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NASA Technical Memorandum 78497

Trajectory Module of the NASA Ames Research Center Aircraft Synthesis Program ACSYNT

Michael E. Tauber and John A. Paterson

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TRAJECTORY MODULE OF THE NASA AMES RESEARCH CENTER AIRCRAFT SYNTHESIS PROGRAM ACSYNT

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SUMMARY

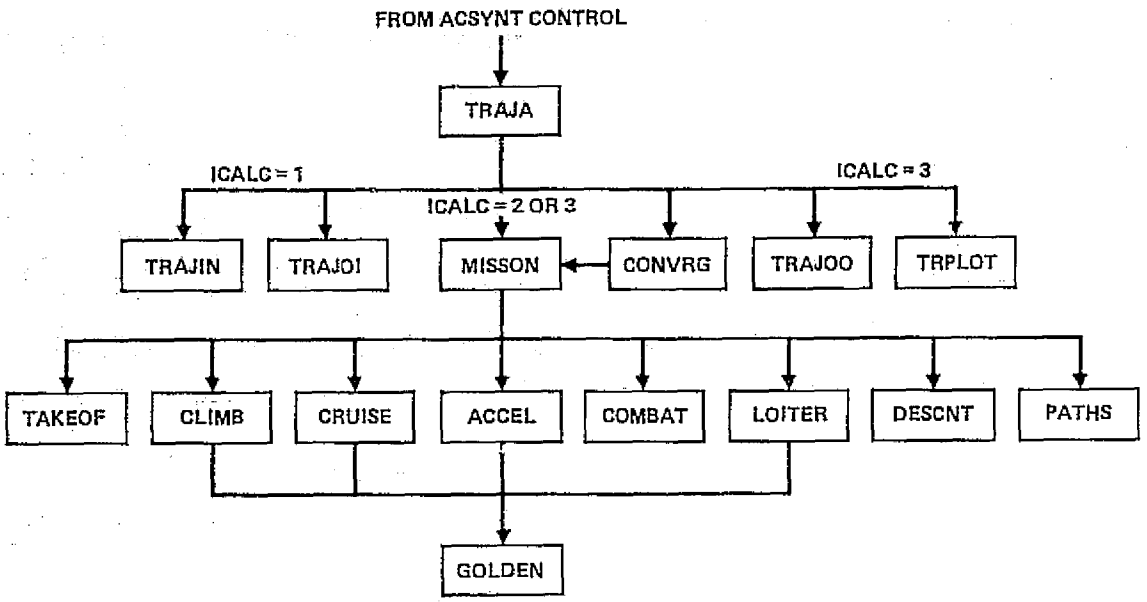
A program was developed to calculate trajectories for both military and commercial aircraft for use in the NASA Ames Research Center aircraft synthesis program, ACSYNT. The function of the trajectory module was to calculate the changes in the vehicle's flight conditions and weight, as fuel is consumed, during the flying of one or more missions. The trajectory calculations started with a takeoff, followed by up to 12 phases chosen from among the following: climb, cruise, acceleration, combat, loiter, descent, and paths. In addition, a balanced field length was computed. The emphasis was on relatively simple formulations and analytic expressions suitable for rapid computation since a prescribed trajectory had to be calculated many times in the process of converging an aircraft design, or finding an optimum configuration. The trajectory module consists of about 2500 cards and was operational, as part of the ACSYNT program, on a CDC 7600 computer.

INTRODUCTION

Computerized aircraft design at the conceptual, or early preliminary design level, has proven to be a practical engineering tool (refs. 1-3). The development of such a program requires the efficient integration of many disciplines such as the aircraft's geometric layout, weight estimation, aerodynamics, propulsion, and trajectory analysis. This report contains a description of a program which was developed to calculate trajectories for both military and commercial aircraft and was used in the NASA Ames Research Center aircraft synthesis program, ACSYNT. The function of the trajectory module was to calculate the changes in the vehicle's flight conditions and weight, as fuel is consumed, during the flying of one or more missions. The trajectory calculations started with a takeoff, followed by up to 12 phases chosen from among the following: climb, cruise, acceleration, combat, loiter, descent, and paths. In addition, a balanced field length was computed. The emphasis was on relatively simple formulations and analytic expressions suitable for rapid computation since a prescribed trajectory had to be calculated many times in the process of converging an aircraft design, or arriving at an optimum configuration. The trajectory module consists of about 2500 cards and was operational, as part of the ACSYNT program, on a CDC 7600 computer. Although it could potentially be modified, the program is presently not suitable for stand-alone computations since it depends on inputs from a propulsion module for thrust and fuel flow rate, and an aerodynamics module for lift and drag coefficients.

GENERAL PROGRAM DESCRIPTION

The function of the trajectory module is to calculate the changes in the flight conditions and weight that take place in a vehicle during the flying of one or more missions. Any number of missions may be flown during a given computer run, where each mission is divided into phases, and particular phases may be further subdivided into legs. A given mission may have up to 12 phases, selected in any order from among the following 7 types: climb, cruise, acceleration, combat, loiter, descent, and paths. The trajectory module (called TRAJ hereafter) consists of 16 different subroutines organized as shown in the block diagram below. The arrows point in the direction of called subroutines.



A brief description of the above subroutines follows:

TRAJA - This is the master control program for TRAJ. ICALC is a control variable passed from ACSYNT control to TRAJA and informs TRAJA what tasks are to be performed.

TRAJIN - Reads all input data for TRAJ.

TRAJOI - Prints all input data for TRAJ.

MISSON - Secondary control program for TRAJ. Calls all necessary subroutines needed to fly one mission. Subroutines for each phase of the mission are called in the same order as the various phases of the mission are read in by TRAJIN.

TAKEOF – Performs all calculations required during takeoff. This is always the first routine called by MISSON. It is not counted as a phase of the mission.

CLIMB – Performs all calculations of a climb phase.

CRUISE – Performs all calculations of a cruise phase.

ACCEL – Performs all calculations of an acceleration phase.

COMBAT – Performs all calculations of a combat phase.

LOITER – Performs all calculations of a loiter phase.

DESCNT – Performs all calculations of a descent phase.

PATHS – Performs all calculations of a paths phase. Input consists of up to 50 pairs of altitude vs velocity (or Mach number) data points.

GOLDEN – Performs golden section type of search for (1) Breguet altitude or (2) maximum endurance altitude or (3) optimum endurance Mach number.

CONVGR – Converges vehicle on gross weight. Process consists of taking estimated gross weight, calling on MISSON to get computed gross weight, comparing estimated and computed gross weight to get a new value of estimated gross weight, and repeating this process until vehicle weight has converged to within a specified tolerance limit.

TRAJOO – Prints all output data for one mission.

TRPLOT – Computes and writes onto tape various parameters which are to be displayed by some graphics device.

CONTROL PROGRAM — TRAJA

This is the master control program for TRAJ. ACSYNT control communicates with TRAJ only through this program. When ACSYNT control calls TRAJA, it always sends a value for a variable called ICALC which tells TRAJA what tasks are to be performed by TRAJ.

Briefly, when ICALC = 1, TRAJ reads and prints all TRAJ input data. When ICALC = 2, TRAJ executes for mission 1 (the basic mission). When ICALC = 3, TRAJ makes one final execution of mission 1 and prints output. Further, if other missions exist (missions 2, 3, 4, . . .), then these missions are executed over and over until they have converged on gross takeoff weight, with the airframe kept fixed as it existed after mission 1 was completed. The output of these converged missions is then printed.

After mission 1 has been completed, the fixed airframe weight is computed by the equation:

WFIXED = WGTO - WFTOT - WPL

where WGTO is the gross takeoff weight of the converged vehicle, WFTOT is the total fuel weight, and WPL is the payload weight.

INPUT-TRAJIN

This routine reads all the TRAJ input data. The data consist of two parts. The first part consists of general input data which is not specific to any one mission. This part is stored in core memory only. The second part is the data relevant to some particular mission. This second part is stored on scratch tape where it can be read back into core memory, mission by mission, as it is needed.

The general TRAJ input data consists of the following 40 variables:

(1) TIMTO1 - Time during takeoff at first power setting

(2) TIMTO2 - Time during takeoff at second power setting

(3) FRFURE - Fuel reserve, as fraction of total fuel

(4) DESLF - Design load factor

(5) ULTLF - Ultimate load factor

(6) RANGE - Aircraft range

(7) WFUEL - Total internal fuel weight

(8) WFEXT - External fuel weight

(9) WFTRAP - Weight of internally trapped fuel

(10) MENDUR - Mach number used for final endurance calculation

(11) QMAX - Maximum dynamic pressure

(12) XDESC - Initial guess for horizontal distance covered during descent

(13) WKFUEL - Fuel multiplication factor

(14) CRMACH - Cruise Mach number

(15) NCRUSE - Number of cruise legs in mission

(16) IPSIZE - Power setting for sizing engine

(17) IPSTO1 - Power setting during first part of takeoff

(18) IPSTO2 - Power setting during second part of takeoff

(19) IBREG - Breguet altitude search indicator

(20) IENDUR - Endurance altitude search indicator

(21) IPRINT - Diagnostic print indicator

(22) KERROR - Error print indicator

(23) NLEGCL - Number of legs per climb phase

(24) NLEGCR - Number of legs per cruise phase

(25) NLEGLO - Number of legs per loiter phase

(26) MILCOM - Takeoff obstacle height indicator

The following quantities are used in the landing field computation:

(27) WKLAND - WLAND = WGTO - WKLAND * WFTOT

(28) FLFAC - FLLAND = (XAIR + XGRLAN)/FLFAC

(29) DECEL - Deceleration factor

The following quantities are used for the plotting routine:

(30) IPLOT - Plotting indicator

(31) HMINP - Minimum altitude

(32) HMAXP - Maximum altitude

(33) DELHP - Altitude interval to be used

(34) SMMINP - Minimum Mach number

(35) SMMAXP - Maximum Mach number

(36) DELMP - Mach number interval to be used

(37) WCOMBP - Aircraft weight used

The following quantities are used for multimission computations:

(38) NMISS - Number of missions per job

(39) FWGMAX - Maximum weight factor used in convergence

(40) TOL - Convergence tolerance

The input for each mission consists of 2 variables which apply to the whole mission, and a series of 14 variables which apply to each phase of the mission.

The two general variables are:

(1) NPHASE – The number of phases in the mission

(2) WPL – Payload weight (not needed for mission 1, where it is supplied by the weights module)

The following 14 variables are input for each phase of the mission, although no single phase makes use of all 14 variables.

(1) MSTART – Starting Mach number. If MSTART > 0, then starting Mach number is set equal to MSTART. If MSTART < 0, then starting Mach number is set equal to final Mach number from preceding phase.

(2) MEND – Ending Mach number

(3) HSTART – Starting altitude. If HSTART ≥ 0, then starting altitude is set equal to HSTART. If HSTART < 0, the starting altitude is set equal to final altitude from preceding phase.

(4) HEND – Ending altitude. In CLIMB, if IBREG = 0 or HEND > 0, then ending altitude is set equal to HEND; otherwise, ending altitude is determined by making a Breguet search.

(5) X – Horizontal distance covered

(6) TIM – Time

(7) NT – Number of turns

(8) VIND – Constant indicated airspeed (for climb)

(9) IP – Power setting
- = 1 maximum afterburner power
- = 2 intermediate (commercial maximum takeoff power)
- = 3 maximum continuous power
- = 4 thrust = drag (cruise)
- = 5 idle

(10) IX – Indicator which tells whether horizontal distance covered during CLIMB, ACCEL, or DESCNT will be added, subtracted, or ignored in computing horizontal distance to be covered during CRUISE phase.

(11) IW – Weapons drag indicator

(12) IPRT – Print indicator

(13) IB – Bombs drop indicator

(14) IA – AMMO drop indicator

The table below indicates which inputs may possibly be needed for each of the seven types of phases.

PHASE	1 MSTART	2 MEND	3 HSTART	4 HEND	5 X	6 TIM	7 NT	8 VIND	9 IP	10 IX	11 IW	12 IPRT	13 IB	14 IA
CLIMB	✓	✓	✓	✓				✓	✓	✓	✓	✓	✓	✓
CRUISE	✓		✓		✓				✓	✓	✓	✓	✓	✓
ACCEL	✓	✓	✓						✓	✓	✓	✓	✓	✓
COMBAT	✓		✓			✓	✓		✓		✓	✓	✓	✓
LOITER	✓		✓		✓	✓					✓	✓	✓	✓
DESCNT				✓							✓	✓	✓	✓
PATHS	Mach vs h table								✓		✓	✓	✓	✓

MISSION

The primary function of this subroutine is to call all the subroutines needed to fly one mission. For example, if a given mission consists of three phases such as climb, cruise, and descent, then MISSON will first call TAKEOF (always called first for all missions), then CLIMB, then CRUISE, then DESCNT. The order of the called subroutines is determined by the order of the various phases of the mission as read by TRAJIN.

After this, MISSON computes used, reserve, total, and internal fuel weights according to the following formulas:

$$WFUSED = WKFUEL * (WGTO - W - f(W))$$
$$WFRES = WFUSED/(1. - FRFURE) - WFUSED$$
$$WFTOT = WFUSED + WFRES + WFTRAP$$
$$WFUEL = WFTOT - WFEXT$$

where WFUSED is the weight of the fuel used, WGTO is gross takeoff weight, W is the landing weight of the vehicle, f(W) is the weight of all missiles, bombs, ammunition, and external tanks jettisoned during the mission, WKFUEL is a multiplying factor, WFRES is the reserve fuel weight, FRFURE is the fraction of fuel kept in reserve, WFTOT is the total fuel weight, WFTRAP is the weight of fuel trapped in the fuel tanks, WFUEL is the weight of internal fuel, and WFEXT is the weight of fuel stored in external tanks.

Next, the landing field length is determined by the following sequence of equations (ref. 4):

$$WLAND = WGTO - WKLAND*WFUSED$$
$$VSTALL = SQRT[2.*WLAND/(SWING*CL*RHO)]$$
$$VSCREN = 1.3*VSTALL$$

```
VTDOWN = 1.15*VSTALL
  XAIR = [(VSCREN**2 - VTDOWN)/64.4 + 50.]*RLD
XGRLAN = VTDOWN**2/(64.4*DECEL)
FLLAND = (XAIR + XGRLAN)/FLFAC
```

where WKLAND, DECEL, and FLFAC are input to TRAJ (see TRAJIN writeup), RHO is sea level air density, CL is lift coefficient at landing, and RLD is lift to drag ratio.

Next, the endurance altitude and endurance time are calculated based on the approximate (input) Mach number (MENDUR). (The results of the approximate calculation for endurance altitude and time were only intended for use in the economics module of ACSYNT and are never used within TRAJ for performance or fuel calculations.) A golden section type of search is performed to find the endurance altitude corresponding to the maximum value of the endurance factor (RLD/SFC). Using this value of the endurance factor, the endurance time is calculated from RLD/SFC[WGTO/(WGTO - WFUSED)].

Finally, the gross weight of the vehicle is calculated using the equation

$$\text{WGCALC} = \text{WFIXED} + \text{WPL} + \text{WFTOT}$$

where WPL is the payload and WFIXED is equal to WGTO - WFTOT - WPL calculated just once after mission 1 has been converged. WGCALC is needed for transfer back to CONVGR.

Takeoff

The first calculation performed in subroutine TAKEOF is the determination of the total static thrust of the aircraft, and the corresponding value of SFC. The fuel used during startup and taxi is based on the static value of the SFC for a power setting which is input (IPSTO1) and for an input time (TIMTO1).

The takeoff balanced field length is computed using an expression from reference 4, which is written

$$\text{FLTO} = 2.10\left(\frac{0.01163\ W}{\rho C_{L_2} S} + 0.374\ \text{TOOBHT}\right)\left(\frac{1}{k_t \frac{T}{W} - 0.04} + 2.7\right) + \frac{32.0}{\rho}$$

where FLTO is in ft, W/S in psf and ρ in slugs/ft^3. The lift coefficient C_{L_2} is evaluated at 1.2 V_{stall}, where

$$V_{stall} = \sqrt{\frac{2\ \text{WGTO}}{\rho C_{L_{stall}} S}}$$

k_t is the thrust lapse factor during takeoff and the program uses the average of the value at takeoff and the value at a velocity of 1.2 V_{stall}. TOOBHT

is the obstacle height and is 50 ft (15.24 m) for military aircraft and 35 ft (10.67 m) for commercial aircraft.

The fuel used during takeoff can be calculated by one of two methods. If the takeoff time (TIMTO2) is input as a positive or zero value, the fuel used is

$$WFTO2 = 0.0167(TIMTO2)(SFC)(TN)$$

where the SFC and thrust (TN) are based on conditions at the end of takeoff. Alternatively, if TIMTO2 is set negative, the fuel used is based on the balanced field length and is

$$WFTO2 = \frac{(TN_{AVE})(SFC_{AVE})(FLTO)}{1800.(1.2\ V_{stall})}$$

where TN_{AVE} and SFC_{AVE} are the values averaged between static and takeoff conditions.

The total fuel used is the sum of the values for startup, taxi and takeoff

$$WFTO = WFTO1 + WFTO2$$

Climb

The program can calculate climb in either of two modes. When VIND > 0, climb is calculated using a constant indicated airspeed. When VIND $\leq$ 0, climb is calculated using an approximate minimum fuel path. If the aircraft is to cruise at Breguet altitude (IBREG > 0), the program performs a search for the ending altitude; otherwise ending altitude must be input (IBREG = 0).

The forces acting on the airplane during climb vary with altitude, necessitating dividing the climb phase into a finite number of legs. The conditions changing with altitude include the temperature, pressure, and density of the ambient air, and the weight and Mach number of the vehicle. Also, since the available power decreases at an ever greater rate as the ceiling altitude of the vehicle is approached, it is desirable to decrease the altitude increments of the legs as altitude increases.

The total number of legs in a climb phase is given by the formula

$$NLEGS = \frac{\text{total interval}}{\text{average step size}} = \int_{H_1}^{H_2} \frac{dH}{f(H)} = \int_{H_1}^{H_2} \frac{dH}{4000 - 0.05\ H}$$

$$= 20\ \ln\left(\frac{4000 - 0.05\ H_1}{4000 - 0.05\ H_2}\right)$$

where H_1 is the starting altitude of the phase, H_2 is the ending altitude of the phase, and f(H) is an expression giving step size as a function of altitude. A further restriction on NLEGS is given by the relation $3 \leq NLEGS \leq 20$. The above formula can be overridden by giving NLEGCL a positive integer value, in which case, NLEGS = NLEGCL. This, however, will cause all climb phases in all missions of a run to have the same value for NLEGS.

Once the number of legs in a climb phase is determined, the distance climbed during each leg is given by the formula:

$$DELH = \ln\left[\frac{1 + (LEG)(e - 1)/NLEGS}{1 + (LEG - 1)(e - 1)/NLEGS}\right](H_2 - H_1)$$

where LEG is the current leg being executed by the program. This causes the step size to decrease logarithmically with increasing altitude.

Summing forces in the axial direction, the equations of motion give

$$\frac{\Delta V}{\Delta t} = g\left(\frac{T}{W} - \frac{D}{W} - \sin \gamma\right)$$

while in the normal direction

$$L + T \sin \alpha = W \cos \gamma$$

which gives two equations in three unknowns. The three unknowns are T, L, and D, or γ.

For the approximation to the most economical or fastest climb, the relation for γ comes from reference 5, and is

$$\sin \gamma = \frac{5}{6}\frac{T}{W} - \frac{\sqrt{\left(\frac{T}{W}\right)^2 E_m^2 + 3}}{6E_m} - \frac{3}{2E_m\left[\frac{T}{W} E_m + \sqrt{\left(\frac{T}{W}\right)^2 E_m^2 + 3}\right]}$$

where

$$E_m = \frac{C_L}{2\sqrt{C_{D_o} C_{D_L}}}$$

For the constant indicated airspeed climb,

$$\sin \gamma = \frac{\Delta h}{V \Delta t}$$

where, now

$$V = \frac{V_{ind}}{\sqrt{\rho/\rho_{SL}}} = \frac{V_{ind}}{\sqrt{\sigma}}$$

and where σ is the density ratio referenced to the sea level value. By differentiating the equation for velocity with respect to time, we find that the relationship between time and altitude is

$$\Delta t = \frac{\frac{\sqrt{\sigma}}{V_{ind}} \Delta h - \frac{V_{ind}}{2g\sigma^{1.5}}}{\frac{T}{W} - \frac{\rho_{SL} V_{ind}^2 C_D S}{2W}}$$

We now have all the necessary terms for calculating flight-path angle.

The fuel used is calculated from

$$\Sigma W_F = \Sigma (sfc) T \, \Delta t$$

and the equivalent ground distance travelled during climb is

$$\Sigma X = \Sigma V \cos \gamma \, \Delta t$$

Cruise

The starting altitude for the cruise phase will be the input value (HSTART) if HSTART is positive. If HSTART = 0 and IBREG = 1, then the starting altitude will be determined by a Breguet search. The ending altitude will be the same as the starting altitude only if the input value (HEND) is set equal to -1. Otherwise, the airplane will be allowed to climb with each leg of the cruise phase as fuel is burned off.

At the beginning and at the end of the cruise phase a test is made to determine whether the fuel used to that point exceeds the weight of the fuel stored in the external tanks if these are present. If it does, then the external fuel tanks are dropped immediately.

In general, the horizontal distance travelled in a given cruise phase is calculated using the formula

$$XCRUSE = X + DXCRUS + XDESC$$

where XCRUSE is the actual horizontal distance that will be traversed in the cruise phase, X is the nominal horizontal distance input for that phase, DXCRUS is the algebraic sum of the horizontal distances traversed in the preceding climb and acceleration phases (but following the preceding cruise

phase if one exists), and XDESC is the horizontal distance traversed in the last descent phase of the mission. An estimated value for XDESC is inputted and used for the first iteration of the mission, and the calculated value from the previous iteration is used for all succeeding iterations of the mission. DXCRUS is set to zero at the beginning of the mission and is reset to zero at the end of every cruise phase. The calculated value of horizontal distance traversed in a climb or acceleration phase will be added or subtracted from DXCRUS or ignored depending on whether IX for that phase is +1, -1, or 0, respectively. Similarly, XDESC will be positive, negative, or zero depending upon whether IX for the cruise phase under consideration is +1, -1, or 0, respectively.

When X is given a negative value, then the formula for XCRUSE becomes

$$\text{XCRUSE} = \text{RANGE}/\text{NCRUSE} + \text{DXCRUS} + \text{XDESC}$$

where RANGE and NCRUSE are input at the beginning of the run.

The number of legs in a given cruise phase (NLEGS) is given by the following inequalities:

$$X < 100, \text{ then NLEGS} = 2$$

$$100 \leq X < 300, \text{ then NLEGS} = 3$$

$$300 \leq X < 1000, \text{ then NLEGS} = 4$$

$$1000 \leq X < 3000, \text{ then NLEGS} = 5$$

$$X \geq 3000, \text{ then NLEGS} = 6$$

The cruise consists of an approximation to the most efficient flight path which uses a stepwise cruise-climb path. There are two options for determining the initial cruising altitude: (1) the Breguet altitude, found by maximizing the value of (V/sfc)(L/D) as a function of altitude and (2) altitude is specified.

The summation of forces tangential to and normal to the flight path are, respectively,

$$T \cos \alpha = D \quad \text{and} \quad L = W$$

From these relations, the weight of fuel used is

$$\Sigma W_F = \Sigma \frac{C_D W(\text{sfc})}{\cos \alpha} \sqrt{\frac{\rho}{2C_L} \frac{S}{W}} \Delta X$$

where ΔX is the distance flown at each altitude and the cruise altitude is increased, as the aircraft burns fuel, according to the relation

$$\rho = \frac{2W}{C_L V^2 S}$$

and C_L is kept constant at the value corresponding to $(L/D)_{max}$; otherwise, C_L is determined by the input values of Mach number and altitude.

