification from its setting for the previous azimuth data.

(9) Step 42. If an error occurred in WRTTP, control is transferred to step 105 to set IFLAG and exit. Otherwise control is transferred to step 111 to bypass rest of the M constant file, after writing only one required record. Return is then made to step 43.

(10) Step 43. An end-of-file is written after the M constant data on tape A5.

(11) Steps 44-55. These steps repeat steps 3-17, processing delta matrix data, rather than missile data.

Control is then transferred to step 106 to restore contents of index registers and exit to user subprogram.

(12) Steps 56-57. In the TAA or MSS mode, missile data is not written on tape A5, but all the data for the first target only is stored in Common. Therefore the I-Ø command in step 97 is now set to read the missile data directly into the appropriate Common registers. The read routine is set to return from step 99 and control is then transferred to step 97 to read a record.

(13) Steps 58-59. If the end-of-file indicator is on at this point, missing data is indicated, U08 prints and writes statement a (modified for missile data), ITYER is set to two, and control is transferred to step 104.

(14) Steps 60-61. The checksum of the missile record now in core is computed, adding the blank identity words, and compared with the checksum from tape. If they do not agree, ITYER is set to one and control is transferred to step 104.

(15) Steps 62-66. The identification of the record from tape is compared with the identification of the required missile data. If no match is found, control is transferred to step 57 to read the next record from the file. If a match is found, the missile identification words are stored in Common registers and the remainder of the tape file is skipped.

(16) Steps 67-77. These steps repeat steps 55-65, processing azimuth data instead of missile data. However, for handover targets, the launcher digit in GCAZL is blanked to enable comparison with PAZID-2.

(17) Steps 78-88. These steps repeat steps 55-66, processing M constant data instead of missile data.

(18) Steps 89-96. These steps repeat steps 55-63, processing delta matrices instead of missile data. The remainder of the file is not skipped. After storage of the identification words of the required record, control is transferred to step 106 to restore contents of indes registers and exit.

(19) Steps 97-106. This is the read tape routine. If a redundancy persists after ten attempts to read a record, U08 prints and writes statement b, ITYER is set to eight, SW(70) is set ØN, IFLAG is set to the identification integer 2154, the contents of the index registers are restored, and the subprogram exits to the user subprogram. If the read is successful, control is transferred to steps 7, 22, 36, 48, 58, 66, 69, 77, 80, 88, or 91 to continue processing the appropriate file.

(20) Steps 107-114. If an error occurred in WRTTP, control is transferred to step 105 to set IFLAG and exit. Otherwise, the count of the number of required records to be written is incremented and checked. If more are to be written, control is transferred to step 6, 21, or 47 to

read additional missile, azimuth, or delta matrix records. If the required records have been written, the remainder of the file is skipped and control is transferred to steps 17, 32, 43, or 55 to write an end-of-file and continue.

2-238. SUBPROGRAM U06 (RIDATA). RIDATA reads and stores the required data from the radar-launcher (R/L) tape B8 according to mode of operation. The FORTRAN II reference statement is CALL RIDATA.

a. Inputs. The inputs are R/L data on tape B8. The following are also inputs:

COMMON TAG	DIMENSION	ITEM
GCRDR	4	Radar identification
GCHPD	10	Identification of launcher data for 10 targets
SW(77)		TAA mode indicator
SW(79)		SIM mode indicator

b. Outputs. The outputs are as follows:

(1) A tape generated on unit A5 (in other than TAA or MSS modes) containing two files. The first file will contain one record of radar data and G constants. The second file may contain from one to 10 records of launcher data.

