2-125. SUBPROGRAM D37 (GMGPHT). GMGPHT converts altitude values from standard geopotential feet units into geometric feet units. Standard geopotential altitude is the potential energy of a body of unit mass at latitude 45° 32' 33" at the corresponding geometric altitude relative to the potential energy of that same body at sea level at that latitude. Geometric altitude is a direct distance measurement of altitude above mean sea level, measured along a perpendicular to the earth ellipsoid. The FORTRAN II reference statement is CALL GMGPHT (A,B).

a. Input. The input is the argument A, which is the standard geopotential altitude of a point, expressed in feet above mean sea level.

b. Outputs. The output is the argument B, expressed in feet above mean sea level. B is the geometric altitude corresponding to the input argument A.

c. Program Logic. Constants used to compute geometric altitude are set in the GRASE area. The geometric altitude is computed by use of expression (1) and stored in two locations. CUTIE is stepped by one and the subprogram returns to the user subprogram.

d. Expressions.

$$\text{Geometric altitude} = 2.6449632 \times 10^{-37} (A)^6 + 5.4156731 \times 10^{-30} (A)^5 + 1.1151391 \times 10^{-22} (A)^4 \quad (1)$$

$$+ 2.3075322 \times 10^{-15} (A)^3$$

$$+ 4.7948987 \times 10^{-8} (A)^2$$

$$+ 1.0 (A)$$

$$+ 0.0$$

A is the standard geopotential altitude of a point.

2-126. SUBPROGRAM D38 (HALT). HALT causes machine operation to discontinue for manual intervention. The FORTRAN II reference statement is CALL HALT.

a. Inputs. The inputs are as follows:

COMMON TAG	DIMENSION	ITEM
CUTIE	1	Computation unit tally
IFLAG	1	Identification integer

b. Outputs. The outputs are the following statements printed and/or written:

a. PROGRAM OPERATION COMPLETED.

b. AC________QP_______MQ________
XREGS A________B______C_______
SENSE LITES__________

c. TAPE CHECK_______MQ OVRFLO______
AC OVRFLO_______DIVIDE CHECK______
SENSE SWITCHES________

d. SUBPROGRAM ID_______COMPUTATION
UNIT TALLY____

e. PROGRAM STOPPING. IMPOSSIBLE TO PROCEED.

c. Program Logic. FD D38

(1) Steps 1-12. The contents of the accumulator are saved and IFLAG is tested with $(77777)_8$. If equal, U08 prints and writes output statement a and the subprogram continues at step 13. Otherwise the tape check, MQ and AC overflow, and divide check indicators are established for output. The contents of the index registers are saved and converted from BCD to binary. The SENSE light and SENSE switch indicator are established for output

and SW(120) is set ØFF. U08 prints and writes output statements b and c. (STH) and (FIL) write output statement d and U08 prints and writes output statement e. Control is transferred to step 13.

(2) Steps 13-17. A1 is rewound. If the subprogram is to continue, an end-of-file mark is written on A7 and the tape is rewound. Otherwise the subprogram halts for manual intervention. If another function is to performed control is transferred to DØCNT, otherwise the subprogram halts for manual intervention.

2-127. SUBPROGRAM P33 (HERGET). HERGET computes the target aim point in the inertial coordinate system, the altitude and geographic latitude and longitude. The input data is the missile position, the missile velocity, and the distance from the center of the earth to the desired end point. After computing the target aim point in the inertial coordinate system and the time of the ballistic flight, XYZGEØ computes the geocentric latitude and the longitudinal altitude of the target aim point. The FORTRAN II reference statement is CALL HERGET.

a. Inputs. The inputs are as follows:

COMMON TAG	DIMENSION	ITEM	UNITS
GCØPS	2,3	Starting point position vector for Herget computation	feet
GCØVL	2,3	Starting point velocity vector for Herget computations	ft/sec
GRAVM	2	Gravitational parameter	ft^3/sec^2
GTAPR	2	Stopping point radius vector magnitude for Herget computation	feet
FPI	2,2	Dual precision π	radians
SW(69)	1	Aim point is on same side of apogee as launch pad	
GCLAT	2	Geographic latitude	degrees
GCØTM	2	Starting point time of flight since liftoff for Herget computations	seconds
GMLAT	2	Geocentric latitude of a point	degrees