The cruising time and the equivalent ground distance covered are, respectively,

$$t = \Sigma \frac{\Delta X}{V} \quad \text{and} \quad X = \Sigma \Delta X$$

Acceleration

The purpose of the acceleration phase (ACCEL) is to increase the Mach number of the vehicle from an initial low value to a specified higher value. The phase is divided into steps with the size of the Mach number steps being 0.02 between Mach 0.87 and 1.1 and equal to 0.05 elsewhere.

The aircraft is assumed to accelerate at a fixed altitude. The equation of motion along the flight path is

$$\frac{dV}{dt} = g\left(\frac{T}{W}\cos\alpha - \frac{D}{W}\right)$$

from which we can calculate the fuel used to be

$$W_F = W\left\{1 - \exp\left[\frac{1}{g}\int \frac{(sfc)T}{T\cos\alpha - D}\, dV\right]\right\}$$

The time required to accelerate is

$$t = \frac{1}{g}\int \frac{W dV}{T\cos\alpha - D}$$

and the equivalent ground distance covered is given by

$$X = \frac{1}{g}\int \frac{W dV}{T\cos\alpha - D}$$

Combat

In the combat phase, the acceleration and turning capabilities are calculated and also the amount of fuel used by performing combat at a fixed altitude, either for a specified time or a fixed number of turns. The airplane's potential acceleration capability is expressed as the "specific excess power," for which the expression is derived below.

The specific energy (sum of potential and kinetic energy per unit airplane weight) is

$$E_S = \frac{E}{W} = h + \frac{V^2}{2g}$$

and differentiating the specific energy with respect to time gives the specific power

$$P_s = \frac{dE_s}{dt} = \frac{dh}{dt} + \frac{V}{g}\frac{dV}{dt}$$

Summing forces along the flight path gives

$$T \cos \alpha - D - W \sin \gamma = m \frac{dV}{dt}$$

Dividing both sides by W and multiplying by V

$$\frac{V(T \cos \alpha - D)}{W} = V \sin \gamma + \frac{V}{g}\frac{dV}{dt}$$

and, since

$$\frac{dh}{dt} = V \sin \gamma$$

we get

$$P_s = \frac{dE_s}{dt} = \frac{V(T \cos \alpha - D)}{W}$$

The relations for turning radius and turning rate are, respectively (ref. 6)

$$R = \frac{V^2}{g \tan \phi} \quad \text{and} \quad \frac{d\theta}{dt} = \dot{\theta} = \frac{V}{R}$$

where the airplane bank angle, ϕ, is related to the load factor, n, through

$$\cos \phi = \frac{1}{n}$$

The load factor is written as

$$n = \frac{L + T \sin \alpha}{W}$$

and cannot exceed the structural design load factor.

Two types of turns are considered. These are: (1) sustained, or coordinated turns for which $P_s = 0$, equiring the solution of the equation $T \cos \alpha = D$ to obtain the aerodynamic parameters needed to find the load factor and (2) instantaneous turns corresponding to the maximum value of P_s and limited by either the maximum lift coefficient, $C_{L_{max}}$, or the structural design load factor of the airplane.

The time required to complete a turn is

$$t = \frac{2\pi R}{V}$$

and the fuel used during combat turns is

$$W_F = \Sigma T(sfc)Nt$$

where N is the number of turns required.

Loiter

The starting altitude for the loiter phase will be the input value (HSTART) if HSTART is positive. If HSTART = 0 and IENDUR = 1, then a search will be made to determine the most economical starting altitude.

The Mach number will change from leg to leg or remain constant throughout the loiter phase depending on the input value of MSTART. Ordinarily, a search for the most economical loiter Mach number will be made for each leg of the phase. However, whenever MSTART is positive, the Mach number will remain equal to MSTART throughout the phase and the altitude in each leg will increase to take advantage of the reduced fuel weight.

Each loiter phase is divided into legs, the number of which depends on the amount of time to be spent in the phase. The number of legs is equal to the time in hours rounded up to the next higher integer, but is not allowed to exceed six.

There are two options for determining the loiter flight conditions: (1) most economical loiter altitude and/or velocity is found by maximizing the value of (L/D)/sfc as a function of altitude, velocity, or both, and (b) altitude and/or velocity is specified.

The fuel used is calculated from

$$\Sigma W_F = \Sigma T(sfc)\Delta t$$

where t is the loiter time. As the aircraft burns fuel, the loiter altitude is increased, or the speed decreased, to maintain the most economical flight condition according to the relation

$$\rho = \frac{2W}{C_L S V^2}$$

Since loitering generally consists of flying in circles, it may be desirable to fly in a smaller circle than that corresponding to the most economical one. To decrease the loiter circle size, more lift is needed. The equation of motion normal to the flight path is

$$L + D \tan \alpha = \frac{W}{\sqrt{1 + \left(\frac{V^2}{gR}\right)^2}}$$

where R is the loiter circle radius. The exact solution is a tedious iteration between C_L, C_D, and α, since

$$C_L - C_D \tan \alpha = \frac{2W}{\rho V^2 S} \sqrt{1 + \left(\frac{V^2}{Rg}\right)^2}$$

However, for most cases of practical interest

$$C_D \tan \alpha << C_L$$

and, we have used the simple approximation

$$C_L \approx \frac{2W}{\rho V^2 S} \sqrt{1 + \left(\frac{V^2}{gR}\right)^2}$$

Descent

The most economical descent path is the flattest descent with engines at idle power setting. The aircraft should fly at $(L/D)_{max}$, thus $C_{D_i} = C_{D_o}$ and for flight with thrust much less than drag, the optimum descent angle is approximately (ref. 6)

$$\sin \gamma = -\frac{2C_{D_o}}{C_L}$$

Summation of forces normal to the flight path gives

$$L = W \cos \gamma$$

resulting in the following expression for the speed

$$V = \sqrt{\frac{2W \cos \gamma}{C_L \rho S}}$$

The descent time is calculated from

$$\Sigma \Delta t = \Sigma \frac{-\Delta h}{V \sin \gamma}$$

while the fuel used is

$$\Sigma W_F = \Sigma T(sfc)\Delta t$$

and the equivalent ground distance covered is

$$\Sigma \Delta X = \Sigma V \cos \gamma \, \Delta t$$

OUTPUT-TRAJOO

The output quantities are listed in tabular form and consist of 19 quantities representing values at the end of each phase. In addition, there are eight values giving a fuel weight. If there are combat phases, an additional 21 values of combat parameters are printed for each combat phase. Lastly, there are 12 miscellaneous quantities printed.

The following 19 quantities are printed for each phase:

(1) Mach number

(2) Altitude

(3) Lift coefficient

(4) Angle of attack

(5) Fuel used in phase

(6) Flight time in phase

(7) Flight velocity

(8) Specific fuel consumption (installed)

(9) Specific fuel consumption (uninstalled)

(10) Total thrust (installed)

(11) Total thrust (uninstalled)

(12) Drag coefficient

(13) Lift-drag ratio

(14) Weight at end of phase

(15) Engine airflow rate

(16) Dynamic pressure

(17) Horizontal distance covered

(18) Engine installation drag coefficient

(19) Pressure recovery

The following eight quantities give a fuel weight:

(1) Fuel weight during takeoff with first power setting

(2) Fuel weight during takeoff with second power setting

(3) Mission fuel weight

(4) Reserve fuel weight

(5) Trapped fuel weight

(6) Internal fuel weight

(7) External fuel weight

(8) Total fuel weight

The following seven quantities are printed for each combat phase for each of three conditions: 1g flight, sustained, and instantaneous — making a total of 21 combat parameters in all. They are:

(1) Specific excess power

(2) Load factor

(3) Turning rate

(4) Radius

(5) Angle of attack

(6) Lift coefficient

(7) Drag coefficient

The following 12 miscellaneous quantities are also printed out:

(1) Total mission time

(2) Total mission range

(3) Takeoff field length (total run)

(4) Landing field length (total run)

(5) Landing field length (ground run)

(6) Weight used for landing calculation

(7) Takeoff weight

(8) Landing weight

(9) Endurance Mach number (input value)

(10) Endurance altitude

(11) Endurance time

(12) Loiter radius

PLOTS-TRPLOT

This routine calculates various parameters which are written onto tape so that they can later be displayed graphically. The main part of this routine calculates certain parameters which may be displayed graphically on a plot of altitude vs Mach number. These parameters are:

(1) PSIG = specific excess power at 1g

(2) NZS = load factor during turn

(3) TDOTS = sustained turning rate

(4) NZI = maximum instantaneous load factor

(5) PSI = maximum instantaneous specific excess power

(6) TDOTI = maximum instantaneous turning rate

(7) Q = dynamic pressure

These parameters are calculated for a certain range of values of altitude and Mach number with beginning, ending, and incremental values of each being input.

The inputs to the routine are:

(1) IPLOT = 0, no print, no plot

= 1, print, no plot

= 2, no print, plot

= 3, print, plot

(2) HMINP = minimum altitude

(3) HMAXP = maximum altitude

(4) DELHP = altitude interval

(5) SMMINP = minimum Mach number

(6) SMMAXP = maximum Mach number

(7) DELMP = Mach number interval

(8) WCOMBP $\leq$ 0, aircraft weight taken from first COMBAT phase

0 < WCOMBP $\leq$ 1, aircraft weight equals WCOMBP times takeoff weight

WCOMBP > 1, aircraft weight equals WCOMBP

The second part of this routine calculates landing field lengths at altitudes of 0, 4000 ft (1219 m), 8000 ft (2438 m), and 12,000 ft (3657 m).