(2) In TAA and MSS modes, Common Areas set in core for one target:

COMMON TAG	DIMENSION	ITEM
XGI	2,24	G constants table
PRRCN-PREFF	39	Radar table
PLWR-PLEFF	31	Launcher table

COMMON TAG	DIMENSION	ITEM
PRWID	7	Radar identification words
PLWID	3	Launcher identification words

(3) The following statements are also outputs:

a. TEN RTCS ENCOUNTERED WHILE ATTEMPTING TO READ A RECORD FROM TAPE UNIT B8. RERUN, USING A NEW TAPE UNIT.

b. TEN RTCS ENCOUNTERED WHILE ATTEMPTING TO WRITE A RECORD ON TAPE UNIT A5. RERUN, USING A NEW TAPE AND/OR TAPE UNIT.

c. LAUNCHER _____ NOT ON R/L TAPE. UNABLE TO PROCEED

d. GRAVITATIONAL COMPONENT FOR LAUNCHER _____ NOT ON R/L TAPE. UNABLE TO PROCEED.

e. RADAR _____ NOT ON R/L TAPE. UNABLE TO PROCEED

c. Program Logic. FD U06

(1) Steps 1-5. The index registers are saved and the work area is cleared. Tape B8 is rewound and IFLAG is set to the identification integer 2106. The desired squadron and complex in GCRDR are determined and a table of required launchers is set up of the different launchers found in GCHPD through GCHPD-9.

(2) Steps 6-8. Redundancy and end-of-file indicators are turned ØFF, and one radar record is read. If a redundancy exists, the subprogram re-reads the record by continuing at step 9. Otherwise control is transferred to step 15.

(3) Steps 9-14. The number of attempts to read the

record is counted. A maximum of 10 attempts is made, after which U08 prints and writes statement a, the error indicator SW(70) is set ØN, and ITYER is set to 8. Control is transferred to step 74.

(4) Steps 15-23. If an end-of-file was reached, control is transferred to step 24. Otherwise the checksum of the record just read is compared with the checksum from tape. If the values do not agree, SW(70) is set ØN in step 18, ITYER is set to one, and control is transferred to step 74. If the values agree, the counter for redundancy attempts is set to zero, and tape record is examined to see if the radar from this squadron is needed. If the radar is not needed, control is transferred to step 6 to read the next record. If the radar is needed, the gravitational anomalies are saved in work tables PVC and MC. The tape record is examined to see if it contains the required complex. If yes, this record is stored in PREFF-6 through PRRCN. Control is transferred to step 6.

(5) Steps 24-40. The first end-of-file has been reached. If the required radar has not been found, U08 prints and writes statement e, SW(70) is set ØN, ITYER is set to 9, and control is transferred to step 74. If the required radar has been found, the redundancy and end-of-file indicators are turned ØFF in step 25, and a launcher record is read. If a redundancy is indicated, the subprogram re-reads the record a maximum of 10 times by repeating steps 9 through 14. If

there is no redundancy, a check is made for a second end-of-file. If a second end-of-file has been reached, control is transferred to step 75. If not, the launcher checksum is compared with the checksum from tape. If the values do not agree, control is transferred to step 18. If the values agree, the counter for redundancy attempts is set to zero. If the launcher required for computing G constants has been previously determined, control is transferred to step 56. Otherwise the record just read is checked for the required launcher. If the last record read does not contain the required launcher, successive records are read until the required record is obtained. If the last record read contains the required launcher, tape B8 is backspaced to the first end-of-file mark. Steps 34 and 75 are modified to indicate that the required launcher was found. Modifying step 34 transfers control to step 56 during the second pass of launcher data. Modifying step 75 prevents printing and writing error statement c. The XGI area for G constants is cleared and GCØNST computes and stores the G constants.

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(6) Steps 41-55. For operation in the TAA or MSS mode (SW(77) or SW(79) = ØN), steps 56, 66, and 79 are modified. The read-in area for launchers in the second pass for TAA or MSS operation overlaps the XGI blocks. This overlap requires saving the first G constants. Control is returned to step 25 to start the second pass. If operation is not in the TAA or MSS mode, the checksum for the combined radar and G constant data is computed and stored. The new record is written on

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tape A5. If a redundancy is indicated, the subprogram rereads the record for a maximum of 10 times, after which U08 prints and writes statement b, the error indicator SW(70) is set ØN, and ITYER is set to 8. Control is transferred to step 74.

