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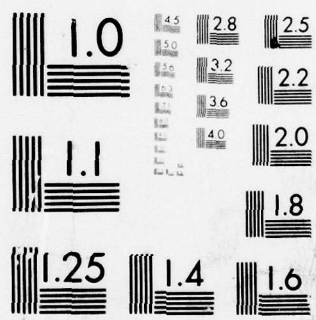
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USERS'S MANUAL FOR "FLYIT3," A THREE-DEGREE-OF-FREEDOM (3-DOF) TRAJECTORY SIMULATION PROGRAM

by

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June 1978

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(10) Gary B. / Burgner

This report constitutes a user's manual for "FLYIT3", a 3-degree-of-freedom trajectory simulation program written in FORTRAN IV. The three degrees of freedom are range, altitude, and pitch attitude.

The program is useful in simulating vertical-plane trajectories involving take-offs, climbs, cruises, dives, landings, and rocket boosts. The program is particularly well suited to the synthesis and analysis of air-to-surface and surface-to-surface missiles (especially cruise missiles) and aircraft trajectories.

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INTRODUCTION

"FLYIT3" is a 3-degree-of-freedom trajectory simulation program written in FORTRAN IV. The three degrees of freedom are range, altitude, and pitch attitude. Pitch attitude (or angle-of-attack) is a pseudo degree of freedom, in that its rate of change is unaffected by the mass properties of the vehicle. In this respect, the vehicle is treated as a particle, the forces acting on which are controlled by its attitude, among other things.

The program is useful in simulating vertical-plane trajectories involving take-offs, climbs, cruises, dives, landings, and rocket boosts. The program assumes that the earth's surface is "flat," in that no force is applied to the vehicle (other than gravity) to prevent growth of the altitude coordinate as the range increases. The program is particularly well suited to the synthesis and analysis of air-to-surface and surface-to-surface missiles (especially cruise missiles) and aircraft trajectories. FLYIT3 should be used for preliminary study only. It is not suitable (due to its ignorance of rigid-body effects, primarily) for air-to-air trajectories, terminal engagements, 2-body problems, or altitudes over 100,000 feet MSL. This manual is written, in part, to familiarize the user with FLYIT3's limitations as well as its capabilities.

FLYIT3 is easy and inexpensive to use, is compatible with batch and demand terminals, and at NWC can automatically produce a plot of any trajectory. The program is simply structured, permitting a user to expand, contract or alter its capabilities. In most cases, the user must, in fact, provide his own coding to describe his vehicle's aerodynamic and propulsion characteristics. However, this manual provides comprehensive guidance in this area. No coding need be provided by the user to "control" the trajectory. Such control is provided by careful selection of the input data. All known "bugs" in the program have been eliminated (although it is not guaranted that there are none). In most cases of difficulty, the content or format of the input data is at fault.

This manual assumes the reader's familiarity with FORTRAN and the UNIVAC 1110 executive system. Operation is described in terms of demand terminal usage, though batch mode is no less compatible.

ACCESS TO THE PROGRAM

At NWC, FLYIT3 is stored in the read-only file FLYIT*3. The program is also stored in a file of the author and as a card deck. Users must copy FLYIT*3 into their own files (permanent or temporary) before use. A minimum of 200 tracks should be assigned to the file to permit additions or alterations to be made to the program in the user's file. In case of difficulty, contact the author or inquire of the Propulsion Analysis Branch, Code 3241.

STRUCTURE OF FLYIT3

The source program is written in FORTRAN IV. Execution and flow-of-control is performed by the main program element, FLYIT3. The main program calls subroutines from other functional groups as needed to supply data with respect to aerodynamics, propulsion, etc. The functional groups are: atmosphere, trajectory controls, aerodynamics, rocket boosters, and sustain propulsion. Each of these groups contains several subroutines, one or more of which is generally used for each trajectory. Each subroutine is (has been) compiled into a binary relocatable element with the same name as its symbolic source element.

The file FLYIT*3 contains a runstream element titled FLYIT*3. REASSEMBLE. As the name suggests, this element is @ADDed to MAP the relocatable elements into an executable element named EXECUTABLE. REASSEMBLE need not be used unless a source program element has been altered and recomplied since the last run.

Another runstream element, DATA, is @ADDed to execute the program. DATA contains the data describing the vehicle, the trajectory to be flown, and the output format. In addition, DATA contains instructions to describe the trajectory plots to be produced, if desired. FLYIT3 uses NWC's SHOMAT plotting program to produce plots at minimum cost. See sections titled "DATA" and "PLOTTING."

Each functional subroutine group is described in some detail in the following sections.

MAIN PROGRAM: FLYIT3

Subroutine FLYIT3 is listed in Appendix A. It begins with condensed input instructions to the user in the form of comment lines. Upon execution (@ADD FLYIT*3.DATA) this subroutine informs the user it is ready to read data by printing "enter data." The data is then read (3 lines) from the runstream element DATA without further interaction with the user. FLYIT3 then establishes the output format based on the data received. Initial conditions are established, also based in part on the input data. When certain output options are specified in the data, FLYIT3 prints the input and output data. Input options are discussed under "DATA" below. Next, FLYIT3 enters four nested DO loops within which the trajectory is simulated. The outer loop in effect defines a limit on the number of "pages" of output printed, via a "max time" limit. The next loop limits the number of output lines printed to 46, at which time new output column headings are printed and output printing may continue. On demand terminals, this results in page-length segments of output suitable for binding. On batch printers, the new output headings are printed at the top of a new page. The next loop controls the print interval in terms of the number of iterations calculated before a line of output is printed. The innermost loop controls the frequency with which new atmospheric properties are calculated. (This feature saves time and cost under conditions where atmospheric properties change slowly or not at all.)

FLYIT3's next move (within the innermost loop) is to call one of three atmosphere subroutines, ATMSTD, ATMHOT, or ATMCLD (if required). These subroutines supply to FLYIT3 the properties of standard, hot-day, and cold-day atmospheres.

The next step is to call one of the subroutines M1, M2, M3...M10, which selects the vehicle angle-of-attack required to fly the desired trajectory. In some cases, the M-subroutines in addition constrain accelerations, flight path angles, altitudes, etc. when required. The subroutine called in this group depends on the value of the variable MGO. MGO is always equal to the subscripted variable M(MM). The subscript MM is the position in a data string of the desired sequence of trajectory segments. Each value of M() from 1 thru 10 in the data string corresponds to a particular mode of flight (climb, dive, cruise, etc.). The modes indicated by M() are briefly described below:

- M=1 Runway take-off at max power from field elevation XLH.
- M=2 Air launch at XLH altitude, XLMN Mach, XLFEE flight path angle, and climb at CLMN Mach DFEEC flight path angle and continuously reduce flight path angle if necessary to maintain speed.
- M=3 Cruise at DCH altitude and CMN Mach until RC range is reached or fuel is exhausted.
- M=4 Dive at -DFEEDD flight path angle until pull-up is initiated.
- M=5 Pull-out from dive at GPU load factor and cruise at DTH altitude and DMN mach.
- M=6 Fly at constant velocity until DCH altitude or RC range is reached or impact.
- M=7 Launch with flight path angle DFEEC first 100 feet.
- M=8 Fly at body angle BAC or BAD degrees until DCH is reached.

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M=9 Approach to landing at glide slope DFEEDD, runway elevation DTH, approach speed DMN Mach.

M=10 Directs the vehicle to fly along the radar horizon when the horizon is intercepted in M=3 cruise. Target antenna is assumed to be at 100 feet above sea level. Range to target must be input as RC (nmi).

If used at all, M=1 and M=7 must be first in the sequence.
If used at all, M=9 will be last in the sequence.
No M value may be used more than once in a trajectory except M=2, 3, 4, 6, 8.
M=4 must be used in the sequence 45, or be the last in the sequence.
M=10 if used at all must be last in the sequence.

(The above was excerpted from the input instructions contained in FLYIT3.) A typical data string (included on the first of the three lines of input data) might be 1834560000. In this case, M(1)=1, M(2)=8, M(3)=3, etc.; other input data indicates cruise altitudes, climb and dive angles, Mach numbers, etc. for each segment (M value) in the trajectory. Input data is discussed in detail under "DATA" below.

Upon receiving commands from the trajectory controls group, FLYIT3 calls for vehicle aerodynamic characteristics from the aerodynamics group, subroutines AERO1, AERO2... AERO15. The subroutine called is indicated by the input data value NAERO. For example, if NAERO is 12, AERO12 will be called. The user is responsible for the contents of AERO12, or whichever subroutine he uses. Fifteen AERO subroutines are provided so that each user's file may constitute a library of aerodynamic characteristics, any of which may be selected by a simple change in the data value NAERO. The same discussion applies to the boost propulsion group and sustain propulsion group, discussed below.

FLYIT3's next call is to the booster propulsion group, subroutines BSTR1 thru BSTR15. The controlling input data value is NBSTR. If NBSTR is blank, zero or negative, a booster is assumed to be absent throughout the trajectory. If a booster is used, the user is responsible for supplying its thrust-time profile, specific impulse, burnt weight (which will be automatically "dropped" at the end-of-boost), and incremental aerodynamics, within the subroutine he uses.

FLYIT3 then calls for sustain propulsion information from subroutines SUST1 thru SUST15. Again, the user is responsible for the contents and selection of these subroutines. The controlling input data value is NSUST. Twenty subroutines are available. If no sustainer is present, NSUST must be blank, zero, or negative. If a sustainer is used, the input data value WO (launch weight) must be greater than the input value WE (empty weight). The difference in these values must include sustain fuel or propellant and booster weight. The sustainer subroutines must set sustain thrust equal to zero when the vehicle weight W becomes less than the empty weight.

```
GROSS FUELLED MISSILE WEIGHT, INCLUDING BOOSTERS 1400.0 POUNDS
MISSILE EMPTY WEIGHT, WITHOUT BOOSTERS 1000.0 POUNDS
DRAG AND LIFT REFERENCE AREA 1.000 SQUARE FEET
DESIRED CLIMB ANGLE TO CRUISE ALTITUDE 25.0 DEGREES
DESIRED CLIMB MACH NUMBER, IF APPLICABLE 1.50
DESIRED CRUISE ALTITUDE  15000. FEET (TO   50. MILES RANGE)
DESIRED CRUISE MACH NUMBER 1.70
DESIRED DESCENT ANGLE FROM CRUISE ALTITUDE -10.0 DEGREES.
DESIRED DESCENT MACH NUMBER  .900
DESIRED DASH ALTITUDE     100. FEET (MACH  .90 )
SUSTAINER THRUST MULTIPLIER (X BASIC THRUST) = 1.00
BOOSTER MULTIPLIER = 1
INLET COOKIE-CUTTER AREA =    .470X TM, SQ.FT.
MAXIMUM G-LOAD PERMITTED IN PULL-UP MANEUVER = 5.0
LIMIT ON ANGLE OF ATTACK = 15.0 DEGREES
BODY ANGLES, IF APPLICABLE - IN CLIMB 15.0  IN DIVE-10.0 (DEGREES)
THIS MISSILE IS AIR-LAUNCHED AND SUBJECT TO THE FOLLOWING ADDITIONAL CONDITIONS.
LAUNCH ALTITUDE      10. FEET
LAUNCH MACH NUMBER .000
LAUNCH FLIGHT PATH ANGLE   .0 DEG.

TRAJECTORY SEQUENCE -- 7234560000

OPTIONS CALLED      BOOSTER  1   NUMBER OF BOOSTERS = 1   SUSTAINER  4   AERODYNAMICS  1
```

FIG. 1. Full-list Output Data Format.

FLYIT3, with all the information thus obtained from subroutine calls each iteration, calculates the vehicle accelerations, velocities, and positions. If the altitude becomes negative or exceeds 105,100 feet MSL, or the Mach number exceeds 5.6, the program will terminate. Range and altitude values are stored for subsequent plotting and output data are printed at selected iteration intervals. The iteration time interval is normally 0.25 second, but is reduced during boost (0.025) and during periods of maneuvering, and lengthened (to 0.5 second) during cruise. Finally, when the trajectory has been claculated to completion, FLYIT3 calls the SHOMAT (Ref. 1) plotting program if plots have been requested by the input data.

FULL-LIST OUTPUT: OUTPT1

OUTPT1 is a subroutine used to print a detailed summary of the input data (Figure 1). This format is not normally used for routine demand terminal work. The alternative output format for listing the input for each trajectory is defined and printed by:

```
7234560000     1    0    1    1    4    5    0    0
1400. 900.  1.00  15.  .47 1.00  5.0  .01  .00   .0
 25.0 1.50  15.0-10.0 20.0 1.70 100. 10.0  .90   .1  .90
STANDARD ATMOSPHERE
```

FIG. 2. Demand-Mode Output Data Format.

ATMOSPHERES

ATMSTD

Subroutine ATMSTD generates air temperatures and densities in accordance with the U.S. Standard Atmosphere, 1962. The densities calculated are in error less than 0.1 percent below 36,152 feet MSL and less than 1.0 percent from 36,152 feet to over 120,000 feet. (See Figure 3). The temperatures calculated are in error by less than 0.05 degree R up to 105,000 feet MSL. Pressure is calculated from density and temperature in subroutine FLYIT3. The resulting pressure is in error by less than 0.9 percent up to 108,000 feet MSL. Atmospheric properties are most accurate in the troposphere, where most trajectories are flown.

ATMHOT

This subroutine supplies air data in accordance with the MIL-STD-210A Tropical Atmosphere. No error analysis has been done on this model, but errors should not exceed 2 percent or 0.2 degree R up to 100,000 feet.

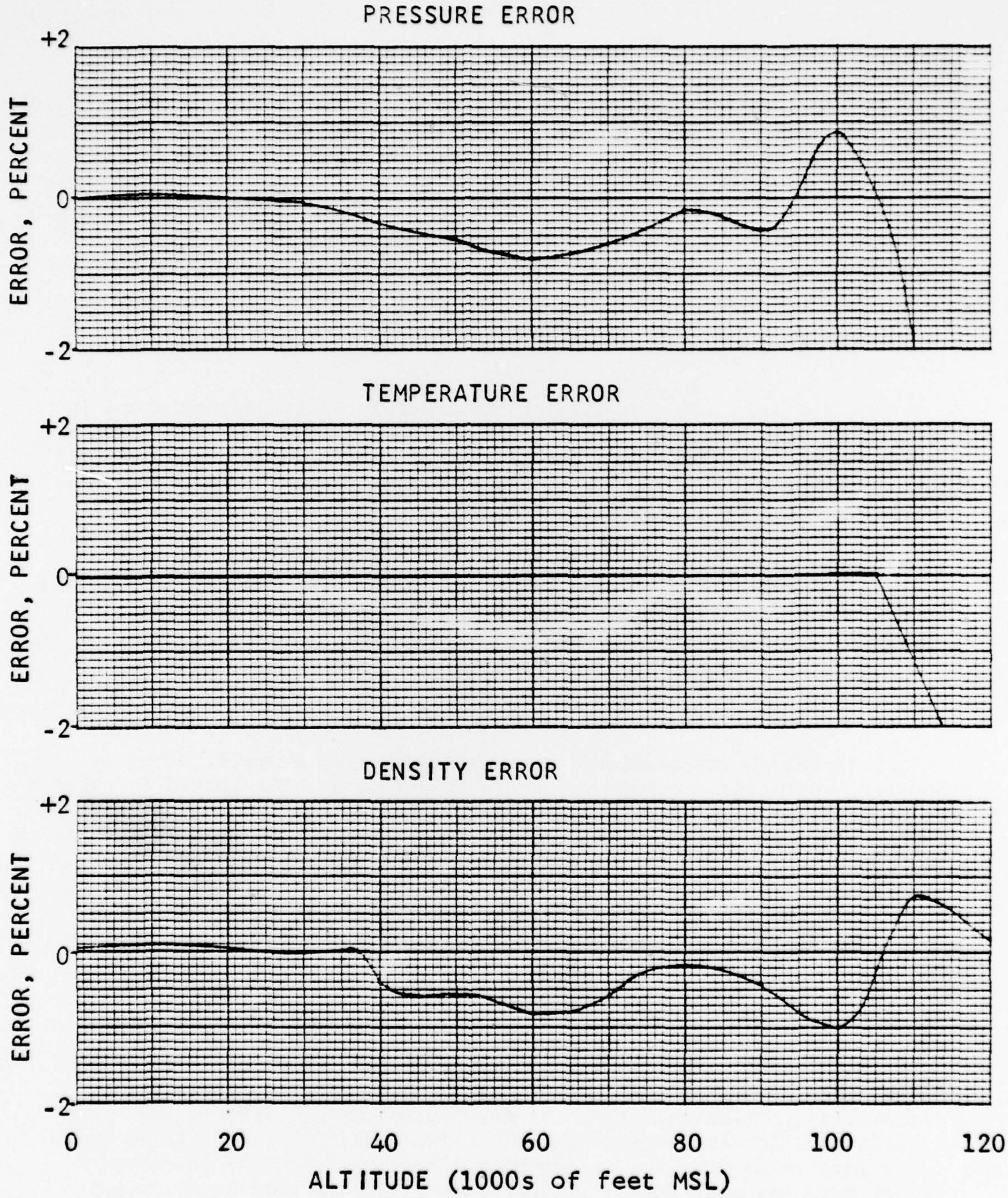

Figure 3. Standard Atmosphere Model (ATMSTD) Deviation from 1962 U.S. Standard Atmoshere.

ATMCLD

This subroutine supplies air data in accordance with the MIL-STD-210A Polar Atmosphere. Densities and pressures are accurate to 1.0 precent below 40,000 feet, but accuracy diminishes at higher altitudes. Temperatures are accurate within 0.2 degree R.

ATMSTD, ATMCLD, and ATMHOT are listed in Appendix C.

TRAJECTORY CONTROLS

The M1, M2, . . . M10 subroutines control the trajectory shape in accordance with the user's data entries, and are thus the real heart of the program. The logic and flow of control within these subroutines is quite complex and the user is cautioned against casual tampering. The user is advised to become familiar with this section and the section titled "DATA" before attempting to use the program. It is surprising, even to the author, what a wide variety of trajectories is capable of being simulated by FLYIT3 with judicious choice of input data. Numerous examples are displayed in Appendix I. The M-subroutines are listed in Appendix D.

M1

This subroutine simulates a runway take-off. Propulsion can be booster, sustainer, or both in series or parallel. The runway is assumed to be level and its elevation above sea level is the input data value XLH, in thousands of feet. Liftoff occurs when the airspeed reaches 1.20 times the airspeed at which lift would equal weight at the angle-of-attack limit, specified by the input data value ALPL (degrees). At the time of liftoff, control of the trajectory is transferred to the next M-subroutine as indicated in the input data sequence M(1), M(2),...M(10).

M2

The M2 subroutine is used for climbing and diving at a specified flight path angle. M2 can be used as the first in the M-sequence to simulate an air-launch. (M4, M6, M7, M8, and M9 can also be used for air-launch. For any air-launch, the launch altitude is specified by the input data value XLH, the launch Mach number by XLMN, and the launch flight path angle by XLFEE. "Air-Launch" could include cases in which prior to "time zero" there occurred a boost phase, catapult launch, ordnance release, etc. In this way, a complex trajectory can be pieced together. The capability of FLYIT3 rarely requires piecing, however.)

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The flight path angle at which the climb or dive is to proceed is entered as the input data value DFEEC (degrees from horizontal). In addition, a climb Mach number can be entered as data (CLMN), which sustain propulsion can be throttled to maintain (if the user's propulsion subroutine is so programmed). In M2, if the propulsion is unable to maintain the specified climb angle, the climb angle will be progressively lowered so as to maintain approximately constant Mach number (to prevent stall or "mushing").

M2 (also M8) anticipates arrival at some cruise altitude (DCH) during the climb. The vehicle is caused to initiate a ballistic (zero-lift) turndown at approximately the time which permits arrival at the cruise altitude at a flight path angle of zero. M2 transfers control to the next M-subroutine in the M-sequence when fuel is exhausted, range exceeds the input data value RC (nautical miles), or cruise altitude is reached. If the flight path angle is reduced to essentially zero, the transition (usually to M3) will be made and DCH redefined as the present altitude.

M3

M3 provides for cruising at altitude DCH and Mach number CMN. Stable altitude-hold is achieved by the use of an equation which represents a proportional feedback control system. Two error signals are used, altitude itself and the flight path angle. Damping is provided by mixing the required angle-of-attack with the one used in the previous iteration. The user is cautioned against changing the gains and coefficients in the altitude-hold equation, as they have been optimized with respect to a broad spectrum of vehicles and trajectories over many years of use.

The M3 cruise leg of a trajectory is normally terminated by either of two events. The first is the attainment of a range specified as input data value RC (nautical miles). The second is fuel exhaustion (current vehicle weight less than vehicle empty weight (WE) pounds in data). When M3 is terminated, trajectory control is transferred to the next M-subroutine in the M-sequence.