SUBROUTINE TRAJA 76/76 OPT=2 FTN 4.5+410

```
      SUBROUTINE TRAJA (ICALC,NERROR,LCEO,KGPRNT,IGPLT)
      EXTERNAL MISSON
      REAL MSTART,MEND,NT,MENDUR
      COMMON /TRAJCM/ ALPHA,ARW,CD,CDL,CDO,CL,DESLF,DRAG,EN,HN,KP,
     1 KLD,SMN,QMAX,RANGE,SFC,SWING,THRUST,TW,ULTLF,W,WAMMUN,WETANK,
     2 WFUEL,WGTOWT,WMISS,WTOT,WPLWT,MSTART(12),HSTART(12),TIM(12),
     3 PSIGT(12),TDOTST(12),NZST(12),PSIT(12),TDOTIT(12),NZIT(12),
     4 WBOMBS,WFEXT,SFCU,THRSTU,CDINSP,PRTOT,WKFUEL,CRMACH,FLTQ,X(12),
     5 FLLAND,TENDUR,BLRANG,BLTIME,TIMTO1,TIMTO2,WFTO,PNAME1(12),
     6 PNAME2(12),SMNT(12),HNT(12),WF1(12),TIMET(12),XT(12),CLT(12),
     7 CDT(12),ALPHAT(12),CLIT(12),CDIT(12),ALPHIT(12),WFUSED,WLAND,
     8 QY(12),RLOT(12),SFCT(12),TNT(12),CET(12),DY(18),
     9 IAQ,IPS,ITS,IWS,IBS,NPHASE,IDY(14)
      COMMON /TRAJEX/ ALP1GT(12),CDINST(12),CD1GT(12),CL1GT(12),DECEL,
     1 DELHP,DELMP,DXCRUS,FLFAC,FRFURE,HEND(12),HENDUR,HMAXP,HMINP,
     2 HPATHT(50),MEND(12),MENDUR,NT(12),PRTOTT(12),RADIT(12),
     3 RADST(12),SF,SFCUT(12),SMMAXP,SMMINP,
     4 TNUT(12),VIND(12),VELT(12),VPATHT(50),WART(12),WCOMBP,WEELT(12),
     5 WFRES,WFTOT,WFTO1,WFTO2,WFTRAP,WKLAND,XDESC,XGRLAN,FWGMAX,TOL,
     6 WFIXED,WGCALC,WPL,WGTO,DUMY(82),IA(12),IAS,IB(12),IBREG,IENDUR,
     7 IMISS,IP(12),IPHASE,IPLOT,IPRINT,IPRT(12),IPSIZE,IPSTO1,IPSTO2,
     8 IW(12),IX(12),KERROR,MILCOM,NCRUSE,NLEGCL,NLEGCR,NLEGLO,NMISS,
     9 NPATH,IDUMY(6)
      DATA PATH/4HPATH/
      WPL=WPLWT
      WGTO=WGTOWT
      IF (KGPRNT.EQ.0) GO TO 5
      KSTORE=KERROR
      KERROR=2
5     IF (ICALC.EQ.1) GO TO 10
      IF (ICALC.EQ.2) GO TO 20
      IF (ICALC.EQ.3) GO TO 30
      IF (KGPRNT.NE.0) KERROR=KSTORE
      RETURN
C-----------
C  ICALC = 1
C-----------
10    TIMTO1=5.0
      TIMTO2=1.0
      FRFURE=.05
      DESLF=2.5
      ULTLF=3.75
      RANGE=1000.
      WFUEL=10000.
      WFEXT=0.0
      WFTRAP=100.
      QMAX=700.
      XDESC=80.
      WKFUEL=1.0
      CRMACH=.8
      WKLAND=.57
      FLFAC=.6
      DECEL=.25
      NCRUSE=2
      IPSIZE=0
      IPSTO1=5
      IPSTO2=2
```

```
      SUBROUTINE TRAJA      76/76   OPT=2                    FTN 4.5+410        (
                        IBREG=0
                        IENDUR=0
   60                   IPRINT=0
                        KERROR=2
                        IPLOT=0
                        HMINP=0.0
                        HMAXP=40000.
   65                   DELHP=4000.
                        SMMINP=.3
                        SMMAXP=.9
                        DELMP=.1
                        WCOMBP=.7
   70                   MILCOM=0
                        MENDUR=.5
                        NLEGCL=0
                        NLEGCR=0
                        NLEGLG=0
   75                   NMISS=1
                        FWGMAX=1.2
                        TOL=.001
                        CALL TRAJIN
                        CALL TRAJOI
   80         C-----READ MISSION 1 FROM TAPE 22.
                12      IMISS=1
                        REWIND 22
                        READ (22,2200) NPHASE,WPLTRA
              2200      FORMAT(I10,E15.8)
   85                   DO 15 IPHASE=1,NPHASE
                        READ (22,2201) PNAME1(IPHASE),PNAME2(IPHASE),MSTART(IPHASE),
                       1 MEND(IPHASE),HSTART(IPHASE),HEND(IPHASE),X(IPHASE),TIM(IPHASE),
                       2 NT(IPHASE),VIND(IPHASE),IP(IPHASE),IX(IPHASE),IW(IPHASE),
                       3 IPRT(IPHASE),IB(IPHASE),IA(IPHASE)
   90         2201      FORMAT(2A4,2X,7E15.8/E15.8,6I10)
                        IF (PNAME1(IPHASE).NE.PATH) GO TO 15
                        READ (22,2200) NPATH
                        READ (22,2202) (HPATHT(I),I=1,NPATH)
                        READ (22,2202) (VPATHT(I),I=1,NPATH)
   95         2202      FORMAT(8E15.8)
              15        CONTINUE
              C-----END OF READING MISSION 1 FROM TAPE 22.
                        IF (ICALC.EQ.3) RETURN
                        WFIXED=0.0
  100                   SF=ULTLF/DESLF
                        ALPHA=0.0
                        CL=0.0
                        DRAG=0.0
                        HN=0.0
  105                   SMN=0.0
                        W=0.0
                        IF (KGPRNT.NE.0) KERROR=KSTORE
                        RETURN
              C-----------
  110         C  ICALC = 2
              C-----------
              20        CALL MISSON(ICALC,NERROR,IGEO,KGPRNT)
                        IF (KGPRNT.NE.0) KERROR=KSTORE
                        RETURN
```

```
115          C-----------
             C  ICALC = 3
             C-----------
             30     IF (NMISS.EQ.1) GOTO 40
                    KCALC=2
120                 CALL MISSON(KCALC,NERROR,IGEO,KGPRNT)
                    IF (NERROR.GE.2) RETURN
             40     CALL TRAJOO
                    IF (IMISS.GE.NMISS) GO TO 70
                    IF (IMISS.GE.2) GO TO 50
125                 WGEST=WGTO
                    WGMAX=FWGMAX*WGEST
                    WFIXED=WGTO-WFTOT-WPL
             C-----READ NEW MISSION FROM TAPE 22.
             50     IMISS=IMISS+1
130                 READ (22,22CO) NPHASE,WPLTRA
                    DO 60 IPHASE=1,NPHASE
                    READ (22,2201) PNAME1(IPHASE),PNAME2(IPHASE),MSTART(IPHASE),
                   1 MEND(IPHASE),HSTART(IPHASE),HEND(IPHASE),X(IPHASE),TIM(IPHASE),
                   2 NT(IPHASE),VEND(IPHASE),IP(IPHASE),IX(IPHASE),IW(IPHASE),
135                3 IB(IPHASE),IA(IPHASE)
                    IF (PNAME1(IPHASE).NE.PATH) GO TO 60
                    READ (22,2200) NPATH
                    READ (22,22C2) (HPATHT(I),I=1,NPATH)
                    READ (22,2202) (VPATHT(I),I=1,NPATH)
140          60     CONTINUE
             C-----END OF READING NEW MISSION FROM TAPE 22.
                    WPL=WPLTRA
                    WGEST1=WGEST
                    IF (IPRINT.EQ.0) GO TO 65
145                 WRITE (6,600) IMISS,WGEST,WGMAX,WFIXED,WFTOT,WGTO,WGCONV,WPL,
                   1 WGEST1,WGCALC
             600    FORMAT(1H1,18H CHECK FOR MISSION,I2/23H BEFORE CALLING CONVGR:/
                   1 9H    WGEST=,E13.6,4X,7H WGMAX=,E13.6,4X,7HWFIXED=,E13.6/
                   2 9H    WFTOT=,E13.6,4X,7H  WGTO=,E13.6,4X,7HWGCONV=,E13.6/
150                3 9H      WPL=,E13.6,4X,7HWGEST1=,E13.6,4X,7HWGCALC=,E13.6)
             65     CALL CONVGR(MISSON,WGEST1,WGCONV,WGMAX,TOL,IPRINT)
                    IF (IPRINT.EQ.0) GO TO 40
                    WRITE (6,601) WGEST,WGMAX,WFIXED,WFTOT,WGTO,WGCONV,WPL,WGEST1,
                   1 WGCALC
155          601    FORMAT(22H AFTER CALLING CONVGR:/
                   1 9H    WGEST=,E13.6,4X,7H WGMAX=,E13.6,4X,7HWFIXED=,E13.6/
                   2 9H    WFTOT=,E13.6,4X,7H  WGTO=,E13.6,4X,7HWGCONV=,E13.6/
                   3 9H      WPL=,E13.6,4X,7HWGEST1=,E13.6,4X,7HWGCALC=,E13.6)
                    GO TO 40
160          70     IF (IPLOT.GT.0) CALL TRPLOT(NERROR,IGEO,KGPRNT)
                    IF (KGPRNT.NE.0) KERROR=KSTORE
                    GOTO 12
                    END
```

```
 SUBROUTINE TRAJIN     76/76   OPT=2                    FTN 4.5+410        05

 1                SUBROUTINE TRAJIN
                  REAL MSTART,MEND,NT,MENDUR
                  COMMON /TRAJCM/ ALPHA,ARW,CD,CDL,CDO,CL,DESLF,DRAG,EN,HN,KP,
                 1 RLD,SMN,QMAX,RANGE,SFC,SWING,THRUST,TW,ULTLF,W,WAMMUN,WETANK,
 5               2 WFUEL,WGTOWT,WMISS,WTOT,WPLWT,MSTART(12),HSTART(12),TIM(12),
                 3 PSIGT(12),TDOTST(12),NZST(12),PSIT(12),TDOTIT(12),NZIT(12),
                 4 WBOMBS,WFEXT,SFCU,THRTU,CDINSP,PRTOT,WKFUEL,CRMACH,FLTO,X(12),
                 5 FLLAND,TENDUR,BLRANG,BLTIME,TIMTO1,TIMTO2,WFTO,PNAME1(12),
                 6 PNAME2(12),SMNT(12),HNT(12),WFT(12),TIMET(12),XT(12),CLT(12),
10               7 CDT(12),ALPHAT(12),CLIT(12),CDIT(12),ALPHIT(12),WFUSED,WLAND,
                 8 QT(12),RLDT(12),SFCT(12),TNT(12),CET(12),DY(18),
                 9 IAD,IPS,ITS,IWS,IBS,NPHASE,IDY(14)
                  COMMON /TRAJEX/ ALPIGT(12),CDINST(12),CDIGT(12),CLIGT(12),DECEL,
                 1 DELHP,DELMP,DXCRUS,FLFAC,FRFURE,HEND(12),HENDUR,HMAXP,HMINP,
15               2 HPATHT(50),MEND(12),MENDUR,NT(12),PRTOTT(12),RADIT(12),
                 3 RADST(12),SF,SFCUT(12),SMMAXP,SMMINP,
                 4 TNUT(12),VIND(12),VELT(12),VPATHT(50),WART(12),WCOMBP,WEELT(12),
                 5 WFRES,WFTOT,WFTO1,WFTO2,WFTRAP,WKLAND,XDESC,XGRLAN,FWGMAX,TOL,
                 6 WFIXED,WGCALC,WPL,WGTO,DUMY(82),IA(12),IAS,IB(12),IBREG,IENDUR,
20               7 IMISS,IP(12),IPHASE,IPLOT,IPRINT,IPRT(12),IPSIZE,IPSTO1,IPSTO2,
                 8 IW(12),IX(12),KERROR,MILCOM,NCRUSE,NLEGCL,NLEGCR,NLEGLO,NMISS,
                 9 NPATH,IDUMY(6)
                  DATA PATH/4HPATH/
                  NAMELIST/TRDATA/TIMTO1,TIMTO2,FRFURE,DESLF,ULTLF,RANGE,WFUEL,
25               1 WFEXT,WFTRAP,QMAX,XDESC,WKFUEL,CRMACH,WKLAND,FLFAC,DECEL,NCRUSE,
                 2 IPSIZE,IPSTO1,IPSTO2,IBREG,IENDUR,IPRINT,KERROR,IPLOT,HMINP,
                 3 HMAXP,DELHP,SMMINP,SMMAXP,DELMP,WCOMBP,MILCOM,MENDUR,NLEGCL,
                 4 NLEGCR,NLEGLO,NMISS,FWGMAX,TOL
                  READ (5,TRDATA)
30                REWIND 22
                  DO 10 IMISS=1,NMISS
                  READ (5,500) NPHASE,WPLTRA
                  WRITE (22,2200) NPHASE,WPLTRA
            500   FORMAT(I10,E10.0)
35          2200  FORMAT(I10,E15.8)
            C  READ IN THE FOLLOWING WORDS FOR EACH PHASE
            C  PHASE(2 PARTS), STARTING MACH, ENDING MACH, STARTING ALTITUDE,
            C  ENDING ALTITUDE, HORIZONTAL DISTANCE, TIME, NUMBER OF TURNS,
            C  CONSTANT INDICATED AIRSPEED CLIMB, POWER SETTING, RANGE INCREMENT
40          C  INDICATOR, WEAPONS RELEASE INDICATOR, BOMBS RELEASE INDICATOR,
            C  AMMO RELEASE INDICATOR.
                  DO 10 IPHASE=1,NPHASE
                  READ (5,501) PNAME1(IPHASE),PNAME2(IPHASE),MSTART(IPHASE),
                 1 MEND(IPHASE),HSTART(IPHASE),HEND(IPHASE),X(IPHASE),TIM(IPHASE),
45               2 NT(IPHASE),VIND(IPHASE),IP(IPHASE),IX(IPHASE),IW(IPHASE),
                 3 IPRT(IPHASE),IB(IPHASE),IA(IPHASE)
            501   FORMAT(2A4,2X,7E10.0/E10.0,6I10)
                  WRITE (22,2201) PNAME1(IPHASE),PNAME2(IPHASE),MSTART(IPHASE),
                 1 MEND(IPHASE),HSTART(IPHASE),HEND(IPHASE),X(IPHASE),TIM(IPHASE),
50               2 NT(IPHASE),VIND(IPHASE),IP(IPHASE),IX(IPHASE),IW(IPHASE),
                 3 IPRT(IPHASE),IB(IPHASE),IA(IPHASE)
            2201  FORMAT(2A4,2X,7E15.8/E15.8,6I10)
                  IF (PNAME1(IPHASE).NE.PATH) GO TO 10
                  READ (5,500) NPATH
55                READ (5,502) (HPATHT(I),I=1,NPATH)
                  READ (5,502) (VPATHT(I),I=1,NPATH)
            502   FORMAT(8E10.0)
```

```
      WRITE (22,2200) NPATH
      WRITE (22,2202) (HPATHT(I),I=1,NPATH)
6C    WRITE (22,2202) (VPATHT(I),I=1,NPATH)
2202  FORMAT(8E15.8)
10    CONTINUE
      RETURN
      END
```

```
SUBROUTINE TRAJOI     76/76   OPT=2                    FTN 4.5+410        0

1                SUBROUTINE TRAJOI
           C  PRINTOUT OF TRAJECTORY INPUT
                REAL MSTART,MEND,NT,MENDUR
                COMMON /TRAJCM/ ALPHA,ARW,CD,CDL,CDO,CL,DESLF,DRAG,EN,HN,KP,
5               1 RLD,SMN,QMAX,RANGE,SFC,SWING,THRUST,TW,ULTLF,W,WAMMUN,WETANK,
                2 WFUEL,WGTOWT,WMISS,WTOT,WPLWT,MSTART(12),HSTART(12),TIM(12),
                3 PS1GT(12),TDOTST(12),NZST(12),PSIT(12),TDOTIT(12),NZIT(12),
                4 WBOMBS,WFEXT,SFCU,THRSTU,CDINSP,PRTOT,WKFUEL,CRMACH,FLTO,X(12),
                5 FLLAND,TENDUR,BLRANG,BLTIME,TIMTO1,TIMTO2,WFTO,PNAME1(12),
10              6 PNAME2(12),SMNT(12),HNT(12),WFT(12),TIMET(12),XT(12),CLT(12),
                7 CDT(12),ALPHAT(12),CLIT(12),CDIT(12),ALPHIT(12),WFUSED,WLAND,
                8 QT(12),RLDT(12),SFCT(12),TNT(12),CET(12),DY(18),
                9 IAO,IPS,ITS,IWS,IBS,NPHASE,IDY(14)
                 COMMON /TRAJEX/ ALP1GT(12),CDINST(12),CD1GT(12),CL1GT(12),DECEL,
15              1 DELHP,DELMP,DXCRUS,FLFAC,FRFURE,HEND(12),HENDUR,HMAXP,HMINP,
                2 HPATHT(50),MEND(12),MENDUR,NT(12),PRTOTT(12),RADIT(12),
                3 RADST(12),SF,SFCUT(12),SMMAXP,SMMINP,
                4 TNUT(12),VIND(12),VELT(12),VPATHT(50),WART(12),WCOMBP,WEELT(12),
                5 WFRES,WFTOT,WFTO1,WFTO2,WFTRAP,WKLAND,XDESC,XGRLAN,FWGMAX,TOL,
20              6 WFIXED,WGCALC,WPL,WGTO,DUMY(82),IA(12),IAS,IB(12),IBREG,IENDUR,
                7 IMISS,IP(12),IPHASE,IPLOT,IPRINT,IPRT(12),IPSIZE,IPSTO1,IPSTO2,
                8 IW(12),IX(12),KERROR,MILCOM,NCRUSE,NLEGCL,NLEGCR,NLEGLO,NMISS,
                9 NPATH,IDUMY(6)
                 DATA PATH/4HPATH/
25               WRITE (6,600) TIMTO1,MENDUR,NCRUSE,IPLOT,TIMTO2,QMAX,IPSIZE,HMINP,
                1 FRFURE,XDESC,IPSTO1,HMAXP,DESLF,WKFUEL,IPSTO2,DELHP,ULTLF,
                2 CRMACH,IBREG,SMMINP,RANGE,WKLAND,IENDUR,SMMAXP,WFUEL,FLFAC,
                3 IPRINT,DELMP,WFEXT,DECEL,KERROR,WCOMBP,WFTRAP,NLEGCL,NLEGCR,
                4 NLEGLO,FWGMAX,TOL,MILCOM,NMISS
30         600   FORMAT(1H1,25X,16HTRAJECTORY INPUT///
                1  1X,8HTIMTO1 =,F4.1, 7X,8HMENDUR =,F6.0, 4X,8HNCRUSE =,I2,
                2  3X,8H IPLOT =,I2  / 1X,8HTIMTO2 =,F4.1, 7X,8H  QMAX =,F7.0,
                3  3X,8HIPSIZE =,I2  , 3X,8H HMINP =,F7.0/ 1X,8HFRFURE =,F5.2,
                4  6X,8H XDESC =,F6.1, 4X,8HIPSTO1 =,I2  , 3X,8H HMAXP =,F7.0/
35              5  1X,8H DESLF =,F5.2, 6X,8HWKFUEL =,F6.3, 4X,8HIPSTO2 =,I2,
                6  3X,8H DELHP =,F7.0/ 1X,8H ULTLF =,F5.2, 6X,8HCRMACH =,F6.3,
                7  4X,8H IBREG =,I2  , 3X,8HSMMINP =,F6.3/ 1X,8H RANGE =,F7.0,
                8  4X,8HWKLAND =,F6.3, 4X,8HIENDUR =,I2  , 3X,8HSMMAXP =,F6.3/
                9  1X,8H WFUEL =,F8.0, 3X,8H FLFAC =,F6.3, 4X,8HIPRINT =,I2,
40              1  3X,8H DELMP =,F6.3/ 1X,8H WFEXT =,F8.0, 3X,8H DECEL =,F6.3,
                2  4X,8HKERROR =,I2  , 3X,8HWCOMBP =,F9.2/ 1X,8HWFTRAP =,F8.0,
                3  3X,8HNLEGCL =,I2  , 8X,8HNLEGCR =,I2  , 3X,8HNLEGLO =,I2/
                4  1X,8HFWGMAX =,F6.3, 5X,8H   TOL =,F6.3, 4X,8HMILCOM =,I2,
                5  3X,8H NMISS =,I2)
45               REWIND 22
                 DO 10 IMISS=1,NMISS
                 READ (22,2200) NPHASE,WPLTRA
           2200  FORMAT(I10,E15.8)
                 IF (IMISS.EQ.1) WRITE (6,601) IMISS
50         601   FORMAT(/// 24X,7HMISSION,I2//
                1 9X,66HMACH   MACH    ALT       ALT    HORIZ          NO.          IP
                2 IX  IW/75H PHASE   START    END   START      END     DIST   TIME  TURNS
                3  VIND   IPRT   IB   IA/)
                 IF (IMISS.GT.1) WRITE (6,602) IMISS,WPLTRA
55         602   FORMAT(/// 24X,7HMISSION,I2,12H  (PAYLOAD =,F8.0,4H LB)//
                1 9X,66HMACH   MACH    ALT       ALT    HORIZ          NO.          IP
                2 IX  IW/75H PHASE   START    END   START      END     DIST   TIME  TURNS
```

```
                3  VIND  IPRT  I8  IA/)
                 DO 10 IPHASE=1,NPHASE
60               READ (22,2201) PNAME1(IPHASE),PNAME2(IPHASE),MSTART(IPHASE),
                1 MEND(IPHASE),HSTART(IPHASE),HEND(IPHASE),X(IPHASE),TIM(IPHASE),
                2 NT(IPHASE),VIND(IPHASE),IP(IPHASE),IX(IPHASE),IW(IPHASE),
                3 IPRT(IPHASE),IB(IPHASE),IA(IPHASE)
           2201  FORMAT(2A4,2X,7E15.8/E15.8,6I10)
65               WRITE (6,603) PNAME1(IPHASE),PNAME2(IPHASE),MSTART(IPHASE),
                1 MEND(IPHASE),HSTART(IPHASE),HEND(IPHASE),X(IPHASE),TIM(IPHASE),
                2 NT(IPHASE),VIND(IPHASE),IP(IPHASE),IX(IPHASE),IW(IPHASE),
                3 IPRT(IPHASE),IB(IPHASE),IA(IPHASE)
           603   FORMAT(1X,A4,A3,F5.2,F6.2,2F8.0,F7.1,F6.1,F6.1,F7.1,I4,I5,I4/
70              1 I65,I5,I4)
                 IF (PNAME1(IPHASE).NE.PATH) GO TO 10
                 READ (22,2200) NPATH
                 READ (22,2202) (HPATHT(I),I=1,NPATH)
                 READ (22,2202) (VPATHT(I),I=1,NPATH)
75         2202  FORMAT(8E15.8)
                 WRITE (6,604) NPATH
                 WRITE (6,605) (HPATHT(I),I=1,NPATH)
                 WRITE (6,606) (VPATHT(I),I=1,NPATH)
                 WRITE (6,607)
80         604   FORMAT(9X,8H NPATH =,I3)
           605   FORMAT(9X,8HHPATHT =,7F8.0/(17X,7F8.0))
           606   FORMAT(9X,8HVPATHT =,7F8.0/(17X,7F8.0))
           607   FORMAT(/)
           10    CONTINUE
85               RETURN
                 END
```

```
      SUBROUTINE MISSON(ICALC,NERROR,IGEO,KGPRNT)
      REAL LOIT,MENDUR
      COMMON /TRAJCM/ ALPHA,ARW,CD,CDL,CDO,CL,DESLF,DRAG,EN,HN,KP,
     1 RLD,SMN,QMAX,RANGE,SFC,SWING,THRUST,TW,ULTLF,W,WAMMUN,WETANK,
     2 WFUEL,WGTOWT,WMISS,WTOT,WPLWT,MSTART(12),HSTART(12),TIM(12),
     3 PS1GT(12),TDOTST(12),NZST(12),PSIT(12),TDOTIT(12),NZIT(12),
     4 WBOMBS,WFEXT,SFCU,THRSTU,CDINSP,PRTOT,WKFUEL,CRMACH,FLTO,X(12),
     5 FLLAND,TENDUR,BLRANG,BLTIME,TIMTO1,TIMTO2,WFTO,PNAME1(12),
     6 PNAME2(12),SMNT(12),HNT(12),WFT(12),TIMET(12),XT(12),CLT(12),
     7 CDT(12),ALPHAT(12),CLIT(12),CDIT(12),ALPHIT(12),WFUSED,WLAND,
     8 QT(12),RLDT(12),SFCT(12),TNT(12),CET(12),DY(18),
     9 IAO,IPS,ITS,IWS,IBS,NPHASE,IDY(14)
      COMMON /TRAJEX/ ALP1GT(12),CDINST(12),CD1GT(12),CL1GT(12),DECEL,
     1 DELHP,DELMP,DXCRUS,FLFAC,FRFURE,HEND(12),HENDUR,HMAXP,HMINP,
     2 HPATHT(50),MEND(12),MENDUR,NT(12),PRTOTT(12),RADIT(12),
     3 RADST(12),SF,SFCUT(12),SMMAXP,SMMINP,
     4 TNUT(12),VIND(12),VELT(12),VPATHT(50),WART(12),WCOMBP,WEELT(12),
     5 WFRES,WFTOT,WFTO1,WFTO2,WFTRAP,WKLAND,XDESC,XGRLAN,FWGMAX,TOL,
     6 WFIXED,WGCALC,WPL,WGTO,DUMY(82),IA(12),IAS,IB(12),IBREG,IENDUR,
     7 IMISS,IP(12),IPHASE,IPLOT,IPRINT,IPRT(12),IPSIZE,IPSTO1,IPSTO2,
     8 IW(12),IX(12),KERROR,MILCOM,NCRUSE,NLEGCL,NLEGCR,NLEGLO,NMISS,
     9 NPATH,IDUMY(6)
      DATA CLIM/4HCLIM/
      DATA CRUI/4HCRUI/
      DATA ACCE/4HACCE/
      DATA COMB/4HCOMB/
      DATA LOIT/4HLOIT/
      DATA DESC/4HDESC/
      DATA PATH/4HPATH/
C  SET ULTLF SO AS TO MAINTAIN RATIO BETWEEN ULTLF AND DESLF
   20 ULTLF=SF*DESLF
C   SET WEAPONS, BOMBS, AMMO, AND TANKS DROP INDICATORS TO 1.
C   THIS WILL CAUSE AERO TO CALCULATE DRAG INCREMENTS
C   FOR WEAPONS, BOMBS, AND TANKS UNTIL SOME TRAJECTORY PHASE
C   SETS THEM TO ZERO.  IF THE AMMO INDICATOR IS CHANGED
C   TO ZERO BY SOME TRAJECTORY PHASE, THIS WILL AFFECT
C   THE CALCULATION OF WFUSED.
      IWS=1
      IBS=1
      IAS=1
      ITS=1
C  SET SUM OF HORIZONTAL DISTANCES COVERED DURING CLIMB AND
C  ACCELERATION PHASES TO ZERO AT BEGINNING OF MISSION. NEW VALUE
C  WILL BE CALCULATED IN EACH CLIMB AND ACCELERATION PHASE AND
C  WILL BE SET BACK TO ZERO AT END OF EACH CRUISE PHASE.
      DXCRUS=0.0
C  SET BLOCK TIME AND BLOCK RANGE TO ZERO SO THAT THEY CAN BE
C  ACCUMULATED IN EACH PHASE.
      BLTIME=0.0
      BLRANG=0.0
      CALL TAKEOF(ICALC,NERROR,IGEO,KGPRNT)
      IF (NERROR.GE.2) GO TO 160
      IF (W.LT.WPL) GO TO 130
C-----PERFORM ALL PHASES OF MISSION IN THE ORDER THEY WERE READ IN.
      DO 120 IPHASE=1,NPHASE
      IF (PNAME1(IPHASE).EQ.CLIM) GO TO 40
      IF (PNAME1(IPHASE).EQ.CRUI) GO TO 50
```

```
      IF (PNAME1(IPHASE).EQ.ACCE) GO TO 60
      IF (PNAME1(IPHASE).EQ.COMB) GO TO 70
60    IF (PNAME1(IPHASE).EQ.LOIT) GO TO 80
      IF (PNAME1(IPHASE).EQ.DESC) GO TO 90
      IF (PNAME1(IPHASE).EQ.PATH) GO TO 100
      WRITE (6,601) IPHASE
601   FORMAT(/47H TRAJECTORY INPUT USES UNDEFINED NAME FOR PHASE,I3/)
65    GO TO 160
40    CALL CLIMB(ICALC,NERROR,IGEO,KGPRNT)
      GO TO 110
50    CALL CRUISE(ICALC,NERROR,IGEO,KGPRNT)
      GO TO 110
70    60  CALL ACCEL(ICALC,NERROR,IGEO,KGPRNT)
      GO TO 110
70    CALL COMBAT(ICALC,NERROR,IGEO,KGPRNT)
      GO TO 110
80    CALL LOITER(ICALC,NERROR,IGEO,KGPRNT)
75    GO TO 110
90    CALL DESCNT(ICALC,NERROR,IGEO,KGPRNT)
      GO TO 110
100   CALL PATHS(ICALC,NERROR,IGEO,KGPRNT)
110   IF (NERROR.GE.2) GO TO 160
80    IF (W.LT.WPL) GO TO 130
120   CONTINUE
C-----COMPUTE USED, RESERVE, TOTAL, AND INTERNAL FUEL WEIGHT.
130   WFUSED=WGTO-W
      IF (IWS.EQ.0) WFUSED=WFUSED-WMISS
85    IF (IBS.EQ.0) WFUSED=WFUSED-WBOMBS
      IF (IAS.EQ.0) WFUSED=WFUSED-WAMMUN
      IF (ITS.EQ.0) WFUSED=WFUSED-WETANK
      WFUSED=WKFUEL*WFUSED
      WFRES=WFUSED/(1.-FRFURE)-WFUSED
90    WFTOT=WFUSED+WFRES+WFTRAP
      WFUEL=WFTOT-WFEXT
      IF (W.GE.WPL) GO TO 140
      IF (KERROR.EQ.2) WRITE (6,602)
602   FORMAT(/37H FUEL WEIGHT EXCEEDS AVAILABLE WEIGHT/)
95    WFUEL=WGTO-WPL
      GO TO 160
C-----CALCULATE LANDING FIELD LENGTH.
140   RHO=.00238
      IAO=12
100   CALL TRAJ01(2)
      CALL AERO(ICALC,NERROR,IGEO,KGPRNT)
      IF (NERROR.GE.2) GO TO 160
      CALL TRAJ01(1)
      WLAND=WGTO-WKLAND*WFUSED
105   VSTALL=SQRT(2.*WLAND/(SWING*CL*RHO))
      VSCREN=1.3*VSTALL
      VTDOWN=1.15*VSTALL
      XAIR=((VSCREN**2-VTDOWN**2)/64.4+50.)*RLD
      XGRLAN=VTDOWN**2/(64.4*DECEL)
110   FLLAND=(XAIR+XGRLAN)/FLFAC
C-----CALCULATE ENDURANCE ALTITUDE AND TIME.
      SMN=MENDUR
      CALL GOLDEN(2000.,55000.,2,12,XX,Y,NERROR,IGEO,KGPRNT)
      IF (NERROR.GE.2) GO TO 160
```

```
   SUBROUTINE MISSON     76/76   OPT=2                          FTN 4.5+410        C

115                HENDUR=XX
                   TENDUR=Y*ALOG(WGTO/(WGTO-WFUSED))
                C------CUMPUTE GROSS WEIGHT.
                   WGCALC=WFIXED+WPL+WFTOT
                   IF (IPRINT.EQ.0) GO TO 160
120                WRITE (6,603) WGTO,WFUSED,WFRES,WFTOT,WFUEL,WPL,W,
                  1 WLAND,XGRLAN,FLLAND,HENDUR,TENDUR,WGCALC
                603   FORMAT(///7X,7HLANDING///3X,6HWGTO =E14.7,1X,8HWFUSED =E14.7,
                  1 2X,7HWFRES =E14.7,2X,7HWFTOT =E14.7,2X,7HWFUEL =E14.7/
                  2 4X,5HWPL =E14.7,6X,3HW =E14.7,2X,7HWLAND =E14.7,
125               3 1X,8HXGRLAN =E14.7,1X,8HFLLAND =E14.7/1X,8HHENDUR =E14.7,
                  4 1X,8HTENDUR =E14.7,1X,8HWGCALC =E14.7/)
                160   RETURN
                      END
```

```
      SUBROUTINE TAKEOF(ICALC,NERROR,IGEO,KGPRNT)
      COMMON /TRAJCM/ ALPHA,ARW,CD,CDL,CDO,CL,DESLF,DRAG,EN,HN,KP,
     1 RLD,SMN,QMAX,RANGE,SFC,SWING,THRUST,TW,ULTLF,W,WAMMUN,WETANK,
     2 WFUEL,WGTOWT,WMISS,WTOT,WPLWT,MSTART(12),HSTART(12),TIM(12),
     3 PS1GT(12),TDOTST(12),NZST(12),PSIT(12),TDOTIT(12),NZIT(12),
     4 WBOMBS,WFEXT,SFCU,THRSTU,CDINSP,PRTOT,WKFUEL,CRMACH,FLTO,X(12),
     5 FLLAND,TENDUR,BLRANG,BLTIME,TIMTO1,TIMTO2,WFTO,PNAME1(12),
     6 PNAME2(12),SMNT(12),HNT(12),WFT(12),TIMET(12),XT(12),CLT(12),
     7 CDT(12),ALPHAT(12),CLIT(12),CDIT(12),ALPHIT(12),WFUSED,WLAND,
     8 QT(12),RLDT(12),SFCT(12),TNT(12),CET(12),DY(18),
     9 IAO,IPS,ITS,IWS,IBS,NPHASE,IDY(14)
      COMMON /TRAJEX/ ALP1GT(12),CDINST(12),CD1GT(12),CL1GT(12),DECEL,
     1 DELHP,DELMP,DXCRUS,FLFAC,FRFURE,HEND(12),HENDUR,HMAXP,HMINP,
     2 HPATHT(50),MEND(12),MENDUR,NT(12),PRTOTT(12),RADIT(12),
     3 RADST(12),SF,SFCUT(12),SMMAXP,SMMINP,
     4 TNUT(12),VIND(12),VELT(12),VPATHT(50),WART(12),WCOMBP,WEELT(12),
     5 WFRES,WFTOT,WFTO1,WFTO2,WFTRAP,WKLAND,XDESC,XGRLAN,FWGMAX,TOL,
     6 WFIXED,WGCALC,WPL,WGTO,DUMY(82),IA(12),IAS,IB(12),IBREG,IENDUR,
     7 IMISS,IP(12),IPHASE,IPLOT,IPRINT,IPRT(12),IPSIZE,IPSTO1,IPSTO2,
     8 IW(12),IX(12),KERROR,MILCOM,NCRUSE,NLEGCL,NLEGCR,NLEGLO,NMISS,
     9 NPATH,IDUMY(6)
      DIMENSION ANS(4)
C-----CALL PROP TO SIZE ENGINE.
      IPS=IPSIZE
      HN=0.
      SMN=0.
      CALL TRAJO1(2)
      CALL PROP(ICALC,NERROR,IGEO,KGPRNT)
      IF (NERROR.GE.2) RETURN
      CALL TRAJO1(1)
C-----CALCULATE STARTUP AND TAXI FUEL USED.
      IPS=IPSTO1
      CALL TRAJO1(2)
      CALL PROP(ICALC,NERROR,IGEO,KGPRNT)
      IF (NERROR.GE.2) RETURN
      CALL TRAJO1(1)
      TN=THRUST*EN
      WFTO1=.0167*TIMTO1*SFC*TN
C-----BEGIN FIELD LENGTH CALCULATION.
      HNTO=HSTART(1)
      HN=HNTO
      CALL AT62(HN,ANS)
      RHO=ANS(1)
      A=ANS(4)
C-----GUESS STALLING MACH NUMBER.
      SMN=.25
      IAO=14
      CALL TRAJO1(2)
      CALL AERO(ICALC,NERROR,IGEO,KGPRNT)
      IF (NERROR.GE.2) RETURN
      CALL TRAJO1(1)
      CLS=CL
C-----CALCULATE STALLING SPEED.
      VS=SQRT(2.*WGTO/(RHO*CLS*SWING))
      V2=1.2*VS
      SMN2=V2/A
      SMN=SMN2
```

```
      CALL TRAJ01(2)
      CALL AERO(ICALC,NERROR,IGEO,KGPRNT)
60    IF (NERROR.GE.2) RETURN
      CALL TRAJ01(1)
      CL2=CL
C-----FIND THRUST AT END OF TAKEOFF.
      IPS=IPSTO2
65    CALL TRAJ01(2)
      CALL PROP(ICALC,NERROR,IGEO,KGPRNT)
      IF (NERROR.GE.2) RETURN
      CALL TRAJ01(1)
      TN=THRUST*EN
70    TN2=TN
      SFC2=SFC
C-----FIND STATIC THRUST.
      SMN=0.
      CALL TRAJ01(2)
75    CALL PROP(ICALC,NERROR,IGEO,KGPRNT)
      IF (NERROR.GE.2) RETURN
      CALL TRAJ01(1)
      TN=THRUST*EN
      TNO=TN
80    SFCO=SFC
C-----CALCULATE AVERAGE THRUST AND SFC DURING TAKEOFF.
      TNAVE=.5*(TNO+TN2)
      SFCAVE=.5*(SFCO+SFC2)
C-----CALCULATE TAKEOFF FIELD LENGTH REQUIRED.
85    IF (MILCOM.EQ.0) TOOBHT=50.0
      IF (MILCOM.NE.0) TOOBHT=35.0
      FLTO=2.10*(.374*TOOBHT+.01163*WGTO/(RHO*CL2*SWING))*
     1 (2.7+1.0/(TNAVE/WGTO-.04))+32.0/SQRT(RHO)
C-----CALCULATE TAKEOFF FUEL USED.
90    IF (TIMTO2.LT.0.0) GO TO 10
      IF (TIMTO2.EQ.0.0) GO TO 20
      HN=0.
      IPS=IPSTO2
      CALL TRAJ01(2)
95    CALL PROP(ICALC,NERROR,IGEO,KGPRNT)
      IF (NERROR.GE.2) RETURN
      CALL TRAJ01(1)
      TN=THRUST*EN
      WFTO2=.0167*TIMTO2*SFC*TN
100   GO TO 30
10    WFTO2=TNAVE*SFC*FLTO/(1800.*V2)
      GO TO 30
20    WFTO2=0.0
C-----CALCULATE TOTAL FUEL USED FOR STARTUP, TAXI, AND TAKEOFF.
105   30    WFTO=WFTO1+WFTO2
      W=WGTO-WFTO
      IF (IPRINT.EQ.0) RETURN
      WRITE (6,600) WGTO,WFTO1,WFTO2,WFTO,W,HNTO,CLS,VS,V2,SMN2,CL2,
     1 TN2,SFC2,TNO,SFCO,TNAVE,SFCAVE,FLTO
110   600   FORMAT(1H1,6X,7HTAKEOFF///3X,6HWGTO =E14.7,2X,7HWFTO1 =E14.7,
     1 2X,7HWFTO2 =E14.7,3X,6HWFTO =E14.7,6X,3HW =E14.7/
     2 3X,6HHNTO =E14.7,4X,5HCLS =E14.7,5X,4HVS =E14.7,5X,4HV2 =E14.7,
     3 3X,6HSMN2 =E14.7/4X,5HCL2 =E14.7,4X,5HTN2 =E14.7,
     4 3X,6HSFC2 =E14.7,4X,5HTNO =E14.7,3X,6HSFCO =E14.7/
115   5 2X,7HTNAVE =E14.7,1X,8HSFCAVE =E14.7,3X,6HFLTO =E14.7/)
      RETURN
      END
```