(7) Steps 56-59. Since tape B8 was backspaced in step 36 after the required record was found, the tape is now going through a second pass. During this pass, each record is compared with the launcher data table set up in step 5. If the record does not contain a desired launcher, the subprogram returns to step 25 to read another record. If the record contains a desired launcher, set the corresponding entry in the launcher data table to zero to indicate that the desired launcher was found. This record will later be written on tape A5 if operation is not in the TAA or MSS mode.

(8) Steps 60-65. The MC table set up in step 21 is examined for the gravitational component corresponding to the desired launcher. If no value is found, U08 prints and writes statement d, SW(70) is set ØN, ITYER is set to 3, and control is transferred to step 74. If a value is found, it is stored in the launcher block. The PVC table is examined in the same manner. If both MC and PVC components are found, the subprogram continues at the next step.

(9) Steps 66-74. For operation in the TAA or MSS mode, the launcher data is stored in core. The first four G constants are restored in core. GCØNST computes and stores the

G constants in the XGI block. The subprogram continues at step 74. If operation is not in the TAA or MSS mode, the launcher checksum is computed and stored. The launcher record is written on tape A5. If a redundancy is indicated, the subprogram re-reads the record a maximum of 10 times by repeating steps 50 through 55.

(10) Step 74. The contents of the index registers are restored and the subprogram exits to the user subprogram.

(11) Steps 75-81. This step is entered from step 30 if the desired launcher has not been found on the first pass or if the desired launcher has been found and a second pass has been made. If step 75 is not modified, the desired launcher has not been found. U08 prints and writes statement c, SW(70) is set ØN, ITYER is set to 9, and control is transferred to step 74. If step 75 is modified, this is the second pass. If this is not the end-of-file also, the subprogram returns to step 27 to read another record. If this is the end-of-file in the TAA or MSS mode, end-of-file is written on tape A5 and the subprogram continues at step 74. For end-of-file not in the TAA or MSS mode, a check is made to determine if all launchers were found. If all launchers were found, end-of-file is written on tape A5. Otherwise statement c is printed, SW(70) and ITYER are set and control is transferred to step 74 as above.

2-239. SUBPROGRAM U44 (TAMSID). TAMSID writes the radar, launcher, missile, and target identification for TAA and SIM modes of operation. The FORTRAN II reference statement is CALL TAMSID.

a. Inputs. The inputs are as follows:

COMMON TAG	DIMENSION	ITEM
PLWID	3	Launcher identification and date
PRWID	7	Radar identification and date
PMWID	2	Missile identification and date
PDMID	3	Delta matrix identification and date
PAZID	3	Azimuth limits identification and date
PMCID	2	M constant identification and date
UMDAT	4,1	MET data date period on tape indicator
SW(77)	1	If ØN, TAA mode of operation requested

b. Outputs. The outputs are the following written statements identifying the launcher, the radar, the missile model, the azimuth limits, missile constants, delta matrix and meteorological data used for this TAA or SIM run:

		MOD	FOR	DATE
a.				
b.	LAUNCHER (MLSDS)		XXL	DDMMMYY
c.	RADAR (MLSDS)		XXX-R	DDMMMYY

d.	AZIMUTH COORDINATE (A)		XXX-R	DDMMMYY
e.	AZIMUTH COORDINATE (B)		XXX-R	DDMMMYY
f.	RANGE COORDINATE (A)		XXX-R	DDMMMYY
g.	RANGE COORDINATE (B)		XXX-R	DDMMMYY
h.	MISSILE MODEL	ZZZ		DDMMMYY
i.	DELTA MATRIX	ZZZ	XXX	DDMMMYY
j.	AZIMUTH LIMITS		XXXLRN	DDMMMYY
k.	M-CONSTANTS		XXX	DDMMMYY
l.	MET DATA	STANDARD CLIMATOLOGY		
m.	MET DATA	ANNUAL AVERAGE		

where

XXX = Squadron, L = Launcher complex, R = Radar complex, N = Launcher number, ZZZ = Missile model, and DD = Day, MMM = Month and YY = Year of the date.

c. Program Logic. FD U44

(1) Steps 1-3. The launcher squadron, complex, and effective date located in PLWID are initialized for output statement b. SW(120) is set ØFF so that all statements are written off line. U08 writes statements a and b.