M3 can be used as an acceleration leg of a trajectory, if that leg is to be followed by another cruise leg at a higher altitude. In this case, M3 terminates when the Mach number CMN is attained in level flight. The second M3 leg will be flown at a Mach number of CLMN +0.5. This feature is useful when a speed much higher than the launch speed is required for good climb performance to a higher altitude.

If M3 is to be followed by an M6 climb, the climb will be initiated when the Mach number exceeds CLMN. M6 will then maintain this approximate Mach number - see under M6.

M4

M4 is used for diving at constant flight path angle. M4 is useful for flying a transition from a cruise altitude to a lower cruise altitude (see M5), for dives to impact (...40... in the M-sequence), and for line-of-sight trajectories (e.g., WALLEYE). The diving flight path angle is entered in the data as DFEEDD (degees, positive for dives). Climbs can also be performed by M4 by entering a negative value for DFEEDD; however, a smooth transition to the next M-subroutine in the sequence cannot be assumed. (An M4 climb would be useful for simulating a "zoom;" for example, just prior to a parachute deployment, to lower the airspeed.) The input data value DVMN provides for a Mach number to be maintained in the dive by means of propulsion throttling.

Flight path angle is sought and maintained (following a ballistic turn-down) by a proportional feedback control system equation which uses flight path angle as the error signal and angle-of-attack mixing as a damping term. In dives, M4 is terminated by impact (attainment of zero altitude) or by arrival at a altitude at which a pull-up must be initiated for transition to an M5 cruise leg.

M5

M5 provides for a low level cruise (dash) leg and the pull-up thereto. Transition to M5 can be made only from M4 (M5 is also used by M9 and M10). The altitude for this dash leg is input as DTH (thousands of feet MSL), and the Mach number as DMN. If DTH has the same value as DCH, the M-sequence ...345... can be used to properly transition (smoothly) from M3 to M5 without significant disturbance of altitude. This sequence is useful for flying a constant-altitude trajectory with a change in speed at RC range from launch.

M5 provides stable altitude hold in the same way as does M3.

The pull-up from dive to level flight is controlled such that the maximum normal load factor is GPU g's, the angle-of-attack limit ALPL is not exceeded, and the maneuver is initiated (usually) in time to prevent substantial undershoot of DTH. Some combinations of dive angle, speed, throttling, aerodynamics, and DCH cause enough undershoot that sea level impact threatens the trajectory. In this case, the angle-of-attack is increased so as to produce load factors greater than GPU in the interest of salvaging the simulation. To avoid this problem, it is recommended that DCH values of less than 0.1 (100 feet MSL) not be used. The impact of this restriction on simulation results is negligible, considering the typical accuracies represented by propulsion and aerodynamics models.

M5 is terminated only by fuel exhaustion, at which time a transition is made to the next M-subroutine in the M-sequence.

M6

The M6 subroutine flies an approximately constant speed trajectory, holding the speed at which transition into M6 is made. However, the speed is maintained by continuous adjustment of the flight path angle rather than throttling the propulsion. This mode of flight is suitable for launch, climbs and dives, and cruise. When the altitude range is small, this mode simulates constant pitch trim. Transition out of M6 can be caused by a number of occurences, such as range exceeding RC, DCH being reached, etc.

M7

M7 provides for air- or surface-launch in which the direction of motion is fixed for the first 100 feet of travel (rail launch). This option, which must be first in the M-sequence if used, is convenient for low-speed or zero-speed launches with or without booster. It eliminates the otherwise troublesome problems of launcher tip-off and lack of aerodynamic control and lift at low speeds.

M8

Subroutine M8 provides a means of climbing and diving which is well suited to traversing wide spans in altitudes. The flight mode is one of a constant pitch attitude with respect to the horizonal. Two pitch angles are input, BAC (body angle for climbs) and BAD (body angle for dives). This mode of flight is one typically used by a pilot flying an aircraft, even if he is not consciously aware of using it. It is equivalent to maintaining a fixed line of sight between the pilot's eyes, some reference point on the aircraft (speck on the windshield, nose highlight, etc.), and the horizon. For fixed thrust, the equivalent airspeed (EAS) will be approximately constant. Flight at constant body attitude is relatively easy to mechanize in an airframe control system, since the only sensor required is a single-axis gyroscope. In constant attitude flight, the angle-of-attack, airspeed, lift, drag, and flight path angle vary in an inherently stable manner. The result, in an atmosphere whose density decreases with altitude, is a tendency for the flight path angle to smoothly approach zero and the speed to increase as high altitudes are approached. The tendency for flight path angle to increase or decrease depends also on the throttle setting and the actual body angle selected. The user will want to try different values of BAC and BAD for each vehicle configuration in order to achieve suitable climb/dive performance (i.e., proper variation of speed with altitude).

M8 will decide, based on the altitude with respect to DCH at the time of transition to M8, whether BAC (climb) or BAD (dive) is appropriate. If fuel exhaustion occurs while M8 is active, M8 will fly at BAD to impact. Otherwise, M8 will fly at BAC or BAD so as to approach DCH. However, if M3 has previously been active in the trajectory or an M2 climb has immediately preceeded current M8 activity, M8 will seek DTH. If M3 is the next indicated subroutine in the sequence, but the range exceeds RC while M8 is active, control is transferred to M3 at that time. (Subsequently, M3 will immediately transfer control to the next M-subroutine in the sequence.) When climbing toward DCH, M8 will anticipate arrival and initiate a ballistic turn-down as in M2.

M9

M9 provides for simulating a final approach to a runway landing and the subsequent roll-out with braking. The runway elevation is input as DTH, the glide path angle is DFEEDD (positive), and approach Mach number DVMN. The user should provide suitable aerodynamics and propulsion for the landing configuration (i.e, flaps and wheels down). To account for braking after touchdown, the user must insert a coefficient of rolling friction (retarding force/weight) into subroutine FLYIT3. The variable name for this coefficient is FRIC, and is defined as a constant (0.5) among the initial conditions of FLYIT (line 120, approximately). The user must edit and recompile FLYIT3 whenever FRIC is redefined.

M9 will print a line of output indicating the time of touchdown and the touchdown flight path angle. This angle is different from the glide path angle, because a 1.1-g flare occurs prior to touchdown. Another output line is printed when the vehicle rolls to a stop, indicating the total runway length used.

When M9 is indicated in the M-sequence, it must be followed by a zero, and must not be preceeded by 45.

M10

Subroutine M10 causes the vehicle to follow a path coincident with the radar horizon with respect to a target. The range from launch point to the target must be input as RC (nautical miles). The target's radar antenna is assumed to be 100 feet above sea level. The transition to M10 must occur from M3 cruise.

The radar horizon path is tangent to the sea surface 12.28 NM from the target. Since the vehicle cannot be expected to fly at zero altitude, it is caused to level off and cruise at 100 feet MSL when the altitude drops to 100 feet. At this time M10 redefines DTH = 100 (feet), and causes a transfer of control to M5. Depending on the user's propulsion coding, the vehicle can be flown at Mach numbers of DVMN or CMN in the descent, and DVMN, CMN, or DMN (among others) in the final cruise leg.

The trajectory will terminate in M10 when the range to target becomes zero. M10 will print the time-to-target and range flown at impact.

AERODYNAMICS: AERO1 THRU AERO15

Subroutines AERO1 thru AERO15 are available to the user to define his vehicles' aerodynamic characteristics. The file FLYIT*3 includes AERO1, AERO2, and AERO3 as real, text-contained elements which serve as examples of satisfactory coding, in addition to possibly being useful to the user. (See Appendix E for listings.)

Each AERO subroutine must provide values for the following variables in the common block:

CDO - zero-lift drag coefficient,

CDI - induced (or drag-due-to-lift) drag coefficient,

CL - lift coefficient (not normal-force coefficient), and

CLAR - the rate of change of CL with angle of attack in radians (lift-curve slope).

All these coefficients are to be based on the input data value AREF, the aerodynamic reference area in square feet.

In order to calculate these variables, the AERO subroutines may use any of the variables in the common block of FLYIT3. Most typically, these are:

M(MM) - the active M-subroutine (or MGO),

W - vehicle weight,

RO - atmospheric density,

ALPHA - angle-of-attack in degrees,

ALPL - angle-of-attack limit in degrees,

V - true airspeed in feet per second,

Q - dynamic pressure in psf,

H - altitude in feet MSL,

AMACH - Mach number, and

AC - inlet capture area in square feet.

The basic aerodynamics can be modified by the user's propulsion subroutines. This is usually the most convenient way to increment zero-lift drag to account for detachable boosters, inlet spillage drag, and engine cold-flow drag.

Subroutine FLYIT3 adds the basic AERO-produced and incremental characteristics and calculates the lift and drag forces.

ROCKET BOOSTERS: BSTR1 THRU BSTR15

Subroutines BSTR1 thru BSTR15 are available to define the characteristics of rocket boosters which may be used on a vehicle. The file FLYIT*3 includes BSTR1, BSTR2, and BSTR3 as real, text-containing, unclassified, elements which serve as examples of satisfactory coding, in addition to possibly being useful to the user. (See Appendix F for listings.) Many booster motors have been modelled by and are available from Code 3241.

Each BSTR subroutine must provide values for the following variables in the common block:

THRB - booster gross thrust in pounds (assumed to be aligned with the angle-of-attack datum, usually the fuselage axis),

FISPB - propellant specific impulse in lbf-sec/lbm,

DT - iteration time interval during boost (this value overrides values established by the M-subroutines - 0.025 is recommended),

EWB - the weight dropped at end-of-boost in pounds,

Any other variable in the common block can be modified by or used by BSTR. These typically include:

TIME - time accumulated since launch in seconds,

CDO - zero-lift drag coefficient (usually incremented by the additional drag of the booster),

H - altitude in feet MSL (used to augment booster thrust and Isp with altitude).

The input data value NB permits multiple boosters to be used on one vehicle, on the assumption that all boosters are ignited simultaneously.

SUSTAINER PROPULSION: SUST1 THRU SUST20

Subroutines SUST1 thru SUST20 are available to define the characteristics of sustainers. The file FLYIT*3 includes SUST1 thru

SUST4 as real, text-containing, unclassified elements which serve as examples of satisfactory coding, in addition to possibly being useful to the user. (See Appendix G for listings.) Other sustainer engines have been modelled and are available from Code 3241.

Each SUST subroutine must provide values for the following variables in the common block:

THRS	- sustainer thrust in pounds
FISPS	- sustainer propellant specific impulse
CDAOFF	- additional zero-lift drag coefficient resulting from an engine-off condition (must be referenced to AREF)

Any other variable in the common block can be modified by or used by SUST. These typically include:

H	- altitude,
AMACH	- Mach number,
RO	- atmospheric density in slugs/ft^3,
ALPHA	- angle of attack,
Q	- dynamic pressure in psf,
DT	- time increment,
TM	- sustainer thrust multiplier (see below),
AC	- inlet capture area for unit value of TM in ft^2 (see below),
CMN	- desired cruise Mach number,
CLMN	- desired climb Mach number,
DVMN	- desired dive Mach number,
DMN	- desired dash Mach number,
PT	- freestream total pressure in psia,
TT	- freestream total temperature in °R,
AMACH1	- flight Mach number prior to last iteration,
THRB	- booster thrust,
T	- ambient air temperature in °R, and
MGO	- M-subroutine currently active.

The input variable TM is a sustainer thrust multiplier. This variable permits the sustainer and its inlet to be conveniently scaled in thrust. If TM = 1.0, the engine will produce the performance coded in SUST. If TM is different from unity, the thrust and inlet capture area will be scaled by TM.

Each sustainer subroutine must contain the performance of an inlet, if applicable. Inlet additive and spillage drag is usually added to CDO in SUST; however, the variable CDAOFF is available as an incremental zero-lift drag coefficient which is added to CDO in subroutine FLYIT3.

The variables ASPEED and TIT (for gas turbines, rotor speed and turbine inlet temperature, respectively) may be used as diagnostic or informative parameters. They are printed as output data in the batch (full list) output format.

The SUST subroutines are responsible for setting THRS = 0.0 if and when the vehicle weight W becomes less than the empty weight WE.

Rocket motors may be modelled as sustainers as well as boosters; however, the coding is not directly interchangeable between BSTR and SUST.

Contractor-supplied engine performance coding can be integrated into or called from a SUST subroutine, but proper interface coding must be provided.

SUST is responsible for engine throttling if this feature is desired. The input variables CMN, CLMN, DMN, and DVMN in conjunction with MGO, AMACH, and AMACH1 indicate whether an increase or decrease in thrust is desired. In simple throttling equations, it is recommended that a proportional control system with damping be used. The quantity (DMN-AMACH), for example, would be the error signal and the rate-of-change of Mach number ((AMACH-AMACH1)/DT) would stabilize the system. To approximate the response time of a real sustainer engine, a limit could be imposed on the rate of change of a critical engine parameter (e.g., rotor speed). The throttling equations can range from no throttling at all to a full digital simulation of a complex fuel control system.

The author disclaims responsibility for the accuracy of models contained in FLYIT*3 representing real engines, existing or proposed. Code 3241 has available coded models of many engines.

REASSEMBLE

Element REASSEMBLE is a runstream element which when @ADDed maps the relocatable elements in FLYIT*3 and the library file PLT*PLOT&LIBRARY into an executable program element named EXECUTABLE. REASSEMBLE should be @ADDed prior to the user's first run attempt and after any source elements in FLYIT*3 have been edited and recompiled (except for element DATA, which is a runstream element and is not complied). FLYIT*3 should be @PACKed following each new MAPping, to prevent a storage overflow. REASSEMBLE is listed in Appendix H.

DATA

Element DATA is a runstream element which causes the absolute program EXECUTABLE to be executed, and which contains the input data for the run. DATA also contains plotting instructions for the SHOMAT plotting program. A successful example of DATA is listed in Figure 4. Line numbers (1 thru 18) have been included for reference, but are not part of the text of DATA. Line 1 causes EXECUTABLE to be excuted. Lines 2, 3, and 4 constitute the input data itself (see discussion below). Lines 5 thru 17 constitute instructions for SHOMAT plotting. If no plotting is desired, lines following line 5 are ignored and can be omitted. Line 18 (@EOF) is necessary only when plotting instructions are used. It signals the end of the plotting instructions and causes the plotting to be executed one trajectory per page. (@EOF replaces @FIN as discussed in Reference 1.) The user is referred to Reference 1 for detailed instructions on the use of SHOMAT.

```
1:@XQT FLYIT*3.EXECUTABLE
2:723456        1    0    1    1    1    5    0    0
3:1400.1100. 1.00 15.0  .47 1.00  5.0  .01  0.9  45.
4:  10.  1.5  15. -10.  20.  1.7 150.  10.  0.9  0.1  0.9
5:IDINFO 3241 G BURGNER PHONE 7301
6:IGSEWB
7:T      L     TRAJECTORY SHAPE
8:T            USERS MANUAL EXAMPLES
9:A            RANGE, NM
10:O           ALTITUDE, FT
11:OBJECT 2.,1.5,9.5,6.5
12:SCALEX 0,300,10,5,5
13:TICKX
14:SCALEY 0,50000,5000,2,2
15:TICKY
16:JOIN
17:END
18:@EOF
```

FIGURE 4. A Successful Version of Element DATA.

INPUT DATA (LINES 2, 3, AND 4)

Lines 2, 3, and 4 are reprinted and dissected in Figure 5 for illustration. Refer to the section on trajectory controls for supplementary descriptions of the functions of each variable. When constructing or editing lines of data, pay strict attention to the field allotments (spacing). Floating point data should have decimals punched. Line 2 should contain no decimal points. In the short-form output data format such as appears in Figure 2, and in the examples of Appendix I, DATA lines 1, 2, and 3 are repeated as output in a similar format.

Line 2: The format is (10I1,8I5). The first ten fields are the M-sequence which indicates qualitatively the trajectory shape and modes of flight. (Lines 3 and 4 contain values which quantify the trajectory and the vehicle.) The M-sequence is discussed in detail under "Trajectory Controls" above. The next field contains the variable NB, the number of booster motors used in parallel. This number is meaningless unless a booster unit is specified by the variable NBSTR. The next field contains the variable NATM. A blank or zero specifies the use of the ATMSTD atmosphere model for the run, "1" calls for Topical Atmosphere (ATMHOT), and "2" calls for Polar Atmosphere (ATMCLD). The next field contains the variable NAERO, which is the aerodynamics subroutine to be used; i.e., "1" calls AERO1, "2" calls AERO2, etc. The next field contains NBSTR. "1" calls subroutine BSTR1, "2" calls BSTR2, etc. The next field contains NSUST. "1" calls SUST1, "2" calls SUST2, etc. The next field contains the variable NOUTPT. The allowable options are 0, 1, 2, 3, 4, and 5. "0" or blank specifies the 132-column output format (Figure 6) (batch-mode) with a short-form listing (Figure 2) of the input data. "1" specifies batch-mode output format (Figure 5) with input data fully described by the full-list format (Figure 1). "2" specifies option "1" plus a plot of the trajectory. "3" specifies the 70-column demand-mode output format with a full-list description of input data. "4" specifies the short-form demand-mode output format (Appendix I). "5" specifies option "4" plus a plot. The next field contains NPRT. If a positive number is placed in the field, the trajectory output data will be printed four times more frequently than usual, allowing a "closer look" at maneuvers, boost phase, etc. The last field contains NFEET. If a positive number is in this field, the range output will be in feet. Use this option only for a short-range trajectories.

Line 3 (Format 10F5.0): The first field contains WO, the loaded (launch) weight of the vehicle, including fuel, boosters, etc. The second field contains WE, the vehicle empty weight, without usable fuel, dropables, etc. Weights must be in pounds. The third field contains AREF, the aerodynamic reference area, in square feet. The fourth field contains the angle-of-attack limit in degrees. The program does not use negative angles of attack, and a lower limit of 0 degrees is assumed. The fifth field contains AC, normally the inlet capture area in square feet per sustainer engine of unit size. AC is automatically scaled by

(line 2)

723456_ _ _ _	1	0	1	1	4	2	0	0
M-sequence	NB	NATM	NAERO	NBSTR	NSUST	NOUTPT	NPRT	NFEET

(line 3)

1400.	1000.	1.00	15.0	.47	1.00	5.0	.01	0.0	0.
WO	WE	AREF	ALPL	AC	TM	GPU	XLH	XLMN	XLFEE

(line 4)

25.	1.5	15.	-10.	15.	1.7	50.	10.	0.9	0.1	0.9
DFEEC	CLMN	BAC	BAD	DCH	CMN	RC	DFEEDD	DVMN	DTH	DMN

Figure 5. Lines 2, 3, and 4 of DATA.