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SUBROUTINE CLIMB      76/76   OPT=2                    FTN 4.5+410          C

      SUBROUTINE CLIMB(ICALC,NERROR,IGEO,KGPRNT)
      REAL MSTART,MEND
      COMMON /TRAJCM/ ALPHA,ARW,CD,CDL,CDO,CL,DESLF,DRAG,EN,HN,KP,
     1 RLD,SMN,QMAX,RANGE,SFC,SWING,THRUST,TW,ULTLF,W,WAMMUN,WETANK,
     2 WFUEL,WGTOWT,WMISS,WTOT,WPLWT,MSTART(12),HSTART(12),TIM(12),
     3 PS1GT(12),TDOTST(12),NZST(12),PSIT(12),TDOTIT(12),NZIT(12),
     4 WBOMBS,WFEXT,SFCU,THRSTU,CDINSP,PRTOT,WKFUEL,CRMACH,FLTO,X(12),
     5 FLLAND,TENDUR,BLRANG,BLTIME,TIMTO1,TIMTO2,WFTO,PNAME1(12),
     6 PNAME2(12),SMNT(12),HNT(12),WFT(12),TIMET(12),XT(12),CLT(12),
     7 CDT(12),ALPHAT(12),CLIT(12),CDIT(12),ALPHIT(12),WFUSED,WLAND,
     8 QT(12),RLDT(12),SFCT(12),TNT(12),CET(12),DY(18),
     9 IAO,IPS,ITS,IWS,IBS,NPHASE,IDY(14)
      COMMON /TRAJEX/ ALP1GT(12),CDINST(12),CD1GT(12),CL1GT(12),DECEL,
     1 DELHP,DELMP,DXCRUS,FLFAC,FRFURE,HEND(12),HENDUR,HMAXP,HMINP,
     2 HPATHT(50),MEND(12),MENDUR,NT(12),PRTOTT(12),RADIT(12),
     3 RADST(12),SF,SFCUT(12),SMMAXP,SMMINP,
     4 TNUT(12),VIND(12),VELT(12),VPATHT(50),WART(12),WCOMBP,WEELT(12),
     5 WFRES,WFTOT,WFTO1,WFTO2,WFTRAP,WKLAND,XDESC,XGRLAN,FWGMAX,TOL,
     6 WFIXED,WGCALC,WPL,WGTO,DUMY(82),IA(12),IAS,IB(12),IBREG,IENDUR,
     7 IMISS,IP112),IPHASE,IPLOT,IPRINT,IPRT(12),IPSIZE,IPSTO1,IPSTO2,
     8 IW(12),IX(12),KERROR,MILCOM,NCRUSE,NLEGCL,NLEGCR,NLEGLO,NMISS,
     9 NPATH,IDUMY(6)
      DIMENSION ANS(4)
      IF (IPRT(IPHASE).NE.0) WRITE (6,600)
  600 FORMAT(///18H          CLIMB PHASE//)
C-----FIX STARTING ALTITUDE
      IF (HSTART(IPHASE).GE.0.0) HNINT=HSTART(IPHASE)
      IF (HSTART(IPHASE).LT.0.0) HNINT=HNT(IPHASE-1)
C-----FIX ENDING ALTITUDE
      HNFIN=HEND(IPHASE)
      IF ((IBREG.EQ.0).OR.(HEND(IPHASE).GT.0.0)) GO TO 40
      SMN=MEND(IPHASE)
      CALL GOLDEN(2000.,60000.,1,12,XX,Y,NERROR,IGEO,KGPRNT)
      IF (NERROR.GE.2) RETURN
      HNFIN=XX
   40 SMN=MSTART(IPHASE)
      IF (MSTART(IPHASE).LT.0.0) SMN=SMNT(IPHASE-1)
      IF (HNFIN.LT.80000.) GO TO 43
      NLEGS=20
      GO TO 45
   43 NLEGS=20.*ALOG((4000.-.05*HNINT)/(4000.-.05*HNFIN))+.5
      IF (NLEGS.LT.3) NLEGS=3
      IF (NLEGS.GT.20) NLEGS=20
   45 IF (NLEGCL.GT.0) NLEGS=NLEGCL
      NLEGS1=NLEGS+1
      B1=HNFIN-HNINT
      B2=1.718282/FLOAT(NLEGS)
      IF (B1.GT.0.0) GO TO 50
      SMNT(IPHASE)=SMN
      HNT(IPHASE)=HNFIN
      CLT(IPHASE)=0.0
      ALPHAT(IPHASE)=0.0
      WFT(IPHASE)=0.0
      TIMET(IPHASE)=0.0
      SFCT(IPHASE)=0.0
      TNT(IPHASE)=0.0
      CDT(IPHASE)=0.0
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```
                RLDT(IPHASE)=0.0
                WEELT(IPHASE)=W
 60             WART(IPHASE)=0.0
                RETURN
          50    HN=HNINT
                TIME=0.0
                WF=0.0
 65             XCLIMB=0.0
                VINDFS=0.0
                IPS=IP(IPHASE)
                IAO=8
                IF (VIND(IPHASE).LE.0.) GO TO 60
 70        C-----INITIALIZE CONDITIONS FOR CONSTANT INDICATED AIRSPEED CLIMB.
                IF (IPRT(IPHASE).NE.0) WRITE (6,601)
          601   FORMAT(/34H CONSTANT INDICATED AIRSPEED CLIMB//)
                IF (MSTART(IPHASE).GE.0.) VINDFS=1.689*VIND(IPHASE)
                IF (MSTART(IPHASE).LT.0.) VINDFS=VELT(IPHASE-1)
 75             CALL AT62(HN,ANS)
                RHOP=ANS(1)
                CL=2.*W/(.002378*VINDFS**2*SWING)
                CALL TRAJ01(2)
                CALL AERO(ICALC,NERROR,IGEO,KGPRNT)
 80             IF (NERROR.GE.2) RETURN
                CALL TRAJ01(1)
                CALL TRAJ01(2)
                CALL PROP(ICALC,NERROR,IGEO,KGPRNT)
                IF (NERROR.GE.2) RETURN
 85             CALL TRAJ01(1)
                TN=THRUST*EN
                TNU=THRSTU*EN
          60    IF (IPRT(IPHASE).EQ.0) GO TO 70
                WRITE (6,602) W,HNINT,HNFIN,SMN,HN
 90        602   FORMAT(/6X,3HW =E14.7,2X,7HHNINT =E14.7,2X,7HHNFIN =E14.7,
                1 4X,5HSMN =E14.7,5X,4HHN =E14.7/)
          70    DO 140 LEG=1,NLEGS1
                IF (LEG.LT.NLEGS1) GO TO 80
                IF (IBREG.EQ.0.OR.HEND(IPHASE).GT.0.) GO TO 140
 95             HN1=HN
                CL1=CL
                ALPHA1=ALPHA
                SFC1=SFC
                TN1=TN
100             CD1=CD
                WTOT1=WTOT
                HLOW=HN1
                HHIGH=HN1+3000.
                SMNSAV=SMN
105             SMN=AMIN1(SMN,MEND(IPHASE))
                CALL GOLDEN(HLOW,HHIGH,1,8,XX,Y,NERROR,IGEO,KGPRNT)
                SMN=SMNSAV
                HNFIN=XX
                DELH=HNFIN-HN1
110             HN=HN1
                CL=CL1
                ALPHA=ALPHA1
                SFC=SFC1
                TN=TN1
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```
   SUBROUTINE CLIMB      76/76   OPT=2                    FTN 4.5+410        0

115                CD=CDI
                   WTOT=WTOT1
                   IF (NERROR.LT.2.AND.DELH.GT.0.005*HN) GO TO 81
                   NERROR=0
                   GO TO 140
120           80   DELH=B1*ALOG((1.+FLOAT(LEG)*B2)/(1.+FLOAT(LEG-1)*B2))
              81   IF (VINDFS.GT.0.) GO TO 120
                   CALL AT62(HN,ANS)
                   RHO=ANS(1)
                   A=ANS(4)
125                IF (LEG.EQ.1) VEL=SMN*A
                   IF (LEG.GT.1) SMN=VEL/A
                   IF (SMN.LT.0.0) NERROR=2
                   IF (SMN.LT.C.0) WRITE (6,610) IPHASE,LEG
              610  FORMAT(/////34H *****FATAL ERROR IN CLIMB. PHASE=,I2,7H   LEG=,I2/
130               1 27H *****NEGATIVE MACH NUMBER./////)
                   IF (SMN.LT.C.0) RETURN
                   Q=.5*RHO*VEL**2
                   QS=Q*SWING
                   CALL TRAJ01(2)
135                CALL PROP(ICALC,NERROR,IGEO,KGPRNT)
                   IF (NERROR.GE.2) RETURN
                   CALL TRAJ01(1)
                   TN=THRUST*EN
                   TNU=THRSTU*EN
140                IF (TN/W.LT.1.5) GO TO 90
              C-----EXECUTE FOLLOWING SECTION ONLY IF TN/W .GE. 1.5
                   SING=1.0
                   IAO=0
                   CALL TRAJ01(2)
145                CALL AERO(ICALC,NERROR,IGEO,KGPRNT)
                   IF (NERROR.GE.2) RETURN
                   CALL TRAJ01(1)
                   CD=CDO
                   GO TO 100
150           C-----EXECUTE FOLLOWING SECTION ONLY IF TN/W .LT. 1.5
              90   CL=(W/QS)*SQRT(1.-.444*(TN/W)**2)
                   IAO=8
                   CALL TRAJ01(2)
                   CALL AERO(ICALC,NERROR,IGEO,KGPRNT)
155                IF (NERROR.GE.2) RETURN
                   CALL TRAJ01(1)
                   CL=CL-TN*SIN(ALPHA/57.3)/QS
                   CALL TRAJ01(2)
                   CALL AERO(ICALC,NERROR,IGEO,KGPRNT)
160                IF (NERROR.GE.2) RETURN
                   CALL TRAJ01(1)
                   EMAX=.5*SQRT(CL**2/(CDO*(CD-CDO)))
                   A1=TN*EMAX/W
                   A2=SQRT(A1**2+3.)
165                SING=.8333*TN/W-.167*A2/EMAX-1.5/(EMAX*(A1+A2))
                   IF(SING.LE.C.0) SING=0.0
                   IF(SING.LE.0.0) GO TO 110
                   COSG=SQRT(1.0-SING**2)
              100  DELT=DELH/(VEL*SING)
170                IF (DELT.GT.0.0) GO TO 110
                   NERROR=2
```

```
      WRITE (6,603) IPHASE,LEG
603   FORMAT(/////34H *****FATAL ERROR IN CLIMB. PHASE=,I2,7H   LEG=,I2/
     1 26H *****NEGATIVE DELTA TIME./////)
      RETURN
110   DVDT=32.2*(TN-CD*QS-W*SING)/W
      IF (DVDT.LT.0.) SING=AMAX1(0.,(TN-CD*QS)/W)
      IF (SING.LE.0.) DVDT=32.2*(TN-CD*QS)/W
      DRAG=CD*QS
      IF(SING.LE.0.0) DELT=60.0
      DELV=DVDT*DELT
      IF(SING.LE.0.0) COSG=1.0
      IF(SING.LE.0.0) DELH=0.0
      DELX=VEL*DELT*COSG/6080.
      VEL=VEL+DELV
      DELWF=TN*SFC*DELT/3600.
C-----TIME TO CLIMB
      TIME=TIME+DELT/60.
C-----FUEL USED DURING CLIMB
      WF=WF+DELWF
C-----GROUND DISTANCE COVERED DURING CLIMB
      XCLIMB=XCLIMB+DELX
      HN=HN+DELH
      W=W-DELWF
      IF (W.GT.WPL) GO TO 115
      IF (KERROR.EQ.2) WRITE (6,605) IPHASE,LEG
605   FORMAT(//26H W.LE.WPL IN CLIMB. PHASE=,I2,7H   LEG=,I2/)
      RETURN
115   IF (IPRT(IPHASE).EQ.0) GO TO 140
      WRITE (6,606) LEG,SMN,HN,RHO,A,VEL,SFC,TN,ALPHA,CL,CDO,CD,EMAX,A1,
     1 A2,SING,COSG,DELT,DVDT,DELV,DELX,DELWF,W,WF,TIME,XCLIMB
606   FORMAT(/4X,5HLEG =I2/4X,5HSMN =E14.7,5X,4HHN =E14.7,4X,
     1 5HRHO =E14.7,6X,3HA =E14.7,4X,5HVEL =E14.7/4X,5HSFC =E14.7,5X,
     2 4HTN =E14.7,2X,7HALPHA =E14.7,5X,4HCL =E14.7,4X,5HCDO =E14.7/5X,
     3 4HCD =E14.7,3X,6HEMAX =E14.7,5X,4HA1 =E14.7,5X,4HA2 =E14.7,3X,
     4 6HSING =E14.7/3X,6HCOSG =E14.7,3X,6HDELT =E14.7,3X,6HDVDT =E14.7,
     5 3X,6HDELV =E14.7,3X,6HDELX =E14.7/2X,7HDELWF =E14.7,6X,3HW =,
     6 E14.7,5X,4HWF =E14.7,3X,6HTIME =E14.7,2X,7HXCLIMB=E14.7/)
      GO TO 140
C-------------------------------------------------
C     START OF CONSTANT INDICATED AIRSPEED SECTION
C-------------------------------------------------
120   HN=HN+DELH
      CALL AT62(HN,ANS)
      RHO=ANS(1)
      A=ANS(4)
      C1=.5*(RHO+RHOP)
      C2=SQRT(C1)
      C3=20.51*C2
      C4=C1*C2
      C5=32.2*C3*DELH/VINDFS-.02438*VINDFS*(RHO-RHOP)/C4
      C6=32.2*(TN/W-.001189*VINDFS**2*CD*SWING/W)
      DELT=C5/C6
      IF (DELT.GT.0.0) GO TO 125
      NERROR=2
      WRITE (6,607) IPHASE,LEG,DELH,VINDFS,RHO,RHOP,TN,W,CD,SWING,DELT,
     1 C1,C2,C3,C4,C5,C6
607   FORMAT(/////34H *****FATAL ERROR IN CLIMB. PHASE=,I2,7H   LEG=,I2/
```

```
     1 40H *****NEGATIVE DELTA TIME IN VIND CLIMB./5X,5HDELH=,E12.5,2X,
230  2 7HVINDFS=,E12.5,2X,4HRHO=,E12.5/5X,5HRHOP=,E12.5,2X,3HTN=,E12.5,
     3 2X,2HW=,E12.5/5X,3HCD=,E12.5,2X,6HSWING=,E12.5,2X,5HDELT=,E12.5/
     4 5X,5HCL-C6/E13.5/E13.5/E13.5/E13.5/E13.5/E13.5//////)
      RETURN
125   TIME=TIME+DELT/60.
235   VEL=VINDFS/SQRT(RHO/.002378)
      SMN=VEL/A
      IF (SMN.LT.0.0) NERROR=2
      IF (SMN.LT.0.0) WRITE (6,610) IPHASE,LEG
      IF (SMN.LT.0.0) RETURN
240   SING=DELH/(VEL*DELT)
      IF (SING.GT.1.) SING=1.0
      COSG=SQRT(1.-SING**2)
      DELX=VEL*DELT*COSG/6080.
      XCLIMB=XCLIMB+DELX
245   CALL TRAJ01(2)
      CALL PROP(ICALC,NERROR,IGEO,KGPRNT)
      IF (NERROR.GE.2) RETURN
      CALL TRAJ01(1)
      TN=THRUST*EN
250   TNU=THRSTU*EN
      DELWF=TN*SFC*DELT/3600.
      WF=WF+DELWF
      W=W-DELWF
      IF (W.GT.WPL) GO TO 130
255   IF (KERROR.EQ.2) WRITE (6,605) IPHASE,LEG
      RETURN
130   C7=1.-(DELH/(VINDFS*DELT*C3))**2
      IF (C7.LT.0.) C7=0.0
      CL=2.*W*SQRT(C7)/(.002378*VINDFS**2*SWING)
260   IAO=8
      CALL TRAJ01(2)
      CALL AERO(ICALC,NERROR,IGEO,KGPRNT)
      IF (NERROR.GE.2) RETURN
      CALL TRAJ01(1)
265   RHOP=RHO
      IF (IPRT(IPHASE).EQ.0) GO TO 140
      WRITE (6,608) LEG,VINDFS,SMN,HN,DELT,DELX,C6,VEL,DELWF,W,TN,CL,CD
608   FORMAT(/4X,5HLEG =I2/
     1 1X,8HVINDFS =E14.7,4X,5HSMN =E14.7,5X,4HHN =E14.7,
270  2 3X,6HDELT =E14.7,3X,6HDELX =E14.7/5X,4HC6 =E14.7,
     3 4X,5HVEL =E14.7,2X,7HDELWF =E14.7,6X,3HW =E14.7,
     4 5X,4HTN =E14.7/5X,4HCL =E14.7,5X,4HCD =E14.7/)
C-------------------------------------------------
C     END OF CONSTANT INDICATED AIRSPEED SECTION
275 C-------------------------------------------------
140   CONTINUE
      CALL AT62(HN,ANS)
      A=ANS(4)
      SMN=VEL/A
280   RHO=ANS(1)
      Q=.5*RHO*VEL**2
      DXCRUS=DXCRUS+XCLIMB*FLOAT(IX(IPHASE))
      BLTIME=BLTIME+TIME/60.
      BLRANG=BLRANG+XCLIMB
285 C-----TEST FOR WEAPONS DROP
```

```
      IF (IW(IPHASE).EQ.0) GO TO 150
      W=W-WMISS
      IWS=0
C-----TEST FOR BOMBS DROP
150   IF (IB(IPHASE).EQ.0) GO TO 160
      W=W-WBOMBS
      IBS=0
C-----TEST FOR AMMO DROP
160   IF (IA(IPHASE).EQ.0) GO TO 170
      W=W-WAMMUN
      IAS=0
170   IF (IPRT(IPHASE).EQ.0) GO TO 180
      WRITE (6,609) SMN,HN,VEL,XCLIMB,DXCRUS,TIME,WF,W
609   FORMAT(/4X,5HSMN =E14.7,5X,4HHN =E14.7,4X,5HVEL =E14.7,
     1 1X,8HXCLIMB =E14.7,1X,8HDXCRUS =E14.7/3X,6HTIME =E14.7,
     2 5X,4HWF =E14.7,6X,3HW =E14.7/)
180   SMNT(IPHASE)=SMN
      HNT(IPHASE)=HN
      CLT(IPHASE)=CL
      ALPHAT(IPHASE)=ALPHA
      WFT(IPHASE)=WF
      TIMET(IPHASE)=TIME
      VELT(IPHASE)=VEL
      SFCT(IPHASE)=SFC
      TNT(IPHASE)=TN
      CDT(IPHASE)=CD
      RLDT(IPHASE)=RLD
      WEELT(IPHASE)=W
      WART(IPHASE)=WTOT
      QT(IPHASE)=Q
      SFCUT(IPHASE)=SFCU
      TNUT(IPHASE)=TNU
      CDINST(IPHASE)=CDINSP
      PRTOTT(IPHASE)=PRTOT
      XT(IPHASE)=XCLIMB
      RETURN
      END
```