(2) Steps 4-5. The radar squadron and complex located in PRWID are initialized for output statements c, d, e, f, and g. The dates for the radar, monolithic azimuth (A), monolithic azimuth (B), range coordinate (A) and range coordinate (B) located in PRWID-1 to PRWID-6 are initialized for the corresponding output statements c, d,

Changed 15 July 1962

e, f, and g. U08 writes these statements.

(3) Steps 6-9. The missile model number and effective date located in PMWID are initialized for output statement h which is written by U08. The delta matrix squadron, missile model number, and effective date located in PDMID are initialized for output statement i which is written by U08. The azimuth limits squadron complex, launcher complex, launcher number, and azimuth limits effective date located in PAZID are initialized for output statement j which is written by U08. The missile constants squadron and effective date located in PMCID are initialized for output statement k which is written by U08.

(4) Steps 10-13. SW(77) is tested. If ØN, operation is in the TAA mode and the subprogram returns to the user subprogram. If ØFF, UMDAT is tested. If ØN, U08 writes statement l. If not ØN, MET data is being used from tape, and U08 writes statement m. The subprogram then returns to the user subprogram.

2-240. C1 SUBPROGRAMS.

2-241. The subprograms described in this area are required during non-powered portions of basic missile flight simulations. This area also includes a few subprograms required only during the powered portions of basic missile flight simulation. The subprograms are as follows:

a.	ACCELR	C17	Total Missile Acceleration Computation Control
b.	CLØØP	P24	Closed Loop Flight Simulation Control (Powered Flight and ØLØØP Control)
c.	FLYER	C70	Position Integrator Control
d.	FSIMLC	P08	Flight Simulator Local (Missile Simulator)
e.	MATTIT	P21	Missile Attitude Integrator
f.	MØNTØR	P37	Monitor 25g and Peak Axial Deceleration Points During Re-entry
g.	ØLØØP	P44	Open-Loop Flight Simulation Control (Non-Powered Flight Only)
h.	PØLY	C72	Predictor-Corrector Integrator
i.	PRESET	P20	Flight Simulator Local Reset
j.	RK	C71	Runge-Kutta Integrator
k.	RSADD	D07	Additional Outputs for RSD Tape
l.	RSDØRE	P36	Store Trajectory Data on Tape for later Range Safety Data Extraction
m.	RSUØ	P84	Set up First and Last Addresses and Write Record
n.	WNDTRP	D56	Interpolate Meteorological Input Data for Current Missile Location

2-242. SUBPROGRAM C17 (ACCELR). ACCELR computes missile acceleration using gravity and motor thrust and aerodynamic drag when applicable. ACCELR also computes missile weight under certain conditions. The FORTRAN II reference statemen is CALL ACCELR.

a. Inputs. The inputs are as follows:

COMMON TAG	DIMENSION	ITEM	SYMBOL	UNITS
GAIR	2	Altitude above mean sea level of upper limit of atmosphere ($=3.0 \times 10^5$)	h_a	feet
ALTPR	1	Altitude of missile at start of previous integration	h_{SI}	feet
FDLT	2	Length of current integration interval	t_{CIi}	seconds
FMALT	2	Current missile altitude above earth ellipsoid	h'_m	feet
GPRM	2	m coefficients for pressure	h_M	pure no.
GDNM	2	m coefficient for density	h'_M	pure no.
GPØLY	2,5	β coefficients of pressure and density denominator polynomial		pure no.
GPRNC	2,5,6	a coefficients for pressure		pure no.
GDNNC	2,5,6	a coefficients for density		pure no.
GPRB	2,5	b coefficients for pressure		pure no.
GDNB	2,5	b coefficients for density		pure no.

The m coefficient is different for pressure and density, but each coefficient is constant for all altitudes. The β coefficients are the same for pressure and density computations and are constant over all altitudes. The (a) coefficients are different for pressure and density and vary with altitude. Six sets of coefficients are used for each of the pressure and density evaluations, each set selected according to one of six altitude bands defined by the (b) coefficients.