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STANDARD ATMOSPHERE

-TIME-	-----VEHICLE PERFORMANCE-----								--ATMOSPHERE--			-VEHICLE ANGLES-			-----AERODYNAMICS-----					-ENGINE PERFORMANCE-				N
SEC	MACH	HEIGHT	VP	AP	RANGE	VH	AH	WEIGHT	TA	TT-2	Q	PA	FP	ALPHA	LIFT	L/D	CDO	CDI	DHAS	THRUST	RPM	TSFC	TIT	
.5	.10	25.	66.	-.0	0.	102.	12.0	1372.	59.	520.	26.	25.0	25.0	.0	-0.	-.3	.02	.00	11.	16040.	100.0	13.03	2359.	1
1.0	.32	78.	109.	.1	0.	320.	12.8	1339.	58.	528.	100.	28.5	28.9	3.1	121.	1.0	.01	.07	68.	17225.	100.0	13.03	2355.	2
1.5	.60	173.	232.	.3	0.	501.	12.0	1307.	58.	543.	347.	28.1	28.9	3.2	298.	1.5	.01	.06	168.	16300.	100.0	13.08	2349.	2
2.0	.65	308.	306.	.3	0.	662.	10.8	1278.	58.	561.	619.	27.7	28.8	2.9	386.	1.0	.02	.05	205.	10085.	100.0	13.73	2388.	2
2.5	.70	878.	368.	.8	0.	799.	5.1	1250.	57.	581.	899.	27.5	28.7	2.8	535.	1.3	.02	.08	817.	4833.	100.0	13.10	2342.	2
7.0	.77	2057.	321.	.6	1.	798.	.2	1180.	53.	578.	698.	25.3	22.0	3.3	620.	1.6	.02	.06	398.	629.	100.0	1.45	2303.	2
12.0	.75	3533.	271.	.6	1.	786.	.2	1139.	47.	565.	751.	22.9	19.0	3.9	701.	1.9	.02	.08	371.	602.	100.0	1.47	2344.	2
17.0	.74	4782.	230.	.3	2.	781.	.2	1137.	43.	558.	691.	20.9	16.4	4.5	765.	2.2	.02	.10	357.	586.	100.0	1.46	2345.	2
22.0	.73	5805.	196.	.8	3.	777.	.2	1136.	39.	552.	648.	19.4	14.2	5.2	886.	2.5	.02	.13	350.	557.	100.0	1.45	2345.	2
27.0	.73	6751.	167.	.6	3.	777.	.2	1135.	35.	548.	617.	17.6	12.1	5.5	912.	2.6	.02	.15	346.	587.	100.0	1.45	2348.	2
32.0	.73	7527.	142.	.8	4.	778.	.2	1134.	33.	545.	597.	15.8	10.3	5.5	882.	2.6	.02	.15	336.	555.	100.0	1.44	2347.	2
37.0	.73	8183.	125.	.5	5.	780.	.2	1133.	30.	542.	583.	15.7	9.1	6.1	965.	2.8	.02	.18	345.	526.	100.0	1.44	2350.	2
42.0	.73	8790.	115.	.8	5.	781.	.2	1132.	28.	540.	570.	14.8	8.8	6.1	959.	2.8	.02	.18	340.	517.	100.0	1.44	2350.	2
47.0	.73	9386.	110.	.5	6.	781.	.1	1131.	26.	538.	561.	14.6	8.0	6.6	1055.	3.0	.02	.22	358.	516.	100.0	1.44	2351.	2
52.0	.73	9902.	109.	.9	7.	780.	.1	1130.	24.	536.	549.	14.7	8.0	6.7	1061.	3.0	.02	.23	352.	501.	100.0	1.43	2352.	2
57.0	.73	10836.	117.	.6	7.	775.	.1	1129.	22.	533.	538.	14.1	7.8	6.2	934.	2.9	.02	.19	326.	458.	100.0	1.43	2353.	2
62.0	.73	10983.	99.	.9	8.	780.	.1	1128.	20.	532.	530.	14.1	7.2	6.9	1098.	3.0	.02	.23	348.	487.	100.0	1.43	2354.	2
67.0	.73	11438.	58.	.5	8.	775.	.1	1127.	18.	530.	520.	14.2	7.2	7.0	1080.	3.1	.02	.25	348.	476.	100.0	1.43	2355.	2
72.0	.73	11924.	98.	.9	9.	778.	.1	1126.	17.	528.	510.	14.3	7.2	7.1	1080.	3.1	.02	.25	342.	473.	100.0	1.43	2356.	2
77.0	.73	12808.	52.	.6	10.	776.	.1	1125.	15.	526.	501.	13.6	6.8	6.6	984.	3.0	.02	.23	328.	466.	100.0	1.42	2356.	2
82.0	.73	12856.	49.	.9	10.	778.	.1	1124.	13.	528.	493.	13.7	6.5	7.3	1052.	3.1	.02	.26	336.	460.	100.0	1.42	2357.	2
87.0	.73	13206.	88.	.5	11.	776.	.1	1123.	12.	523.	485.	13.5	6.5	7.4	1056.	3.2	.02	.28	335.	458.	100.0	1.42	2358.	2
92.0	.73	13734.	86.	.9	12.	775.	.1	1122.	10.	521.	476.	13.3	6.0	7.0	968.	3.1	.02	.24	318.	448.	100.0	1.42	2359.	2
97.0	.78	14183.	69.	.6	12.	776.	.1	1122.	9.	519.	470.	13.0	5.9	7.5	1046.	3.2	.02	.28	324.	443.	100.0	1.42	2340.	2
102.0	.78	14538.	79.	.9	13.	775.	.1	1121.	7.	518.	462.	13.5	5.8	7.7	1057.	3.2	.02	.30	330.	435.	99.9	1.41	2355.	2
107.0	.78	14928.	35.	.6	14.	778.	.1	1120.	6.	516.	455.	12.9	5.5	7.4	956.	3.2	.02	.28	316.	430.	99.8	1.41	2349.	2
110.0	.78	15015.	10.	-.0	14.	788.	.2	1120.	5.	517.	465.	1.0	.7	.8	-27.	-.1	.02	.00	195.	451.	93.8	1.41	2353.	3
111.0	.75	15012.	-2.	1.0	14.	795.	.1	1119.	5.	518.	472.	7.5	-.2	7.6	1012.	3.2	.02	.29	336.	432.	94.9	1.42	2356.	3
113.0	.76	15008.	-2.	1.0	14.	800.	.1	1119.	5.	518.	479.	7.4	-.1	7.5	1070.	3.2	.02	.29	337.	438.	100.0	1.42	2359.	3
115.0	.76	15006.	-1.	1.0	15.	806.	.1	1118.	5.	519.	486.	7.3	-.1	7.4	1066.	3.2	.02	.28	336.	435.	100.0	1.42	2340.	3
117.0	.77	15002.	-1.	1.0	15.	811.	.1	1118.	5.	520.	492.	7.3	-.1	7.4	1067.	3.1	.02	.27	340.	435.	100.0	1.42	2340.	3
127.0	.79	14995.	-0.	1.0	16.	836.	.1	1116.	5.	523.	524.	7.0	-.0	7.0	1060.	3.1	.02	.24	346.	441.	100.0	1.43	2358.	3
137.0	.82	14992.	-0.	1.0	18.	868.	.1	1115.	5.	527.	557.	6.7	-.0	6.7	1063.	3.0	.03	.21	354.	447.	100.0	1.43	2356.	3
147.0	.84	14990.	-0.	1.0	19.	887.	.1	1113.	5.	531.	588.	6.4	-.0	6.4	1062.	2.9	.04	.19	372.	452.	100.0	1.44	2354.	3
157.0	.86	14989.	-0.	1.0	21.	908.	.1	1111.	5.	538.	617.	6.2	-.0	6.2	1062.	2.7	.07	.16	387.	458.	100.0	1.45	2353.	3
167.0	.88	14988.	-0.	1.0	22.	927.	.1	1109.	5.	537.	642.	6.0	-.0	6.0	1061.	2.6	.50	.13	404.	452.	100.0	1.44	2352.	3
177.0	.89	14987.	-0.	1.0	24.	941.	.1	1107.	5.	539.	662.	5.9	-.0	5.9	1060.	2.5	.53	.11	421.	455.	100.0	1.45	2351.	3
187.0	.90	14986.	-0.	1.0	25.	951.	.0	1105.	5.	541.	677.	5.8	-.0	5.8	1058.	2.4	.56	.09	436.	456.	100.0	1.44	2350.	3
197.0	.90	14991.	1.	1.3	27.	953.	-.1	1103.	5.	541.	681.	6.7	.0	6.6	1420.	2.7	.57	.21	526.	459.	100.0	1.45	2350.	3
207.0	.90	14988.	10.	1.4	28.	951.	-.1	1102.	5.	541.	680.	7.6	.6	7.1	1753.	2.9	.56	.32	597.	465.	100.0	1.44	2350.	3
217.0	.90	14990.	8.	.8	30.	952.	.1	1100.	5.	541.	677.	3.1	.3	2.8	406.	1.1	.56	-.02	364.	458.	100.0	1.45	2350.	3
227.0	.90	14986.	-9.	.6	31.	954.	.0	1098.	5.	541.	681.	5.2	-.5	5.7	858.	2.0	.57	.08	441.	465.	100.0	1.44	2350.	3
237.0	.90	14981.	-0.	1.5	33.	953.	-.1	1096.	5.	541.	682.	7.8	-.0	7.8	1686.	2.9	.57	.29	506.	459.	100.0	1.45	2350.	3
247.0	.90	14991.	12.	.1	35.	951.	.1	1094.	5.	541.	678.	4.0	.7	4.3	716.	1.8	.56	.02	391.	459.	100.0	1.44	2350.	3
257.0	.90	15005.	1.	.3	36.	953.	.1	1092.	5.	541.	678.	2.4	.1	2.3	311.	.9	.56	-.03	360.	458.	100.0	1.45	2350.	3
267.0	.90	14995.	-13.	.1	38.	950.	.0	1090.	5.	541.	681.	4.7	-.8	5.5	734.	1.7	.57	.06	423.	469.	100.0	1.44	2350.	3

Figure 6. Batch-Mode Output Format

the input data value TM. AC may be used for another purpose if inlet capture area has no bearing on the trajectory, since it is included in the common block. The sixth field contains TM, the thrust multiplier or sustainer engine scaler. TM scales the sustainer thrust, inlet drag, airflow, etc. The seventh field contains GPU, the normal load factor used for pull-up maneuvers performed in M5, in g's. The last three fields contain the launch parameters XLH (launch altitude), XLMN (launch Mach number), and XLFEE (flight path angle above horizonal), respectively. All input altitudes are in thousands of feet MSL, and all input angles are in degrees.

Line 4 (FORMAT 11F5.0): The first field contains DFEEC, the desired or initial climb flight path angle for use by M2 and M7. The second field contains CLMN, the desired climb Mach number for use in M2. If the M-sequence begins 2383..., attainment of CLMN in the first occupation of M3 will trigger transition to the M8 climb. The third field contains BAC, the vehicle body angle to be used for climbs in M8. The fourth field contains BAD, the body angle to be used for M8 dives. The fifth field contains DCH, the desired cruise altitude. This altitude will be sought during the first climb or dive if 3 is included in the M-sequence. The sixth field contains CMN, the desired cruise Mach number, for use in M3. The seventh field contains RC. This is the range in nautical miles which, when attained, causes a transition to the next M-subroutine in the M-sequence. Normally RC triggers the end of cruise. When the M-sequence includes ...310..., RC is assumed to be the distance from launch point to target. The eighth field contains DFEEDD, the desired flight path angle for use in M4 and M9. For dives and landing approaches, positive values should be used. The ninth field contains DVMN, the Mach number sought in M4 and M9. The tenth field contains DTH, the altitude to be sought and held for cruising in M5. DTH is also the field elevation for M9 landings. The last field contains DMN, the Mach number to be sought and held in M5.

REFERENCES

1. Craig, Alan L. and C. Howard Shomate. User Oriented Computer Graphics with Subroutines PLOTSG, CURVEG, and SHOMAT. NWC TN 404-133. Naval Weapons Center, China Lake, Calif., March 1972.

Appendix A

SUBROUTINE FLYIT3 LISTING

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```
C      SUBROUTINE FLYIT3 (MAIN PROGRAM)
C     INPUT INSTRUCTIONS
C     A COMPLETE DATA DECK CONSISTS OF 3 CARDS PER TRAJECTORY
C     FIRST DATA CARD - TRAJECTORY PHASE SEQUENCE IN 10I1 FORMAT, M VALUES
C        M=1  RUNWAY TAKE-OFF AT MAX POWER FROM FIELD ELEVATION XLH
C        M=2 AIR LAUNCH AT XLH ALTITUDE, XLM MACH, XLFEE FLIGHT PATH ANGLE, AND
C          CLIMB AT CLMN MACH DFEEC FLIGHT PATH ANGLE AND CONTINUOUSLY REDUCE
C          FLIGHT PATH ANGLE IF NECESSARY TO MAINTAIN SPEED.
C        M=3  CRUISE AT DCH ALTITUDE AND CMN MACH UNTIL RC RANGE IS REACHED
C              OR FUEL IS EXHAUSTED
C        M=4  DIVE AT -DFEEDD FLIGHT PATH ANGLE UNTIL PULL-UP IS INITIATED
C        M=5  PULL-OUT FROM DIVE AT GPU LOAD FACTOR AND CRUISE AT DTH ALTITUDE AND
C        DMN MACH
C        M=6  FLY AT CONSTANT VELOCITY UNTIL DCH ALTITUDE OR RC RANGE IS REACHED
C          OR IMPACT
C        M=7  BOOSTER LAUNCH WITH FLIGHT PATH ANGLE DFEEC FIRST 100 FEET
C        M=8  FLY AT BODY ANGLE BAC OR BAD DEGREES UNTIL DCH IS REACHED
C        M=9  APPROACH TO LANDING AT GLIDE SLOPE DFEEDD, RUNWAY ELEVATION DTH,
C          APPROACH SPEED DMN MACH
C        M=10  DIRECTS THE VEHICLE TO FLY ALONG THE RADAR HORIZON WHEN THE
C          HORIZON IS INTERCEPTED IN M=3 CRUISE.  TARGET ANTENNA IS ASSUMED
C          TO BE AT 100 FEET ABOVE SEA LEVEL.  RANGE TO TARGET MUST BE INPUT
C          AS RC (NMI).
C        IF USED AT ALL, M=1 AND M=7 MUST BE FIRST IN THE SEQUENCE.
C        IF USED AT ALL, M=9 WILL BE LAST IN THE SEQUENCE.
C        NO M VALUE MAY BE USED MORE THAN ONCE IN A TRAJECTORY EXCEPT 2,3,4,6,8.
C        M=4 MUST BE USED IN THE SEQUENCE 45, OR BE THE LAST IN THE SEQUENCE.
C        M=10 IF USED AT ALL MUST BE LAST IN THE SEQUENCE
C          REMAINDER OF FIRST CARD IN FORMAT 8I5. --
C            BOOSTER MULTIPLIER
C            ATMOSPHERE - 0 FOR STD, 1 FOR HOT DAY, 2 FOR COLD DAY
C            AERODYNAMICS - SUBROUTINE NUMBER FROM AERO LIBRARY
C            BOOST PROPULSION - SUBROUTINE NUMBER FROM BOOSTER LIBRARY - 0 IF NONE
C            SUSTAIN PROPULSION - SUBROUTINE NUMBER FROM SUSTAINER LIBRARY - 0 IF
C              NO SUSTAINER
C            OUTPUT OPTIONS - 0 GIVES BRIEF FORMAT (REPEATS DATA CARD ENTRIES)
C                             1 GIVES FULL PRINTER LIST OF INPUT DATA
C                             2 GIVES OPTION 1 PLUS A PLOT OF THE TRAJECTORY
C                             3 INDICATES DEMAND TERMINAL OUTPUT FORMAT (FULL LIST
C                             4 INDICATES SHORT FORM DEMAND TERMINAL OUTPUT
C                             5 INDICATES OPTION 4 PLUS TRAJECTORY PLOT
C            CLOSER-LOOK OPTION - IF FINER PRINT RESOLUTION DESIRED, PUNCH 1 IN 45
C            RANGE OUTPUT WILL BE IN FEET IF 1 IS PUNCHED IN 50
C     SECOND DATA CARD - MISSILE LAUNCH WEIGHT INCLUDING BOOSTER, MISSILE EMPTY
C          WEIGHT INCLUDING UNUSEABLE FUEL, MISSILE REFERENCE AREA IN SQ FT,
C          ANGLE OF ATTACK LIMIT IN DEGREES, ENGINE INLET CAPTURE AREA IN SQ FT,
C          SUSTAINER THRUST MULTIPLIER, LOAD FACTOR TO BE USED IN ANY PULL-UP
C          MANEUVER, LAUNCH ALTITUDE, LAUNCH MACH NUMBER,LAUNCH FLIGHT PATH ANGLE
C          - ALL IN FORMAT 12F5.0.
C     THIRD DATA CARD - DESIRED CLIMB FLIGHT PATH ANGLE, CLIMB MACH NUMBER, CLIMB
```

FLYIT3 CONTINUED

```
C          BODY ANGLE, DIVE BODY ANGLE, CRUISE ALTITUDE, CRUISE MACH NUMBER, CRUISE
C          RANGE, DIVE ANGLE, DIVE MACH NUMBER, DASH ALTITUDE, DASH MACH NUMBER
C          - ALL IN FORMAT 12F5.0.
C     INPUT DATA UNITS IN DEGREES, THOUSANDS OF FEET, SQUARE FEET, MACH NUMBER,
C       NAUTICAL MILES, G'S, POUNDS
C     MAIN PROGRAM
C
        DIMENSION M(10),PP(2000),RS(900),HS(900),RSFT(400),HSLD(400)
       COMMON W,WO,WE,RO,AREF,CLAR,ALPHA,ALPHA1,ALPL,V,VR,VH,Q,THR,FEED,
      1DCH,DT,H,DFEEC,Q4,AMACH,CMACH,R,RC,GPU,JCT,DFEEDD,DFEADD,LCT,TIT,
      2NTD,TIME,FEER,ALPHR,D,XLH,BAC,BAD,ITD,DTB,IKT,NB,RS,HS,RSFT,CL,CD,
      3HSLD,MCT,NCT,TM,AC,CMN,CLMN,DVMN,DMN,PT,PRI,TT,ASPEED,AMACH1,FISP,
      4THRS,THRB,T,CDO,CDI,CDA,CDAOFF,MM,M,PP,MGO,DTH,XLFEE,XLMN
      5,P,A,FISPB,FISPS,NBSTR,NSUST,NAERO,BA
C     THE FOLLOWING FUNCTION IS A LINEAR INTERPOLATION
       TERP1(X,A,B) = B + (A - B) * X
C     THE FOLLOWING FUNCTION INTERPOLATES ALONG AN EXPONENTIAL DECAY (NON-LINEAR).
C     A IS VALUE OF HIGHER ORDINATE, B IS THE ABCISSA OF INTEREST BETWEEN C AND E,
C     C IS THE LOWER ABCISSA VALUE, D IS THE LOWER ORDINATE VALUE, AND E IS THE
C     HIGHER ABCISSA VALUE.
       TERP2(A,B,C,D,E)=A*EXP((B-C)*LOG(D/A)/(E-C))
C     THE FOLLOWING FUNCTION IS A LINEAR INTERPOLATION
       TERP3(X1,X2,X,Y1,Y2)=Y1+(Y2-Y1)*(X-X1)/(X2-X1)
       WRITE(6,20)
   20  FORMAT(' ENTER DATA.')
C     READ INPUT DATA CARDS
    1  READ(5,2,END=9999)M(1),M(2),M(3),M(4),M(5),M(6),M(7),M(8),M(9),
      1M(10),NB,NATM,NAERO,NBSTR,NSUST,NOUTPT,NPRT,NFEET
    2  FORMAT(10I1,8I5)
       READ(5,3)WO,WE,AREF,ALPL,AC,TM,GPU,XLH,XLMN,XLFEE
    3  FORMAT(12F5.0)
       READ(5,3)DFEEC,CLMN,BAC,BAD,DCH,CMN,RC,DFEEDD,DVMN,DTH,DMN
       IF(NOUTPT.NE.0.AND.NOUTPT.LT.4)GO TO 100
       WRITE(6,12)(M(I),I=1,10),NB,NATM,NAERO,NBSTR,NSUST,NOUTPT,NPRT,
      1NFEET
   12  FORMAT('1',10I1,8I5)
       WRITE(6,13)WO,WE,AREF,ALPL,AC,TM,GPU,XLH,XLMN,XLFEE
   13  FORMAT(' ',F5.0,F5.0,F5.2,F5.0,F5.2,F5.2,F5.1,F5.2,F5.2,F5.1)
       WRITE(6,14)DFEEC,CLMN,BAC,BAD,DCH,CMN,RC,DFEEDD,DVMN,DTH,DMN
   14  FORMAT(F6.1,F5.2,F5.1,F5.1,F5.1,F5.2,F5.0,F5.1,F5.2,F5.1,F5.2)
C
C     DEFINE SPECIAL FUNCTIONS AND INITIAL CONDITIONS
  100  XLH=XLH*1000.
       DTH=DTH*1000.
       DCH=DCH*1000.
       NATM=NATM+1
       MM=1
       ITD=0
       ECT=0
       JCT=0
```

FLYIT3 CONTINUED

```
      IKT=0
      KCT=0
      KP=1
      RS(1)=0.0
      RSFT(1)=0.0
      HS(1)=XLH
      HSLD(1)=XLH
      K5=0
      LCT=0
      MCT=0
      NCT=0
      NTD=0
      EWB=0.0
      KK=0
      TIME=0.0
      DTB=0.025
      TIM=0.0
      R=0.0
      CDA=0.0
      ASPEED=100.
      FRIC=0.5
      CMACH=0.25
      H=XLH
      FEED=XLFEE
      IF(M(MM).EQ.1)FEED=0.0
      DFEEDD=-DFEEDD
      DFEADD=DFEEDD
      FEER=FEED/57.2958
      AMACH=XLMN
      IF(M(MM).EQ.1)AMACH=0.0
      DO 8 MI=1,10
      IF(M(MI+1).EQ.1)M(MI+1)=10
    8 CONTINUE
      Q3=518.688-0.00356616*XLH
      V=AMACH*49.01*SQRT(Q3)
      Q=0.001*V**2.0
      VR=V*COS(FEED/57.3)
      VH=V*SIN(FEED/57.3)
      AR1=0.0
      AH1=0.0
      VH1=0.0
      VR1=0.0
      IF(M(MM)-2)34,33,33
   33 ALPHA=6.0
      ALPHA1=ALPHA
      GO TO 35
   34 ALPHA=ALPL
   35 ALPHR=ALPHA/57.3
      AL=0.9*W0
      PRI=1.
```

FLYIT3 CONTINUED