```
      SUBROUTINE CRUISE(ICALC,NERROR,IGEO,KGPRNT)
      REAL MSTART
      COMMON /TRAJCM/ ALPHA,ARW,CD,CDL,CDO,CL,DESLF,DRAG,EN,HN,KP,
     1 RLD,SMN,QMAX,RANGE,SFC,SWING,THRUST,TW,ULTLF,W,WAMMUN,WETANK,
     2 WFUEL,WGTOWT,WMISS,WTOT,WPLWT,MSTART(12),HSTART(12),TIM(12),
     3 PS1GT(12),TDOTST(12),NZST(12),PSIT(12),TDOTIT(12),NZIT(12),
     4 WBOMBS,WFEXT,SFCU,THRSTU,CDINSP,PRTOT,WKFUEL,CRMACH,FLTO,X(12),
     5 FLLAND,TENDUR,BLRANG,BLTIME,TIMTO1,TIMTO2,WFTO,PNAME1(12),
     6 PNAME2(12),SMNT(12),HNT(12),WFT(12),TIMET(12),XT(12),CLT(12),
     7 CDT(12),ALPHAT(12),CLIT(12),CDIT(12),ALPHIT(12),WFUSED,WLAND,
     8 QT(12),RLDT(12),SFCT(12),TNT(12),CET(12),DY(18),
     9 IAO,IPS,ITS,IWS,IBS,NPHASE,IDY(14)
      COMMON /TRAJEX/ ALP1GT(12),CDINST(12),CD1GT(12),CL1GT(12),DECEL,
     1 DELHP,DELMP,DXCRUS,FLFAC,FRFURE,HEND(12),HENDUR,HMAXP,HMINP,
     2 HPATHT(50),MEND(12),MENDUR,NT(12),PRTOTT(12),RADIT(12),
     3 RADST(12),SF,SFCUT(12),SMMAXP,SMMINP,
     4 TNUT(12),VIND(12),VELT(12),VPATHT(50),WART(12),WCOMBP,WEELT(12),
     5 WFRES,WFTOT,WFTO1,WFTO2,WFTRAP,WKLAND,XDESC,XGRLAN,FWGMAX,TOL,
     6 WFIXED,WGCALC,WPL,WGTO,DUMY(82),IA(12),IAS,IB(12),IBREG,IENDUR,
     7 IMISS,IP(12),IPHASE,IPLOT,IPRINT,IPRT(12),IPSIZE,IPSTO1,IPSTO2,
     8 IW(12),IX(12),KERROR,MILCOM,NCRUSE,NLEGCL,NLEGCR,NLEGLO,NMISS,
     9 NPATH,IDUMY(6)
      DIMENSION ANS(4),HNTAB(10),SHTAB(10)
      DATA HNTAB/0.,5000.,10000.,15000.,20000.,25000.,30000.,
     1 35000.,37000.,100000./
      DATA SHTAB/34500.,32900.,31400.,30500.,29400.,28200.,27110.,
     1 25950.,20900.,20900./
      DATA DMON/0.0/
      IF (IPRT(IPHASE).NE.0) WRITE (6,600)
600   FORMAT(///19H       CRUISE PHASE//)
C-----TEST FOR TANKS DROP
      WFUSED=WGTO-W
      IF (IWS.EQ.0) WFUSED=WFUSED-WMISS
      IF (IBS.EQ.0) WFUSED=WFUSED-WBOMBS
      IF (IAS.EQ.0) WFUSED=WFUSED-WAMMUN
      IF (ITS.EQ.1.AND.WFUSED.GE.WFEXT) W=W-WETANK
      IF (ITS.EQ.1.AND.WFUSED.GE.WFEXT) ITS=0
      IPS=IP(IPHASE)
      SMN=MSTART(IPHASE)
      HN=HSTART(IPHASE)
      IF (MSTART(IPHASE).LT.0.0) SMN=SMNT(IPHASE-1)
      IF (HSTART(IPHASE).LT.0.0) HN=HNT(IPHASE-1)
      IF (IBREG.EQ.0.OR.HSTART(IPHASE).NE.0.0) GO TO 10
      CALL GOLDEN(2000.,60000.,1,12,XX,Y,NERROR,IGEO,KGPRNT)
      IF (NERROR.GE.2) RETURN
      HN=XX
10    CALL AT62(HN,ANS)
      RHO=ANS(1)
      A=ANS(4)
      VEL=SMN*A
      CL=2.*W/(RHO*SWING*VEL**2)
      IAO=8
      CALL TRAJO1(2)
      CALL AERO(ICALC,NERROR,IGEO,KGPRNT)
      IF (NERROR.GE.2) RETURN
      CALL TRAJO1(1)
      COSA=COS(ALPHA/57.3)
```

```
  SUBROUTINE CRUISE     76/76   OPT=2                          FTN 4.5+410        05

                      TIME=0.0
                      WF=0.0
   60                 IF(X(IPHASE).GE.0.)XCRUSE=X(IPHASE)+DXCRUS+XDESC*FLOAT(IX(IPHASE))
                      IF(X(IPHASE).LT.0.)XCRUSE=RANGE/FLOAT(NCRUSE)+DXCRUS+
                     1   XDESC*FLOAT(IX(IPHASE))
                      IF (XCRUSE .LE. 0.) DXCRUS=0.0
                      IF (XCRUSE .LE. 0.) GO TO 90
   65                 IF (X(IPHASE).LT.100.) NLEGS=2
                      IF ((X(IPHASE).GE.100.).AND.(X(IPHASE).LT.300.)) NLEGS=3
                      IF ((X(IPHASE).GE.300.).AND.(X(IPHASE).LT.1000.)) NLEGS=4
                      IF ((X(IPHASE).GE.1000.).AND.(X(IPHASE).LT.3000.)) NLEGS=5
                      IF (X(IPHASE).GE.3000.) NLEGS=6
   70                 IF (NLEGCR.GT.0) NLEGS=NLEGCR
                      DELX=XCRUSE/FLOAT(NLEGS)
                      IF (IPRT(IPHASE).EQ.0) GO TO 20
                      WRITE (6,601) W,SMN,HN,RHO,A,VEL,CL,ALPHA,TIME,WF,XCRUSE,DXCRUS,
                     1 DELX,IAO,IPS
   75          601    FORMAT(/6X,3HW =E14.7,4X,5HSMN =E14.7,5X,4HHN =E14.7,4X,4HRHO =
                     1 E14.7,6X,3HA =E14.7/4X,5HVEL =E14.7,5X,4HCL =E14.7,2X,7HALPHA =
                     2 E14.7,3X,6HTIME =E14.7,5X,4HWF =E14.7/1X,8HXCRUSE =E14.7,1X,
                     3 8HDXCRUS =E14.7,3X,6HDELX =E14.7,4X,5HIAO =I2,16X,5HIPS =I2/)
               20     DO 50 LEG=1,NLEGS
   80                 IF (HEND(IPHASE).EQ.-1.) GO TO 21
                      RHO1=RHO
                      RHO2=2.*W/(CL*SWING*VEL**2)
                      CALL TAINT(HNTAB,SHTAB,HN,SH,10,1,NERR,DMON)
                      HN=HN+2.*SH*(RHO1-RHO2)/(RHO1+RHO2)
   85                 CALL AT62(HN,ANS)
                      A=ANS(4)
                      VEL=SMN*A
                      RHO=2.*W/(CL*SWING*VEL**2)
                      Q=.5*RHO*VEL**2
   90                 QS=Q*SWING
                      GO TO 22
               21     HN=HSTART(IPHASE)
                      CALL AT62(HN,ANS)
                      A=ANS(4)
   95                 RHO=ANS(1)
                      VEL=SMN*A
                      Q=.5*RHO*VEL**2
                      QS=Q*SWING
                      CL=W/QS
  100          22     CALL TRAJ01(2)
                      CALL AERO(ICALC,NERROR,IGEO,KGPRNT)
                      IF (NERROR.GE.2) RETURN
                      CALL TRAJ01(1)
                      DRAG=CD*QS
  105                 CALL TRAJ01(2)
                      CALL PROP(ICALC,NERROR,IGEO,KGPRNT)
                      IF (NERROR.GE.2) RETURN
                      CALL TRAJ01(1)
                      TN=THRUST*EN
  110                 TNU=THRSTU*EN
                      IF (ABS(DRAG/TN-1.0).LE.0.03) GO TO 30
                      IF (KERROR.EQ.2) WRITE (6,602) IPHASE,LEG,DRAG,TN
               602    FORMAT(/ 17H IN CRUISE, PHASE,I2,5H, LEG,I2,  46H, THRUST DOES NOT
                     1 MATCH DRAG WITHIN 3 PERCENT./7H DRAG =,E12.5,4X,4HTN =,E12.5/)
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```
      30    DELWF=.8444*W*SFC*CD*DELX*SQRT(2.*RHO*SWING/(CL*W))/COSA
      C-----FUEL USED DURING CRUISE
            WF=WF+DELWF
            DELT=6080.*DELX/VEL
      C-----CRUISING TIME TO TARGET
            TIME=TIME+DELT/60.
            W=W-DELWF
      C-----TEST FOR TANKS DROP
            WFUSED=WGTO-W
            IF (IWS.EQ.0) WFUSED=WFUSED-WMISS
            IF (IBS.EQ.0) WFUSED=WFUSED-WBOMBS
            IF (IAS.EQ.0) WFUSED=WFUSED-WAMMUN
            IF (ITS.EQ.1.AND.WFUSED.GE.WFEXT) W=W-WETANK
            IF (ITS.EQ.1.AND.WFUSED.GE.WFEXT) ITS=0
            IF (IPRT(IPHASE).EQ.0) GO TO 40
            WRITE (6,603) LEG,RHO1,RHO2,SH,HN,A,VEL,RHO,Q,QS,CD,DRAG,TN,SFC,
           1 DELWF,WF,DELT,TIME,W
      603   FORMAT(/4X,5HLEG =I2/3X,6HRHO1 =E14.7,3X,6HRHO2 =E14.7,5X,4HSH =
           1 E14.7,5X,4HHN =E14.7,6X,3HA =E14.7/4X,5HVEL =E14.7,4X,5HRHO =
           2 E14.7,6X,3HQ =E14.7,5X,4HQS =E14.7,5X,4HCD =E14.7/3X,6HDRAG =
           3 E14.7,5X,4HTN =E14.7,4X,5HSFC =E14.7,2X,7HDELWF =E14.7,5X,4HWF =
           4 E14.7/3X,6HDELT =E14.7,3X,6HTIME =E14.7,6X,3HW =E14.7/)
      40    IF (W.GT.WPL) GO TO 50
            IF (KERROR.EQ.2) WRITE (6,604) IPHASE,LEG
      604   FORMAT(//27H W.LE.WPL IN CRUISE. PHASE=,I2,7H   LEG=,I2/)
            RETURN
      50    CONTINUE
            BLTIME=BLTIME+TIME/60.
            BLRANG=BLRANG+XCRUSE
            DXCRUS=0.0
      C-----TEST FOR WEAPONS DROP
            IF (IW(IPHASE).EQ.0) GO TO 60
            W=W-WMISS
            IWS=0
      C-----TEST FOR BOMBS DROP
      60    IF (IB(IPHASE).EQ.0) GO TO 70
            W=W-WBOMBS
            IBS=0
      C-----TEST FOR AMMO DROP
      70    IF (IA(IPHASE).EQ.0) GO TO 80
            W=W-WAMMUN
            IAS=0
      80    IF (IPRINT.EQ.0) GO TO 90
            WRITE (6,605) W
      605   FORMAT(/6X,3HW =E14.7/)
      90    SMNT(IPHASE)=SMN
            HNT(IPHASE)=HN
            CLT(IPHASE)=CL
            ALPHAT(IPHASE)=ALPHA
            WFT(IPHASE)=WF
            TIMET(IPHASE)=TIME
            VELT(IPHASE)=VEL
            SFCT(IPHASE)=SFC
            TNT(IPHASE)=TN
            CDT(IPHASE)=CD
            RLDT(IPHASE)=RLD
            WEELT(IPHASE)=W
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```
                WART(IPHASE)=WTOT
                QT(IPHASE)=Q
                SFCUT(IPHASE)=SFCU
175             TNUT(IPHASE)=TNU
                CDINST(IPHASE)=CDINSP
                PRTOTT(IPHASE)=PRTOT
                XT(IPHASE)=XCRUSE
                RETURN
180             END
```

```
      SUBROUTINE ACCEL(ICALC,NERROR,IGEO,KGPRNT)
      REAL MSTART,MEND
      COMMON /TRAJCM/ ALPHA,ARW,CD,CDL,CDO,CL,DESLF,DRAG,EN,HN,KP,
     1 RLD,SMN,QMAX,RANGE,SFC,SWING,THRUST,TW,ULTLF,W,WAMMUN,WETANK,
     2 WFUEL,WGTOWT,WMISS,WTOT,WPLWT,MSTART(12),HSTART(12),TIM(12),
     3 PSIGT(12),TDOTST(12),NZST(12),PSIT(12),TDOTIT(12),NZIT(12),
     4 NBOMBS,WFEXT,SFCU,THRSTU,CDINSP,PRTOT,WKFUEL,CRMACH,FLTO,X(12),
     5 FLLAND,TENDUR,BLRANG,BLTIME,TIMTO1,TIMTO2,WFTO,PNAME1(12),
     6 PNAME2(12),SMNT(12),HNT(12),WFT(12),TIMET(12),XT(12),CLT(12),
     7 CDT(12),ALPHAT(12),CLIT(12),CDIT(12),ALPHIT(12),WFUSED,WLAND,
     8 QT(12),RLDT(12),SFCT(12),TNT(12),CET(12),DY(18),
     9 IAO,IPS,ITS,IWS,IBS,NPHASE,IDY(14)
      COMMON /TRAJEX/ ALP1GT(12),CDINST(12),CD1GT(12),CL1GT(12),DECEL,
     1 DELHP,DELMP,DXCRUS,FLFAC,FRFURE,HEND(12),HENDUR,HMAXP,HMINP,
     2 HPATHT(50),MEND(12),MENDUR,NT(12),PRTOTT(12),RADIT(12),
     3 RADST(12),SF,SFCUT(12),SMMAXP,SMMINP,
     4 TNUT(12),VIND(12),VELT(12),VPATHT(50),WART(12),WCOMBP,WEELT(12),
     5 WFRES,WFTOT,WFTO1,WFTO2,WFTRAP,WKLAND,XDESC,XGRLAN,FWGMAX,TOL,
     6 WFIXED,WGCALC,WPL,WGTO,DUMY(82),IA(12),IAS,IB(12),IBREG,IENDUR,
     7 IMISS,IP(12),IPHASE,IPLOT,IPRINT,IPRT(12),IPSIZE,IPSTO1,IPSTO2,
     8 IW(12),IX(12),KERROR,MILCOM,NCRUSE,NLEGCL,NLEGCR,NLEGLO,NMISS,
     9 NPATH,IDUMY(6)
      DIMENSION ANS(4)
      IF (IPRT(IPHASE).NE.0) WRITE (6,600)
  600 FORMAT(///25H ____ ACCELERATION PHASE//)
      IF (MSTART(IPHASE).LT.0.0) SMN=SMNT(IPHASE-1)
      IF (MSTART(IPHASE).GE.0.0) SMN=MSTART(IPHASE)
      IF (HSTART(IPHASE).LT.0.0) HN=HNT(IPHASE-1)
      IF (HSTART(IPHASE).GE.0.0) HN=HSTART(IPHASE)
      CALL AT62(HN,ANS)
      A=ANS(4)
      RHO=ANS(1)
      TEMP=1.8*ANS(3)
      SQTEMP=SQRT(TEMP)
      IPS=IP(IPHASE)
      IAO=8
C-----COMPUTE INTEGRALS SUMWF AND SUMDT BY TRAPEZOIDAL RULE
      SUMWF=0.0
      SUMDT=0.0
      XACCEL=0.0
      TIMECR=0.0
      FUELCR=0.0
      WF=0.0
      TIME=0.0
      LEG=0
      IF (IPRT(IPHASE).EQ.0) GO TO 10
      WRITE (6,601) LEG,HN,A,RHO,TEMP,SUMWF,SUMDT,SMN,W,IAO,IPS
  601 FORMAT(/4X,5HLEG =I2/5X,4HHN =E14.7,6X,3HA =E14.7,4X,
     1 5HRHO =E14.7,3X,6HTEMP =E14.7,2X,7HSUMWF =E14.7/2X,7HSUMDT =,
     2 E14.7,4X,5HSMN =E14.7,6X,3HW =E14.7,4X,5HIAO =I2,16X,5HIPS =I2/)
   10 IF (MSTART(IPHASE).GE.MEND(IPHASE)) GO TO 120
      IF (SMNT(IPHASE-1).GE.MEND(IPHASE)) GO TO 120
C-----START OF LOOP.
   20 LEG=LEG+1
      IF (LEG.GT.50) GO TO 80
      CALL TRAJ01(2)
      CALL PROP(ICALC,NERROR,IGEO,KGPRNT)
```

```
 SUBROUTINE ACCEL      76/76   OPT=2                          FTN 4.5+410        05


                IF (NERROR.GE.2) RETURN
                CALL TRAJ01(1)
 60             TN=THRUST*EN
                TNU=THRSTU*EN
                VEL=SMN*A
          30    CL=2.*W/(RHO*SWING*VEL**2)
                CALL TRAJ01(2)
 65             CALL AERO(ICALC,NERROR,IGEO,KGPRNT)
                IF (NERROR.GE.2) RETURN
                CALL TRAJ01(1)
                DENOM=TN*COS(ALPHA/57.3)-.5*CD*RHO*SWING*VEL**2
                YWF=SFC*TN/DENOM
 70             YDT=1./DENOM
                IF ((YWF.GT.0.0).AND.(YDT.GT.0.0)) GO TO 50
                DTIME=60.
                DFUEL=TN*SFC*DTIME/3600.
                W=W-DFUEL
 75             IF (W.GT.WPL) GO TO 40
                IF (KERROR.EQ.2) WRITE (6,602) IPHASE,LEG
          602   FORMAT(//26H W.LE.WPL IN ACCEL. PHASE=,I2,7H   LEG=,I2/)
                RETURN
          40    DXCR=VEL*DTIME/6080.
 80             TIMECR=(TIMECR+DTIME)/60.
                FUELCR=FUELCR+DFUEL
                XACCEL=XACCEL+DXCR
                GO TO 30
          50    IF (LEG.EQ.1) GO TO 60
 85             SUMWF=SUMWF+.5*(YWF+YWFP)*(SMN-SMNP)
                SUMDT=SUMDT+.5*(YDT+YDTP)*(SMN-SMNP)
                DELX=.7625*(YDT+YDTP)*(SMN-SMNP)*VEL*W*SQTEMP/6080.
                XACCEL=XACCEL+DELX
                WF=(EXP(1.525*SUMWF*SQTEMP/3600.)-1.)*W
 90             DELWF=WF-WFP
                W=W-DELWF
                TIME=1.525*SUMDT*SQTEMP*W/60.
                DELT=TIME-TIMEP
          60    IF (IPRT(IPHASE).EQ.0) GO TO 70
 95             WRITE (6,603) LEG,TN,SFC,VEL,SMN,ALPHA,CL,CD,DENOM,YWF,YDT,SUMWF,
               1 DELWF,SUMDT,DELT,DELX,XACCEL
          603   FORMAT(/4X,5HLEG =I2/5X,4HTN =E14.7,4X,5HSFC =E14.7,4X,
               1 5HVEL =E14.7,4X,5HSMN =E14.7,2X,7HALPHA =E14.7/5X,4HCL =E14.7,5X,
               2 4HCD =E14.7,2X,7HDENOM =E14.7,4X,5HYWF =E14.7,4X,5HYDT =E14.7/
100            3 2X,7HSUMWF =E14.7,2X,7HDELWF =E14.7,2X,7HSUMDT =E14.7,
               4 3X,6HDELT =E14.7,3X,6HDELX =E14.7/1X,8HXACCEL =E14.7/)
          C-----MAKE TEST TO SEE IF YOU ARE DONE. IF SO, JUMP OUT OF LOOP.
          70    IF (SMN.GE.MEND(IPHASE)) GO TO 80
                YWFP=YWF
105             YDTP=YDT
                SMNP=SMN
                WFP=WF
                TIMEP=TIME
                IF (SMN.LE..87.OR.SMN.GE.1.1) DELSMN=.05
110             IF (SMN.GT..87.AND.SMN.LT.1.1) DELSMN=.02
                SMN=SMN+DELSMN
                IF (SMN.GE.MEND(IPHASE)) SMN=MEND(IPHASE)
          C-----END OF LOOP. GO BACK TO START OF LOOP.
                GO TO 20
```

```
115           C-----FUEL USED DURING ACCELERATION RUN
              80    WF=WF+FUELCR
              C-----TIME ELAPSED DURING ACCELERATION RUN
                    TIME=TIME+TIMECR
                    BLTIME=BLTIME+TIME/60.
120                 BLRANG=BLRANG+XACCEL
                    IF (W.GT.WPL) GO TO 90
                    IF (KERROR.EQ.2) WRITE (6,604) IPHASE
              604   FORMAT(/26H W.LE.WPL IN ACCEL. PHASE=,I2/)
                    RETURN
125           90    VEL=SMN*A
                    Q=.5*RHO*VEL**2
                    DXCRUS=DXCRUS+XACCEL*FLOAT(IX(IPHASE))
              C-----TEST FOR WEAPONS DROP
                    IF (IW(IPHASE).EQ.0) GO TO 100
130                 W=W-WMISS
                    IWS=0
              C-----TEST FOR BOMBS DROP
              100   IF (IB(IPHASE).EQ.0) GO TO 110
                    W=W-WBOMBS
135                 IBS=0
              C-----TEST FOR AMMO DROP
              110   IF (IA(IPHASE).EQ.0) GO TO 120
                    W=W-WAMMUN
                    IAS=0
140           120   IF (IPRT(IPHASE).EQ.0) GO TO 130
                    WRITE (6,605) SUMWF,SUMDT,TIME,VEL,Q,XACCEL,DXCRUS,WF,W
              605   FORMAT(/2X,7HSUMWF =E14.7,2X,7HSUMDT =E14.7,3X,6HTIME =
                   1 E14.7,4X,5HVEL =E14.7,6X,3HQ =E14.7/1X,8HXACCEL =E14.7,1X,
                   2 8HDXCRUS =E14.7,5X,4HWF =E14.7,6X,3HW =E14.7/)
145           130   SMNT(IPHASE)=SMN
                    HNT(IPHASE)=HN
                    CLT(IPHASE)=CL
                    ALPHAT(IPHASE)=ALPHA
                    WFT(IPHASE)=WF
150                 TIMET(IPHASE)=TIME
                    VELT(IPHASE)=VEL
                    SFCT(IPHASE)=SFC
                    TNT(IPHASE)=TN
                    CDT(IPHASE)=CD
155                 RLDT(IPHASE)=RLD
                    WEELT(IPHASE)=W
                    WART(IPHASE)=WTOT
                    QT(IPHASE)=Q
                    SFCUT(IPHASE)=SFCU
160                 TNUT(IPHASE)=TNU
                    CDINST(IPHASE)=CDINSP
                    PRTOTT(IPHASE)=PRTOT
                    XT(IPHASE)=XACCEL
                    RETURN
165                 END
```