COMMON TAG	DIMENSION	ITEM	UNITS
GMLØN	2	Longitude of a point west of Greenwich	degrees
GMALT	2	Altitude of a point above earth ellipsoid	feet

b. Outputs. The outputs are as follows:

COMMON TAG	DIMENSION	ITEM	SYMBOL	UNITS
GTPPS	2,3	Final adjusted target aim point position vector	X_H, Y_H, Z_H	feet
GTPVL	2,3	Final velocity vector	$\dot{X}_H, \dot{Y}_H, \dot{Z}_H$	ft/sec
GTMB	2	Time of ballistic flight from cutoff to final target aim point	T_b	seconds
TAPLT	2	Target aim point geocentric latitude		degrees
TAPLN	2	Target aim point longitude west of Greenwich		degrees
TAPAL	2	Target aim point altitude above real-earth ellipsoid		feet
IFLAG	1	Identification integer		
FSPPS	2,3	Current missile position vector		feet
GTMFL	2	Total time of flight since liftoff at which a point position is valid		seconds

c. Program Logic. FD P33

(1) Steps 1-18. Data is initialized for computation of the Herget equations. The square of the radius r^2 from the center of the earth is computed. Expression (2) evaluates the velocity squared v^2. *SQRØØT* computes the radius from the center of the earth using expression (1). Expres-

sion (3) evaluates the semi-major axis of the trajectory (a). Expressions (4) and (5) are evaluated for use in evaluating expression (6). Expressions (7) and (8) are evaluated and IFLAG is set to identification integer 1633. INTRØG interrogates SW(69) to determine if the aim point is on the same side of apogee as the launch pad. If ØN, the subprogram continues at step 19. Otherwise, expression (8) is multiplied by minus one.

(2) Steps 19-32. Expressions (9), (10), and (11) are evaluated for use in evaluating expression (12). Expression (13) evaluates the final adjusted target aim point position vector. Expressions (15) and (16) are evaluated for use in expression (17) which is used in computing the final velocity vector. ARCSIN computes the arcsine of expression (10). If the arcsine and the value of expression (9) are greater than or equal to zero, the subprogram continues at step 30. If the arcsine is less than zero, expression (10) is added to 2π and the subprogram continues at step 30. For all other combinations of expression (9) and the arcsine of expression (10), expression (10) is subtracted from 2π and the subprogram continues at step 30.

(3) Steps 33-40. Expression (14) evaluates the time of ballistic flight from cutoff to final aim point. The current missile position vector and total time of flight are computed. XYZGEØ computes the geocentric latitude and longitudinal altitude of the target aim point. The geocentric latitude is computed. LCTØLG computes the geographic lati-

tude. Simplexed values of the target aim point geocentric latitude, longitude west of Greenwich, and the altitude above real-earth ellipsoid are computed. CUTIE is stepped by one and control is transferred to the user subprogram.

d. Expressions.

$$r = \sqrt{X^2 + Y^2 + Z^2} \tag{1}$$

$$v^2 = \dot{X}^2 + \dot{Y}^2 + \dot{Z}^2 \tag{2}$$

$$a = \frac{r}{2 - (rv^2/GM)} \tag{3}$$

$$e \cos E = (rv^2/GM) - 1 \tag{4}$$

$$e \sin E = (1/\sqrt{aGM})\,(X\dot{X} + Y\dot{Y} + Z\dot{Z}) \tag{5}$$

$$e^2 = (e \cos E)^2 - (e \sin E)^2 \tag{6}$$

$$e \cos E_T = 1 - (r_t/a) \tag{7}$$

$$e \sin E_T = \sqrt{e^2 - (e \cos E_T)^2} \tag{8}$$

$$\cos (E_T - E) = 1/e^2 \left[(e \cos E_T)(e \cos E) + (e \sin E_T)(e \sin E)\right] \tag{9}$$

$$\sin (E_T - E) = 1/e^2 \left[(e \sin E_T)(e \cos E) - (e \cos E_T)(e \sin E)\right] \tag{10}$$

$$f = \left[1/(1 - e \cos E)\right]\left[\cos (E_T - E) - e \cos E\right] \tag{11}$$

$$g = \left[\sin (E_T - E) + e \sin E - e \sin E_T\right]\left[a^{3/2}/\sqrt{GM}\right] \tag{12}$$