COMMON TAG	DIMENSION	ITEM	SYMBOL	UNITS
FQDNS	2	Current density deviation factor at missile	$P_{\rho dev}$	pure no.
FQPRS	2	Current pressure deviation factor at missile	P_{cdev}	pure no.
FSPPS	6	Current missile position vector	$\vec{r}_m$	feet
FRDUS	2	Current distance of missile from center of earth	r_m	feet
FRDSQ	2	Square of current missile distance from center of earth	r_m^2	feet
GRAVA	2	Gravitational parameter equal to radius of earth at equator of earth ellipsoid model (2.092601×10^7 feet)	r	feet
GRAVD	2	Gravitational parameter (0.0000107)	d	pure no.
GRAVJ	2	Gravitational parameter J oblateness constant (0.001638)	J	pure no.
FSPVL	2,3	Current missile velocity vector, single precision	$\vec{V}_m$	ft/sec
FSXI	2,3,5	Current, and past 4, single precision roll attitude vectors	$\vec{\xi}$	

Changed 31 October 1962

COMMON TAG	DIMENSION	ITEM	SYMBOL	UNITS
FTCA	2,33,1	Current missile parameter table: C_A vs Mach number	C_D vs M	
SW(54)	ØN	Booster shell impact point is to be determined		
VTCAB	2,33,1	C_A vs Mach number table, entire missile ensemble	C_{De}	
VTCPS	2,21	Center of pressure table vs Mach number alone, stage II missile ensemble	d'_{CP}	feet
GRAVZ	2	Gravitational parameter $g_o = \frac{GM}{r^2}$. Acceleration of gravity at equator of nonrotating ellipsoid earth model. M = mass of earth. r = earth radius at equator of earth ellipsoid model. G = universal g constant	g_o	ft/sec^2
FSGCL	2	Sine of current missile geocentric latitude	$\sin L_{CM}$	pure no.
FBSL	2,1	Booster thrust at sea level	F_{BSL}	pounds
FRTØD	2	Constant of conversion from radians to degrees (57.29578)		deg/rad
FMASS	2	Current mass of the missile	m	slugs
FCGR	2	Conversion constant: mass in slugs to weight at sea level in pounds force (= 32.174)		ft/sec^2
FTCG	2,24,1	Table of center of gravity and weight of missile		
VTCPB	2,17	Table of center of pressure and mach number, entire missile		
FCRØS	2	Cross sectional area S of the missile		$feet^2$

COMMON TAG	DIMENSION		SYMBOL	UNITS
FRCDR	2,51	Table of values - mach number vs C_D	C_{Dref}	
FRCDP	2,41	Table of values for altitude vs C_D	C'_D	
FRCDD	2,41	Table of values for altitude vs C_D	C''_D	
FRDCD	2,41	Table of values for altitude vs C_D	ΔC_D	
GRSPD	2	Re-entry speed	S_{RE}	ft/sec
GRNGL	2	Re-entry angle		radians
VABAR	2	Effective cross section area of re-entry vehicle for re-entry drag computation	S_{REV}	feet^2
VMBAR	2	Effective mass of re-entry vehicle for re-entry drag computation	M_{rVE}	slugs
VBSCD	2	Booster shell drag computation parameter	$\overline{C}_D \frac{\overline{A}}{M}$	ft^2/slug
FGALT	2	Current missile altitude above geoid (mean sea level)	h_m	feet
FKLMD	2,20,1	Coefficients for re-entry vehicle drag computations	k_{ij}, λ_{ij}, V_{ref}	
VCRØS	2,3	Effective cross section area, entire missile, stage I and stage II	S_e	feet^2
FSPPS	6	X,Y,Z coordinates giving missile position in the inertial earth-centered rectangular coordinate system	$\vec{r}_m$	feet
FSGCL	2	Sine of the angle of geocentric latitude of the missile	$\sin L_{CM}$	pure no.
FQNTH	2	North wind velocity in the vicinity of the missile	V_{NW}	ft/sec