```
      THR=AL/5.0
      THRB=0.0
      THRS=0.0
      FISPB=0.0
      FISPS=0.0
      THROT=1.0
      D=THR
      W=WO
      NLINE=46
      NPRNT=4
      CDX=0.
      IF(NOUTPT.GT.2)NPRNT=8
      IF(NPRT.GT.0)NPRNT=NPRNT/4
      IF(NOUTPT.GT.2)NLINE=50
      IF(NOUTPT.LT.1) GO TO 101
      IF(NOUTPT.GT.0.AND.NOUTPT.LT.4)CALL OUTPT1
  101 GO TO(102,104,106),NATM
  102 WRITE(6,103)
  103 FORMAT(' STANDARD ATMOSPHERE'/)
      GO TO 30
  104 WRITE(6,105)
  105 FORMAT(' HOT DAY ATMOSPHERE'/)
      GO TO 30
  106 WRITE(6,107)
  107 FORMAT(' COLD DAY ATMOSPHERE'/)
   30 IF(NOUTPT.GE.3)WRITE(6,15)
   15 FORMAT('  TIME    ALT    MACH RANGE WEIGHT  THRUST  DRAG  ALPHA L/D  F
     1  FPA  CDX  M')
      IF(NOUTPT.GE.3)WRITE(6,16)
   16 FORMAT('  SEC.    FT.     NO    NM      LB       LB      LB    DEG         DEG
     1  DEG      ')
   17 FORMAT(F7.1,F7.0,F5.2,F6.1,F7.1,F8.1,F7.1,F5.1,F5.1,F6.1,F5.2,I3)
      IF(NOUTPT.GE.3)GO TO36
      WRITE(6,31)
   31 FORMAT(132H -TIME- -----------VEHICLE PERFORMANCE-----------  --AT
     1MOSPHERE--  -VEHICLE ANGLES-  -----AERODYNAMICS----   -ENGINE PERF
     2ORMANCE-  M)
      WRITE(6,32)
   32 FORMAT(129H   SEC  MACH HEIGHT  VH   AH  RANGE  VR  AR  WEIGHT TA
     1 TT-2   Q      BA     FP  ALPHA LIFT L/D CDO CDI DRAG  THRUST RPM  T
     2SFC  TIT/)
   36 DO 97 J=1,19
      DO 91 N=1,NLINE
      DO 4 NN=1,NPRNT
      DO 94 I=1,5
      IF(M(MM).EQ.0)MM=MM-1
      MGO=M(MM)
      MM1=MM
      GO TO(6,5,6,5,6,6,5,5,6,5),MGO
    5 IF(I.EQ.1)GO TO 7
```

FLYIT3 CONTINUED

```
      GO TO 112
    6 IF(I*NN.NE.1)GO TO 112
    7 GO TO(109,110,111),NATM
  109 CALL ATMSTD
      GO TO 112
  110 CALL ATMHOT
      GO TO 112
  111 CALL ATMCLD
  112 P=11.9146*RO*T
      A=49.01*SQRT(T)
      TT=T*(1.0+0.2*AMACH**2.0)
      TA=T-460.
      TRAT=TT/T
      PT=P*TRAT**3.5
      Q=0.5*RO*V**2.0
      DT=0.25
 1121 GO TO(113,114,115,116,117,118,119,120,121,122),MGO
  113 CALL M1
      GO TO 845
  114 CALL M2
      GO TO 845
  115 CALL M3
      GO TO 845
  116 CALL M4
      GO TO 845
  117 CALL M5
      GO TO 845
  118 CALL M6
      GO TO 845
  119 CALL M7
      GO TO 845
  120 CALL M8
      GO TO 845
  121 CALL M9
      GO TO 845
  122 CALL M10
  845 IF(ALPHA.LT.0.0)ALPHA=0.0
      IF(MM.NE.MM1)GO TO 8441
      IF(ALPHA.GT.ALPL)ALPHA=ALPL
      ALPHA1=ALPHA
  842 IF(H)843,843,123
  843 WRITE(6,844)
      WRITE(6,846)
      WRITE(6,847)
      WRITE(6,848)
      WRITE(6,849)
  844 FORMAT(/' S    S    S    SSSS    S      SSSSS  SSSSS  SSSSS  S    S  !')
     1!')
  846 FORMAT(' S  S    S S  S   S  S     S  S  S  S  S       S S   !')
     1')
```

FLYIT3 CONTINUED

```
 847 FORMAT(' SSS    SSSSS  SSSS   S        S   S   S    S   SSSS       S      !'
     1')
 848 FORMAT(' S  S    S    S  S    S  S        S   S   S    S   S           S      !'
     1')
 849 FORMAT(' S    S  S    S  SSSS    SSSSS  SSSSS  SSSSS  SSSSS     S      0'/
     1'/)
     R=R+H/TAN(FEER)/6076.1
     RFT=R*6076.1
     H=0.01
     KP=KP+1
     RS(KP)=R
     HS(KP)=H
     GO TO 92
8441 MGO=M(MM)
     MM1=MM
     GO TO 1121
C    LIFT AND DRAG BLOCK
 123 GO TO (124,125,126,127,128,129,130,131,132,133,1331,1332,1333,
     1       1334,1335),NAERO
 124 CALL AERO1
     GO TO 134
 125 CALL AERO2
     GO TO 134
 126 CALL AERO3
     GO TO 134
 127 CALL AERO4
     GO TO 134
 128 CALL AERO5
     GO TO 134
 129 CALL AERO6
     GO TO 134
 130 CALL AERO7
     GO TO 134
 131 CALL AERO8
     GO TO 134
 132 CALL AERO9
     GO TO 134
 133 CALL AERO10
     GO TO 134
1331 CALL AERO11
     GO TO 134
1332 CALL AERO12
     GO TO 134
1333 CALL AERO13
     GO TO 134
1334 CALL AERO14
     GO TO 134
1335 CALL AERO15
 134 IF(NBSTR.LT.1)GO TO 145
     GO TO(135,136,137,138,139,140,141,142,143,144,1440,1441,1442,1443,
```

FLYIT3 CONTINUED

```
     11444),NBSTR
 135 CALL BSTR1
     GO TO 145
 136 CALL BSTR2
     GO TO 145
 137 CALL BSTR3
     GO TO 145
 138 CALL BSTR4
     GO TO 145
 139 CALL BSTR5
     GO TO 145
 140 CALL BSTR6
     GO TO 145
 141 CALL BSTR7
     GO TO 145
 142 CALL BSTR8
     GO TO 145
 143 CALL BSTR9
     GO TO 145
 144 CALL BSTR10
     GO TO 145
1440 CALL BSTR11
     GO TO 145
1441 CALL BSTR12
     GO TO 145
1442 CALL BSTR13
     GO TO 145
1443 CALL BSTR14
     GO TO 145
1444 CALL BSTR15
 145 IF(NSUST.LT.1)GO TO 1000
     GO TO(146,147,148,149,150,151,152,153,154,155,156,157,158,159,160,
     1161,162,163,164,165),NSUST
 146 CALL SUST1
     GO TO 1000
 147 CALL SUST2
     GO TO 1000
 148 CALL SUST3
     GO TO 1000
 149 CALL SUST4
     GO TO 1000
 150 CALL SUST5
     GO TO 1000
 151 CALL SUST6
     GO TO 1000
 152 CALL SUST7
     GO TO 1000
 153 CALL SUST8
     GO TO 1000
 154 CALL SUST9
```

FLYIT3 CONTINUED

```
      GO TO 1000
  155 CALL SUST10
      GO TO 1000
  156 CALL SUST11
      GO TO 1000
  157 CALL SUST12
      GO TO 1000
  158 CALL SUST13
      GO TO 1000
  159 CALL SUST14
      GO TO 1000
  160 CALL SUST15
      GO TO 1000
  161 CALL SUST16
      GO TO 1000
  162 CALL SUST17
      GO TO 1000
  163 CALL SUST18
      GO TO 1000
  164 CALL SUST19
      GO TO 1000
  165 CALL SUST20
 1000 CDO=CDO+CDAOFF
      CDX=CDO
      IF(XLFEE.GT.0.0001.AND.XLFEE.LT.10.)CDX=XLFEE
      SFC=3600./(THRS+THRB)*(THRB/FISPB+THRS/FISPS)
      FISP=3600./SFC
      THR=THRB+THRS
C    FLIGHT EQUATIONS OF MOTION
      Q=0.5*RO*V**2.0
      CD=CDO+CDI
      W=W-DT*THR/FISP/2.0
      D=AREF*CD*Q
      AL=AREF*CL*Q
      ALD=CL/CD
      ALPHR=ALPHA/57.3
      FR=THR*COS(FEER+ALPHR)-AL*SIN(FEER)-D*COS(FEER)
      FH=THR*SIN(FEER+ALPHR)+AL*COS(FEER)-D*SIN(FEER)-W
      IF(ITD.LT.1)GO TO 1007
      FR=FR-W*FRIC
 1007 AR=32.1725*FR/W
      IF(ITD-1)1004,1001,1001
 1004 IF(M(MM)-1)1002,1001,1005
 1001 AH=0.0
      VH=0.0
      AH1=0.0
      GO TO 1003
 1005 IF(MGO.NE.7)GO TO1002
      AA=32.174*(THR-D-W*SIN(FEER))/W
      AR=AA*COS(FEER)
```

FLYIT3 CONTINUED

```
      AH=AA*SIN(FEER)
      GO TO 1003
 1002 AH=32.1725*FH/W
 1003 VR=VR+AR1*DT+0.5*(AR-AR1)*DT
      VH=VH+AH1*DT+0.5*(AH-AH1)*DT
      R=R+(VR1*DT+0.5*(VR-VR1)*DT)/6076.1
      H=H+(VH1*DT+0.5*(VH-VH1)*DT)
      AR1=AR
      AH1=AH
      VR1=VR
      VH1=VH
      FEER=ATAN(VH/VR)
      FEED=57.2958*FEER
      Q1=VH**2.0+VR**2.0
      V=SQRT(Q1)
      AMACH1=AMACH
      AMACH=V/A
      W=W-DT*THR/FISP/2.0
      GA=(THR-D)/W
      GL=AL/W
      BA=ALPHA+FEED
      Q4=Q
      RTGT=RC-R
      IF(M(MM+1).NE.10.AND.M(MM+2).NE.10)GO TO 1006
      RHORH=.66314*(RTGT-12.28)**2
      IF(H.GT.RHORH)MM=MM+1
      MGO=M(MM)
 1006 IF(H.GT.105100.0)GO TO 40
      IF(AMACH.GT.5.6)GO TO 40
      IF(H)843,843,94
   94 TIME=TIME+DT
    4 CONTINUE
      RFT=R*6076.1
      ROC=VH*60.
      IF(I.NE.3.AND.I.NE.5)GO TO 940
      KP=KP+1
      RS(KP)=R
      HS(KP)=H
  940 IF(NBSTR.LT.1)GO TO 92
      IF(TIME.GT.10.)GO TO 92
      RSFT(N+1)=R*6076.1
      HSLD(N+1)=H
   92 IF(NOUTPT.GT.2)GO TO 93
   98 WRITE(6,99)TIME,AMACH,H,VH,GL,R,VR,GA,W,TA,TT ,Q,BA,FEED,ALPHA,AL,
     1ALD,CDO,CDI,D,THR,ASPEED,SFC,TIT,MGO
   99 FORMAT(F7.1,F5.2,F7.0,F6.0,F4.1,F5.0,F6.0,F4.1,F6.0,F5.0,F5.0,F6.0
     1,F6.1,F6.1,F5.1,F6.0,F4.1,F4.2,F4.2,F6.0,F6.0,F6.1,F5.2,F6.0,I2)
      GO TO 932
   93 IF(NFEET)930,930,931
  930 WRITE(6,17)TIME,H,AMACH,R,W,THR,D,ALPHA,ALD,FEED,CDX,MGO
```

FLYIT3 CONTINUED

```
      GO TO 932
  931 WRITE(6,17)TIME,H,AMACH,RFT,W,THR,D,ALPHA,ALD,FEED,CDX,MGO
  932 IF(H.LT.0.1)GO TO 40
   91 CONTINUE
   95 WRITE(6,19)
   19 FORMAT(1H1////////)
      IF(NOUTPT.GT.2)GO TO 90
   96 WRITE(6,31)
      WRITE(6,32)
      GO TO 97
   90 WRITE(6,15)
   97 CONTINUE
   40 IF(NOUTPT.EQ.2.OR.NOUTPT.EQ.5)CALL SHOMAT(PP,KP,RS,HS)
 9999 CALL EXIT
      END
```

Appendix B

SUBROUTINE OUTPT1 LISTING

```
      SUBROUTINE OUTPT1
       DIMENSION M(10),PP(2000),RS(900),HS(900),RSFT(400),HSLD(400)
      COMMON W,WO,WE,RO,AREF,CLAR,ALPHA,ALPHA1,ALPL,V,VR,VH,Q,THR,FEED,
     1DCH,DT,H,DFEEC,Q4,AMACH,CMACH,R,RC,GPU,JCT,DFEEDD,DFEADD,LCT,TIT,
     2NTD,TIME,FEER,ALPHR,D,XLH,BAC,BAD,ITD,DTB,IKT,NB,RS,HS,RSFT,CL,CD,
     3HSLD,MCT,NCT,TM,AC,CMN,CLMN,DVMN,DMN,PT,PRI,TT,ASPEED,AMACHI,FISP,
     4THRS,THRB,T,CDO,CDI,CDA,CDAOFF,MM,M,PP,MGO,DTH,XLFEE,XLMN
     5,P,A,FISPB,FISPS,NBSTR,NSUST,NAERO,BA
      WRITE(6,6)WO
    6 FORMAT(49H1GROSS FUELLED MISSILE WEIGHT, INCLUDING BOOSTERS,F7.1,7
     1H POUNDS)
      WRITE(6,7)WE
    7 FORMAT(39H MISSILE EMPTY WEIGHT, WITHOUT BOOSTERS,F7.1,7H POUNDS)
      WRITE(6,8)AREF
    8 FORMAT(29H DRAG AND LIFT REFERENCE AREA,F6.3,12H SQUARE FEET)
      WRITE(6,10)DFEEC
   10 FORMAT(39H DESIRED CLIMB ANGLE TO CRUISE ALTITUDE,F5.1,8H DEGREES)
      WRITE(6,11)CLMN
   11 FORMAT(41H DESIRED CLIMB MACH NUMBER, IF APPLICABLE,F5.2)
      WRITE(6,12)DCH,RC
   12 FORMAT(24H DESIRED CRUISE ALTITUDE,F8.0,9H FEET (TO,F6.0,13H MILES
     1 RANGE))
      WRITE(6,13)CMN
   13 FORMAT(27H DESIRED CRUISE MACH NUMBER,F5.2)
      WRITE(6,14)DFEEDD
   14 FORMAT(43H DESIRED DESCENT ANGLE FROM CRUISE ALTITUDE,F6.1,9H DEGR
     1EES.)
      WRITE(6,15)DVMN
   15 FORMAT(28H DESIRED DESCENT MACH NUMBER,F6.3)
      WRITE(6,16)DTH    ,DMN
   16 FORMAT(22H DESIRED DASH ALTITUDE,F8.0,11H FEET (MACH,F5.2,2H ))
      WRITE(6,36)TM
   36 FORMAT(47H SUSTAINER THRUST MULTIPLIER (X BASIC THRUST) =,F5.2)
      WRITE(6,5)NB
    5 FORMAT(' BOOSTER MULTIPLIER = ',I1)
      WRITE(6,28)AC
   28 FORMAT(27H INLET COOKIE-CUTTER AREA =,F8.3,12HX TM, SQ.FT.)
      WRITE(6,38)GPU
   38 FORMAT(47H MAXIMUM G-LOAD PERMITTED IN PULL-UP MANEUVER =,F4.1)
      WRITE(6,25)ALPL
   25 FORMAT(28H LIMIT ON ANGLE OF ATTACK = ,F4.1,8H DEGREES)
      WRITE(6,1)BAC,BAD
    1 FORMAT(' BODY ANGLES, IF APPLICABLE - IN CLIMB',F5.1,'  IN DIVE',F
     15.1,' (DEGREES)')
      IF(M(MM)-1)17,17,20
   17 WRITE(6,18)
   18 FORMAT( 69H THIS MISSILE IS SURFACE-LAUNCHED BY GROUND ROLL UNDER
     1ITS OWN POWER./////)
      GO TO 29
   20 WRITE(6,21)
```

OUTPT1 CONTINUED

```
   21 FORMAT( 81H THIS MISSILE IS AIR-LAUNCHED AND SUBJECT TO THE FOLLOW
     1ING ADDITIONAL CONDITIONS.)
      WRITE(6,22)XLH
   22 FORMAT(16H LAUNCH ALTITUDE,F8.0,5H FEET)
      WRITE(6,23)XLMN
   23 FORMAT(19H LAUNCH MACH NUMBER,F5.3)
      WRITE(6,24) XLFEE
   24 FORMAT(25H LAUNCH FLIGHT PATH ANGLE,F5.1,5H DEG.//)
   29 WRITE(6,26)(M(I),I=1,10)
   26 FORMAT(' TRAJECTORY SEQUENCE -- ',10I1//)
      WRITE(6,2)NBSTR,NB,NSUST,NAERO
    2 FORMAT(' OPTIONS CALLED      BOOSTER',I3,'   NUMBER OF BOOSTERS ='
     1,I2,'   SUSTAINER',I3,'   AERODYNAMICS',I3///)
      IF(NOUTPT.EQ.2)WRITE(6,27)
   27 FORMAT(' TRAJECTORY PLOT REQUESTED'///)
      WRITE(6,19)
   19 FORMAT(1H1)
      RETURN
      END
```

Appendix C

SUBROUTINES ATMSTD, ATMCLD, ATMHOT LISTINGS

```
      SUBROUTINE ATMSTD
       DIMENSION M(10),PP(2000),RS(900),HS(900),RSFT(400),HSLD(400)
      COMMON W,WO,WE,RO,AREF,CLAR,ALPHA,ALPHA1,ALPL,V,VR,VH,Q,THR,FEED,
     1DCH,DT,H,DFEEC,Q4,AMACH,CMACH,R,RC,GPU,JCT,DFEEDD,DFEADD,LCT,TIT,
     2NTD,TIME,FEER,ALPHR,D,XLH,BAC,BAD,ITD,DTB,IKT,NB,RS,HS,RSFT,CL,CD,
     3HSLD,MCT,NCT,TM,AC,CMN,CLMN,DVMN,DMN,PT,PRI,TT,ASPEED,AMACH1,FISP,
     4THRS,THRB,T,CDO,CDI,CDA,CDAOFF,MM,M,PP,MGO,DTH,XLFEE,XLMN
     5,P,A,FISPB,FISPS,NBSTR,NSUST,NAERO,BA
  103 IF(H-36152.)100,100,101
  100 T=518.688-0.00356616*H
      ROK=(2.6325*H**1.1439/1000000.0+2.926)/100000.0
      RO=0.002378*EXP(-ROK*H)
      RETURN
  101 T=389.988
      RO=0.29619*EXP((36152.-H)/20805.5)*0.002378
      RETURN
      END
```

```
      SUBROUTINE ATMCLD
       DIMENSION M(10),PP(2000),RS(900),HS(900),RSFT(400),HSLD(400)
      COMMON W,WO,WE,RO,AREF,CLAR,ALPHA,ALPHA1,ALPL,V,VR,VH,Q,THR,FEED,
     1DCH,DT,H,DFEEC,Q4,AMACH,CMACH,R,RC,GPU,JCT,DFEEDD,DFEADD,LCT,TIT,
     2NTD,TIME,FEER,ALPHR,D,XLH,BAC,BAD,ITD,DTB,IKT,NB,RS,HS,RSFT,CL,CD,
     3HSLD,MCT,NCT,TM,AC,CMN,CLMN,DVMN,DMN,PT,PRI,TT,ASPEED,AMACH1,FISP,
     4THRS,THRB,T,CD0,CDI,CDA,CDAOFF,MM,M,PP,MGO,DTH,XLFEE,XLMN
     5,P,A,FISPB,FISPS,NBSTR,NSUST,NAERO,BA
      IF(H-3243.)1,1,2
    1 T=440.+0.004286*H
      GO TO 11
    2 IF(H-9882.)3,3,4
    3 T=455.66-0.0005422*H
      GO TO 11
    4 IF(H-30065.)5,5,6
    5 T=478.5-0.0028539*H
      GO TO 11
    6 IF(H-86092.)7,7,8
    7 T=400.43-0.00025702*H
      GO TO 11
    8 T=378.3
   11 RO=0.002779-.12421497E-06*H+.47360342E-05*(.001*H)**2-.14828645E-
     106*(.001*H)**3+.24341821E-08*(.001*H)**4-.11436813E-10*(.001*H)**5
     2-.16878897E-12*(.001*H)**6+.23010166E-14*(.001*H)**7
     3-.797595E-17*(.001*H)**8
      RETURN
      END
```