$$X_H = Xf + \dot{X}g$$

$$Y_H = Yf + \dot{Y}g \tag{13}$$

$$Z_H = Zf + \dot{Z}g$$

$$Tf = (E_T - E + e \sin E - e \sin E_T)(a^{3/2}/\sqrt{GM}) \quad (14)$$

$$f' = - \sin (E_T - E) \sqrt{GM}/\left[(1 - e \cos E)(1 - e \cos E_T) \; a^{3/2}\right] \quad (15)$$

$$g' = (\cos (E_T - E) - e \cos E_T)/(1 - e \cos E_T) \quad (16)$$

$$\begin{aligned} \dot{X}_H &= Xf' + \dot{X}g' \\ \dot{Y}_H &= Yf' + \dot{Y}g' \\ \dot{Z}_H &= Zf' + \dot{Z}g' \end{aligned} \quad (17)$$

 Mod F1

2-128. SUBPROGRAM U38 (IDLIST). IDLIST lists the record identification and date information on the Radar-Launcher (R/L), Missile-Trajectory (M/T), and/or Input Tape, as requested. The FORTRAN II reference statement is CALL IDLIST.

a. Inputs. AIPR-89 to AIPR-91 are set to RLTAP, MTTAP, and INTAP, respectively, as determined by the tape listings desired.

b. Outputs. The identification and date information are listed from the R/L, M/T, and/or Binary Input Tapes. If an error occurs, SW(70) and SW(123) are set to ØN and ITYER is set to eight. The following statements are also outputs:

a. RADAR/LAUNCHER TAPE

b. RADAR RECORDS

c. NO. ID DATE

d. MLSDS MØN A MØN B RCN A RCN B

e. LAUNCHER RECORDS

f. MISSILE TRAJECTORY TAPE

g. MISSILE RECORDS

h. AZIMUTH RECORDS

i. M-CONSTANTS RECORDS

j. DELTA MATRIX RECORDS

k. INPUT TAPE

l. RECORD NO. DATA TYPE ID DATE MØN A MØN B RCN A RCN B

c. Program Logic. FD U38

(1) SW(120) is set ØFF to cause U08 to print off-line

in all cases (i.e., write all images on tape A7). Therefore, all references to printing images or restoration of pages, actually indicates the writing of the appropriate records on tape A7. Except when entered to restore the page, whenever U08 is called, it is immediately followed by checking to see if SW(70) is ØN. If so, an error is indicated and control is transferred to step 170 to restore the contents of the index registers and exit to the user subprogram.

(2) A redundancy check is made after each of the two read instructions (steps 139 and 164). If a redundancy persists after ten attempts to read a record, control is transferred to step 168 to set indications of an error condition and exit to the user subprogram.

(3) Steps 1-3. The contents of the index registers are saved, SW(70), SW(120), and SW(123) are set to ØFF, and IFLAG is set to the identification integer 2138.

(4) Steps 4-14. If a listing of the Radar-Launcher tape is not requested, control is transferred to step 46 to determine if another tape's listing is desired. If the R/L tape is requested, the read and backspace instructions in the read routine are modified to address tape B8, the radar record count is initialized to zero, and U08 writes the R/L tape heading, Radar Records heading, NO. ID DATE subheading, and Radar data heading (statements a, b, c, and d).

(5) Steps 15-20. The line count is set to nine and

the read routine is entered to read a record from tape B8. If an end-of-file is read, control is transferred to step 24 to begin processing the next file on tape. Otherwise, the BCD record count is incremented and printed along with the radar identification and dates by U08. The line count is then incremented by two.

(6) Steps 21-23. If the line count at this point is greater than 52, it is reset to six, U08 restores the page and control is transferred to step nine to rewrite statements b, c, and d. Otherwise, control is transferred directly to step 16 to read the next record from the radar file.

(7) Steps 24-31. If the line count is greater than 42, it is reset to six and the page is restored, before the launchers headings are printed. Otherwise the line count is incremented by six and U08 prints the Launcher Records heading and the NO. ID DATE subheading (statements e and c).

(8) Steps 32-35. The record count is reset to zero for the launcher records and a record is read from tape. If an end-of-file is read, control is transferred to step 45 to rewind the tape and begin processing the next tape. Otherwise the BCD record count is incremented and printed along with the launcher identification and date by U08. The line count is then incremented by two.