```
 SUBROUTINE COMBAT     76/76   OPT=2                    FTN 4.5+410        0

 1                SUBROUTINE COMBAT(ICALC,NERROR,IGEO,KGPRNT)
                  REAL MSTART,NT,NTURNS,LIFT,NZS,NZI,NZST,NZIT
                  COMMON /TRAJCM/ ALPHA,ARW,CD,CDL,CDO,CL,DESLF,DRAG,EN,HN,KP,
                 1 RLD,SMN,SMAX,RANGE,SFC,SWING,THRUST,TW,ULTLF,W,WAMMUN,WETANK,
 5               2 WFUEL,WGTOWT,WMISS,WTOT,WPLWT,MSTART(12),HSTART(12),TIM(12),
                 3 PS1GT(12),TDOTST(12),NZST(12),PSIT(12),TDOTIT(12),NZIT(12),
                 4 WBOMBS,WFEXT,SFCU,THRSTU,CDINSP,PRTOT,WKFUEL,CRMACH,FLTO,X(12),
                 5 FLLAND,TENDUR,BLRANG,BLTIME,TIMTO  TIMTO2,WFTO,PNAME1(12),
                 6 PNAME2(12),SMNT(12),HNT(12),WFT(12),TIMET(12),XT(12),CLT(12),
10               7 CDT(12),ALPHAT(12),CLIT(12),CDIT(12),ALPHIT(12),WFUSED,WLAND,
                 8 QT(12),RLDT(12),SFCT(12),TNT(12),CET(12),DY(18),
                 9 IAO,IPS,ITS,IWS,IBS,NPHASE,IDY(14)
                  COMMON /TRAJEX/ ALP1GT(12),CDINST(12),CD1GT(12),CL1GT(12),DECEL,
                 1 DELHP,DELMP,DXCRUS,FLFAC,FRFURE,HEND(12),HENDUR,HMAXP,HMINP,
15               2 HPATHT(50),MEND(12),MENDUR,NT(12),PRTOTT(12),RADIT(12),
                 3 RADST(12),SF,SFCUT(12),SMMAXP,SMMINP,
                 4 TNUT(12),VIND(12),VELT(12),VPATHT(50),WAPT(12),WCOMBP,WEELT(12),
                 5 WFRES,WFTOT,WFTO1,WFTO2,WFTRAP,WKLAND,XDESC,XGRLAN,FWGMAX,TOL,
                 6 WFIXED,WGCALC,WPL,WGTO,DUMY(82),IA(12),IAS,IB(12),IBREG,IENDUR,
20               7 IMISS,IP(12),IPHASE,IPLOT,IPRINT,IPRT(12),IPSIZE,IPSTO1,IPSTO2,
                 8 IW(12),IX(12),KERROR,MILCOM,NCRUSE,NLEGCL,NLEGCR,NLEGLO,NMISS,
                 9 NPATH,IDUMY(6)
                  DIMENSION ANS(4)
                  HN=HSTART(IPHASE)
25                IF (HSTART(IPHASE).LT.0.0) HN=HNT(IPHASE-1)
                  CALL AT62(HN,ANS)
                  RHO=ANS(1)
                  A=ANS(4)
                  SMN=MSTART(IPHASE)
30                IF (MSTART(IPHASE).LT.0.0) SMN=SMNT(IPHASE-1)
                  VEL=SMN*A
                  Q=.5*RHO*VEL**2
                  QS=Q*SWING
                  XCOMB=0.0
35                IF (IPRT(IPHASE).NE.0) WRITE (6,600) W,HN,RHO,A,SMN,VEL,Q,QS,XCOMB
          600     FORMAT(///19H        COMBAT PHASE///
                 1 6X,3HW =E14.7,5X,4HHN =E14.7,4X,5HRHO =E14.7,6X,3HA =E14.7,
                 2 4X,5HSMN =E14.7/4X,5HVEL =E14.7,6X,3HQ =E14.7,5X,4HQS =E14.7,
                 3 2X,7HXCOMB =E14.7/)
40                C--------------
                  C  ONE G FLIGHT
                  C--------------
                        CL=W/QS
                        IAO=8
45                      CALL TRAJ01(2)
                        CALL AERO(ICALC,NERROR,IGEO,KGPRNT)
                        IF (NERROR.GE.2) RETURN
                        CALL TRAJ01(1)
                        DRAG=CD*QS
50                      IPS=IP(IPHASE)
                        CALL TRAJ01(2)
                        CALL PROP(ICALC,NERROR,IGEO,KGPRNT)
                        IF (NERROR.GE.2) RETURN
                        CALL TRAJ01(1)
55                      TN=THRUST*EN
                        TNU=THRSTU*EN
                        PS1G=(TN-DRAG)*VEL/W
```

```
            PS1GT(IPHASE)=PS1G
            ALP1GT(IPHASE)=ALPHA
 60         CL1GT(IPHASE)=CL
            CD1GT(IPHASE)=CD
            IF (IPRT(IPHASE).EQ.0) GO TO 10
            WRITE (6,601) IAO,CL,CD,ALPHA,DRAG,IPS,TN,SFC,PS1G
      601   FORMAT(/1X,12HONE G FLIGHT// 4X,5HIAO =I2,17X,4HCL =E14.7,
 65        1 5X,4HCD =E14.7,2X,7HALPHA =E14.7,3X,6HDRAG =E14.7/
           2 4X,5HIPS =I2,17X,4HTN =E14.7,4X,5HSFC =E14.7,3X,6HPS1G =E14.7/)
      C-----------------
      C  SUSTAINED TURNS
      C-----------------
 70   10    NZS=1.001
            IF(PS1G.LE.0.) GO TO 40
            IAO=4
            CALL TRAJ01(2)
            CALL AERO(ICALC,NERROR,IGEO,KGPRNT)
 75         IF (NERROR.GE.2) RETURN
            CALL TRAJ01(1)
            LIFT=CL*QS
      C  LOAD FACTOR
            NZS=(LIFT+TN*SIN(ALPHA/57.2958))/W
 80         IF (IPRT(IPHASE).EQ.0) GO TO 20
            WRITE (6,602) IAO,CL,CD,ALPHA,LIFT,NZS
      602   FORMAT(/1X,15HSUSTAINED TURNS// 4X,5HIAO =I2,17X,4HCL =E14.7,
           1 5X,4HCD =E14.7,2X,7HALPHA =E14.7,3X,6HLIFT =E14.7/
           2 4X,5HNZS =E14.7/)
 85   20    IF (NZS.LE.DESLF) GO TO 30
            IAO=6
            CALL TRAJ01(2)
            CALL AERO(ICALC,NERROR,IGEO,KGPRNT)
            IF (NERROR.GE.2) RETURN
 90         CALL TRAJ01(1)
            NZS=DESLF
            IF (IPRT(IPHASE).EQ.0) GO TO 30
            WRITE (6,603) IAO,CL,CD,ALPHA,DESLF,NZS
      603   FORMAT(/4X,5HIAO =I2,17X,4HCL =E14.7,5X,4HCD =E14.7,
 95        1 2X,7HALPHA =E14.7,2X,7HDESLF =E14.7/4X,5HNZS =E14.7/)
      30    IF (NZS.GT.1.0) GO TO 50
      40    IF (KERROR.EQ.2) WRITE (6,604) IPHASE,NZS
      604   FORMAT(//36H INSUFFICIENT LIFT IN COMBAT. PHASE=,I2,5X,
           1 4HNZS=,1PE11.4)
100         NZS=1.001
            WRITE (6,605) NZS
      605   FORMAT(/4X,5HNZS =E14.7/)
      50    PHI=ARCOS(1.0/NZS)
      C  TURN RADIUS
105         RADIUS=VEL**2/(32.2*TAN(PHI))
      C  TURNING TIME OR NUMBER OF TURNS
            TIME=TIM(IPHASE)
            NTURNS=NT(IPHASE)
            IF (TIME.LE.0.0) TIME=NTURNS*RADIUS/(9.55*VEL)
110         IF (NTURNS.LE.0.0) NTURNS=9.55*TIME*VEL/RADIUS
            XCOMB=VEL*TIME*60./6080.
            BLTIME=BLTIME+TIME/60.
            BLRANG=BLRANG+XCOMB
      C  FUEL USED DURING TURNS
```

```
115                 WF=SFC*TN*TIME/60.
                C   COMBAT ENERGY
                    CE=3600.*WF*PSIG/(SFC*TN)
                    TDOTS=57.3*VEL/RADIUS
                    RADS=RADIUS
120                 IF (IPRT(IPHASE).EQ.0) GO TO 60
                    WRITE (6,606) PHI,RADIUS,TIME,NTURNS,WF,TDOTS,XCOMB
                606 FORMAT(/4X,5HPHI =E14.7,1X,8HRADIUS =E14.7,3X,6HTIME =E14.7,
                   1 1X,8HNTURNS =E14.7,5X,4HWF =E14.7/2X,7HTDOTS =E14.7,
                   2 2X,7HXCOMB =E14.7/)
125             60  SMNT(IPHASE)=SMN
                    HNT(IPHASE)=HN
                    CLT(IPHASE)=CL
                    ALPHAT(IPHASE)=ALPHA
                    WFT(IPHASE)=WF
130                 VELT(IPHASE)=VEL
                    TIMET(IPHASE)=TIME
                    SFCT(IPHASE)=SFC
                    TNT(IPHASE)=TN
                    CDT(IPHASE)=CD
135                 RLDT(IPHASE)=RLD
                    WART(IPHASE)=WTOT
                    QT(IPHASE)=Q
                    SFCUT(IPHASE)=SFCU
                    TNUT(IPHASE)=TNU
140                 CDINST(IPHASE)=CDINSP
                    PRTOTT(IPHASE)=PRTOT
                    XT(IPHASE)=XCOMB
                    TDOTST(IPHASE)=TDOTS
                    RADST(IPHASE)=RADS
145                 NZST(IPHASE)=NZS
                    CET(IPHASE)=CE
                C---------------------------------
                C   MAXIMUM INSTANTANEOUS CONDITIONS
                C---------------------------------
150                 IAO=5
                    CALL TRAJ01(2)
                    CALL AERO(ICALC,NERROR,IGEO,KGPRNT)
                    IF (NERROR.GE.2) RETURN
                    CALL TRAJ01(1)
155                 CLMAX=CL
                    LIFT=CLMAX*QS
                C   LOAD FACTOR
                    NZI=(LIFT+TN*SIN(ALPHA/57.2958))/W
                    IF (IPRT(IPHASE).EQ.0) GO TO 70
160                 WRITE (6,607) IAO,CL,CD,ALPHA,LIFT,NZI
                607 FORMAT(/1X,19HINSTANTANEOUS TURNS// 4X,5HIAO =I2,17X,4HCL =E14.7,
                   1 5X,4HCD =E14.7,2X,7HALPHA =E14.7,3X,6HLIFT =E14.7/
                   2 4X,5HNZI =E14.7/)
                70  IF (NZI.LE.DESLF) GO TO 80
165                 IAO=6
                    CALL TRAJ01(2)
                    CALL AERO(ICALC,NERROR,IGEO,KGPRNT)
                    IF (NERROR.GE.2) RETURN
                    CALL TRAJ01(1)
170                 NZI=DESLF
                    IF (IPRT(IPHASE).EQ.0) GO TO 80
```

```
                WRITE (6,608) IAD,CL,CD,ALPHA,DESLF,NZI
          608   FORMAT(/4X,5HIAD =I2,17X,4HCL =E14.7,5X,4HCD =E14.7,
               1 2X,7HALPHA =E14.7,2X,7HDESLF =E14.7/4X,5HNZI =E14.7/)
    175   80    IF (NZI.GT.1.0) GO TO 90
                IF (KERROR.EQ.2) WRITE (6,609) IPHASE,NZI
          609   FORMAT(//36H INSUFFICIENT LIFT IN COMBAT. PHASE=,I2,5X,
               1 4HNZI=,1PE11.4)
                RETURN
    180   C  PS FOR MAXIMUM INSTANTANEOUS TURN RATE
          90    DRAG=CD*QS
                PSI=(TN*COS(ALPHA/57.3)-DRAG)*VEL/W
                ALPHI=ALPHA
                CLI=CL
    185         CDI=CD
                PHI=ARCOS(1.0/NZI)
          C  MAXIMUM INSTANTANEOUS TURN RATE AND RADIUS
                RADIUS=VEL**2/(32.2*TAN(PHI))
                TDOTI=57.3*VEL/RADIUS
    190         RADI=RADIUS
                W=W-WF
                IF (W.GT.WPL) GO TO 100
                IF (KERROR.EQ.2) WRITE (6,610) IPHASE
          610   FORMAT(//27H W.LE.WPL IN COMBAT. PHASE=,I2)
    195         RETURN
          C  TEST FOR WEAPONS DROP
          100   IF (IW(IPHASE).EQ.0) GO TO 110
                W=W-WMISS
                IWS=0
    200   C  TEST FOR BOMBS DROP
          110   IF (IB(IPHASE).EQ.0) GO TO 120
                W=W-WBOMBS
                IBS=0
          C     TEST FOR AMMO DROP
    205   120   IF (IA(IPHASE).EQ.0) GO TO 130
                W=W-WAMMUN
                IAS=0
          130   IF (IPRT(IPHASE).EQ.0) GO TO 140
                WRITE (6,611) DRAG,PSI,PHI,RADIUS,TDOTI,W
    210   611   FORMAT(/3X,6HDRAG =E14.7,4X,5HPSI =E14.7,4X,5HPHI =E14.7,
               1 1X,8HRADIUS =E14.7,2X,7HTDOTI =E14.7//6X,3HW =E14.7/)
          140   WEELT(IPHASE)=W
                PSIT(IPHASE)=PSI
                TDOTIT(IPHASE)=TDOTI
    215         RADIT(IPHASE)=RADI
                NZIT(IPHASE)=NZI
                ALPHIT(IPHASE)=ALPHI
                CLIT(IPHASE)=CLI
                CDIT(IPHASE)=CDI
    220         RETURN
                END
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```
  SUBROUTINE LOITER     76/76   OPT=2                    FTN 4.5+410        05

 1                SUBROUTINE LOITER(ICALC,NERROR,IGEO,KGPRNT)
                  REAL MSTART,KP,NZLOIT
                  COMMON /TRAJCM/ ALPHA,ARW,CD,CDL,CDO,CL,DESLF,DRAG,EN,HN,KP,
                 1 RLD,SMN,QMAX,RANGE,SFC,SWING,THRUST,TW,ULTLF,W,WAMMUN,WETANK,
 5               2 WFUEL,WGTOWT,WMISS,WTOT,WPLWT,MSTART(12),HSTART(12),TIM(12),
                 3 PSIGT(12),TDOTST(12),NZST(12),PSIT(12),TDOTIT(12),NZIT(12),
                 4 WBOMBS,WFEXT,SFCU,THRSTU,COINSP,PRTOT,WKFUEL,CRMACH,FLTO,X(12),
                 5 FLLAND,TENDUR,BLRANG,BLTIME,TIMTO1,TIMTO2,WFTO,PNAME1(12),
                 6 PNAME2(12),SMNT(12),HNT(12),WFT(12),TIMET(12),XT(12),CLT(12),
10               7 CDT(12),ALPHAT(12),CLIT(12),CDIT(12),ALPHIT(12),WFUSED,WLAND,
                 8 GT(12),RLDT(12),SFCT(12),TNT(12),CET(12),DY(18),
                 9 IAO,IPS,ITS,IWS,IBS,NPHASE,IDY(14)
                  COMMON /TRAJEX/ ALP1GT(12),CDINST(12),CD1GT(12),CL1GT(12),DECEL,
                 1 DELHP,DELMP,DXCRUS,FLFAC,FRFURE,HEND(12),HENDUR,HMAXP,HMINP,
15               2 HPATHT(50),MEND(12),MENDUR,NT(12),PRTOTT(12),RADIT(12),
                 3 RADST(12),SF,SFCUT(12),SMMAXP,SMMINP,
                 4 TNUT(12),VIND(12),VELT(12),VPATHT(50),WART(12),WCOMBP,WEELT(12),
                 5 WFRES,WFTOT,WFTO1,WFTO2,WFTRAP,WKLAND,XDESC,XGRLAN,FWGMAX,TOL,
                 6 WFIXED,WGCALC,WPL,WGTO,DUMY(82),IA(12),IAS,IB(12),IBREG,IENDUR,
20               7 IMISS,IP(12),IPHASE,IPLOT,IPRINT,IPRT(12),IPSIZE,IPSTO1,IPSTO2,
                 8 IW(12),IX(12),KERROR,MILCOM,NCRUSE,NLEGCL,NLEGCR,NLEGLO,NMISS,
                 9 NPATH,IDUMY(6)
                  DIMENSION ANS(4),HNTAB(10),SHTAB(10)
                  DATA HNTAB/0.,5000.,10000.,15000.,20000.,25000.,30000.,
25               1 35000.,37000.,100000./
                  DATA SHTAB/34500.,32900.,31400.,30500.,29400.,28200.,27110.,
                 1 25950.,20900.,20900./
                  DATA DMON/0.0/
                  IF (IPRT(IPHASE).NE.0) WRITE (6,600)
30          600   FORMAT(///19H        LOITER PHASE//)
                  IPS=4
                  SMNIN=MSTART(IPHASE)
                  IF (MSTART(IPHASE).LT.0.0) SMNIN=SMNT(IPHASE-1)
                  SMN=SMNIN
35                HN=HSTART(IPHASE)
                  IF (HSTART(IPHASE).LT.0.0) HN=HNT(IPHASE-1)
                  IF (IENDUR.EQ.0.OR.HSTART(IPHASE).NE.0.0) GO TO 10
                  CALL GOLDEN(2000.,65000.,2,12,XX,Y,NERROR,IGEO,KGPRNT)
                  IF (NERROR.GE.2) RETURN
40                HN=XX
             10   CALL AT62(HN,ANS)
                  RHO=ANS(1)
                  A=ANS(4)
                  VEL=SMN*A
45                IF (SMN.GT.0.0) CL=2.*W/(RHO*SWING*VEL**2)
                  TIME=TIM(IPHASE)
                  NLEGS=TIME/60.+1.0
                  IF (NLEGS.LT.1) NLEGS=1
                  IF (NLEGS.GT.6) NLEGS=6
50                IF (NLEGLO.GT.0) NLEGS=NLEGLO
                  DELT=TIME/FLOAT(NLEGS)
                  WF=0.0
                  XLOIT=0.0
                  IF (IPRT(IPHASE).EQ.0) GO TO 20
55                WRITE (6,601) SMNIN,SMN,HN,RHO,A,VEL,CL,TIME,NLEGS,DELT,WF,XLOIT
          601     FORMAT(/2X,7HSMNIN =E14.7,4X,5HSMN =E14.7,5X,4HHN =
                 1 E14.7,4X,5HRHO =E14.7,6X,3HA =E14.7/4X,5HVEL =E14.7,5X,4HCL =,
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```
     2 E14.7,3X,6HTIME =E14.7,2X,7HNLEGS =I2,15X,6HDELT =E14.7/5X,
     3 4HWF =E14.7,2X,7HXLOIT =E14.7/)
60         20   DO 90 LEG=1,NLEGS
                IF (SMNIN.GT.0.0) GO TO 30
           C-----PERFORM OPTIMUM LOITER MACH NO. SEARCH.
                CALL GOLDEN(.3,.9,3,8,XX,Y,NERROR,IGEO,KGPRNT)
                IF (NERROR.GE.2) RETURN
65              SMN=XX
                VEL=SMN*A
                IF (LEG.EQ.1) CLOUM=2.*W/(RHO*SWING*VEL**2)
                CL=CLOUM
                GO TO 40
70         C---OPTION TO INCREASE ALTITUDE AS A/C WEIGHT DECREASES, MACH KEPT CONST
           30   RHO1=RHO
                RHO2=2.*W/(CL*SWING*VEL**2)
                CALL TAINT(HNTAB,SHTAB,HN,SH,10,1,NERR,DMON)
                HN=HN+2.*SH*(RHO1-RHO2)/(RHO1+RHO2)
75              CALL AT62(HN,ANS)
                A=ANS(4)
                VEL=SMN*A
                RHO=2.*W/(CL*SWING*VEL**2)
           C---END OF INCREASE ALTITUDE OPTION
80         40   IAO=8
                CALL TRAJ01(2)
                CALL AERO(ICALC,NERROR,IGEO,KGPRNT)
                IF (NERROR.GE.2) RETURN
                CALL TRAJ01(1)
85              DRAG=.5*RHO*SWING*CD*VEL**2
                CALL TRAJ01(2)
                CALL PROP(ICALC,NERROR,IGEO,KGPRNT)
                IF (NERROR.GE.2) RETURN
                CALL TRAJ01(1)
90              TN=THRUST*EN
                TNU=THRSTU*EN
           C-----CHECK LOITER RADIUS.
                RALOIT=X(IPHASE)
                IF (RALOIT.LE.0.0) GO TO 60
95              NZLOIT=(.5*CL*RHO*SWING*VEL**2+TN*SIN(ALPHA/57.3))/W
                IF (NZLOIT.LT.1.00001) NZLOIT=1.00001
                COSPHI=1./NZLOIT
           C-----RADIUS FOR OPTIMUM LOITER.
                RLOIT=(5.11E-6*VEL**2*COSPHI)/SQRT(1.-COSPHI**2)
00              IF (RLOIT.LE.RALOIT) GO TO 60
                DO 50 J=1,3
                DRAGP=DRAG
                CL=(W/(SWING*.5*RHO*VEL**2))*SQRT(1.+(5.11E-6*VEL**2/RALOIT)**2)
                IAO=8
05              CALL TRAJ01(2)
                CALL AERO(ICALC,NERROR,IGEO,KGPRNT)
                IF (NERROR.GE.2) RETURN
                CALL TRAJ01(1)
                DRAG=.5*RHO*SWING*CD*VEL**2
10              IF (ABS(DRAG/DRAGP-1.0).LE.0.03) GO TO 60
                IF (J.EQ.3) WRITE (6,602) IPHASE,LEG
           602  FORMAT(//55H INSUFFICIENT THRUST FOR REQUIRED LOITER RADIUS. PHASE
                1=,I2,7H   LEG=,I2/)
                CALL TRAJ01(2)
```

```
                CALL PROP(ICALC,NERROR,IGEO,KGPRNT)
                IF (NERROR.GE.2) RETURN
                CALL TRAJ01(1)
                TN=THRUST*EN
                TNO=THRSTO*EN
        50      CONTINUE
        60      TEST=DRAG/TN
                IF ((ABS(TEST-1.0).LE.0.05).AND.(SMNIN.LE.3.0)) GO TO 70
                IF (TEST.GT.1.0) TN=DRAG
                CD=2.*TN/(RHO*SWING*VEL**2)
                DRAG=.5*RHO*SWING*CD*VEL**2
                IF (KERROR.EQ.2) WRITE (6,603) IPHASE,LEG,TEST
        603     FORMAT(//17H IN LOITER, PHASE,I2,3H, LEG,I2,8H, DRAG =,F6.3,
               1 7H OF TN./28H CD CHANGED TO MATCH THRUST./)
        70      DELWF=SFC*TN*DELT/60.
                WF=WF+DELWF
                W=W-DELWF
                DELX=VEL*DELT*60./6080.
                XLOIT=XLOIT+DELX
                IF (IPRT(IPHASE).EQ.0) GO TO 80
                WRITE (6,604) LEG,SMNIN,SMN,ALPHA,CL,CDO,CD,KP,RHO1,RHO2,SH,HN,A,
               1 RHO,VEL,DRAG,TN,DELWF,WF,W,DELX,XLOIT,SFC,NZLOIT,COSPHI,RLOIT
        604     FORMAT(/4X,5HLEG =I2/2X,7HSMNIN =E14.7,4X,5HSMN =E14.7,
               1 2X,7HALPHA =E14.7,5X,4HCL =E14.7,4X,5HCDO =E14.7/5X,4HCD =E14.7,
               2 5X,4HKP =E14.7,3X,6HRHO1 =E14.7,3X,6HRHO2 =E14.7,5X,4HSH =E14.7/
               3 5X,4HHN =E14.7,6X,3HA =E14.7,4X,5HRHO =E14.7,4X,5HVEL =E14.7,
               4 3X,6HDRAG =E14.7/5X,4HTN =E14.7,2X,7HDELWF =E14.7,5X,4HWF =E14.7,
               5 6X,3HW =E14.7,3X,6HDELX =E14.7/2X,7HXLOIT =E14.7,4X,5HSFC =E14.7,
               6 1X,8HNZLOIT =E14.7,1X,8HCOSPHI =E14.7,2X,7HRLOIT =E14.7/)
        80      IF (W.GT.WPL) GO TO 90
                IF (KERROR.EQ.2) WRITE (6,605) IPHASE,LEG
        605     FORMAT(//27H W.LE.WPL IN LOITER. PHASE=,I2,7H   LEG=,I2/)
                RETURN
        90      CONTINUE
                Q=.5*RHO*VEL**2
                BLTIME=BLTIME+TIME/60.
                BLRANG=BLRANG+XLOIT
        C-----TEST FOR WEAPONS DROP
                IF (IW(IPHASE).EQ.0) GO TO 100
                W=W-WMISS
                IWS=0
        C-----TEST FOR BOMBS DROP
        100     IF (IB(IPHASE).EQ.0) GO TO 110
                W=W-WBOMBS
                IBS=0
        C       TEST FOR AMMO DROP
        110     IF (IA(IPHASE).EQ.0) GO TO 120
                W=W-WAMMUN
                IAS=0
        120     SMNT(IPHASE)=SMN
                HNT(IPHASE)=HN
                CLT(IPHASE)=CL
                ALPHAT(IPHASE)=ALPHA
                WFT(IPHASE)=WF
                TIMET(IPHASE)=TIME
                VELT(IPHASE)=VEL
                SFCT(IPHASE)=SFC
```