```
      SUBROUTINE ATMHOT
       DIMENSION M(10),PP(2000),RS(900),HS(900),RSFT(400),HSLD(400)
      COMMON W,WO,WE,RO,AREF,CLAR,ALPHA,ALPHA1,ALPL,V,VR,VH,Q,THR,FEED,
     1DCH,DT,H,DFEEC,Q4,AMACH,CMACH,R,RC,GPU,JCT,DFEEDD,DFEADD,LCT,TIT,
     2NTD,TIME,FEER,ALPHR,D,XLH,BAC,BAD,ITD,DTB,IKT,NB,RS,HS,RSFT,CL,CD,
     3HSLD,MCT,NCT,TM,AC,CMN,CLMN,DVMN,DMN,PT,PRI,TT,ASPEED,AMACH1,FISP,
     4THRS,THRB,T,CDO,CDI,CDA,CDAOFF,MM,M,PP,MGO,DTH,XLFEE,XLMN
     5,P,A,FISPB,FISPS,NBSTR,NSUST,NAERO,BA
      IF(H-42619.4)1,1,2
    1 T=549.5-0.00386*H
      GO TO 9
    2 IF(H-53595.)3,3,4
    3 T=529.78-.0033973*H
      GO TO 9
    4 IF(H-69620.)5,5,9
    5 T=227.3+.0022465*H
      GO TO 9
    9 RO=0.002213*EXP(-H*(.0000291873+(3.7297E-12)*H**1.3264))
      RETURN
      END
```

Appendix D

SUBROUTINES M1 THRU M10 LISTINGS

```
      SUBROUTINE M1
       DIMENSION M(10),PP(2000),RS(900),HS(900),RSFT(400),HSLD(400)
      COMMON W,WO,WE,RO,AREF,CLAR,ALPHA,ALPHA1,ALPL,V,VR,VH,Q,THR,FEED,
     1DCH,DT,H,DFEEC,Q4,AMACH,CMACH,R,RC,GPU,JCT,DFEEDD,DFEADD,LCT,TIT,
     2NTD,TIME,FEER,ALPHR,D,XLH,BAC,BAD,ITD,DTB,IKT,NB,RS,HS,RSFT,CL,CD,
     3HSLD,MCT,NCT,TM,AC,CMN,CLMN,DVMN,DMN,PT,PRI,TT,ASPEED,AMACH1,FISP,
     4THRS,THRB,T,CDO,CDI,CDA,CDAOFF,MM,M,PP,MGO,DTH,XLFEE,XLMN
     5,P,A,FISPB,FISPS,NBSTR,NSUST,NAERO,BA
      DT=0.1
      Q2=2.0*W/RO/AREF/CLAR/ALPL*57.2958
      VMIN=SQRT(Q2)
      IF(VR-1.2*VMIN)802,802,803
  802 H=XLH
      ALPHA=0.0
      ALPHA1=ALPHA
      RETURN
  803 MM=MM+1
      RTO=R*6076.1
      WRITE(6,800)RTO
  800 FORMAT(' TAKE-OFF ROLL REQUIRED ',F6.0,' FEET.')
      RETURN
      END
```

```
      SUBROUTINE M2
       DIMENSION M(10),PP(2000),RS(900),HS(900),RSFT(400),HSLD(400)
      COMMON W,WO,WE,RO,AREF,CLAR,ALPHA,ALPHA1,ALPL,V,VR,VH,Q,THR,FEED,
     1DCH,DT,H,DFEEC,Q4,AMACH,CMACH,R,RC,GPU,JCT,DFEEDD,DFEADD,LCT,TIT,
     2NTD,TIME,FEER,ALPHR,D,XLH,BAC,BAD,ITD,DTB,IKT,NB,RS,HS,RSFT,CL,CD,
     3HSLD,MCT,NCT,TM,AC,CMN,CLMN,DVMN,DMN,PT,PRI,TT,ASPEED,AMACH1,FISP,
     4THRS,THRB,T,CDO,CDI,CDA,CDAOFF,MM,M,PP,MGO,DTH,XLFEE,XLMN
     5,P,A,FISPB,FISPS,NBSTR,NSUST,NAERO,BA
      DT=0.25
      IF(TIME.GT.0.5.AND.M(4).EQ.3)GO TO 808
      IF(R.GT.RC)GO TO 808
      IF(W.LT.WE)GO TO 808
      DHC=V*V*(-COS(FEED/57.3)+1.0)/32.174
      IF(H-(DCH-DHC))806,805,805
  805 ALPHA=0.
      IF(ABS(H-DCH).LT.100.)MM=MM+1
      RETURN
  806 IF(H-DCH)807,807,808
  808 MM=MM+1
      RETURN
  807 ICT=0
 8094 ALPHA=57.3*W*COS(DFEEC/57.3)/(Q*AREF*CLAR+THR)*0.5+0.5*ALPHA1+0.5*
     1(DFEEC-FEED)
      IF(ALPHA.LT.0.0)ALPHA=0.0
      ALPHA2=ALPHA1+2.0
      IF(ALPHA.GT.ALPHA2)ALPHA=ALPHA2
      IF (ALPHA - ALPL)8091,8091,811
 8091 IF(AMACH-CMACH+0.0001)8093,8093,8092
 8093 IF(ICT-5)811,811,8092
 8092 CMACH=AMACH
      RETURN
  811 IF(FEED.LT.DFEEC)DFEEC=DFEEC*0.95
      IF(DFEEC-.001)8110,8110,8111
 8110 MM=MM+1
      DCH=H
      RETURN
 8111 ICT=ICT+1
      IF(Q.GT.Q4)DFEEC=DFEEC/0.95
      IF(ICT-5)8094,8092,8092
      END
```

```
      SUBROUTINE M3
       DIMENSION M(10),PP(2000),RS(900),HS(900),RSFT(400),HSLD(400)
      COMMON W,WO,WE,RO,AREF,CLAR,ALPHA,ALPHA1,ALPL,V,VR,VH,Q,THR,FEED,
     1DCH,DT,H,DFEEC,Q4,AMACH,CMACH,R,RC,GPU,JCT,DFEEDD,DFEADD,LCT,TIT,
     2NTD,TIME,FEER,ALPHR,D,XLH,BAC,BAD,ITD,DTB,IKT,NB,RS,HS,RSFT,CL,CD,
     3HSLD,MCT,NCT,TM,AC,CMN,CLMN,DVMN,DMN,PT,PRI,TT,ASPEED,AMACH1,FISP,
     4THRS,THRB,T,CDO,CDI,CDA,CDAOFF,MM,M,PP,MGO,DTH,XLFEE,XLMN
     5,P,A,FISPB,FISPS,NBSTR,NSUST,NAERO,BA
      DT=0.1
      DCHX=DCH
      IF(W.LT.WE)GO TO 815
      IF(M(MM+2).EQ.3)GO TO 817
      IF(R-RC  )8182,815,815
  815 MM=MM+1
      CMN=CMNT
  818 IF(M(MM).EQ.0)M(MM)=5
      IF(M(MM).EQ.0)DTH=H
      RETURN
  817 DCHX=XLH
      CMNT=CMN
      CMN=CLMN+0.5
      IF(AMACH.GT.CLMN)GO TO 816
 8182 MCT=MCT+1
      IF(MCT.GT.100)DT=0.5
      GLW=LOG(ABS(DCHX-H)/100.0+1.0)*(DCHX-H)/ABS(DCHX-H)
     1-1.20*LOG(ABS(FEED)+1.)*(FEED)/ABS(FEED)
      ALPHA =(GLW+1.0)*57.2958*(W-THR*ALPHA1/57.3)/Q/AREF/CLAR*.5+.5*ALP
     1HA1
      IF(ALPHA.GT.57.3*GPU*W/Q/AREF/CLAR)ALPHA=120.*W/Q/AREF/CLAR
      IF(M(MM+1).EQ.6.AND.M(MM+2).GT.0)GO TO 816
      RETURN
  816 IF(AMACH.GT.CLMN)MM=MM+1
      GO TO 818
      END
```

```
      SUBROUTINE M4
       DIMENSION M(10),PP(2000),RS(900),HS(900),RSFT(400),HSLD(400)
      COMMON W,WO,WE,RO,AREF,CLAR,ALPHA,ALPHA1,ALPL,V,VR,VH,Q,THR,FEED,
     1DCH,DT,H,DFEEC,Q4,AMACH,CMACH,R,RC,GPU,JCT,DFEEDD,DFEADD,LCT,TIT,
     2NTD,TIME,FEER,ALPHR,D,XLH,BAC,BAD,ITD,DTB,IKT,NB,RS,HS,RSFT,CL,CD,
     3HSLD,MCT,NCT,TM,AC,CMN,CLMN,DVMN,DMN,PT,PRI,TT,ASPEED,AMACH1,FISP,
     4THRS,THRB,T,CDO,CDI,CDA,CDAOFF,MM,M,PP,MGO,DTH,XLFEE,XLMN
     5,P,A,FISPB,FISPS,NBSTR,NSUST,NAERO,BA
      DT=0.5
      IF(M(MM).EQ.4.AND.M(MM+1).EQ.0)DTH=-10000.
      IF(DTH.LT.-5000.)GO TO 830
      DTX=DTH+V*V*(1.0-COS(FEED/57.3))/32.174/(GPU-1.0)-0.5
      IF(H.GT.DTX)GO TO 830
      JCT=200
      IF(M(MM).EQ.9)GO TO 800
  824 MM=MM+1
      GO TO 800
  830 ALPHA=57.3*W*COS(DFEEDD/57.3)/(CLAR*Q*AREF+THR)*0.7+0.3*ALPHA1+2.0
     1*(DFEEDD-FEED)
  800 RETURN
      END
```

```
      SUBROUTINE M5
       DIMENSION M(10),PP(2000),RS(900),HS(900),RSFT(400),HSLD(400)
      COMMON W,WO,WE,RO,AREF,CLAR,ALPHA,ALPHA1,ALPL,V,VR,VH,Q,THR,FEED,
     1DCH,DT,H,DFEEC,Q4,AMACH,CMACH,R,RC,GPU,JCT,DFEEDD,DFEADD,LCT,TIT,
     2NTD,TIME,FEER,ALPHR,D,XLH,BAC,BAD,ITD,DTB,IKT,NB,RS,HS,RSFT,CL,CD,
     3HSLD,MCT,NCT,TM,AC,CMN,CLMN,DVMN,DMN,PT,PRI,TT,ASPEED,AMACH1,FISP,
     4THRS,THRB,T,CDO,CDI,CDA,CDAOFF,MM,M,PP,MGO,DTH,XLFEE,XLMN
     5,P,A,FISPB,FISPS,NBSTR,NSUST,NAERO,BA
      IF(NCT.LT.1)KK=0
      DT=0.1
      IF(M(MM+1).EQ.0)GO TO 8374
      IF(W.GT.WE)GO TO 8373
  837 MM=MM+1
      RETURN
 8373 IF(MCT.GT.0)GO TO 8374
      IF(R.GT.RC)GO TO 837
 8374 NCT=NCT+1
      IF(NCT.GT.201)DT=0.250
      IF(H.LT.90.0)ALPHA=1.1*ALPHA1
      IF(H.LT.90.0)RETURN
      IF(FEED.GT.0.0)KK=1
      IF(KK.GT.0)GO TO 839
      IF(FEED)838,839,839
  838 IF(  H-DTH-1.0)839,8381,8381
 8381 ALPHA=57.3*W*GPU/(CLAR*Q*AREF+THR)
      RETURN
  839 GLW=LOG(ABS(DTH-H)/100.0+1.0)*(DTH-H)/ABS(DTH-H)
     1-1.50*LOG(ABS(FEED)+1.)*(FEED)/ABS(FEED)
      ALPHA=(GLW+1.0)*57.2958*(W-THR*ALPHA1/57.2958)/Q/AREF/CLAR*0.5+0.5
     1*ALPHA1
      IF(M(MM-1).NE.10)RETURN
      KGLW=KGLW+1
      IF(KGLW.EQ.2)MM=MM-1
      IF(KGLW.EQ.2)KGLW=0
      RETURN
      END
```

```
      SUBROUTINE M6
       DIMENSION M(10),PP(2000),RS(900),HS(900),RSFT(400),HSLD(400)
      COMMON W,WO,WE,RO,AREF,CLAR,ALPHA,ALPHA1,ALPL,V,VR,VH,Q,THR,FEED,
     1DCH,DT,H,DFEEC,Q4,AMACH,CMACH,R,RC,GPU,JCT,DFEEDD,DFEADD,LCT,TIT,
     2NTD,TIME,FEER,ALPHR,D,XLH,BAC,BAD,ITD,DTB,IKT,NB,RS,HS,RSFT,CL,CD,
     3HSLD,MCT,NCT,TM,AC,CMN,CLMN,DVMN,DMN,PT,PRI,TT,ASPEED,AMACH1,FISP,
     4THRS,THRB,T,CDO,CDI,CDA,CDAOFF,MM,M,PP,MGO,DTH,XLFEE,XLMN
     5,P,A,FISPB,FISPS,NBSTR,NSUST,NAERO,BA
      DT=0.25
      IF(R.GT.RC.AND.MM.LT.4)GO TO 8513
      IF(MM.EQ.1)GO TO 8514
      MMM=M(MM-1)+1
      GO TO (8510,8510,8510,8512,851,850,851,8510,8512,851),MMM
  850 IF(MCT)8510,8510,851
 8510 IF(H-DCH)8512,8513,8513
 8513 IF(M(MM).EQ.2)GO TO 8512
 8515 MM=MM+1
      IF(M(MM).EQ.0)GO TO 8517
 8516 RETURN
 8517 M(MM)=6
      GO TO 852
 8514 IF(H.LT.DCH)GO TO 8515
 8512 IF(RC-R)8515,8515,851
  851 IF(TIME-0.0001)854,852,852
  854 DT=0.00001
      FEED=DFEADD
      FEER=FEED/57.2958
      VR=V*COS(FEER)
      VH=V*SIN(FEER)
  852 DFEADD=57.2958*(THR*COS(ALPHR)-D)/W
  853 ALPHA=57.2958*W*COS(DFEADD/57.2958)/(CLAR*Q*AREF+THR)*0.5+0.5*ALPH
     1A1+0.5*(DFEADD-FEED)
      IF(ALPHA.LT.0.0)ALPHA=0.0
      IF(M(MM-1).EQ.1)ALPHA1=ALPL
      ALPHA2=ALPHA1*1.1
      IF(ALPHA.GT.ALPHA2)ALPHA=ALPHA2
      GO TO 8516
      END
```

```
      SUBROUTINE M7
       DIMENSION M(10),PP(2000),RS(900),HS(900),RSFT(400),HSLD(400)
      COMMON W,WO,WE,RO,AREF,CLAR,ALPHA,ALPHA1,ALPL,V,VR,VH,Q,THR,FEED,
     1DCH,DT,H,DFEEC,Q4,AMACH,CMACH,R,RC,GPU,JCT,DFEEDD,DFEADD,LCT,TIT,
     2NTD,TIME,FEER,ALPHR,D,XLH,BAC,BAD,ITD,DTB,IKT,NB,RS,HS,RSFT,CL,CD,
     3HSLD,MCT,NCT,TM,AC,CMN,CLMN,DVMN,DMN,PT,PRI,TT,ASPEED,AMACH1,FISP,
     4THRS,THRB,T,CDO,CDI,CDA,CDAOFF,MM,M,PP,MGO,DTH,XLFEE,XLMN
     5,P,A,FISPB,FISPS,NSTR,NSUST,NAERO,BA
      RAIL=((R*6076.1)**2.+(H-XLH)**2)**0.5
      IF(RAIL-100.)860,861,861
  861 MM=MM+1
      RETURN
  860 ALPHA=0.
      FEED=DFEEC
      FEER=FEED/57.2958
      DT=0.025
      RETURN
      END
```

```
      SUBROUTINE M8
       DIMENSION M(10),PP(2000),RS(900),HS(900),RSFT(400),HSLD(400)
      COMMON W,WO,WE,RO,AREF,CLAR,ALPHA,ALPHAI,ALPL,V,VR,VH,Q,THR,FEED,
     1DCH,DT,H,DFEEC,Q4,AMACH,CMACH,R,RC,GPU,JCT,DFEEDD,DFEADD,LCT,TIT,
     2NTD,TIME,FEER,ALPHR,D,XLH,BAC,BAD,ITD,DTB,IKT,NB,RS,HS,RSFT,CL,CD,
     3HSLD,MCT,NCT,TM,AC,CMN,CLMN,DVMN,DMN,PT,PRI,TT,ASPEED,AMACHI,FISP,
     4THRS,THRB,T,CDO,CDI,CDA,CDAOFF,MM,M,PP,MGO,DTH,XLFEE,XLMN
     5,P,A,FISPB,FISPS,NBSTR,NSUST,NAERO,BA
C     BEGIN CONSTANT BODY ANGLE FLIGHT, SEEKING DCH.
      DT=0.25
      IF(W.LT.WE)DCH=-10000.
      IF(W.LT.WE)GO TO 892
      IF(M(MM+1).EQ.3)GO TO 890
      IF(MCT.GT.0.OR.M(MM-1).EQ.2)DCH=DTH
  890 IF(R.GT.RC.AND.MM.LT.4)GO TO 894
      IF(H-DCH)891,891,892
  891 XH=V*V*(1.-COS(FEED/57.3))*0.04
      IF(M(MM+1).EQ.3.AND.H.GT.(DCH-XH))GO TO 895
      ALPHA=BAC-FEED
      BA=BAC
      GO TO 893
  892 ALPHA=BAD-FEED
      BA=BAD
      IF(M(MM+1).NE.5)GO TO 893
      DTX=DTH+V*V*(1.-COS(FEED/57.3))/32.174/(GPU-1.)-.5
      IF(H.LT.DTX)MM=MM+1
      IF(H.LT.DTX)RETURN
  893 IF(ABS(H-DCH).GT.20.)RETURN
  894 MM=MM+1
      IF(M(MM).NE.0)RETURN
      DTH=-10000.
      DCH=DTH
      MM=MM-1
      GO TO 892
  895 IF(FEED.LT.0.)GO TO 894
      ALPHA=0.
      RETURN
      END
```

```
      SUBROUTINE M9
       DIMENSION M(10),PP(2000),RS(900),HS(900),RSFT(400),HSLD(400)
      COMMON W,WO,WE,RO,AREF,CLAR,ALPHA,ALPHA1,ALPL,V,VR,VH,Q,THR,FEED,
     1DCH,DT,H,DFEEC,Q4,AMACH,CMACH,R,RC,GPU,JCT,DFEEDD,DFEADD,LCT,TIT,
     2NTD,TIME,FEER,ALPHR,D,XLH,BAC,BAD,ITD,DTB,IKT,NB,RS,HS,RSFT,CL,CD,
     3HSLD,MCT,NCT,TM,AC,CMN,CLMN,DVMN,DMN,PT,PRI,TT,ASPEED,AMACH1,FISP,
     4THRS,THRB,T,CDO,CDI,CDA,CDAOFF,MM,M,PP,MGO,DTH,XLFEE,XLMN
     5,P,A,FISPB,FISPS,NBSTR,NSUST,NAERO,BA
C  BEGIN LANDING APPROACH AND ROLL-OUT.  FIELD ELEVATION IS DTH, GLIDE PATH
C  ANGLE IS DFEEDD, DESIRED APPROACH SPEED IS DVMN. SPECIAL AERODYNAMICS AND
C  WHEEL FRICTION MAY APPLY.
      NTD=1
      GPU=1.1
  870 CALL M4
C   JCT=200 WHEN FLARE BEGINS
      IF(JCT.EQ.200)GO TO 8702
 8701 RETURN
 8702 IF(ITD.GT.0)GO TO 884
      CALL M5
      IF((H-DTH).LT.5.0.AND.FEED.GT.-0.2)ALPHA=0.0
      IF(H.LT.(DTH+5.).AND.FEED.LT.1.)ALPHA=1.1*ALPHA
      IF(H.GT.(DTH+5.))GO TO 8701
  871 WRITE(6,872)FEED
  872 FORMAT(34H TOUCHDOWN AT FLIGHT PATH ANGLE OF,F6.2,8H DEGREES)
      DT=0.1
      TDR=R
  884 H=DTH-0.0001
      ITD=ITD+1
      ALPHA=0.0
      FEED=0.0
      RWL=(R-TDR)*6076.1
      IF(VR.GT.0)GO TO 8701
  885 WRITE(6,886)RWL
  886 FORMAT(34H LANDING COMPLETED TO FULL STOP IN,F6.0,20H FEET FROM TOUCHD
     1UCHDOWN)
  887 H=-10.
      GO TO 8701
      END
```