(9) Steps 36-42. If the line count is greater than 54 at this point, U08 restores the page, statements e and c

are reprinted and the line count is set to eight. Otherwise control is transferred directly to step 43 to print the launcher data image.

(10) Steps 43-44. The launcher data image is printed and control is transferred to step 33 to read the next record from the launcher file.

(11) Step 45. Tape B8 is rewound.

(12) Steps 46-47. These steps repeat steps 4-23, processing the Missile-Trajectory tape's first file (missile records) instead of radar records, continuing at end-of-file to step 68, Statements b, g, and c are used as headings, in place of statements a, b, and c.

(13) Steps 68-88. These steps repeat steps 24-44, processing the second file of tape B7 (azimuth records) instead of the second file of tape B8 (launcher records), continuing at end-of-file to step 89. Statements h and c are used in place of statements e and c.

(14) Steps 89-109. These steps repeat steps 24-44, processing the third file of tape B7 (M constants records) instead of launcher records, continuing at end-of-file, to step 110. Statements i and c are used in place of statements e and c.

(15) Steps 110-130. These steps repeat steps 24-44, processing the fourth file of tape B7 (delta-matrix records)

instead of launcher records, continuing at end-of-file to step 131). Statements j and c are used in place of statements e anc c.

(16) Step 131. The Missile-Trajectory Tape B7, is recorded.

(17) Steps 132-141. If a listing of the input tape is not required, control is transferred to step 170 to return to the user subprogram. Otherwise the input record count is initialized to zero and a record is read from input tape A4. If it is an end-of-file, tape A4 is rewound and control is transferred to step 170 to return to the user program. Otherwise the record count is incremented, converted to BCD, and stored in the printout image.

(18) Steps 142-147. If there is no data to be printed, control is transferred to step 147; otherwise, U08 prints the Input Tape and Input Data headings (statements k and l). The radar record identity and dates are stored in the printout image.

(19) Step 148. U08 prints the radar data printout image.

(20) Steps 149-163. The launcher, missile, azimuth, M constant, and delta matrix identification and dates are stored respectively in the printout image and printed by U08. If four records from the input tape have been read and processed, control is transferred to step 143 to continue printing on a new page, otherwise, control is transferred to step 134 to continue printing on the same page.

(21) Steps 164-173. A record is read from tape B7 or B8. If it is an end-of-file, control is transferred to begin processing the next file on the tape, or to rewind the tape and begin processing the next tape. Otherwise, if the reading is successful, the record count is incremented by one, converted to BCD, and control is transferred to store the data just read in the printout image. If the reading is not successful after ten attempts, SW(70) and SW(123) are set ØN, ITYER is set to eight, the contents of the index registers are restored, and the subprogram returns to the user subprogram.

mod G1

2-129. SUBPROGRAM P35 (INITAL). INITAL initializes data tables to provide missile position, velocity, and attitude vectors and missile mass values for flight simulation. The FORTRAN II reference statement is CALL INITAL.

a. Inputs. The inputs are as follows:

COMMON TAG	DIMENSION	ITEM	UNITS
VSRCS		Staging rockets cases, nominal value and standard deviation	
VNCSM		Standard deviation re-entry vehicle mass	
FRTØD		Conversion constant: Radians to degrees ($\frac{180}{\pi} = 57.295780$)	
PLLAT		Geographic latitude of this launch pad	
ISLØT	1	Current target slot number	integer
IINEN	2,10	Impact area data counter	positive integer
AIPR	2,10,10	Impact area pressure deviations	1 + ratio
AIDN	2,10,10	Impact area density deviations	1 + ratio
AIWN	2,10,10	Impact area north wind components	ft/sec
AIWE	2,10,10	Impact area west wind components	ft/sec
AIHT	2,10,10	Impact area altitude	feet-geometric
VPP	2,5,2	Pitch programmer nominal parameters and standard deviations	sec and deg/sec
GSGMA	2,20,1	Sigma levels for missile parameters of current simulation	pure no.
FZETA	4,3	Current ζ attitude vector - double precision	