```
                TNT(IPHASE)=TN
                CDT(IPHASE)=CD
                RLDT(IPHASE)=RLD
175             WEELT(IPHASE)=W
                WART(IPHASE)=WTOT
                QT(IPHASE)=Q
                SFCUT(IPHASE)=SFCU
                TNUT(IPHASE)=TNU
18C             CDINST(IPHASE)=CDINSP
                PRTOTT(IPHASE)=PRTOT
                XT(IPHASE)=XLOIT
                RETURN
                END
```

```
  SUBROUTINE DESCNT     76/76   OPT=2                    FTN 4.5+410        (

 1                SUBROUTINE DESCNT(ICALC,NERROR,IGEO,KGPRNT)
                  REAL KP
                  COMMON /TRAJCM/ ALPHA,ARW,CD,CDL,CDO,CL,DESLF,DRAG,EN,HN,KP,
                 1 RLD,SMN,QMAX,RANGE,SFC,SWING,THRUST,TW,ULTLF,W,WAMMUN,WETANK,
 5               2 WFUEL,WGTOWT,WMISS,WTOT,WPLWT,MSTART(12),HSTART(12),TIM(12),
                 3 PSIGT(12),TDOTST(12),NZST(12),PSIT(12),TDOTIT(12),NZIT(12),
                 4 WBOMBS,WFEXT,SFCU,THRSTU,CDINSP,PRTOT,WKFUEL,CRMACH,FLTO,X(12),
                 5 FLLAND,TENDUR,BLRANG,BLTIME,TIMTO1,TIMTO2,WFTO,PNAME1(12),
                 6 PNAME2(12),SMNT(12),HNT(12),WFT(12),TIMET(12),XT(12),CLT(12),
10               7 CDT(12),ALPHAT(12),CLIT(12),CDIT(12),ALPHIT(12),WFUSED,WLAND,
                 8 QT(12),RLDT(12),SFCT(12),TNT(12),CET(12),DY(18),
                 9 IAO,IPS,ITS,IWS,IBS,NPHASE,IDY(14)
                  COMMON /TRAJEX/ ALPIGT(12),CDINST(12),CD1GT(12),CL1GT(12),DECEL,
                 1 DELHP,DELMP,DXCRUS,FLFAC,FRFURE,HEND(12),HENDUR,HMAXP,HMINP,
15               2 HPATHT(50),MEND(12),MENDUR,NT(12),PRTOTT(12),RADIT(12),
                 3 RADST(12),SF,SFCUT(12),SMMAXP,SMMINP,
                 4 TNUT(12),VIND(12),VELT(12),VPATHT(50),WART(12),WCOMBP,WEELT(12),
                 5 WFRES,WFTOT,WFTO1,WFTO2,WFTRAP,WKLAND,XDESC,XGRLAN,FWGMAX,TOL,
                 6 WFIXED,WGCALC,WPL,WGTO,DUMY(82),IA(12),IAS,IB(12),IBREG,IENDUR,
20               7 IMISS,IP(12),IPHASE,IPLOT,IPRINT,IPRT(12),IPSIZE,IPSTO1,IPSTO2,
                 8 IW(12),IX(12),KERROR,MILCOM,NCRUSE,NLEGCL,NLEGCR,NLEGLO,NMISS,
                 9 NPATH,IDUMY(6)
                  DIMENSION ANS(4)
                  IF (IPRT(IPHASE).NE.0) WRITE (6,600)
25          600   FORMAT(///20H        DESCENT PHASE//)
                  HNINT=HNT(IPHASE-1)
                  HNFIN=HEND(IPHASE)
                  IPS=5
                  VEL=VELT(IPHASE-1)
30                NLEGS=5
                  DELH=(HNFIN-HNINT)/FLOAT(NLEGS)
                  HN=HNINT
                  TIME=0.0
                  WF=0.0
35                XDESC=0.0
                  IF (IPRT(IPHASE).EQ.0) GO TO 10
                  WRITE (6,601) HNINT,HNFIN,CL,RLD,VEL,HN,DELT,TIME,XDESC,WF
            601   FORMAT(/2X,7HHNINT =E14.7,2X,7HHNFIN =E14.7,5X,4HCL =
                 1 E14.7,4X,5HRLD =E14.7,4X,5HVEL =E14.7/5X,4HHN =E14.7,3X,6HDELT =,
40               2 E14.7,3X,6HTIME =E14.7,2X,7HXDESC =E14.7,5X,4HWF =E14.7/)
            10    DO 30 LEG=1,NLEGS
                  CALL AT62(HN,ANS)
                  RHO=ANS(1)
                  A=ANS(4)
45                SMN=VEL/A
                  CALL TRAJ01(2)
                  CALL PROP(ICALC,NERROR,IGEO,KGPRNT)
                  IF (NERROR. .2) RETURN
                  CALL TRAJ01,1)
50                TN=THRUST*EN
                  TNU=THRSTU*EN
                  IAO=9
                  CALL TRAJ01(2)
                  CALL AERO(ICALC,NERROR,IGEO,KGPRNT)
55                IF (NERROR.GE.2) RETURN
                  CALL TRAJ01(1)
                  CL=SQRT(CDO/KP)
```

```
      SING=2.*COD/CL
      COSG=SQRT(1.-SING**2)
6C    VEL=SQRT(2.*W*COSG/(CL*SWING*RHO))
      DELT=-DELH/(VEL*SING)
      TIME=TIME+DELT/60.
      DELWF=SFC*TN*DELT/3600.
      WF=WF+DELWF
65    DELX=VEL*DELT*COSG/6080.
      XDESC=XDESC+DELX
      HN=HN+DELH
      W=W-DELWF
      IF (IPRT(IPHASE).EQ.0) GO TO 20
7C    WRITE (6,602) LEG,RHO,A,SMN,TN,SFC,DELV,VEL,COSG,SING,DELT,TIME,
     1 DELX,XDESC,HN,CL,CD,KP,DELWF,WF,W
602   FORMAT(/4X,5HLEG =I2/4X,5HRHO =E14.7,6X,3HA =E14.7,4X,
     1 5HSMN =E14.7,5X,4HTN =E14.7,4X,5HSFC =E14.7/3X,6HDELV =E14.7,4X,
     2 5HVEL =E14.7,3X,6HCOSG =E14.7,3X,6HSING =E14.7,3X,6HDELT =E14.7/
75   3 3X,6HTIME =E14.7,3X,6HDELX =E14.7,2X,7HXDESC =E14.7,5X,4HHN =,
     4 E14.7,5X,4HCL =E14.7/5X,4HCD =E14.7,5X,4HKP =E14.7,2X,7HDELWF =,
     5 E14.7,5X,4HWF =E14.7,6X,3HW =E14.7/)
20    IF (W.GT.WPL) GO TO 30
      IF (KERROR.EQ.2) WRITE (6,603) IPHASE,LEG
80    603 FORMAT(//28H W.LE.WPL IN DESCENT. PHASE=,I2,7H   LEG=,I2/)
      RETURN
30    CONTINUE
      CALL AT62(HN,ANS)
      A=ANS(4)
85    SMN=VEL/A
      RHO=ANS(1)
      Q=.5*RHO*VEL**2
      BLTIME=BLTIME+TIME/60.
      BLRANG=BLRANG+XDESC
90    C-----TEST FOR WEAPONS DROP
      IF (IW(IPHASE).EQ.0) GO TO 40
      W=W-WMISS
      IWS=0
      C-----TEST FOR BOMBS DROP
95    40    IF (IB(IPHASE).EQ.0) GO TO 50
      W=W-WBOMBS
      IBS=0
      C-----TEST FOR AMMO DROP
      50    IF (IA(IPHASE).EQ.0) GO TO 60
10C   W=W-WAMMUN
      IAS=0
      60    IF (IPRT(IPHASE).EQ.0) GO TO 70
      WRITE (6,604) HN,A,SMN,RHO,Q,DXCRUS,W
      604   FORMAT(/5X,4HHN =E14.7,6X,3HA =E14.7,4X,5HSMN =E14.7,
105  1 4X,5HRHO =E14.7,6X,3HQ =E14.7/1X,8HDXCRUS =E14.7,6X,3HW =E14.7/)
      70    SMNT(IPHASE)=SMN
      HNT(IPHASE)=HN
      CLT(IPHASE)=CL
      ALPHAT(IPHASE)=ALPHA
11C   WFT(IPHASE)=WF
      TIMET(IPHASE)=TIME
      VELT(IPHASE)=VEL
      SFCT(IPHASE)=SFC
      TNT(IPHASE)=TN
```

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115                 CDT(IPHASE)=CD
                    RLDT(IPHASE)=RLD
                    WEELT(IPHASE)=W
                    WART(IPHASE)=WTOT
                    QT(IPHASE)=Q
120                 SFCUT(IPHASE)=SFCU
                    TNUT(IPHASE)=TNU
                    CDINST(IPHASE)=CDINSP
                    PRTOTT(IPHASE)=PRTOT
                    XT(IPHASE)=XDESC
125                 RETURN
                    END
```

```
      SUBROUTINE PATHS(ICALC,NERROR,IGEO,KGPRNT)
      REAL KP
      COMMON /TRAJCM/ ALPHA,ARW,CD,CDL,CDO,CL,DESLF,DRAG,EN,HN,KP,
     1 RLD,SMN,QMAX,RANGE,SFC,SWING,THRUST,TW,ULTLF,W,WAMMUN,WETANK,
     2 WFUEL,WGTOWT,WMISS,WTOT,WPLWT,MSTART(12),HSTART(12),TIM(12),
     3 PSIGT(12),TDOTST(12),NZST(12),PSIT(12),TDOTIT(12),NZIT(12),
     4 WBOMBS,WFEXT,SFCU,THRSTU,CDINSP,PRTOT,WKFUEL,CRMACH,FLTO,X(12),
     5 FLLAND,TENDUR,BLRANG,BLTIME,TIMTO1,TIMTO2,WFTO,PNAME1(12),
     6 PNAME2(12),SMNT(12),HNT(12),WFT(12),TIMET(12),XT(12),CLT(12),
     7 CDT(12),ALPHAT(12),CLIT(12),CDIT(12),ALPHIT(12),WFUSED,WLAND,
     8 QT(12),RLDT(12),SFCT(12),TNT(12),CET(12),DY(18),
     9 IAO,IPS,ITS,IWS,IBS,NPHASE,IDY(14)
      COMMON /TRAJEX/ ALPIGT(12),CDINST(12),CD1GT(12),CL1GT(12),DECEL,
     1 DELHP,DELMP,DXCRUS,FLFAC,FRFURE,HEND(12),HENDUR,HMAXP,HMINP,
     2 HPATHT(50),MEND(12),MENDUR,NT(12),PRTOTT(12),RADIT(12),
     3 RADST(12),SF,SFCUT(12),SMMAXP,SMMINP,
     4 TNUT(12),VIND(12),VELT(12),VPATHT(50),WART(12),WCOMBP,WEELT(12),
     5 WFRES,WFTOT,WFTO1,WFTO2,WFTRAP,WKLAND,XDESC,XGRLAN,FWGMAX,TOL,
     6 WFIXED,WGCALC,WPL,WGTO,DUMY(82),IA(12),IAS,IB(12),IBREG,IENDUR,
     7 IMISS,IP(12),IPHASE,IPLOT,IPRINT,IPRT(12),IPSIZE,IPSTO1,IPSTO2,
     8 IW(12),IX(12),KERROR,MILCOM,NCRUSE,NLEGCL,NLEGCR,NLEGLO,NMISS,
     9 NPATH,IDUMY(6)
      DIMENSION ANS(4)
      IPS=IP(IPHASE)
      TIME=0.0
      XPATH=0.0
      WF=0.0
      IF (IPRT(IPHASE).NE.0) WRITE (6,600) IPS,TIME,XPATH,WF,W
  600 FORMAT(///17H       PATH PHASE///4X,5HIPS =I2,15X,6HTIME =E14.7,
     1 2X,7HXPATH =E14.7,5X,4HWF =E14.7,6X,3HW =E14.7/)
      DO 60 I=2,NPATH
      LEG=I-1
      H1=HPATHT(I-1)
      H2=HPATHT(I)
      HN=.5*(H1+H2)
      DELH=H2-H1
      CALL AT62(HN,ANS)
      RHO=ANS(1)
      A=ANS(4)
      VM1=VPATHT(I-1)
      VM2=VPATHT(I)
      VM=.5*(VM1+VM2)
C-----MAKE TEST TO SEE WHETHER VM IS MACH OR VELOCITY.
      IF (VM.GT.10.0) GO TO 10
      SMN1=VM1
      SMN2=VM2
      SMN=VM
      VEL1=SMN1*A
      VEL2=SMN2*A
      VEL=SMN*A
      GO TO 20
   10 VEL1=VM1
      VEL2=VM2
      VEL=VM
      SMN1=VEL1/A
      SMN2=VEL2/A
      SMN=VEL/A
```

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```
      20    DELV=VEL2-VEL1
      C-----CALL PROP TO GET TN, SFC.
      CALL TRAJ01(2)
      CALL PROP(ICALC,NERROR,IGEO,KGPRNT)
      IF (NERROR.GE.2) RETURN
      CALL TRAJ01(1)
      TN=THRUST*EN
      TNU=THRSTU*EN
      C-----CALL AERO TO GET CDO, KP.
      IAO=1
      ALPHA=5.0
      CALL TRAJ01(2)
      CALL AERO(ICALC,NERROR,IGEO,KGPRNT)
      IF (NERROR.GE.2) RETURN
      CALL TRAJ01(1)
      Q=.5*RHO*VEL**2
      QS=Q*SWING
      C1=QS/W
      C2=VEL*DELV/(32.2*DELH)+1.0
      C3=TN/W-C1*CDO
      C4=(C2/KP)**2
      C5=SQRT(.25*C4**2-C4*C3/(C1*KP)+C4/C1**2)
      C-----CALCULATE FIRST APPROXIMATION TO CL.
      CL1=SQRT(-.5*C4+C3/(C1*KP)+C5)
      C-----CALL AERO TO GET CD, ALPHA.
      CL=CL1
      IAO=8
      CALL TRAJ01(2)
      CALL AERO(ICALC,NERROR,IGEO,KGPRNT)
      IF (NERROR.GE.2) RETURN
      CALL TRAJ01(1)
      C6=((TN/W)*COS(ALPHA/57.3)-C1*CD)/C2
      C-----CALCULATE SECOND APPROXIMATION TO CL.
      CL2=SQRT(1.-C6**2)/C1
      C-----CALL AERO TO GET CD, ALPHA.
      CL=CL2
      CALL TRAJ01(2)
      CALL AERO(ICALC,NERROR,IGEO,KGPRNT)
      IF (NERROR.GE.2) RETURN
      CALL TRAJ01(1)
      C-----CALCULATE FLIGHT PATH ANGLE.
      SING=((TN/W)*COS(ALPHA/57.3)-C1*CO)/C2
      IF ((SING.GE.0.0).OR.(DELH.LE.0.0)) GO TO 30
      NERROR=2
      WRITE (6,601) IPHASE,LEG
      601   FORMAT(/////33H *****FATAL ERROR IN PATH. PHASE=,I2,3X,4HLEG=,I2/
     1 41H *****INSUFFICIENT THRUST TO FOLLOW PATH.//////)
      RETURN
      30    IF (SING.GT.1.0) SING=1.0
      C-----CHECK CAPABILITY TO MATCH PATH ALTITUDE.
      DELHC=VEL*DELV*SING/(32.2*(SING*C2-SING))
      IF (ABS((DELHC-DELH)/DELH).LE.0.2) GO TO 40
      NERROR=2
      WRITE (6,602) IPHASE,LEG
      602   FORMAT(/////33H *****FATAL ERROR IN PATH. PHASE=,I2,3X,4HLEG=,I2/
     1 44H *****PATH ALTITUDE DEVIATION EXCEEDS LIMIT.//////)
      RETURN
```

```
      40    DELT=DELH/(VEL*SING)
            COSG=SQRT(1.-SING**2)
            DELX=VEL*DELT*COSG/6080.
            DELWF=TN*SFC*DELT/3600.
            TIME=TIME+DELT/60.
            XPATH=XPATH+DELX
            WF=WF+DELWF
            W=W-DELWF
            IF (IPRT(IPHASE).EQ.0) GO TO 50
            WRITE (6,603) LEG,H1,H2,HN,DELH,SMN1,SMN2,SMN,VEL1,VEL2,VEL,DELV,
           1 RHO,A,TN,SFC,ALPHA,CDO,KP,Q,C1,C2,C3,C4,C5,CL1,C6,CL2,CL,CD,
           2 SING,COSG,DELHC,DELT,DELX,DELWF,TIME,XPATH,WF,W
     603    FORMAT(/1X,5HLEG =I2/5X,4HH1 =E14.7,5X,4HH2 =E14.7,5X,4HHN =E14.7,
           1 3X,6HDELH =E14.7,3X,6HSMN1 =E14.7/3X,6HSMN2 =E14.7,4X,5HSMN =
           2 E14.7,3X,6HVEL1 =E14.7,3X,6HVEL2 =E14.7,4X,5HVEL =E14.7/
           3 3X,6HDELV =E14.7,4X,5HRHO =E14.7,6X,3HA =E14.7,5X,4HTN =E14.7,
           4 4X,5HSFC =E14.7/2X,7HALPHA =E14.7,4X,5HCDO =E14.7,5X,4HKP =E14.7,
           5 6X,3HQ =E14.7,5X,4HC1 =E14.7/5X,4HC2 =E14.7,5X,4HC3 =E14.7,
           6 5X,4HC4 =E14.7,5X,4HC5 =E14.7,4X,5HCL1 =E14.7/5X,4HC6 =E14.7,
           7 4X,5HCL2 =E14.7,5X,4HCL =E14.7,5X,4HCD =E14.7,3X,6HSING =E14.7/
           8 3X,6HCOSG =E14.7,2X,7HDELHC =E14.7,3X,6HDELT =E14.7,3X,6HDELX =
           9 E14.7,2X,7HDELWF =E14.7/3X,6HTIME =E14.7,2X,7HXPATH =E14.7,
           1 5X,4HWF =E14.7,6X,3HW =E14.7/)
      50    IF (W.GT.WPL) GO TO 60
            IF (KERROR.EQ.2) WRITE (6,604) IPHASE,LEG
     604    FORMAT(//25H W.LE.WPL IN PATH. PHASE=,I2,7H   LEG=I2/)
            RETURN
      60    CONTINUE
            HN=H2
            SMN=SMN2
            VEL=VEL2
            BLTIME=BLTIME+TIME/60.
            BLRANG=BLRANG+XPATH
     C------TEST FOR WEAPONS DROP
            IF (IW(IPHASE).EQ.0) GO TO 70
            W=W-WMISS
            IWS=0
     C------TEST FOR BOMBS DROP
      70    IF (IB(IPHASE).EQ.0) GO TO 80
            W=W-WBOMBS
            IBS=0
     C------TEST FOR AMMO DROP
      80    IF (IA(IPHASE).EQ.0) GO TO 90
            W=W-WAMMUN
            IAS=0
      90    IF (IPRT(IPHASE).EQ.0) GO TO 100
            WRITE (6,605) W,HN,SMN,VEL
     605    FORMAT(/6X,3HW =E14.7,5X,4HHN =E14.7,4X,5HSMN =E14.7,
           1 4X,5HVEL =E14.7/)
     100    SMNT(IPHASE)=SMN
            HNT(IPHASE)=HN
            CLT(IPHASE)=CL
            ALPHAT(IPHASE)=ALPHA
            WFT(IPHASE)=WF
            TIMET(IPHASE)=TIME
            VELT(IPHASE)=VEL
            SFCT(IPHASE)=SFC
```

```
                TNT(IPHASE)=TN
                CDT(IPHASE)=CD
                RLDT(IPHASE)=RLD
175             WEELT(IPHASE)=W
                WART(IPHASE)=WTOT
                QT(IPHASE)=Q
                SFCUT(IPHASE)=SFCU
                TNUT(IPHASE)=TNU
180             CDINST(IPHASE)=CDINSP
                PRTOTT(IPHASE)=PRTOT
                XT(IPHASE)=XPATH
                RETURN
                END
```

```
      SUBROUTINE TRAJ00
C  OUTPUT OF RESULTS FROM TRAJECTORY ROUTINE
      REAL NZST,NZIT,NZ1G,MENDUR,LOIT
      COMMON /TRAJCM/ ALPHA,ARW,CD,CDL,CDU,CL,DESLF,DRAG,EN,HN,KP,
     1 RLD,SMN,JMAX,RANGE,SFC,SWING,THRUST,TW,ULTLF,W,WAMMUN,WETANK,
     2 WFUEL,WGTOWT,WMISS,WTOT,WPLWT,MSTART(12),HSTART(12),TIM(12),
     3 PSIGT(12),TDOTST(12),NZST(12),PSIT(12),TDOTIT(12),NZIT(12),
     4 WBOMBS,WFEXT,SFCU,THRSTU,CDINSP,PRTOT,WKFUEL,CRMACH,FLTO,X(12),
     5 FLLAND,TENDUR,BLRANG,BLTIME,TIMTO1,TIMTO2,WFTO,PNAME1(12),
     6 PNAME2(12),SMNT(12),HNT(12),WFT(12),TIMET(12),XT(12),CLT(12),
     7 CDT(12),ALPHAT(12),CLIT(12),CDIT(12),ALPHIT(12),WFUSED,WLAND,
     8 QT(12),RLDT(12),SFCT(12),TNT(12),CET(12),DY(18),
     9 IAO,IPS,ITS,IWS,IBS,NPHASE,IDY(14)
      COMMON /TRAJEX/ ALPIGT(12),CDINST(12),CDIGT(12),CL1GT(12),DECEL,
     1 DELHP,DELMP,DXCRUS,FLFAC,FRFURE,HEND(12),HENDUR,HMAXP,HMINP,
     2 HPATHT(50),MEND(12),MENDUR,NT(12),PRTOTT(12),RADIT(12),
     3 RADST(12),SF,SFCUT(12),SMMAXP,SMMINP,
     4 TNUT(12),VIND(12),VELT(12),VPATHT(50),WART(12),WCOMBP,WEELT(12),
     5 WFRES,WFTOT,WFTO1,WFTO2,WFTRAP,WKLAND,XDESC,XGRLAN,FWGMAX,TOL,
     6 WFIXED,WGCALC,WPL,WGTO,DUMY(82),IA(12),IAS,IB(12),IBREG,IENDUR,
     7 IMISS,IP(12),IPHASE,IPLOT,IPRINT,IPRT(12),IPSIZE,IPSTO1,IPSTO2,
     8 IW(12),IX(12),KERROR,MILCOM,NCRUSE,NLEGCL,NLEGCR,NLEGLO,NMISS,
     9 NPATH,IDUMY(6)
      DATA COMB/4HCOMB/
      DATA LOIT/4HLOIT/
      WRITE (6,6CC) IMISS,WPL
 6CC  FORMAT(1H1,24X,17HTRAJECTORY OUTPUT//
     1 24X,7HMISSION,I2,12H  (PAYLOAD =,F8.J,4H LB)//
     2 67H PHASE     M          H          CL        ALPHA     WFUEL     TIME
     3  VEL/9X,57HSFC(I)  THRUST(I)     CD        L/D        W         WA
     4  O/9X,57HSFC(U)  THRUST(U)  CDINST                          PR
     5X)
      DO 1C IPHASE=1,NPHASE
      WRITE (6,601) PNAME1(IPHASE),PNAME2(IPHASE),SMNT(IPHASE),
     1 HNT(IPHASE),CLT(IPHASE),ALPHAT(IPHASE),WFT(IPHASE),TIMET(IPHASE),
     2 VELT(IPHASE),SFCT(IPHASE),TNT(IPHASE),CDT(IPHASE),RLDT(IPHASE),
     3 WEELT(IPHASE),WART(IPHASE),QT(IPHASE),SFCUT(IPHASE),TNUT(IPHASE),
     4 CDINST(IPHASE),PRTOTT(IPHASE),XT(IPHASE)
 601  FORMAT(/1X,2A4,F4.2,F11.0,F10.4,F8.2,F10.1,F8.2,F8.0/
     1 F13.2,F11.0,F10.4,F8.2,F10.1,F8.2,F8.0/
     2 F13.2,F11.0,F10.4,18X,F8.2,F8.0)
 1C   CONTINUE
      WRITE (6,602) WFTO1,WFTOT,WFTO2,WFEXT,WFUSED,WFUEL,WFRES,WFTRAP
 602  FORMAT(1H1,20X,12HFUEL SUMMARY//14H  TAKEOFF FUEL/
     1 9X,7HWFTO1 =,F8.0,5X,12HTOTAL FUEL =,F8.0/
     2 9X,7HWFTO2 =,F8.0,5X,12H  EXTERNAL =,F8.0/
     3 16H  MISSION FUEL =,F8.0,5X,12H  INTERNAL =,F8.0/
     4 16H  RESERVE FUEL =,F8.0/16H  TRAPPED FUEL =,F8.0)
      J=0
      NZ1G=1.0
      TDOT1G=0.0
      RAD1G=0.0
      PSS=0.0
      DO 30 IPHASE=1,NPHASE
      IF (PNAME1(IPHASE).NE.COMB) GO TO 30
      IF (J.NE.0) GO TO 20
      WRITE (6,603)
```