```
      SUBROUTINE M10
       DIMENSION M(10),PP(2000),RS(900),HS(900),RSFT(400),HSLD(400)
      COMMON W,WO,WE,RO,AREF,CLAR,ALPHA,ALPHA1,ALPL,V,VR,VH,Q,THR,FEED,
     1DCH,DT,H,DFEEC,Q4,AMACH,CMACH,R,RC,GPU,JCT,DFEEDD,DFEADD,LCT,TIT,
     2NTD,TIME,FEER,ALPHR,D,XLH,BAC,BAD,ITD,DTB,IKT,NB,RS,HS,RSFT,CL,CD,
     3HSLD,MCT,NCT,TM,AC,CMN,CLMN,DVMN,DMN,PT,PRI,TT,ASPEED,AMACH1,FISP,
     4THRS,THRB,T,CDO,CDI,CDA,CDAOFF,MM,M,PP,MGO,DTH,XLFEE,XLMN
     5,P,A,FISPB,FISPS,NBSTR,NSUST,NAERO,BA
C   THIS AUTOPILOT DIRECTS THE VEHICLE TO FLY ALONG THE RADAR HORIZON
C     WHEN THE HORIZON IS INTERCEPTED FROM M=3 CRUISE.  THE TARGET ANTENNA
C     IS ASSUMED TO BE AT 100 FEET ABOVE SEA LEVEL.  RANGE FROM LAUNCH
C     TO TARGET IS INPUT AS RC NMI.
      DT=0.5
      RTGT=RC-R
      IF(RTGT)1,1,2
    1 H=-20.
      WRITE(6,3)R,TIME
    3 FORMAT(' TARGET IMPACT AT',F5.0,' NM AND TIME',F7.1)
      RETURN
    2 RHORH=.66314*(RTGT-12.28)**2
      IF(RTGT.LT.24.56)GO TO 4
      FPARHR=-0.0004963658*(RTGT-12.28)
      IF(RTGT.LT.18.)FPARHR=0.
      ALPHA=57.3*W*COS(FPARHR)/(CLAR*Q*AREF+THR)*0.7*(1.-.20*SQRT
     1(ABS(H-RHORH))*(H-RHORH)/ABS(H-RHORH))+0.3*ALPHA1+ 80.*(FPARHR-
     2FEER)
      RETURN
    4 M(MM+1)=5
      MM=MM+1
      DTH=100.
      RETURN
      END
```

Appendix E

SUBROUTINES AERO1, AERO2, AERO3 LISTINGS

```
      SUBROUTINE AERO1
       DIMENSION M(10),PP(2000),RS(900),HS(900),RSFT(400),HSLD(400)
      COMMON W,WO,WE,RO,AREF,CLAR,ALPHA,ALPHA1,ALPL,V,VR,VH,Q,THR,FEED,
     1DCH,DT,H,DFEEC,Q4,AMACH,CMACH,R,RC,GPU,JCT,DFEEDD,DFEADD,LCT,TIT,
     2NTD,TIME,FEER,ALPHR,D,XLH,BAC,BAD,ITD,DTB,IKT,NB,RS,HS,RSFT,CL,CD,
     3HSLD,MCT,NCT,TM,AC,CMN,CLMN,DVMN,DMN,PT,PRI,TT,ASPEED,AMACH1,FISP,
     4THRS,THRB,T,CDO,CDI,CDA,CDAOFF,MM,M,PP,MGO,DTH,XLFEE,XLMN
     5,P,A,FISPB,FISPS
C    APPROXIMATE AERODYNAMICS FOR MISSILE X, ESP AT MACH 0.4-0.8.
  900 CN=0.05345*(ALPHA+5.2)**1.6091-0.9
      CA=(0.432-0.004077*(ABS(ALPHA-3.))**1.3)+(280.+1.9*(ABS(ALPHA-5.5)
     1)**3.)*(ABS(AMACH-0.4))**12.
      CDO=(0.432-0.004077*3.**1.3)+(280.+1.9*5.5**3.)*(ABS(AMACH-0.4))**
     112.
      CL      =CN*COS(ALPHA/57.3)-CA*SIN(ALPHA/57.3)
      CD      =CA*COS(ALPHA/57.3)+CN*SIN(ALPHA/57.3)
      IF(AMACH.GT.0.90.AND.AMACH.LT.1.10)CDO=0.8-10.67*(AMACH-1.05)**2
      IF(AMACH.GE.1.10)CDO=0.5+0.29*EXP(-1.6667*(AMACH-1.10))
      CLAR=15.88+0.3*ALPHA
      CDI=CD-CDO
      IF(AMACH.GT.0.9)CL=CLAR*ALPHR
      IF(AMACH.GT.0.9)CDI=0.0474*CL*CL
      RETURN
      END
```

```
      SUBROUTINE AERO2
       DIMENSION M(10),PP(2000),RS(900),HS(900),RSFT(400),HSLD(400)
      COMMON W,WO,WE,RO,AREF,CLAR,ALPHA,ALPHAI,ALPL,V,VR,VH,Q,THR,FEED,
     1DCH,DT,H,DFEEC,Q4,AMACH,CMACH,R,RC,GPU,JCT,DFEEDD,DFEADD,LCT,TIT,
     2NTD,TIME,FEER,ALPHR,D,XLH,BAC,BAD,ITD,DTB,IKT,NB,RS,HS,RSFT,CL,CD,
     3HSLD,MCT,NCT,TM,AC,CMN,CLMN,DVMN,DMN,PT,PRI,TT,ASPEED,AMACHI,FISP,
     4THRS,THRB,T,CDO,CDI,CDA,CDAOFF,MM,M,PP,MGO,DTH,XLFEE,XLMN
     5,P,A,FISPB,FISPS
C  AERODYNAMICS FOR MISSILE Y
  900 IF(AMACH.GT.2.2)GO TO 910
      IF(AMACH-1.)901,901,902
  901 CDO=0.16+2.3333333*(ABS(AMACH-0.7))**2.
      GO TO 909
  902 IF(AMACH-1.4)903,903,904
  903 CDO=0.49-1.92*(ABS(AMACH-1.25))**2.
      GO TO 909
  904 CDO=0.2+0.07783*(ABS(AMACH-3.))**2.455
  909 CDI=0.0034+0.00881*EXP(4.9231*(0.8-AMACH))*ABS(ALPHA)**
     1(2.1-0.6305*(ABS
     2(AMACH-1.8))**2.811)
      CL=3.3-0.589295*(17.5-ALPHA)**0.565
      GO TO 911
  910 CL=(0.19+0.01*ALPHA+0.0006759*(ABS(ALPHA))**4.869/1000.0)*EXP(-(0.
     1078+ 0.001785*(ABS(ALPHA-7.2))**2.302)*(AMACH-2.0))+0.12*ALPHA-0.1
      CD =.19+0.000421*(ABS(ALPHA))**2.664+(.055+0.0175*ALPHA-0.0018*AL
     1PHA*2.+0.0001*(ABS(ALPHA))**3.0)*EXP(-(0.531-0.00969*(ABS(ALPHA-4.
     25))**1.578)*(AMACH-2.2))
      CDO=0.19+0.055*EXP(-0.427*(AMACH-2.2))
      CDI=CD-CDO
  911 CLAR=CL/ALPHA*57.3
      IF(CLAR.LT.0.0)CLAR=20.
      RETURN
      END
```

```
      SUBROUTINE AERO3
       DIMENSION M(10),PP(2000),RS(900),HS(900),RSFT(400),HSLD(400),
     1XAMACH(21),CDOO(21),CDICLS(21)
      COMMON W,WO,WE,RO,AREF,CLAR,ALPHA,ALPHAI,ALPL,V,VR,VH,Q,THR,FEED,
     1DCH,DT,H,DFEEC,Q4,AMACH,CMACH,R,RC,GPU,JCT,DFEEDD,DFEADD,LCT,TIT,
     2NTD,TIME,FEER,ALPHR,D,XLH,BAC,BAD,ITD,DTB,IKT,NB,RS,HS,RSFT,CL,CD,
     3HSLD,MCT,NCT,TM,AC,CMN,CLMN,DVMN,DMN,PT,PRI,TT,ASPEED,AMACHI,FISP,
     4THRS,THRB,T,CDO,CDI,CDA,CDAOFF,MM,M,PP,MGO,DTH,XLFEE,XLMN
     5,P,A,FISPB,FISPS,NBSTR,NSUST,NAERO,BA
C    AERODYNAMICS FOR MISSILE Z
      TERPI(X,A,B) = B + (A - B) * X
      DATA XAMACH /
     1.0,.38,.7,.8,.86,.88,.9,.92,.96,1.,1.05,1.1,1.15,1.2,1.4,1.6,
     21.8,2.0,2.5,4. /
      DATA CDOO /
     1.326,.321,.31,.307,.307,.307,.307,.307,.307,.318,.391,.423,.435,
     2.44,.441,.413,.388,.37,.358,.327,.28 /
      DATA CDICLS/
     1.6,.6,.6,.6,.6,.6,.6,.6,.6,.6,.6,.6,.6,.6,.6,.6,.6,.6,.6,.6 /
  900 IF(AMACH.GT.XAMACH(1)) GO TO 9050
      IXU=2
      XXU=0.0
      GO TO 9065
 9050 DO 9055 IXU=2,22
      IF(AMACH.GE.XAMACH(IXU-1).AND.AMACH.LT.XAMACH(IXU)) GO TO 9060
 9055 CONTINUE
      IXU=22
      XXU=1.0
      GO TO 9065
 9060 XXU=(AMACH-XAMACH(IXU-1))/(XAMACH(IXU)-XAMACH(IXU-1))
 9065 CDO=TERPI(XXU,CDOO(IXU),CDOO(IXU-1))
      CDO=CDO*(1.+.00000203*H+0.219*(.00001*H)**2+0.0781*(.00001*H)**3)
      CDICL=TERPI(XXU,CDICLS(IXU),CDICLS(IXU-1))
      CLA=0.15
      CLAR=CLA*57.3
      AW=6.0
      CL=CLA*ALPHA
      CDI=CDICL*CL**2.0*AREF/AW
      RETURN
      END
```

Appendix F

SUBROUTINES BSTR1, BSTR2, BSTR3 LISTINGS

```
      SUBROUTINE BSTR1
       DIMENSION M(10),PP(2000),RS(900),HS(900),RSFT(400),HSLD(400)
      COMMON W,WO,WE,RO,AREF,CLAR,ALPHA,ALPHA1,ALPL,V,VR,VH,Q,THR,FEED,
     1DCH,DT,H,DFEEC,Q4,AMACH,CMACH,R,RC,GPU,JCT,DFEEDD,DFEADD,LCT,TIT,
     2NTD,TIME,FEER,ALPHR,D,XLH,BAC,BAD,ITD,DTB,IKT,NB,RS,HS,RSFT,CL,CD,
     3HSLD,MCT,NCT,TM,AC,CMN,CLMN,DVMN,DMN,PT,PRI,TT,ASPEED,AMACH1,FISP,
     4THRS,THRB,T,CDO,CDI,CDA,CDAOFF,MM,M,PP,MGO,DTH,XLFEE,XLMN
     5,P,A,FISPB,FISPS,NBSTR,NSUST,NAERO,BA
C    BOOSTER MOTOR X AT 70F
  790 IF(TIME.GT.2.535)IKT=IKT+1
      IF(IKT.EQ.1)W=W-EWB
      IF(IKT.EQ.1)THRB=0.
      IF(TIME-2.535)791,702,702
  791 IF(TIME.LT.0.04)THRB=350000.0*TIME
      IF(TIME.LT.0.04)GO TO 792
      IF(TIME.LT.0.7)THRB=4242.4*TIME+13830.
      IF(TIME.LT.0.7)GO TO 792
      IF(TIME.LT.1.32)THRB=17251.6-645.2*TIME
      IF(TIME.LT.1.32)GO TO 792
      IF(TIME.LT.2.42)THRB=22406.-4550.*TIME
      IF(TIME.LT.2.42)GO TO 792
      IF(TIME.LT.2.535)THRB=261215.2-103043.5*TIME
  792 FISPB=251.355
      DT=DTB
C    NO CHANGE IN CDO -- BOOSTER IN-LINE
      EWB=112.4
  702 RETURN
      END
```

```
      SUBROUTINE BSTR2
       DIMENSION M(10),PP(2000),RS(900),HS(900),RSFT(400),HSLD(400)
      COMMON W,WO,WE,RO,AREF,CLAR,ALPHA,ALPHA1,ALPL,V,VR,VH,Q,THR,FEED,
     1DCH,DT,H,DFEEC,Q4,AMACH,CMACH,R,RC,GPU,JCT,DFEEDD,DFEADD,LCT,TIT,
     2NTD,TIME,FEER,ALPHR,D,XLH,BAC,BAD,ITD,DTB,IKT,NB,RS,HS,RSFT,CL,CD,
     3HSLD,MCT,NCT,TM,AC,CMN,CLMN,DVMN,DMN,PT,PRI,TT,ASPEED,AMACH1,FISP,
     4THRS,THRB,T,CDO,CDI,CDA,CDAOFF,MM,M,PP,MGO,DTH,XLFEE,XLMN
     5,P,A,FISPB,FISPS,NBSTR,NSUST,NAERO
C  ROCKET BOOSTER Y AT 60 F  WO=688.  I=116,840.
  790 IF(TIME.GT.6.0000)IKT=IKT+1
      IF(IKT.EQ.1)W=W-EWB
      IF(IKT.EQ.1)THRB=0.0
      IF(TIME-6.0000)791,702,702
  791 IF(TIME.LT.0.08)THR=820000.0*TIME +2.
      IF(TIME.LT.0.08)GO TO 792
      IF(TIME.LT..875)THR=3030.3*TIME+40848.5
      IF(TIME.LT..875)GO TO 792
      IF(TIME.LT.2.13)THR=45940.-2788.8*TIME
      IF(TIME.LT.2.13)GO TO 792
      IF(TIME.LT.2.24)THR=233636.4-90909.1*TIME
      IF(TIME.LT.2.24)GO TO 792
      IF(TIME.LT.3.45)THR=80359.3-22481.8*TIME
      IF(TIME.LT.3.45   )GO TO 792
      IF(TIME.LT.6.)THR=5763.-859.7*TIME
  792 FISPB=232.286
      DT=DTB
      CDO=CDO+.3068/AREF*NB
      EWB=185.*NB
      THRB= NB*THR
  702 RETURN
      END
```

```
      SUBROUTINE BSTR3
C  BOOSTER Z AT 70F, WITH ALTITUDE CORRECTIONS.
       DIMENSION M(10),PP(2000),RS(900),HS(900),RSFT(400),HSLD(400)
      COMMON W,WO,WE,RO,AREF,CLAR,ALPHA,ALPHA1,ALPL,V,VR,VH,Q,THR,FEED,
     1DCH,DT,H,DFEEC,Q4,AMACH,CMACH,R,RC,GPU,JCT,DFEEDD,DFEADD,LCT,TIT,
     2NTD,TIME,FEER,ALPHR,D,XLH,BAC,BAD,ITD,DTB,IKT,NB,RS,HS,RSFT,CL,CD,
     3HSLD,MCT,NCT,TM,AC,CMN,CLMN,DVMN,DMN,PT,PRI,TT,ASPEED,AMACH1,FISP,
     4THRS,THRB,T,CDO,CDI,CDA,CDAOFF,MM,M,PP,MGO,DTH,XLFEE,XLMN
     5,P,A,FISPB,FISPS,NBSTR,NSUST,NAERO,BA
  790 IF(TIME.GT.11.52)IKT=IKT+1
      IF(IKT.EQ.1)W=W-EWB
      IF(IKT.EQ.1)THRB=0.0
      IF(TIME-11.52)791,702,702
  791 IF(TIME.LT.0.25)THRB=92000.*TIME
      IF(TIME.LT.0.25)GO TO 792
      IF(TIME.LT.11.2)THRB=365.2968*TIME+22909.
      IF(TIME.LT.11.2)GO TO 792
      IF(TIME.LT.11.52)THRB=972000.-84375.*TIME
  792 AUG=1.0675-.0675*EXP(-H/22400.)
      FISPB=255.99
      FISPB=AUG*FISPB
      DT=DTB
      THRB=AUG*THRB*NB
      CDO=CDO+NB*0.3/AREF
      EWB=344.*NB
  702 RETURN
      END
```

Appendix G

SUBROUTINES SUST1 THRU SUST4 LISTINGS

```
      SUBROUTINE SUSTI
       DIMENSION M(10),PP(2000),RS(900),HS(900),RSFT(400),HSLD(400)
       COMMON W,WO,WE,RO,AREF,CLAR,ALPHA,ALPHAI,ALPL,V,VR,VH,Q,THR,FEED,
     1DCH,DT,H,DFEEC,Q4,AMACH,CMACH,R,RC,GPU,JCT,DFEEDD,DFEADD,LCT,TIT,
     2NTD,TIME,FEER,ALPHR,D,XLH,BAC,BAD,ITD,DT3,IKT,NB,RS,HS,RSFT,CL,CD,
     3HSLD,MCT,NCT,TM,AC,CMN,CLMN,DVMN,DMN,PT,PRI,TT,ASPEED,AMACHI,FISP,
     4THRS,THRB,T,CDO,CDI,CDA,CDAOFF,MM,M,PP,MGO,DTH,XLFEE,XLMN
     5,P,A,FISPB,FISPS,NBSTR,NSUST,NAERO,BA
C   CURTISS-WRIGHT ETE  3 MAY 78  NORMAL SHOCK INLET  3 PERCENT DUCT LOSS
C   NO BYPASS  NO BLEED  THROTTLE ENGINE TO SUBCRITICAL
      PRI=0.97
      IF(W-WE)701,702,702
  701 THRS=0.
      GO TO 799
   37 FORMAT(' C-W ETE 3 MAY 78 NORMAL SHOCK INLET  3 PCNT DUCT LOSS')
  702 IF(AMACH-1.0)703,703,704
  703 DELTA=PT/14.696*PRI
      GO TO 705
  704 DELTA=PRI*PT/14.696/(1.0+1.16667*(AMACH**2.0-1.0))**2.5/(0.166667+
     10.83333/AMACH**2.0)**3.5
  705 THETA=TT/518.7
      IF(TT-550.0)706,706,707
  706 RPMMAX=(26960.+TT*3.2727273)/286.5
      GO TO 708
  707 RPMMAX=(26581.+TT*3.961538)/286.5
  708 MGO=M(MM)
      KTHRT=0
      GO TO (715,715,709,710,711,715,709,715,710,710),MGO
  709 DM=CMN
      GO TO 712
  710 IF(ITD)717,717,720
  717 DM=DVMN
      GO TO 712
  720 DM=0.0
      GO TO 712
  711 DM=DMN
  712 ASPEED=(ASPEED+5.*(DM-AMACH))-100.0*(AMACH-AMACHI)
      GO TO 716
  715 IF(M(MM+1).EQ.5)GO TO 717
      ASPEED=RPMMAX
      KTHRT=1
  716 IF(ASPEED.GT.RPMMAX)ASPEED=RPMMAX
      IF(ITD.GT.1)ASPEED=0.95*ASPEED
      IF(ASPEED.LT.80.0)ASPEED=80.0*SQRT(THETA)
      IF(AMACH.LT.0.4.OR.ASPEED.LT.80.1)GO TO 7169
      IF(KTHRT.LT.1)GO TO 7169
      AOAC=1.0
      IF(AMACH.LT.1.)AOAC=1.+1.15625*(1.-AMACH)
 7161 WDOTAC=-36.696+.09568*DELTA+0.9856624238*RSPEED-.00396340333*
     1RSPEED**2.0
```

SUSTI CONTINUED

```
     1RSPEED**2.0
      WDOT=WDOTAC*DELTA*TM/SQRT(THETA)
      AO=0.09132*WDOT/(RO*AMACH*SQRT(T))/144.0
      CAR=AO/AC/TM
      IF(CAR.LT.AOAC)GO TO 7169
      ASPEED=ASPEED*(1.-.85*(1.-AOAC/CAR))-.01
      RSPEED=ASPEED/SQRT(THETA)
      GO TO 7161
 7169 RSPEED=ASPEED/SQRT(THETA)
      IF(H.GT.20000.0)GO TO 718
      IF(AMACH-0.9)7170,7170,7171
 7170 AF=99.4+0.004420*H+(-271.56-0.000528*H)*AMACH
      BF=0.816085-0.00001081*H+(0.1930622+0.0000066981*H)*AMACH
      GO TO 7182
 7171 AF=-50.05+0.0118925*H+(-105.5-0.008775*H)*AMACH
      BF=0.7808925-0.00000905*H+(0.232165+0.000004743*H)*AMACH
      GO TO 7182
  718 IF(AMACH-1.5)7180,7180,7181
 7180 AF=226.84-0.001952*H+(-422.45+0.00707267*H)*AMACH
      BF=0.5228045+0.000003854*H+(0.500093-0.000008653*H)*AMACH
      GO TO 7182
 7181 AF=410.07-0.011113*H+(-536.2+0.01276*H)*AMACH
      BF=0.5226605+0.0000038616*H+(0.500189-0.0000086582*H)*AMACH
 7182 FDOTC=AF+BF*(ABS(RSPEED-54.11))**2.0
  719 FDOTA=TM*FDOTC*DELTA*SQRT(THETA)
      THRDEL=(48.89-5.549*(ABS(AMACH-0.9))**3.3547)*RSPEED-(3563.-523.1*
     1(ABS(AMACH-0.9))**2.5663)
      IF(AMACH.LT.0.9)THRDEL=(47.5+1.54444444*AMACH)*RSPEED-(3563.-523.1
     1*(ABS(AMACH-0.9))**2.5663)
  722 THR=TM*DELTA*THRDEL
      IF(THR.LT.0.0)THR=+1.0
      FISP=3600.*THR/FDOTA
      IF(FISP.LT.200.00)FISP=200.00
      TITT2=0.00003*(RSPEED+1585.04)**2.0-80.629
      TIT=TITT2*TT
      IF(AMACH.GT.1.)CDA=(1.517*(LOG(AMACH))**0.4)*(1.0-CAR)*AC*TM/AREF
      IF(CDA.LT.0.000001)CDA=0.0
      CDO=CDO+CDA
      XLFEE=CDA
      THRS=THR
      FISPS=FISP
  799 CDAOFF=(PT+P)*AC*66.0/SQRT(TT)/(1.0+0.2*AMACH**2.0)**3.0*SQRT(5.0*
     1((0.5*(PT+P)/P)**(.286)-1.0))*(V-A*SQRT(5.0*((0.5*(PT+P)/P)**(.286
     2)-1.0)))/32.174*TM/Q/AREF
      IF(THRS.GT.0.01)CDAOFF=0.0
C     END OF SUSTAINER DECK
      RETURN
      END
```