COMMON TAG	DIMENSION	ITEM	UNITS
~~VGYD~~	~~2,3,3~~	~~Gyro drift rate standard deviations: pitch, yaw, roll; booster, sustainer vernier~~	~~deg/sec~~
PLCLT	2	Launch pad geocentric latitude	degrees
PLLØN	2	Launch pad geographic longitude	degrees
PLDRV	2	Launch pad distance from center of earth	feet
FBKPS	2,2,3	Current missile position vector - double precision	feet
FSPPS	2,3	Current missile position vector - single precision	feet
VIBUL	2,2	Pre-ignition booster usable LOX - nominal value and standard deviation	slugs
VLBLC	2,2	Ignition to liftoff booster LOX consumption	slugs
VIBUK	2,2	Pre-ignition booster usable fuel - nominal value and standard deviation	slugs
VLBFC	2,2	Ignition to liftoff booster fuel consumption - nominal value and standard deviation	slugs
VIBES	2,2	Pre-ignition booster empty shell plus nonburnable propellant - nominal value and standard deviation	slugs
VSRPP	2,2	Staging rockets proplellants - nominal values and standard deviations	slugs
VISUL	2,2	Pre-ignition stage II usable LOX - nominal value and standard deviation	slugs
VISLB	2,2	Ignition to liftoff stage II LOX bleed - nominal value and standard deviation	slugs
VISUK	2,2	Pre-ignition stage II usable fuel - nominal value and standard deviation	slugs

COMMON TAG	DIMENSION	ITEM	UNITS
VISES	2,2	Pre-ignition stage II including adapter ring; not including staging rockets or re-entry vehicle - nominal value and standard deviation	slugs
VREVM	2	Mass of re-entry vehicle plus warhead; not including adapter ring - nominal value	slugs
VBDIM	2,2	Booster thrust decay normalized integral $\frac{1}{t_4 - t_2} \int_{t_2}^{t_4} \sigma_B dt$ nominal value and standard deviation	pure no.
VBFRT	2,2	Booster fuel flow rate - nominal value and standard deviation	slugs/sec
FWBG	2,1	Booster fuel flow rate	slugs/sec
VBFMR	2,2	Booster LOX/FUEL mass mixture ratio - nominal value and standard deviation	pure no.
VGBFR	2,2	Stage II gas generator bypass fuel flow rate - nominal value and standard deviation	slugs/
FPRGG	2,1	Stage II gas generator bypass fuel flow rate	slugs/sec
VGBFM	2,2	Stage II gas generator bypass LOX/FUEL mass mixture ratio - nominal value and standard deviation	pure no.
VGNFR	2,2	Stage II gas generator non-bypass fuel flow rate - nominal value plus standard deviation	slugs/

COMMON TAG	DIMENSION	ITEM	UNITS
FPSGG	2,1	Stage II gas generator non-bypass fuel flow rate	slugs/sec
VGNFM	2,2	Stage II gas generator non-bypass LOX/FUEL mass mixture ratio - nominal value and standard deviation	pure no.
VSFRT	2,2	Stage II sustainer fuel flow rate - nominal value and standard deviation	slugs/sec
FPRFG	2,1	Stage II sustainer fuel flow rate	slugs/sec
VSFMR	2,2	Stage II sustainer LOX/FUEL mass mixture ratio - nominal value and standard deviation	pure no.
VSBFC	2,2	Sustainer buildup total fuel consumption - nominal value and standard deviation	slugs
VSBLC	2,2	Sustainer buildup total LOX consumption	slugs
VSDFC	2,2	Sustainer decay total fuel consumption - nominal value and standard deviation	slugs
VSDLC	2,2	Sustainer decay total LOX consumption - nominal value and standard deviation	slugs
VBDFC	2,2	Booster decay total fuel consumption - nominal value and standard deviation	slugs
VBDLC	2,2	Booster decay total LOX consumption - nominal value and standard deviation	slugs
VLBLD	2,2	Liftoff to stage II ignition stage II LOX bleed rate	slugs/sec
VISBU	2,2	Sustainer thrust buildup total impulse	pounds sec
VBSLT	2,2	Booster sea-level thrust - nominal value and standard deviation	pounds