COMMON TAG	DIMENSION	ITEM	SYMBOL	UNITS
FQEST	2	East wind velocity in the vicinity of the missile	V_{EW}	ft/sec
FXYPJ	2	X,Y projection of missile radius vector	r_{mxy}	feet
FRDUS	2	Missile radius vector	r_m	feet
FSPVL	6	Current velocity of the missile	V_m	ft/sec
GØMGA	2	Rate of rotation of the earth	Ω	rad/sec
GAMMA	2	Ratio of specific heats of atmosphere (1.4)	1.4	
FPN	2	Nominal sea level atmospheric pressure	P_{SL}	pounds/in^2
FSV	2,1	Sustainer thrust in vacuum	F_{SV}	pounds
FVB	2,1	Vernier thrust, bypass	F_{VB}	pounds
FVS	2,1	Vernier thrust, non-bypass (sustainer mode)	F_{VS}	pounds
FSRN	2,1	Total staging rocket thrust	F_{SR}	pounds
FK1	2,1	Booster thrust coefficient	K1	inches^2
FK2	2,1	Sustainer thrust coefficient	K2	inches^2
FTCN1	2,1	Booster thrust decay normalized integral $1/(t_4-t_2)\int_{t_2}^{t_4}\sigma_B dt$		pure no.
FTTWØ	2	Magnitude of total thrust at time t_2	F_{Tt2}	pounds
FISBU	2	Sustainer thrust build-up total impulse	F_I	lb-sec

COMMON TAG	DIMENSION	ITEM	SYMBOL	UNITS
FT42	2,1	$(t_4 - t_2)$		seconds
FT43	2,1	$(t_4 - t_3) = (t_4 - t_2) - (t_3 - t_2)$		seconds
FT54	2,1	$(t_5 - t_4) = (t_5 - t_2) - (t_4 - t_2)$		seconds
FT63	2,1	$(t_6 - t_3)$		seconds
FT64	2,1	$(t_6 - t_4) = (t_6 - t_3) - (t_4 - t_3)$		seconds
FT74	2,1	$(t_7 - t_4) = (t_7 - t_6)$		seconds
FT75	2,1	$(t_7 - t_5) = (t_7 - t_5)$		seconds
FT98	2,1	$(t_9 - t_8)$		seconds
LSEQ	1	Flight stage and sub-stage indicator for normal sequencing		positive integer
FWBG	2	Booster fuel flow rate	$\dot{F}_B$	slugs/ second
FWBL	2	Booster LOX flow rate	$\dot{L}_B$	slugs/ second
FWBSD	2	Booster thrust decay total propellant consumption	P_{BD}	slugs
FWLB	2	Stage II LOX bleed rate	$\dot{L}_{SBL}$	slugs/ second
FPRGL	2	Stage II gas generator bypass LOX flow rate	$\dot{L}_{ggb}$	slugs/ second
FPRGG	2	Stage II gas generator bypass fuel flow rate	$\dot{F}_{ggb}$	slugs/ second
FPSGL	2	Stage II gas generator non-bypass LOX flow rate	$\dot{L}_{ggnb}$	slugs/ second
FPSGG	2	Stage II gas generator non-bypass fuel flow rate	$\dot{F}_{ggnb}$	slugs/ second

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COMMON TAG	DIMENSION	ITEM	SYMBOL	UNITS
FWSRP	2	Staging rockets propellants	M_{SRP}	slugs
FWRC	2	Staging rockets cases	M_{SRC}	slugs
FPRSL	2	Sustainer thrust build-up total LOX consumption	L_{STB}	slugs
FPRSG	2	Sustainer thrust build-up total fuel consumption	F_{STB}	slugs
FPRFL	2	Stage II sustainer LOX flow rate	$\dot{L}_s$	slugs/second
FPRFG	2	Stage II sustainer fuel flow rate	$\dot{F}_s$	slugs/second
FPSSL	2	Sustainer thrust decay total LOX consumption	L_{STD}	slugs
FPSSG	2	Sustainer thrust decay total fuel consumption	F_{STG}	slugs
SW(20)	1	If ØN, use d gravitational parameter		
SW(21)	1	If ØN, use J gravitational parameter		
SW(39)	1	If ØN, missile is in ballistic phase of flight		
SW(40)	1	If ØN, missile is in the re-entry stage of flight		
SW(78)	1	If ØN, RSD has been requested		

b. Outputs. The outputs are as follows:

COMMON TAG	DIMENSION	ITEM	SYMBOL	UNITS
FMPRS	2	Current atmospheric pressure at missile	P	lbs/in^2
FMDNS	2	Current atmospheric density at missile	ρ	slugs/ft^3

COMMON TAG	DIMENSION	ITEM	SYMBOL	UNITS
FGRAV	2,3	Current gravitational acceleration vector at missile	g_x, g_y, g_z	ft/sec^2
FTHR	2	Magnitude of current total thrust produced	F_t	pounds
FDM	2	Current integrator's derivative of mass of missile	$\dot{m}$	slugs/ sec
FXEYE	2,3	$\vec{\xi}$ -Attitude vector - integrator output		
FALPH	2,3	Total angular acceleration vector	α	rad/sec^2
FTEUX	2,3	Negative of vector cross product of angular acceleration vector and roll axis unit vector	$\vec{r}$	rad/sec^2
FMACH	2	Current speed of sound at missile	C	ft/sec
FVWX	2,3	Current wind velocity at missile	V_w	ft/sec
FVAX	2,3	Current missile velocity relative to local air mass	V_{mr}	ft/sec
FVAUX	2,3	Unit vector of direction of FVAX	$\vec{U}$	
FVA	2	Magnitude of FVAX	S_M	ft/sec
FMCHN	2	Mach number of FVAX	M	pure no.
FCOSA	2	Cosine of current missile angle of attack	$\cos \theta$	pure no.
FLPHR	2	Current angle of attack	θ	radians
FDYNQ	2	Current dynamic pressure of missile	q	lbs/ft^2
FQLPH	2	Product of the angle of attack in degrees and the dynamic pressure on the missile	$q\theta$	$\frac{\text{lb-deg}}{\text{ft}^2}$

COMMON TAG	DIMENSION	ITEM	SYMBOL	UNITS
FRTIØ	2	Current forces moment arm ratio	$\frac{d_1+d_2}{d_2}$	
FWAIT	2	Current missile weight	W_M	lbs at sea level
FCG	2	Current axial position of missile center of gravity from point zero	ℓ_{CG}	feet
FCP	2	Current axial position of missile center of pressure from point zero	ℓ_{CP}	feet
FDAX	6	Current axial drag plus lift	F_{DX}, F_{DY}, F_{DZ}	ft/sec^2
FDNX	6	Current normal drag force	F_{AN}	pounds
FCDBR	2	Current value of C_D of aero drag computations	$\bar{C}_D$	pure no.
FNERT	2	Current pitch, yaw axis missile moment of inertia	I_p	$\frac{\text{slugs-ft}}{\text{radians}}$
FTEX	2,3	Current steering - producing normal thrust vector	F_{TN}	pounds
FTNX	2,3	Current drag - resisting normal thrust vector	$\vec{F}_{TN}$	pounds
FTNP	2	Magnitude of FTNPX	F'_{TN}	pounds
FTAPX	2,3	Current total axial thrust vector	F'_T	pounds
FSINT	2	Sine of current gimbal angle	$\sin\beta$	pure no.
FCA	2	Current axial aerodynamic force coefficient C_D of missile	C_D	pure no.
FDVX	2	Current integrator's derivative of X coordinate of velocity	$\ddot{X}$	ft/sec^2

COMMON TAG	DIMENSION	ITEM	SYMBOL	UNITS
FDVY	2	Current integrator's derivative of Y co-ordinate of velocity	$\ddot{Y}$	ft/sec^2
FDVZ	2	Current integrator's derivative of Z co-ordinate of velocity	$\ddot{Z}$	ft/sec^2
FDX	2	Current integrator's derivative of X co-ordinate of position	$\dot{X}$	ft/sec
FDY	2	Current integrator's derivative of Y co-ordinate of position	$\dot{Y}$	ft/sec
FDZ	2	Current integrator's derivative of Z co-ordinate of position	$\dot{Z}$	ft/sec