```
      SUBROUTINE SUST2
       DIMENSION M(10),PP(2000),RS(900),HS(900),RSFT(400),HSLD(400)
      COMMON W,WO,WE,RO,AREF,CLAR,ALPHA,ALPHAI,ALPL,V,VR,VH,Q,THR,FEED,
     1DCH,DT,H,DFEEC,Q4,AMACH,CMACH,R,RC,GPU,JCT,DFEEDD,DFEADD,LCT,TIT,
     2NTD,TIME,FEER,ALPHR,D,XLH,BAC,BAD,ITD,DTB,IKT,NB,RS,HS,RSFT,CL,CD,
     3HSLD,MCT,NCT,TM,AC,CMN,CLMN,DVMN,DMN,PT,PRI,TT,ASPEED,AMACHI,FISP,
     4THRS,THRB,T,CDO,CDI,CDA,CDAOFF,MM,M,PP,MGO,DTH,XLFEE,XLMN
     5,P,A,FISPB,FISPS
C    THE FOLLOWING FUNCTION IS A LINEAR INTERPOLATION
      TERPI(X,A,B) = B + (A - B) * X
C    THE FOLLOWING FUNCTION INTERPOLATES ALONG AN EXPONENTIAL DECAY (NON-LINEAR)

C    A IS VALUE OF HIGHER ORDINATE, B IS THE ABCISSA OF INTEREST BETWEEN C AND E

C    C IS THE LOWER ABCISSA VALUE, D IS THE  LOWER ORDINATE VALUE, AND E IS THE

C    HIGHER ABCISSA VALUE.
      TERP2(A,B,C,D,E)=A*EXP((B-C)*LOG(D/A)/(E-C))
C    PERFORMANCE OF J69-T406 TURBOJET ENGINE WITH FULL AFTERBURNER, 99 PCT
C    INLET RECOVERY AND 6 PCT INLET DISTORTION. STD DAY ONLY.   4 DEC 74.
      IF(W-WE)701,702,702
  701 THRS=0.
      GO TO 799
   37 FORMAT(' PERFORMANCE OF J69-T406 TURBOJET ENGINE WITH FULL AFTERBURN
     1RNER')
  702 MGO=M(MM)
      GO TO (715,708,709,710,711,715,715,715,710,710),MGO
  708 DM=CLMN
      GO TO 724
  709 DM=CMN
      GO TO 724
  710 IF(ITD)717,717,720
  717 DM=DVMN
      GO TO 724
  720 DM=0.0
      GO TO 724
  711 DM=DMN
  724 ASPEED=(ASPEED+(0.010*(DM-AMACH)-0.050*(AMACH-AMACHI)/DT)*(H+
     110000.0))*0.5+0.5*ASPEED
      IF(ASPEED.GT.100.0)ASPEED=100.0
      IF(ASPEED.LT.90.0)ASPEED=90.0
      GO TO 714
  715 ASPEED=100.0
  714 RSPEED=ASPEED*SQRT(518.688/TT)
      AAA=(ASPEED*221.5-19936.)/2214.
      THROT=ASPEED/100.
  713 IF(H.LT.20000.0)GO TO 719
      THR40=221.4+652.1*AMACH+195.2*AMACH**2-17.02*AMACH**3
      THR40T=2224.8-3199.9*AMACH+2429.5*AMACH**2.-478.94*AMACH**3.
      SFC40=2.0284+0.00601*AMACH-0.0253*AMACH**2+0.04085*AMACH**3
      SFC40T=1.746+0.9308*AMACH-0.6792*AMACH**2.+0.1839*AMACH**3.
      IF(ASPEED.LT.100.)THR40=TERPI(AAA,THR40,THR40T)
      IF(ASPEED.LT.100.)SFC40=TERPI(AAA,SFC40,SFC40T)
```

SUST2 CONTINUED

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 719 THR20=1443.3-295.4*AMACH+1327.2*AMACH**2-272.93*AMACH**3
     THR20T=1335.0-383.2*AMACH+955.5*AMACH**2.0-153.94*AMACH**3.
     SFC20=2.06+0.1905*AMACH-0.21593*AMACH**2+0.1074*AMACH**3
     SFC20T=2.186+0.21488*AMACH-0.1692*AMACH**2.+0.07522*AMACH**3.
     IF(ASPEED.LT.100.)THR20=TERP1(AAA,THR20,THR20T)
     IF(ASPEED.LT.100.)SFC20=TERP1(AAA,SFC20,SFC20T)
     IF(H.LT.20000.0)GO TO 718
     THR=TERP2(THR20,H,20000.0,THR40,40000.0)
     SFC=TERP2(SFC20,H,20000.0,SFC40,40000.0)
     GO TO 723
 718 THRSL=2710.4-681.6*AMACH+1994.6*AMACH**2-381.7*AMACH**3
     THRSLT=2862.1-3257.6*AMACH+4426.*AMACH**2.-1297.47*AMACH**3.
     SFCSL=2.079+0.50106*AMACH-0.4442*AMACH**2+0.17152*AMACH**3
     SFCSLT=2.055+1.5328*AMACH-1.5281*AMACH**2.+0.5237*AMACH**3.
     IF(ASPEED.LT.100.)THRSL=TERP1(AAA,THRSL,THRSLT)
     IF(ASPEED.LT.100.)SFCSL=TERP1(AAA,SFCSL,SFCSLT)
     THR=TERP2(THRSL,H,0,THR20,20000.0)
     SFC=TERP2(SFCSL,H,0.0,SFC20,20000.0)
 723 PRDUCT=0.9898
     IF(AMACH.GT.1.0)PRDUCT=(0.9898*(2.4*AMACH**2.0/(0.4*AMACH**2.0+2.0
    1))**3.5/(1.0+1.16666667*(AMACH**2.0-1.0))**2.5)/(1.0-0.075*(AMACH-
    21.0)**1.35)
     THR=THR*(1.0-(1.40+0.3903*(ABS(112.867-RSPEED))**4.0725 /1000000.0
    1)*(1.0-PRDUCT))
     DELTA=PT*PRDUCT/14.696
     THETA=SQRT(TT/518.7)
     FISPS=3600.0/SFC
     THRS=THR*TM
     WDOTAC=32.1-0.8382*(ABS(RSPEED*0.2215-24.5))**1.325
     TIT=TT*(1.0+0.0335*(ABS(RSPEED*0.2215-10.0))**1.739)+350.0
     WDOT=WDOTAC*DELTA*TM/SQRT(THETA)
     A0=0.09132*WDOT/(RO*AMACH*SQRT(T))/144.0
     CAR=A0/AC/TM
     CDA=0.0
     IF(AMACH.GT.1.0)CDA=(1.517*(LOG(AMACH))**0.4)*(1.0-CAR)*AC/AREF
     IF(CDA.LT.0.0)CDA=-0.001
     IF(CDA)725,716,716
 725 ASPEED=0.999*ASPEED
     GO TO 714
 716 CDO=CDO+CDA
 799 CDAOFF=(PT+P)*AC*66.0/SQRT(TT)/(1.0+0.2*AMACH**2.0)**3.0*SQRT(5.0*
    1((0.5*(PT+P)/P)**(.286)-1.0))*(V-A*SQRT(5.0*((0.5*(PT+P)/P)**(.286
    2)-1.0)))/32.174*TM/Q/AREF
     IF(THRS.GT.0.01)CDAOFF=0.0
C    END OF SUSTAINER PERFORMANCE DECK
     RETURN
     END
```

```
      SUBROUTINE SUST3
       DIMENSION M(10),PP(2000),RS(900),HS(900),RSFT(400),HSLD(400)
      COMMON W,WO,WE,RO,AREF,CLAR,ALPHA,ALPHAI,ALPL,V,VR,VH,Q,THR,FEED,
     1DCH,DT,H,DFEEC,Q4,AMACH,CMACH,R,RC,GPU,JCT,DFEEDD,DFEADD,LCT,TIT,
     2NTD,TIME,FEER,ALPHR,D,XLH,BAC,BAD,ITD,DTB,IKT,NB,RS,HS,RSFT,CL,CD,
     3HSLD,MCT,NCT,TM,AC,CMN,CLMN,DVMN,DMN,PT,PRI,TT,ASPEED,AMACHI,FISP,
     4THRS,THRB,T,CDO,CDI,CDA,CDAOFF,MM,M,PP,MGO,DTH,XLFEE,XLMN
     5,P,A,FISPB,FISPS,NBSTR,NSUST,NAERO,BA
C    CONSTANT THRUST ROCKET MOTOR WITH 232.9 ISP, 19622 IMPULSE, AND 380 POUNDS
C    THRUST.  THRUST MULTIPLIER MAY BE USED TO CHANGE THRUST AND CORRESPONDING
C    BURN TIME WHILE MAINTAINING TOTAL IMPULSE.
  702 THRS=0.0
      IF(MGO.EQ.3.OR.MGO.EQ.8)JCT=JCT+1
      IF(JCT.EQ.1)TIGN=TIME
      IF(JCT.LT.1)GO TO 799
      THRS=380.*TM
      IF((TIME-TIGN).GT.(19622./THRS))THRS=0.0
      FISPS=232.9
  799 CDAOFF=0.01/AREF/AMACH
      IF(THRS.GT.1.)CDAOFF=0.0
      CDO=CDO+.02*TM/AREF
      RETURN
      END
```

```
      SUBROUTINE SUST4
      DIMENSION M(10),PP(2000),RS(900),HS(900),RSFT(400),HSLD(400)
      COMMON W,WO,WE,RO,AREF,CLAR,ALPHA,ALPHAI,ALPL,V,VR,VH,Q,THR,FEED,
     1DCH,DT,H,DFEEC,Q4,AMACH,CMACH,R,RC,GPU,JCT,DFEEDD,DFEADD,LCT,TIT,
     2NTD,TIME,FEER,ALPHR,D,XLH,BAC,BAD,ITD,DTB,IKT,NB,RS,HS,RSFT,CL,CD,
     3HSLD,MCT,NCT,TM,AC,CMN,CLMN,DVMN,DMN,PT,PRI,TT,ASPEED,AMACHI,FISP,
     4THRS,THRB,T,CDO,CDI,CDA,CDAOFF,MM,M,PP,MGO,DTH,XLFEE,XLMN
     5,P,A,FISPB,FISPS,NBSTR,NSUST,NAERO,BA
C   THE FOLLOWING FUNCTION IS A LINEAR INTERPOLATION
      TERPI(X,A,B) = B + (A - B) * X
C TELEDYNE CAE J402-CA-400 HARPOON ENGINE 21 JAN 75 GRB
   37 FORMAT(' J402-CA-400 MISSILE TURBOJET ENGINE (HARPOON)')
      IF(W-WE)701,702,702
  701 THRS=0.
      GO TO 799
  702 IF(AMACH-1.0)703,703,704
  703 DELTA=PT/14.696*PRI
      GO TO 705
  704 DELTA=PRI*PT/14.696/(1.0+1.16667*(AMACH**2.0-1.0))**2.5/(0.166667+
     10.83333/AMACH**2.0)**3.5
  705 THETA=TT/518.7
  713 RPMMAX=100.
      GO TO (715,715,709,710,711,715,709,715,710,710),MGO
  709 DM=CMN
      GO TO 712
  710 IF(ITD)717,717,720
  717 DM=DVMN
      GO TO 712
  720 DM=0.0
      GO TO 712
  711 DM=DMN
      IF(NTD.GT.0)DM=0.0
  712 ASPEED=(ASPEED+10.*(DM-AMACH))-500.0*(AMACH-AMACHI)
      GO TO 716
  715 ASPEED=RPMMAX
  716 IF(ASPEED.GT.RPMMAX)ASPEED=RPMMAX
      IF(ITD.GT.1)ASPEED=0.95*ASPEED
      IF(ASPEED.LT.80.0)ASPEED=80.0
      RSPEED=ASPEED/SQRT(THETA)
      CN=408.*RSPEED
      IF(RSPEED-100.)718,718,706
  706 RSPEED=100.0
  718 CN=408.*RSPEED
      ASPEED=RSPEED*SQRT(THETA)
      IF(AMACH-0.2)730,730,731
  730 CTHR1=  .7179E-4 -.9544264E-1*CN+ .48508175E-5*CN**2 -.5185561E-10
     1*CN**3
      CTHR2=  .8170E-4 -.7754703E-1*CN+ .38823050E-5*CN**2 -.3975332E-10
     1*CN**3
      FDOTC1= .3193E-3 -.2292694E-1*CN+ .82364066E-6*CN**2+ .5166617E-11
```

SUST4 CONTINUED

```
     1*CN**3
      FDOTC2= .2822E-3+ .4430061E-1*CN -.26297909E-5*CN**2+ .4934756E-10
     1*CN**3
      XXX=AMACH/0.2
      GO TO 721
  731 IF(AMACH-0.4)732,732,733
  732 CTHR1=  .8170E-4 -.7754703E-1*CN+ .38823050E-5*CN**2 -.3975332E-10
     1*CN**3
      FDOTC1= .2822E-3+ .4430061E-1*CN -.26297909E-5*CN**2+ .4934756E-10
     1*CN**3
      CTHR2=  .1757E-3 -.1035853E+0*CN+ .51447335E-5*CN**2 -.5556964E-10
     1*CN**3
      FDOTC2= .3668E-3 -.9836357E-2*CN+ .11748998E-6*CN**2+ .1445194E-10
     1*CN**3
      XXX=(AMACH-0.2)/0.2
      GO TO 721
  733 IF(AMACH-0.6)734,734,735
  734 CTHR1=  .1757E-3 -.1035853E+0*CN+ .51447335E-5*CN**2 -.5556964E-10
     1*CN**3
      FDOTC1= .3668E-3 -.9836357E-2*CN+ .11748998E-6*CN**2+ .1445194E-10
     1*CN**3
      CTHR2=  .2357E-3 -.1331252E+0*CN+ .66680686E-5*CN**2 -.7552624E-10
     1*CN**3
      FDOTC2= .5258E-3 -.1234748E+0*CN+ .60270536E-5*CN**2 -.6236748E-10
     1*CN**3
      XXX=(AMACH-0.4)/0.2
      GO TO 721
  735 IF(AMACH-0.8)736,736,737
  736 CTHR1=  .2357E-3 -.1331252E+0*CN+ .66680686E-5*CN**2 -.7552624E-10
     1*CN**3
      FDOTC1= .5258E-3 -.1234748E+0*CN+ .60270536E-5*CN**2 -.6236748E-10
     1*CN**3
      CTHR2=  .2324E-3 -.1313627E+0*CN+ .66043162E-5*CN**2 -.7526726E-10
     1*CN**3
      FDOTC2= .4769E-3 -.1739247E+0*CN+ .87405830E-5*CN**2 -.9883180E-10
     1*CN**3
      XXX=(AMACH-0.6)/0.2
      GO TO 721
  737 IF(AMACH-1.0)738,738,739
  738 CTHR1=  .2324E-3 -.1313627E+0*CN+ .66043162E-5*CN**2 -.7526726E-10
     1*CN**3
      FDOTC1= .4769E-3 -.1739247E+0*CN+ .87405830E-5*CN**2 -.9883180E-10
     1*CN**3
      CTHR2= -.1139E-4 -.1296110E+0*CN+ .65869443E-5*CN**2 -.7605028E-10
     1*CN**3
      FDOTC2= .9288E-4 -.1400073E+0*CN+ .69644416E-5*CN**2 -.7556360E-10
     1*CN**3
      XXX=(AMACH-0.8)/0.2
      GO TO 721
  739 IF(AMACH-1.1)740,740,741
```

SUST4 CONTINUED

```
  740 CTHR1= -.1139E-4 -.1296110E+0*CN+ .65869443E-5*CN**2 -.7605028E-10
     1*CN**3
      FDOTC1= .9288E-4 -.1400073E+0*CN+ .69644416E-5*CN**2 -.7556360E-10
     1*CN**3
      CTHR2= -.1198E-3 -.1314196E+0*CN+ .67603638E-5*CN**2 -.7934215E-10
     1*CN**3
      FDOTC2=-.1768E-3 -.9625581E-1*CN+ .45264029E-5*CN**2 -.4151616E-10
     1*CN**3
      XXX=(AMACH-1.0)/0.1
  721 CTHR=TERP1(XXX,CTHR2,CTHR1)
      FDOTC=TERP1(XXX,FDOTC2,FDOTC1)
      GO TO 742
  741 CTHR = -.1198E-3 -.1314196E+0*CN+ .67603638E-5*CN**2 -.7934215E-10
     1*CN**3
      FDOTC =-.1768E-3 -.9625581E-1*CN+ .45264029E-5*CN**2 -.4151616E-10
     1*CN**3
  742 THR=TM*DELTA*CTHR
      FDOTA=TM*FDOTC*DELTA*SQRT(THETA)
      IF(THR.LT.0.0)THR=+1.0
      IF(ITD.GT.10)THR=0.0
      IF(ITD.GT.10)FDOTA=0.001
      FISP=3600.*THR/FDOTA
      IF(FISP.LT.200.00)FISP=200.00
      TITT2=3.06+0.00594*(ABS(RSPEED-75.0))**1.71646
      TIT=TITT2*TT
      WDOTAC=10.02-0.0065*(106.0-RSPEED)**1.87272
      WDOT=WDOTAC*DELTA*TM/SQRT(THETA)
      AO=0.09132*WDOT/(RO*AMACH*SQRT(T))/144.0
      CAR=AO/AC/TM
      CDA=0.0
      IF(AMACH.GT.1.0)CDA=(1.517*(LOG(AMACH))**0.4)*(1.0-CAR)*AC/AREF
      IF(CDA.LT.0.000001)CDA=0.0
      CDO=CDO+CDA
      THROT=ASPEED
      THRS=THR
      FISPS=FISP
  799 CDAOFF=(PT+P)*AC*66.0/SQRT(TT)/(1.0+0.2*AMACH**2.0)**3.0*SQRT(5.0*
     1((0.5*(PT+P)/P)**(.286)-1.0))*(V-A*SQRT(5.0*((0.5*(PT+P)/P)**(.286
     2)-1.0)))/32.174*TM/Q/AREF
      IF(THRS.GT.0.01)CDAOFF=0.0
C     END OF SUSTAINER DECK
      RETURN
      END
```

Appendix H

ELEMENT REASSEMBLE LISTING

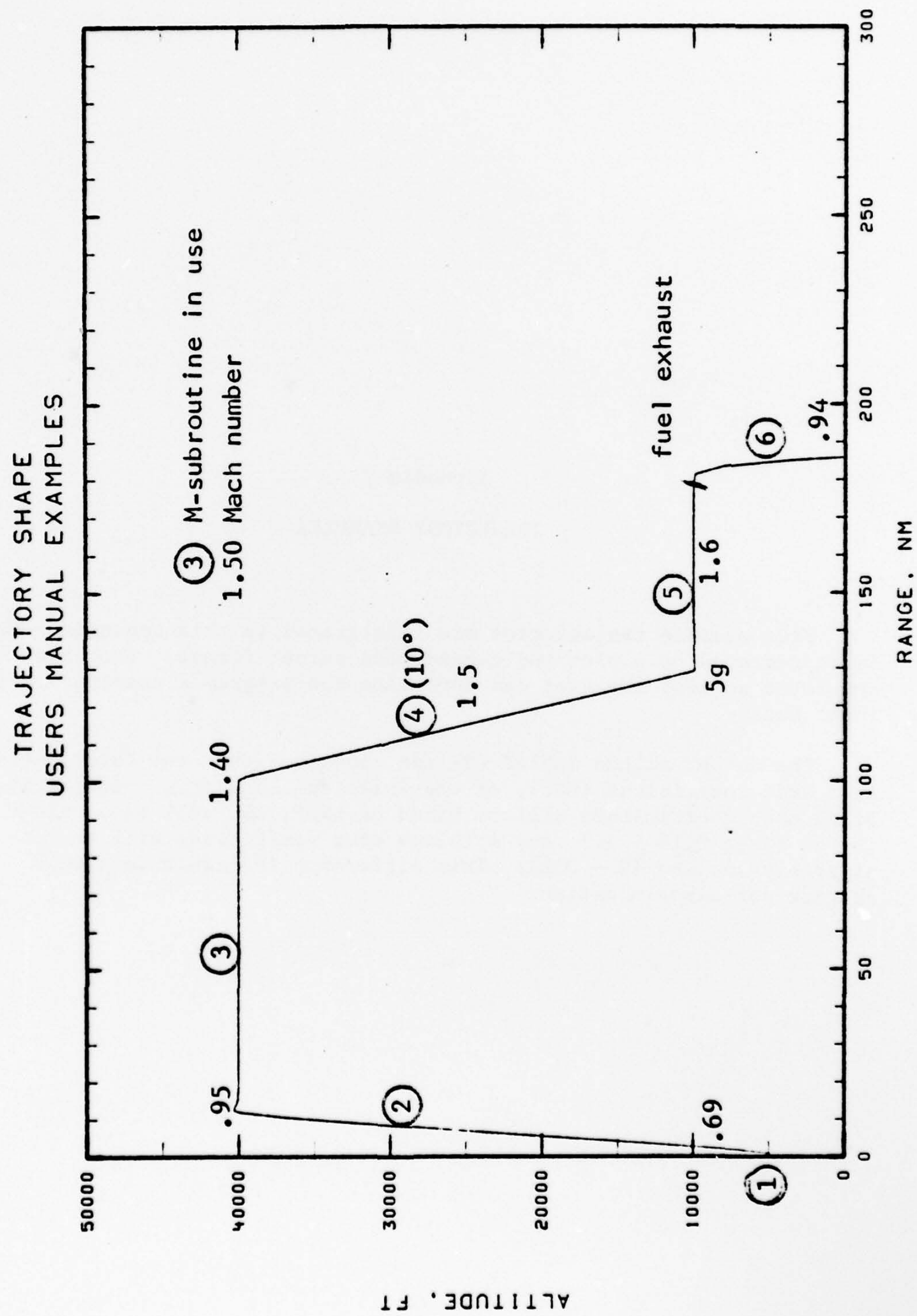
```
@MAP,I FLYIT*3.ASSEMBLER,FLYIT*3.EXECUTABLE
 IN FLYIT*3.
 LIB PLT*PLOT$LIBRARY.
 END
```

Appendix I

TRAJECTORY EXAMPLES

Five example trajectories are illustrated in this appendix. Each is represented by a plot and demand mode output format. Each plot is annotated so that the user can correlate the program's response to the input data.