COMMON TAG	DIMENSION	ITEM	UNITS
VBTK1	2,2	Booster thrust coefficient K1 $\frac{\text{VACUUM THRUST-SEA LEVEL THRUST}}{\text{SEA LEVEL ATMOSPHERIC PRESSURE}}$ nominal value and standard deviation	inches^2
VSVT	2,2	Stage II sustainer vacuum thrust - nominal value and standard deviation	pounds
VSTK2	2,2	Sustainer thrust coefficient K2 $\frac{\text{VACUUM THRUST-SEA LEVEL THRUST}}{\text{SEA LEVEL ATMOSPHERE}}$ nominal value and standard deviation	inches^2
VGBNT	2,2	Stage II gas generator bypass vacuum thrust and standard deviation	pounds
VGNNT	2,2	Gas generator non-bypass vacuum thrust - nominal value and standard deviation	pounds
VSRNT	2,2	Staging rockets total thrust - nominal value and standard deviation	pounds
VSPMP	2,2	Velocity impulse imparted to re-entry vehicle at separation - nominal value and standard deviation	ft/sec
VSRBT	2,2	Total staging rockets burning time	seconds
VBSSD	2,2	Separation bolts firing delay time since t_2 - nominal value and standard deviation	seconds
VSRDL	2,2	Staging rockets ignition delay time since t_2 - nominal value and standard deviation	seconds
VSIGN	2,2	Stage II ignition time delay after liftoff - nominal value and standard deviation	seconds

COMMON TAG	DIMENSION	ITEM	UNITS
VSSIG	2,2	Sustainer ignition delay time since t_2 - nominal value and standard deviation	seconds
VSBTM	2,2	Sustainer thrust buildup total time - nominal value and standard deviation	seconds
VVDTM	2,2	Vernier thrust decay effective time - nominal value and standard deviation	seconds
VSPTM	2,2	Re-entry vehicle separation delay time - nominal value and standard deviation	seconds
VSDTM	2,2	Sustainer thrust decay effective time - nominal value and standard deviation	seconds
FULB	2,1	Usable booster LOX remaining	slugs
FUFB	2,1	Usable booster fuel remaining	slugs
FBCMS	2,1	Booster shell plus nonusable propellants	slugs
FWSRP	2,1	Staging rockets propellants	slugs
FWRC	2,1	Staging rockets cases	slugs
FULS	2,1	Usable stage II LOX remaining	slugs
FUFS	2,1	Usable stage II fuel remaining	slugs
FSCMS	2,1	Booster shell plus nonusable propellants	slugs
FRVMS	2,1	Re-entry vehicle	slugs

b. Outputs. The outputs from P35 are as follows:

COMMON TAG	DIMENSION	ITEM	UNITS
FIPRS	2,21,1	Current detonation area pressure deviations	pure no.
FIDNS	2,21,1	Current detonation area density deviations	pure no.

COMMON TAG	DIMENSION	ITEM	UNITS
FINTH	2,21,1	Current detonation area north wind component	ft/sec
FIEST	2,21,1	Current detonation area east wind component	ft/sec
FSZTA	3	Pitch attitude vector - single precision	
FSETA	3	Yaw attitude vector - single precision	
LSEQ	1	Flight stage and sub-stage for normal sequencing	positive integer
FTFSP	2	Current time of flight since liftoff, single precision	seconds
FTMFL	2,2	Current time of flight since liftoff, double precision	seconds
GPTLT	2	Geocentric latitude of point, general	degrees
GPTLN	2	Longitude of point west of Greenwich, general	degrees
PLDRE	2	Radius of earth ellipsoid at geocentric latitude of the point	feet
GPTGS	2	Geoidal separation at point, general	feet
GPTHT	2	Altitude of point above geoid, general	feet
FTFSP	2	Current time of flight since liftoff, single precision	seconds
FBKPS	2,2,3	Current missile position vector - double precision	feet
FBKVL	2,2,3	Current missile velocity vector - double precision	ft/sec
FSPVL	2,3	Current missile velocity vector - single precision	ft/sec

COMMON TAG	DIMENSION	ITEM	UNITS
FSXI	3	Roll attitude vector - single precision	
FXI	4,3	Current $\vec{\xi}$ attitude vector - single precision	
FZETA	4,3	Current $\vec{\zeta}$ attitude vector - single precision	
FETA	4,3	Current $\vec{\eta}$ attitude vector - single precision	
FSPPS	2,3	Current missile position vector - single precision	feet
FULB	2,1	Usable booster LOX remaining	slugs
FUFB	2,1	Usable booster fuel remaining	slugs
FBCMS	2,1	Booster shell plus nonusable propellants	slugs
FWSRP	2,1	Staging rocket propellants	slugs
FWRC	2,1	Staging rocket cases	slugs
FULS	2,1	Usable stage II LOX remaining	slugs
FUFS	2,1	Usable stage II fuel remaining	slugs
FSCMS	2,1	Stage II shell plus adapter ring, not including re-entry vehicle	slugs
FRVMS	2,1	Re-entry vehicle	slugs
FTCN1	2,1	Booster thrust decay normalized integral	pure no.