```
      603   FORMAT(///19X,28HADDITIONAL COMBAT PARAMETERS//13X,
           1 58HCONDITIONS    PS      NZ     TDOT  RADIUS  ALPHA   CL      CD)
60          J=1
      20    WRITE (6,604) SMNT(IPHASE),PS1GT(IPHASE),NZ1G,TDOT1G,RAD1G,
           1 ALP1GT(IPHASE),CL1GT(IPHASE),CD1GT(IPHASE),HNT(IPHASE),PSS,
           2 NZST(IPHASE),TDOTST(IPHASE),RADST(IPHASE),ALPHAT(IPHASE),
           3 CLT(IPHASE),CDT(IPHASE),PSIT(IPHASE),NZIT(IPHASE),TDOTIT(IPHASE),
65         4 RADIT(IPHASE),ALPHIT(IPHASE),CLIT(IPHASE),CDIT(IPHASE),
           5 CET(IPHASE)
      604   FORMAT(/3H M=,F5.2,15H     1 G FLIGHT,F8.1,F6.2,F7.2,F8.0,F7.2,
           1 F7.3,F8.4/3H H=,F6.0,13H    SUSTAINED,F9.1,F6.2,F7.2,F8.0,F7.2,
           2 F7.3,F8.4/13X,10HMAX. INST.,F8.1,F6.2,F7.2,F8.0,F7.2,F7.3,F8.4/
70         3 13X,15HCOMBAT ENERGY =,E13.6)
      30    CONTINUE
            WRITE (6,605) BLTIME,BLRANG,FLTO,FLLAND,XGRLAN,WLAND,WGTO,W,
           1 MENDUR,HENDUR,TENDUR
      605   FORMAT(///12X,23H          BLOCK TIME   =,F7.3,7H  HOURS/
75         1 35H                      BLOCK RANGE  =,F7.1,7H  N. M./
           2 35H TAKEOFF FIELD LENGTH(TOTAL RUN)   =,F7.0,6H  FEET/
           3 35H LANDING FIELD LENGTH(TOTAL RUN)   =,F7.0,6H  FEET/
           4 35H LANDING FIELD LENGTH(GROUND RUN)  =,F7.0,6H  FEET/
           5 35H   WEIGHT FOR LANDING CALCULATION  =,F8.0,7H POUNDS/
80         6 35H                  TAKEOFF WEIGHT   =,F8.0,7H POUNDS/
           7 35H                  LANDING WEIGHT   =,F8.0,7H POUNDS/
           8 35H              ENDURANCE MACH NO.   =,F5.1/
           9 35H              ENDURANCE ALTITUDE   =,F7.0,6H  FEET/
           1 35H              ENDURANCE TIME       =,F7.3,7H  HOURS)
85          DO 40 IPHASE =1,NPHASE
            IF (PNAME1(IPHASE).NE.LOIT) GO TO 40
            WRITE (6,606) X(IPHASE)
      606   FORMAT(20X,15HLOITER RADIUS =,F6.2,8H   N. M.)
      40    CONTINUE
90          RETURN
            END
```

```
  SUBROUTINE TRPLOT     76/76   OPT=2                          FTN 4.5+410

 1                SUBROUTINE TRPLOT(NERROR,IGEO,KGPRNT)
                  REAL LIFT,NZS,NZI
                  COMMON /TRAJCM/ ALPHA,ARW,CD,CDL,CDO,CL,DESLF,DRAG,EN,HN,KP,
                 1 RLD,SMN,SMAX,RANGE,SFC,SWING,THRUST,TW,ULTLF,W,WAMMUN,WETANK,
 5               2 WFUEL,WGTOWT,WMISS,WTOT,WPLWT,MSTART(12),HSTART(12),TIM(12),
                 3 PSIGT(12),TDOTST(12),NZST(12),PSIT(12),TDOTIT(12),NZIT(12),
                 4 WBOMBS,WFEXT,SECU,THRSTU,CDINSP,PRTOT,WKFUEL,CRMACH,FLTO,X(12),
                 5 FLLAND,TENDUR,BLRANG,BLTIME,TIMTO1,TIMTO2,WFTO,PNAME1(12),
                 6 PNAME2(12),SMNT(12),HNT(12),WFT(12),TIMET(12),XT(12),CLT(12),
10               7 CDT(12),ALPHAT(12),CLIT(12),CDIT(12),ALPHIT(12),WFUSED,WLAND,
                 8 QT(12),RLDT(12),SFCT(12),TNT(12),CET(12),DY(18),
                 9 IAO,IPS,ITS,IWS,IBS,NPHASE,IDY(14)
                  COMMON /TRAJEX/ ALPIGT(12),CDINST(12),CDIGT(12),CLIGT(12),DECEL,
                 1 DELHP,DELMP,DXCRUS,FLFAC,FRFURE,HEND(12),HENDUR,HMAXP,HMINP,
15               2 HPATHT(50),MEND(12),MENDUR,NT(12),PRTOTT(12),RADIT(12),
                 3 RADST(12),SF,SFCUT(12),SMMAXP,SMMINP,
                 4 TNUT(12),VIND(12),VELT(12),VPATHT(50),WART(12),WCOMBP,WEELT(12),
                 5 WFRES,WFTOT,WFTO1,WFTO2,WFTRAP,WKLAND,XDESC,XGRLAN,FWGMAX,TOL,
                 6 WFIXED,WGCALC,WPL,WGTO,DUMY(82),IA(12),IAS,IB(12),IBREG,IENDUR,
20               7 IMISS,IP(12),IPHASE,IPLOT,IPRINT,IPRT(12),IPSIZE,IPSTO1,IPSTO2,
                 8 IW(12),IX(12),KERROR,MILCOM,NCRUSE,NLEGCL,NLEGCR,NLEGLO,NMISS,
                 9 NPATH,IDUMY(6)
                  DIMENSION ANS(4)
                  DATA COMB/4HCOMB/
25          C-----IPLOT = 0, NO PRINT, NO PLOT
            C-----IPLOT = 1,    PRINT, NO PLOT
            C-----IPLOT = 2, NO PRINT,    PLOT
            C-----IPLOT = 3,    PRINT,    PLOT
            C-----WCOMBP .LE. 0.0, W = W FROM LAST COMBAT PHASE
30          C-----WCOMBP BETWEEN 0.0 AND 1.0, W = WCOMBP*WGTO
            C-----WCOMBP .GT. 1.0, W = WCOMBP
            C-----CALCULATE COMBAT PARAMETERS.
                  J=0
                  DO 10 IPHASE=1,NPHASE
35                IF (PNAME1(IPHASE).NE.COMB) GO TO 10
                  J=IPHASE
            10    CONTINUE
                  IF (J.EQ.0) IPS=2
                  IF (J.GT.0) IPS=IP(J)
40                JM1=J-1
                  IF (JM1.EQ.0) JM1=1
                  IF ((WCOMBP.LE.0.0).AND.(J.EQ.0)) W=.7*WGTO
                  IF ((WCOMBP.LE.0.0).AND.(J.GT.0)) W=WEELT(JM1)
                  IF ((WCOMBP.GT.0.0).AND.(WCOMBP.LE.1.0)) W=WCOMBP*WGTO
45                IF (WCOMBP.GT.1.0) W=WCOMBP
                  NH=(HMAXP-HMINP)/DELHP+1.0
                  NM=(SMMAXP-SMMINP)/DELMP+1.0
                  IF ((IPLOT.EQ.1).OR.(IPLOT.EQ.3)) WRITE (6,600) HMINP,HMAXP,
                 1 DELHP,SMMINP,SMMAXP,DELMP,WCOMBP,IPLOT,QMAX,W
50          600   FORMAT(1H1,9H  HMINP =F7.0/10H   HMAXP =F7.0/10H   DELHP =F7.0/
                 1 10H  SMMINP =F6.2/10H  SMMAXP =F6.2/10H   DELMP =F6.2/
                 2 10H  WCOMBP =F9.2/10H   IPLOT =I2/10H    QMAX =F7.0/
                 3 10H       W =F8.1//85H     H     M     PSIG        NZS        TDOT:
                 4       NZI         PSI         TDOTI         Q/)
55                IF (IPLOT.GE.2) WRITE (42,601) NH,NM,DELHP,DELMP,QMAX
            601   FORMAT(2I8,3F8.2)
                  DO 40 IH=1,NH
```

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                HN=FLOAT(IH-1)*DELHP
                CALL AT62(HN,ANS)
60              RHO=ANS(1)
                A=ANS(4)
                DO 40 IM=1,NM
                SMN=FLOAT(IM-1)*DELMP+SMMINP
                VEL=SMN*A
65              Q=.5*RHO*VEL**2
                QS=Q*SWING
                CL=W/QS
                IAO=8
                CALL TRAJ01(2)
70              CALL AERO(2,NERROR,IGEO,KGPRNT)
                IF (NERROR.GE.2) RETURN
                CALL TRAJ01(1)
                DRAG=CD*QS
                CALL TRAJ01(2)
75              CALL PROP(2,NERROR,IGEO,KGPRNT)
                IF (NERROR.GE.2) RETURN
                CALL TRAJ01(1)
                TN=THRUST*EN
                PS1G=(TN-DRAG)*VEL/W
80              NZS=1.001
                IF (PS1G.LE.0.) GO TO 20
                IAO=4
                CALL TRAJ01(2)
                CALL AERO(2,NERROR,IGEO,KGPRNT)
85              IF (NERROR.GE.2) RETURN
                CALL TRAJ01(1)
                LIFT=CL*QS
                NZS=(LIFT+TN*SIN(ALPHA/57.3))/W
                IF (NZS.LE.DESLF) GO TO 20
90              IAO=6
                CALL TRAJ01(2)
                CALL AERO(2,NERROR,IGEO,KGPRNT)
                IF (NERROR.GE.2) RETURN
                CALL TRAJ01(1)
95              NZS=DESLF
          20    IF (NZS.LE.1.0) NZS=1.001
                PHI=ARCOS(1.0/NZS)
                RADIUS=VEL**2/(32.2*TAN(PHI))
                TDOTS=57.3*VEL/RADIUS
100             IAO=5
                CALL TRAJ01(2)
                CALL AERO(2,NERROR,IGEO,KGPRNT)
                IF (NERROR.GE.2) RETURN
                CALL TRAJ01(1)
105             LIFT=CL*QS
                NZI=(LIFT+TN*SIN(ALPHA/57.3))/W
                IF (NZI.LE.DESLF) GO TO 30
                IAO=6
                CALL TRAJ01(2)
110             CALL AERO(2,NERROR,IGEO,KGPRNT)
                IF (NERROR.GE.2) RETURN
                CALL TRAJ01(1)
                NZI=DESLF
          30    IF (NZI.LE.1.0) NZI=1.001
```

```
      DRAG=CD*QS
      PSI=(TN*COS(ALPHA/57.3)-DRAG)*VEL/W
      PHI=ARCOS(1.0/NZI)
      RADIUS=VEL**2/(32.2*TAN(PHI))
      TDOTI=57.3*VEL/RADIUS
      IF ((IPLOT.EQ.1).OR.(IPLOT.EQ.3)) WRITE (6,602) HN,SMN,
     1 PSIG,NZS,TDOTS,NZI,PSI,TDOTI,Q
      IF (IPLOT.GE.2) WRITE (42,602) HN,SMN,PSIG,NZS,TDOTS,NZI,PSI,
     1 TDOTI,Q
  602 FORMAT(F7.0,F6.2,1P7E11.3)
   40 CONTINUE
C-----LANDING FIELD LENGTHS AT ALTITUDES OF 0, 4000, 8000, AND 12000 FT.
      IF ((IPLOT.EQ.1).OR.(IPLOT.EQ.3)) WRITE (6,603)
  603 FORMAT(1H1,8X,33HLANDING FIELD LENGTH CALCULATIONS//
     1 6cH   ALT        WMIN        FLLAN(WMIN)       WGTO          FLLAN(W
     2GTO)//)
      WMIN=WGTO-WFTOT-WPL
      IAD=12
      DO 50 I=1,4
      HN=(I-1)*4000
      CALL AT62(HN,ANS)
      RHO=ANS(1)
      CALL TRAJ01(2)
      CALL AERO(2,NERROR,IGEO,KGPRNT)
      IF (NERROR.GE.2) RETURN
      CALL TRAJ01(1)
      VSTALL=SQRT(2.*WMIN/(SWING*CL*RHO))
      VSCREN=1.3*VSTALL
      VTDOWN=1.15*VSTALL
      XAIR=((VSCREN**2-VTDOWN**2)/64.4+50.)*RLD
      XGRLAN=VTDOWN**2/(64.4*DECEL)
      FLLAN1=(XAIR+XGRLAN)/FLFAC
      VSTALL=SQRT(2.*WGTO/(SWING*CL*RHO))
      VSCREN=1.3*VSTALL
      VTDOWN=1.15*VSTALL
      XAIR=((VSCREN**2-VTDOWN**2)/64.4+50.)*RLD
      XGRLAN=VTDOWN**2/(64.4*DECEL)
      FLLAN2=(XAIR+XGRLAN)/FLFAC
      IF ((IPLOT.EQ.1).OR.(IPLOT.EQ.3)) WRITE (6,604) HN,WMIN,FLLAN1,
     1 WGTO,FLLAN2
  604 FORMAT(F7.0,4E15.6)
      IF (IPLOT.GE.2) WRITE (42,604) HN,WMIN,FLLAN1,WGTO,FLLAN2
   50 CONTINUE
      RETURN
      END
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SUBROUTINE GOLDEN     76/76   OPT=2                    FTN 4.5+410

      SUBROUTINE GOLDEN(XMIN,XMAX,IXY,NMAX,XX,Y,NERROR,IGEO,KGPRNT)
C-----THIS ROUTINE USES THE GOLDEN SECTION METHOD TO FIND
C     THE X CORRESPONDING TO THE MAXIMUM Y IN THE INTERVAL
C     BETWEEN XMIN AND XMAX.
C-----IF IXY = 1, THEN X = ALT. AND Y = BREG. FACTOR
C-----IF IXY = 2, THEN X = ALT. AND Y = ENDUR. FACTOR
C-----IF IXY = 3, THEN X = MACH AND Y = ENDUR. FACTOR
      COMMON /TRAJCM/ ALPHA,ARW,CD,CDL,CDO,CL,DESLF,DRAG,EN,HN,KP,
     1 RLD,SMN,QMAX,RANGE,SFC,SWING,THRUST,TW,ULTLF,W,WAMMUN,WETANK,
     2 WFUEL,WGTOWT,WMISS,WTOT,WPLWT,MSTART(12),HSTART(12),TIM(12),
     3 PS1GT(12),TDOTST(12),NZST(12),PSIT(12),TDOTIT(12),NZIT(12),
     4 WBOMBS,WFEXT,SFCU,THRSTU,CDINSP,PRTOT,WKFUEL,CRMACH,FLTO,X(12),
     5 FLLAND,TENDUR,BLRANG,BLTIME,TIMTO1,TIMTO2,WFTO,PNAME1(12),
     6 PNAME2(12),SMNT(12),HNT(12),WFT(12),TIMET(12),XT(12),CLT(12),
     7 CDT(12),ALPHAT(12),CLIT(12),CDIT(12),ALPHIT(12),WFUSED,WLAND,
     8 QT(12),RLDT(12),SFCT(12),TNT(12),CET(12),DY(18),
     9 IAO,IPS,ITS,IWS,IBS,NPHASE,IDY(14)
      COMMON /TRAJEX/ ALP1GT(12),CDINST(12),CD1GT(12),CL1GT(12),DECEL,
     1 DELHP,DELMP,DXCRUS,FLFAC,FRFURE,HEND(12),HENDUR,HMAXP,HMINP,
     2 HPATHT(50),MEND(12),MENDUR,NT(12),PRTOTT(12),RADIT(12),
     3 RADST(12),SF,SFCUT(12),SMMAXP,SMMINP,
     4 TNUT(12),VIND(12),VELT(12),VPATHT(50),WART(12),WCOMBP,WEELT(12),
     5 WFRES,WFTOT,WFTO1,WFTO2,WFTRAP,WKLAND,XDESC,XGRLAN,FWGMAX,TOL,
     6 WFIXED,WGCALC,WPL,WGTO,DUMY(82),IA(12),IAS,IB(12),IBREG,IENDUR,
     7 IMISS,IP(12),IPHASE,IPLOT,IPRINT,IPRT(12),IPSIZE,IPSTO1,IPSTO2,
     8 IW(12),IX(12),KERROR,MILCOM,NCRUSE,NLEGCL,NLEGCR,NLEGLO,NMISS,
     9 NPATH,IDUMY(6)
      DIMENSION ANS(4)
      IPSAVE=IPS
      KCALC=2
      IAO=8
      IPS=4
      IF ((IPRINT.GE.2).AND.(IXY.EQ.1)) WRITE (6,600)
      IF ((IPRINT.GE.2).AND.(IXY.EQ.2)) WRITE (6,601)
      IF ((IPRINT.GE.2).AND.(IXY.EQ.3)) WRITE (6,602)
600   FORMAT(/22H SEARCH FOR BREG. ALT./23H   ALT.      BREG. FACT.,
     1 5X,4HMACH,8X,2HCL,8X,2HCD,7X,6HTHRUST,3X,3HSFC)
601   FORMAT(/23H SEARCH FOR ENDUR. ALT./23H   ALT.     ENDUR. FACT.,
     1 5X,4HMACH,8X,2HCL,8X,2HCD,7X,6HTHRUST,3X,3HSFC)
602   FORMAT(/23H SEARCH FOR ENDUR. MACH/23H   MACH     ENDUR. FACT.,
     1 5X,4HMACH,8X,2HCL,8X,2HCD,7X,6HTHRUST,3X,3HSFC)
      X1=XMIN
      X2=XMAX
      XX=X1
      N=0
      XBEST=XX
      YBEST=-1.
      IF (IXY.LE.2) HN=XX
      IF (IXY.EQ.3) SMN=XX
      IRETRN=1
C-------------------------------
C     START OF FUNCTION EVALUATION
C-------------------------------
10    N=N+1
      CALL AT62(HN,ANS)
      RHO=ANS(1)
      A=ANS(4)
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                VEL=SMN*A
                CL=2.*W/(RHO*SWING*VEL**2)
60              CALL TRAJ01(2)
                CALL AERO(KCALC,NERROR,IGEO,KGPRNT)
                IF (NERROR.GE.2) RETURN
                CALL TRAJ01(1)
                DRAG=.5*RHO*SWING*CD*VEL**2
65              CALL TRAJ01(2)
                CALL PROP(KCALC,NERROR,IGEO,KGPRNT)
                IF (NERROR.GE.2) RETURN
                CALL TRAJ01(1)
                IF (IXY.EQ.1) Y=3600.*VEL*RLD/SFC
70              IF (IXY.GE.2) Y=RLD/SFC
                IF (NERROR.EQ.1) Y=-1.0
                IF (IPRINT.GE.2) WRITE (6,603) XX,Y,SMN,CL,CD,THRUST,SFC
          603   FORMAT(1X,G9.3,G13.4,G14.3,2G12.4,G13.6,G12.3)
                IF (Y.GT.YBEST) XBEST=XX
75              IF (Y.GT.YBEST) YBEST=Y
          C-----------------------------
          C     END OF FUNCTION EVALUATION
          C-----------------------------
                GO TO (20,30,40,60),IRETRN
80        20    Y1=Y
                XX=X2
                IF (IXY.LE.2) HN=XX
                IF (IXY.EQ.3) SMN=XX
                IRETRN=2
85              GO TO 10
          30    Y2=Y
                TAU=.5*(SQRT(5.)-1.)
                X3=X2-TAU*(X2-X1)
                XX=X3
90              IF (IXY.LE.2) HN=XX
                IF (IXY.EQ.3) SMN=XX
                IRETRN=3
                GO TO 10
          40    Y3=Y
95        50    X12=.5*(X1+X2)
                DELX=ABS(X12-X3)
                X4=X12+DELX
                IF (X3.GT.X12) X4=X12-DELX
                XX=X4
.00             IF (IXY.LE.2) HN=XX
                IF (IXY.EQ.3) SMN=XX
                IRETRN=4
                GO TO 10
          60    Y4=Y
05              IF (Y3.GE.Y4) GO TO 90
                IF (X4.LT.X3) GO TO 70
                X1=X3
                Y1=Y3
                GO TO 80
.10       70    X2=X3
                Y2=Y3
          80    X3=X4
                Y3=Y4
                GO TO 110
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```
   SUBROUTINE GOLDEN     76/76   OPT=2                    FTN 4.5+410        0

115           90     IF (X3.LT.X4) GO TO 100
                     X1=X4
                     Y1=Y4
                     GO TO 110
              100    X2=X4
120                  Y2=Y4
              110    IF (N.LE.NMAX) GO TO 50
                     XX=XBEST
                     Y=YBEST
                     IF (Y.EQ.-1.0) NERROR=2
125                  IF (NERROR.EQ.2) WRITE (6,604) XX,Y,IXY
              604    FORMAT(35H  ***FATAL ERROR IN GOLDEN ROUTINE./
                    1 5X,3HX =,E12.5,2X,3HY =,E12.5,2X,5HIXY =,I5)
                     IF ((IPRINT.GE.2).OR.(KERROR.EQ.2)) WRITE (6,605) XX,Y
              605    FORMAT(/35H MACH OR ALTITUDE SEARCH CONCLUDED./
130                 1 5X,3HX =,E12.5,2X,3HY =,E12.5)
                     IPS=IPSAVE
                     RETURN
                     END
```

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