If a gimbal angle is encountered which exceeds the maximum allowed angle, the following output will also result:

COMMON TAG	DIMENSION	ITEM	SYMBOL
GXSNT	2	Sine of largest excessive gimbal angle so far	$\sin\beta_{maxe}$
GXLGA	2	Sine of maximum allowable gimbal angle	$\sin\beta_{maxa}$
GXTFL	2	Time of flight since lift-off of occurrence of GXSNT	$t\beta_{maxe}$
SW(67)	1	Switch set ØN	

c. <u>Program Logic</u>. FD C17

(1) Step 1. LØCALT computes the sine of geocentric latitude, value of geocentric latitude, and the missile altitude above the earth ellipsoid.

(2) Steps 2-11. IFLAG is set to identification integer 334. The value of X in expression (1) is defined as the product of altitude and the m coefficient for pressure. The (a) coefficient for pressure is obtained using the present missile altitude as defined within the limits of the (b) coefficient for pressure. Expression (1) evaluates atmospheric pressure at missile altitude if the missile is not above the upper limit of atmosphere and WNDTRP computes meteorological input data for current missile position. Otherwise, atmospheric pressure is set to zero. The atmospheric pressure is adjusted by the current pressure deviation factor at the missile.

(3) Steps 12-19. The value of X in expression (1) is defined as the product of altitude and the m coefficient for density. The (a) coefficient for density is obtained using the present missile altitude as defined within the limits of the (b) coefficient for density. Expression (1) evaluates atmospheric density at missile altitude if the missile is not above the upper limit of atmosphere. Otherwise, atmospheric density is set to zero. The atmospheric density is adjusted by the current density deviation factor at the missile.

(4) Steps 20-28. IFLAG is set to identification integer 431. H and L are computed by use of different expressions depending on the settings of SW(20) and SW(21). The components of gravitational acceleration acting on the mis-

sile are computed. The X, Y, and Z components are evaluated by expressions (2), (3), and (4).

(5) Steps 29-35. Prior to new computations, the subprogram clears to zero the registers containing the last computed values of normal drag force, axial drag and lift acceleration components, and the interpolated value of the unit vector parallel to the missile roll axis. IFLAG is set to identification integer 317. INTRØG interrogates SW(39) and SW(40) to determine the present stage of flight. If SW(39) is set ØN, the missile is in ballistic flight and the subprogram continues at step 125. If SW(40) is set ØN, the missile is in the re-entry stage of flight and the subprogram continues at step 78. If both SW(39) and SW(40) are set ØFF, the missile is in powered flight and the subprogram continues at step 36.

(6) Steps 36-53. With the missile in powered flight, the magnitude of thrust is computed. The thrust computation depends on the present time of flight. A time sequencing device in LSEQ determines the expression to be used as follows:

LSEQ	TIME LESS THAN	STAGE OF FLIGHT	EXPRESSION
1	t_1	Liftoff	13
2	t_2	Stage II gas generator start	14
3	t_4	Prior to booster jettison	15
4	t_7	Prior to sustainer full thrust	16

LSEQ	TIME LESS THAN	STAGE OF FLIGHT	EXPRESSION
5	t_8	Sustainer full thrust	17
6	t_9	Sustainer cutoff command	18
7	t_{10}	Sustainer thrust decay	19
8	t_{11}	Vernier cutoff command	19
9	t_{12}	Vernier thrust decay	20

(7) Steps 54-71. The rate at which the mass of the missile decreases is computed. The computation of rate of change of mass depends on the present phase of flight. A time sequencing device in LSEQ determines the expression to be used as follows:

LSEQ	TIME LESS THAN	STAGE OF FLIGHT	EXPRESSION
1	t_1	Liftoff	21
2	t_2	Stage II gas generator start	22
3	t_4	Prior to booster jettison	23
4	t_7	Prior to sustainer full thrust	24
5	t_8	Sustainer full thrust	25
6	t_9	Sustainer cutoff command	26
7	t_{10}	Sustainer thrust decay	27
8	t_{11}	Vernier cutoff command	27
9	t_{12}	Vernier thrust decay	28