$$\frac{1}{t_4 - t_2} \int_{t_2}^{t_4} \sigma_B dt$$

COMMON TAG	DIMENSION	ITEM	UNITS
FWBG	2,1	Booster fuel flow rate	slugs/sec
FWBL	2,1	Booster LOX flow rate	slugs/sec
FPRGG	2,1	Stage II gas generator bypass fuel flow rate	slugs/sec
FPRGL	2,1	Stage II gas generator bypass LOX flow rate	slugs/sec
FPSGG	2,1	Stage II gas generator non-bypass fuel flow rate	slugs/sec
FPSGL	2,1	Stage II generator non-bypass LOX flow rate	slugs/sec
FPRFG	2,1	Stage II sustainer fuel flow rate	slugs/sec
FPRFL	2,1	Stage II sustainer LOX flow rate	slugs/sec
FPRSG	2,1	Sustainer thrust buildup total fuel consumption	slugs
FPRSL	2,1	Sustainer thrust buildup total LOX consumption	slugs
FPSSG	2,1	Sustainer thrust decay total fuel consumption	slugs
FPSSL	2,1	Sustainer thrust decay total LOX consumption	slugs
FWBSD	2,1	Booster thrust decay total propellant consumption	slugs
FWLB	2,1	Stage II bleed rate	slugs/sec
FISBU	2	Sustainer thrust buildup total impulse	lb-sec
FBSL	2,1	Booster thrust at sea level	pounds
FK1	2,1	Booster thrust coefficient K1 $= \frac{\text{VACUUM THRUST-SEA LEVEL THRUST}}{\text{SEA LEVEL ATMOSPHERIC PRESSURE}}$	$inches^2$

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COMMON TAG	DIMENSION	ITEM	UNITS
FSV	2,1	Sustainer thrust in vacuum	pounds
FK2	2,1	Sustainer thrust coefficient K2 $\frac{\text{VACUUM THRUST-SEA LEVEL THRUST}}{\text{SEA LEVEL ATMOSPHERIC PRESSURE}}$	$inches^2$
FVB	2,1	Vernier thrust during bypass (non-sustainer) operation	pounds
FVS	2,1	Vernier thrust during sustainer operation	pounds
FSRN	2,1	Total staging rockets thrust	pounds
FNSDV	2,1	Re-entry vehicle separation velocity impulses	ft/sec
FT121	2,1	$t_{12} - t_{11} = (t_{12} - t_{10}) - (t_{11} - t_{10})$	seconds
FT74	2,1	$t_7 - t_4 = (t_7 - t_6) + (t_6 - t_4)$	seconds
SW(22)		If ØN, FSIMLC is initialized for starting a new flight simulation	
FMASS	2	Current missile mass - single precision	slugs
FDPMS	2,2	Current missile mass - double precision	slugs

c. Program Logic. FD P35

(1) Steps 1-7. Meteorological data tables are set up. Turning rates in degrees per second are converted into units of command per 0.0097603 second. Time of flight at liftoff and missile pre-launch position, velocity, and attitude vectors are initialized. Geocentric latitude, longitude, and altitude are converted into inertial rectangular coordinates

X, Y, Z, from which the current missile position vector is determined by GEØXYZ. The missile pre-launch eastward velocity is computed and the current missile velocity vector is set. The missile pre-launch attitude vectors are computed and the current missile velocity vectors are set.

(2) Steps 8-10. SW(22) is set ØN to initialize total mass for the integrator by use of expression (1). CUTIE is stepped by one and control is returned to the user subprogram.

d. Expressions.

$$FMASS = FULB + FUFB + FBCMS + FWSRP + FWRC + FULS + FUFS + FSCMS + FRVMS \qquad (1)$$

2-130. SUBPROGRAM D21 (LAZMTH). LAZMTH estimates the proper launch azimuth of a TITAN missile shoot in order to minimize yaw steering during guidance. The FORTRAN II reference statement is CALL LAZMTH.

a. Inputs. The inputs are as follows:

COMMON TAG	DIMENSION	ITEM	SYMBOL	UNITS
GTBRG	2	Target bearing	B_T	degrees
GCBRG	2	cos B_T		
PLCCL	2	cos L_{CL}		

b. Outputs. The output is the estimated launch azimuth A_L in degrees. A_L is stored in GLAZM.

c. Program Logic. FD D21

(1) Steps 1-5. LAZMTH computes an estimated launch azimuth by use of expression (1). If the result of (1) is a negative angle, add 360 degrees to launch azimuth. Set duplexed registers equal. Step CUTIE by one and return to user subprogram.

d. Expressions.

$$A_L = B_T - 4.4 \cos B_T \cos L_{CL} \qquad (1)$$

2-131. SUBPROGRAM U39 (METDTA). METDTA reads and processes the MET cards. The FORTRAN II reference statement is CALL METDTA.

a. Inputs. The inputs are MET cards, an END card, and the following Common tags:

COMMON TAG	DIMENSION	ITEM
SW(79)	1	If ØN, SIM mode of operation requested
TØLT	2,10	Geographic latitude of target
TØLN	2,10	Geographic longitude of target

b. Outputs. The outputs are the following Common tags:

COMMON TAG	DIMENSION	ITEM
IINEN	2,10	Number of entries in each MET data table
AIPR (50)-(59)	10	If ØN, data for corresponding target is from MET tape
AIHT	2,10,10	Target area MET data table - altitudes
AIWN	2,10,10	Target area MET data table - north wind components
AIWE	2,10,10	Target area MET data table - west wind components
AIDN	2,10,10	Target area MET data table - density deviations
UMDAT	4,1	MET data date period or tape indicator

The MET card image and following statements written and printed are also outputs:

a. INCORRECT MET DATA CARD

b. MET DATA NOT SUPPLIED FOR LATITUDE ____ , LONGITUDE ______

c. Program Logic. FD U39

(1) Steps 1-8. The contents of the index registers are saved. METDTA is initialized by setting the end-of-file and tape redundancy indicators ØFF, and clearing the work storage table, AIPR registers, and IINEN registers. If operation is in the SIM mode, the MET indicator register UMDAT is set ØN for use in TAMSID. Steps 19, 31, and 35 are modified so that METDTA processes only one target in the SIM mode. The subprogram continues at step 17. If not in the SIM mode, SW(120) is set ØFF.

(2) Steps 9-14. If this target requires standard climatology, the target count is increased by one and the subprogram continues at step 20. If this target requires MET data from the tape, the subprogram continues at step 15. If neither standard climatology nor tape is indicated, U08 prints and writes statement a. Error switch SW(70) is set ØN and ITYER is set to 4 to indicate card error. IFLAG is set to identification integer 2139. The subprogram continues at step 39.

(3) Steps 15-25. If the MET card shows target number S, the number is changed to correspond to target slot 10. The number of entries in the MET data table is set to 10 in step 17. The latitude TØLT and longitude TØLN for the five degree grid containing the target are placed in a table to identify the

meteorological data required from the MET tape. This grid is identified on the tape by the coordinates of the northeast corner. For the SIM mode, the subprogram continues at step 26. Otherwise U20 reads the next MET card and U08 writes the card image. If a read or a write error occurs, control is transferred to step 40. If the card just read in is not an END card, the subprogram continues at step 9. If the card is an END card, all MET cards have been processed. If all ten targets requested standard climatology, the subprogram continues at step 40. If data are required from the MET tape, the subprogram continues at the next step.

(4) Steps 26-30. The first (next) meteorological record is read into core from the MET tape. If an end-of-file was not reached, the subprogram continues at step 31. If an end-of-file was reached, the table of requested latitude and longitude identifications is checked for nonzero entries. If any identifications are missing, U08 prints and writes statement b. The number of entries in the MET table is set to zero. The subprogram continues at step 39. If there are no missing identifications, the subprogram continues at step 39.

(5) Steps 31-38. The latitude and longitude identifications of this record are compared with the latitude and longitude identifications requested by the MET cards. If matching identifications are not found, the subprogram reads another record. If matching identifications are found, or if in SIM mode, zeros are stored in the identification stor-