The output column labled CDX can contain either the total zero-lift drag coefficient (CDO), or the inlet spillage drag coefficient. Since both coefficients will be based on AREF, CDO will be a number in the range 0.15 - 1.5, and spillage drag coefficient will be considerably smaller (0 - 0.1). This difference in magnitude should provide for discrimination.


TRAJECTORY SHAPE
USERS MANUAL EXAMPLES
③ M-subroutine in use
1.50 Mach number
ALTITUDE, FT
RANGE, NM
50000
40000
30000
20000
10000
0
50
100
150
200
250
300
①
.69
②
.95
③
1.40
④ (10°)
1.5
5g
⑤
1.6
fuel exhaust
⑥
.94

```
1234560000    0    0   15    0    1    5    0    0
1200. 900. 1.58  15.  .47 1.00  5.0 5.00  .00  .0
 30.0  .90 10.0-10.040.00 1.40 100. 10.0 1.5010.00 1.60
```

STANDARD ATMOSPHERE

TIME SEC.	ALT FT.	MACH NO	RANGE NM	WEIGHT LB	THRUST LB	DRAG LB	ALPHA DEG	L/D	FPA DEG	CDX	M
4.0	5000.	.13	.0	1198.4	1264.1	7.	.0	.0	.0	.23	1
8.0	5000.	.25	.2	1196.7	1222.6	26.	.0	.0	.0	.22	1
12.0	5000.	.36	.4	1194.9	1211.0	56.	.0	.0	.0	.22	1
TAKE-OFF ROLL REQUIRED 3797. FEET.											
17.3	4988.	.50	.8	1192.5	1230.9	532.	15.0	4.0	1.3	.22	2
27.3	7008.	.60	1.7	1187.7	1215.6	214.	5.2	4.7	29.8	.22	2
37.3	10529.	.70	2.7	1183.0	1161.0	226.	4.1	4.2	30.0	.22	2
47.3	14509.	.79	3.9	1178.7	1096.1	240.	3.8	4.0	30.0	.23	2
57.3	18841.	.86	5.1	1174.7	1017.1	244.	3.8	3.9	30.0	.23	2
67.3	23417.	.91	6.4	1171.0	922.7	237.	4.1	4.0	30.0	.24	2
77.3	28117.	[illegible]	7.8	1167.8	814.2	235.	4.7	4.0	30.0	.25	2
87.3	32677.	.95	9.1	1165.0	706.3	230.	5.6	4.1	28.5	.27	2
97.3	36966.	.93	10.5	1162.6	600.6	208.	7.1	4.5	27.2	.26	2
107.3	39926.	.95	11.9	1160.6	517.3	109.	.0	.0	9.6	.28	2
111.3	40292.	.98	12.5	1159.9	523.4	147.	.0	.0	1.7	.35	3
115.3	40228.	1.01	13.1	1159.1	526.4	368.	8.7	3.1	-1.8	.00	3
127.3	40036.	1.06	15.1	1156.8	547.2	407.	7.8	2.7	-.3	.00	3
147.3	40002.	1.15	18.6	1152.6	585.5	441.	6.5	2.5	-.0	.01	3
167.3	40000.	1.23	22.4	1148.1	622.1	468.	5.6	2.3	-.0	.01	3
187.3	40000.	1.32	26.5	1143.4	660.0	500.	4.9	2.2	-.0	.01	3
207.3	40000.	1.40	30.8	1138.4	627.5	537.	4.3	2.0	-.0	.01	3
227.3	40000.	1.41	35.3	1134.3	519.5	543.	4.3	2.0	-.0	.01	3
247.3	40000.	1.40	39.8	1130.6	521.9	536.	4.3	2.0	.0	.01	3
267.3	40000.	1.40	44.2	1126.8	540.2	534.	4.3	2.0	.0	.01	3
287.3	40000.	1.40	48.7	1122.9	538.8	535.	4.3	2.0	-.0	.01	3
307.3	40000.	1.40	53.2	1119.0	534.6	534.	4.3	2.0	-.0	.01	3
327.3	40000.	1.40	57.6	1115.2	533.9	533.	4.3	2.0	-.0	.01	3
347.3	40000.	1.40	62.1	1111.3	533.7	532.	4.3	2.0	-.0	.01	3
367.3	40000.	1.40	66.5	1107.5	532.9	531.	4.2	2.0	-.0	.01	3
387.3	40000.	1.40	71.0	1103.6	532.0	531.	4.2	2.0	-.0	.01	3
407.3	40000.	1.40	75.5	1099.8	531.2	530.	4.2	2.0	-.0	.01	3
427.3	40000.	1.40	79.9	1096.0	530.4	529.	4.2	2.0	-.0	.01	3
447.3	40000.	1.40	84.4	1092.1	529.7	528.	4.2	2.0	-.0	.01	3
467.3	40000.	1.40	88.9	1088.3	528.9	527.	4.2	2.0	-.0	.01	3
487.3	40000.	1.40	93.3	1084.5	528.1	527.	4.2	2.0	-.0	.01	3
507.3	40000.	1.40	97.8	1080.7	527.3	526.	4.1	2.0	-.0	.01	3
519.3	39939.	1.41	100.5	1078.4	699.3	424.	.0	.0	-2.6	.01	4
523.3	39424.	1.46	101.4	1077.3	732.5	457.	.0	.0	-7.9	.01	4
527.3	38476.	1.51	102.3	1076.2	710.0	589.	3.2	1.7	-10.0	.01	4
547.3	33280.	1.53	107.1	1072.3	459.0	708.	2.6	1.5	-10.0	.01	4
567.3	28125.	1.49	112.0	1068.1	675.1	814.	2.1	1.3	-10.0	.01	4
587.3	22898.	1.49	116.8	1062.2	859.1	984.	1.7	1.0	-10.0	.01	4
607.3	17547.	1.49	121.8	1054.7	1063.2	1193.	1.3	.8	-10.0	.01	4
627.3	12081.	1.49	126.9	1045.1	1316.2	1444.	1.1	.7	-10.0	.01	4
635.2	10018.	1.48	129.0	1040.4	1782.0	2162.	5.0	2.3	-3.9	.01	5
637.2	9943.	1.48	129.5	1038.8	1810.8	1605.	1.5	.9	.0	.01	5
640.4	9966.	1.50	130.3	1036.3	1826.5	1608.	.9	.6	.3	.01	5
650.4	9996.	1.55	133.0	1028.4	1857.7	1704.	.9	.6	.0	.01	5
660.4	10000.	1.59	135.8	1020.4	1860.3	1770.	.8	.6	.0	.01	5
670.4	10000.	1.60	138.7	1012.6	1791.2	1790.	.8	.6	.0	.01	5
680.4	10000.	1.60	141.5	1004.9	1786.2	1788.	.8	.5	.0	.01	5

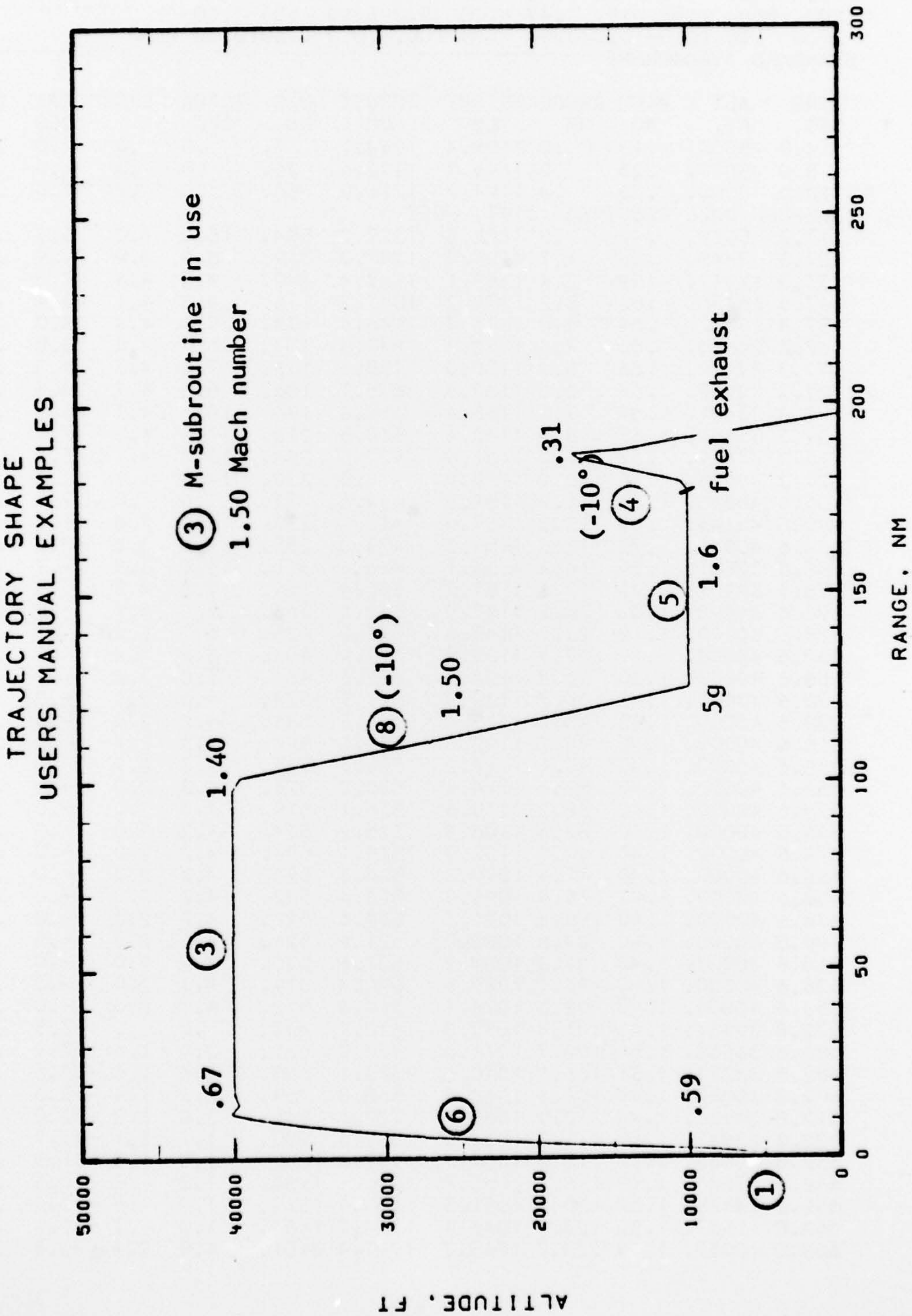
TIME	ALT	MACH	RANGE	WEIGHT	THRUST	DRAG	ALPHA	L/D	FPA	CDX	M
690.4	10000.	1.60	144.3	997.3	1787.6	1787.	.8	.5	.0	.01	5
700.4	10000.	1.60	147.2	989.7	1787.3	1787.	.8	.5	.0	.01	5
710.4	10000.	1.60	150.0	982.0	1786.9	1787.	.8	.5	.0	.01	5
720.4	10000.	1.60	152.9	974.4	1786.6	1786.	.8	.5	.0	.01	5
730.4	10000.	1.60	155.7	966.8	1786.3	1786.	.8	.5	.0	.01	5
740.4	10000.	1.60	158.5	959.1	1786.0	1786.	.8	.5	.0	.01	5
750.4	10000.	1.60	161.4	951.5	1785.7	1786.	.8	.5	.0	.01	5
760.4	10000.	1.60	164.2	943.9	1785.3	1785.	.8	.5	.0	.01	5
770.4	10000.	1.60	167.0	936.3	1785.0	1785.	.7	.5	.0	.01	5
780.4	10000.	1.60	169.9	928.6	1784.7	1785.	.7	.5	.0	.01	5
790.4	10000.	1.60	172.7	921.0	1784.4	1784.	.7	.5	.0	.01	5
800.4	10000.	1.60	175.5	913.4	1784.1	1784.	.7	.5	.0	.01	5
810.4	10000.	1.60	178.4	905.8	1783.8	1784.	.7	.5	.0	.01	5
820.4	9944.	1.47	181.2	899.9	.0	1752.	.0	.0	-2.1	.01	6
830.4	7999.	1.08	183.4	899.9	.0	972.	.0	.0	-15.9	.01	6
840.4	3701.	.96	185.0	899.9	.0	513.	.0	.0	-31.6	.01	6

```
S   S    S    SSSS  S        SSSSS  SSSSS  SSSSS  S   S  !
 S S    S S   S   S S        S   S  S   S  S       S S   !
  SSS   SSSSS SSSS  S        S   S  S   S  SSSS     S    !
 S S   S    S S   S S        S   S  S   S  S        S    !
S   S  S    S SSSS  SSSSS    SSSSS  SSSSS  SSSSS    S    0
```

846.4	0.	.94	185.9	899.9	.0	539.	.0	.0	-40.6	.01	6

IT HAS BEEN A PLEASURE SERVING YOU. I HOPE YOU ENJOY YOUR 1 FRAMES OF FR-80 UT.

>


TRAJECTORY SHAPE
USERS MANUAL EXAMPLES
(3) M-subroutine in use
1.50 Mach number
.67
(3)
1.40
(8) (-10°)
1.50
(6)
.59
(1)
5g
(5)
1.6
(-10°)
(4)
.31
fuel exhaust
ALTITUDE, FT
RANGE, NM
0
10000
20000
30000
40000
50000
0
50
100
150
200
250
300

1638540000 0 0 15 0 1 5 0 0
1200. 900. 1.58 15. .47 1.00 5.0 5.00 .00 .0
20.0 .90 10.0-10.040.00 1.40 100.-10.0 1.5010.00 1.60
STANDARD ATMOSPHERE

TIME SEC.	ALT FT.	MACH NO	RANGE NM	WEIGHT LB	THRUST LB	DRAG LB	ALPHA DEG	L/D	FPA DEG	CDX	M
4.0	5000.	.13	.0	1198.4	1264.1	7.	.0	.0	.0	.23	1
8.0	5000.	.25	.2	1196.7	1222.6	26.	.0	.0	.0	.22	1
12.0	5000.	.36	.4	1194.9	1211.0	56.	.0	.0	.0	.22	1
TAKE-OFF ROLL REQUIRED 3797. FEET.											
17.3	5059.	.49	.8	1192.5	1227.2	504.	15.0	4.0	6.3	.22	6
27.3	7449.	.55	1.7	1187.7	1247.3	319.	8.9	4.9	39.9	.22	6
37.3	11862.	.59	2.4	1183.1	1187.4	190.	4.5	4.3	47.6	.23	6
47.3	16465.	.62	3.2	1179.2	1067.2	176.	4.3	4.1	43.4	.23	6
57.3	20742.	.64	4.0	1175.7	946.6	173.	5.1	4.4	38.0	.24	6
67.3	24586.	.65	4.9	1172.7	840.5	174.	6.1	4.6	33.0	.25	6
77.3	27979.	.66	5.9	1170.0	750.6	178.	7.3	4.7	28.5	.25	6
87.3	30935.	.67	6.8	1167.6	675.7	186.	8.6	4.7	24.5	.26	6
97.3	33481.	.67	7.9	1165.4	614.0	196.	10.1	4.5	21.0	.26	6
107.3	35651.	.67	8.9	1163.4	563.5	210.	11.6	4.3	17.9	.26	6
117.3	37479.	.67	9.9	1161.6	522.5	224.	13.1	4.1	15.0	.26	6
127.3	38978.	.66	10.9	1159.9	478.0	239.	14.7	3.9	12.2	.27	6
136.6	40046.	.66	11.9	1158.5	444.5	53.	.0	.0	7.6	.27	3
140.6	40146.	.69	12.3	1157.9	430.0	239.	15.0	3.8	-1.3	.27	3
144.6	40061.	.72	12.8	1157.3	433.8	255.	15.0	3.8	-2.2	.27	3
158.6	39701.	.79	14.4	1155.1	456.6	311.	15.0	3.8	-.7	.26	3
178.6	39957.	.91	17.1	1151.7	502.6	229.	9.8	4.5	.4	.26	3
198.6	39998.	1.03	20.2	1147.9	541.6	366.	7.9	2.9	.0	.45	3
218.6	40000.	1.12	23.7	1143.8	576.2	425.	6.7	2.5	.0	.48	3
238.6	40000.	1.21	27.4	1139.5	612.9	454.	5.8	2.4	.0	.48	3
258.6	40000.	1.30	31.4	1134.7	652.6	486.	5.0	2.2	.0	.48	3
278.6	40000.	1.40	35.7	1129.8	641.9	524.	4.3	2.1	-.0	.48	3
298.6	40000.	1.42	40.2	1125.6	516.5	536.	4.2	2.0	-.0	.48	3
318.6	40000.	1.40	44.7	1122.0	509.0	528.	4.3	2.1	.0	.48	3
338.6	40000.	1.40	49.1	1118.2	530.6	525.	4.3	2.1	.0	.48	3
358.6	40000.	1.40	53.6	1114.4	530.8	526.	4.3	2.0	-.0	.48	3
378.6	40000.	1.40	58.0	1110.6	526.1	525.	4.3	2.0	-.0	.48	3
398.6	40000.	1.40	62.5	1106.8	525.2	524.	4.2	2.0	-.0	.48	3
418.6	40000.	1.40	67.0	1103.0	525.1	524.	4.2	2.0	-.0	.48	3
438.6	40000.	1.40	71.4	1099.3	524.3	523.	4.2	2.0	-.0	.48	3
458.6	40000.	1.40	75.9	1095.5	523.4	522.	4.2	2.0	-.0	.48	3
478.6	40000.	1.40	80.3	1091.7	522.6	521.	4.2	2.0	-.0	.48	3
498.6	40000.	1.40	84.8	1088.0	521.9	521.	4.2	2.0	-.0	.48	3
518.6	40000.	1.40	89.3	1084.2	521.1	520.	4.2	2.0	-.0	.48	3
538.6	40000.	1.40	93.7	1080.5	520.4	519.	4.1	2.0	-.0	.48	3
558.6	40000.	1.40	98.2	1076.7	519.6	518.	4.1	2.0	-.0	.48	3
572.8	39487.	1.45	101.4	1073.8	670.7	437.	.0	.0	-7.5	.48	8
582.8	36558.	1.54	103.7	1071.6	487.0	629.	2.9	1.6	-12.9	.47	8
592.8	33272.	1.51	106.1	1070.1	393.1	693.	2.6	1.5	-12.6	.46	8
602.8	30087.	1.49	108.5	1068.4	568.8	754.	2.3	1.4	-12.3	.46	8
612.8	26956.	1.49	110.9	1065.9	722.1	845.	2.0	1.2	-12.0	.46	8
622.8	23847.	1.50	113.3	1063.0	805.6	950.	1.7	1.1	-11.7	.45	8
632.8	20758.	1.50	115.8	1059.7	907.6	1060.	1.5	1.0	-11.5	.45	8
642.8	17686.	1.49	118.3	1055.9	1036.7	1182.	1.3	.9	-11.3	.44	8
652.8	14625.	1.50	120.8	1051.5	1175.2	1317.	1.2	.8	-11.2	.44	8
662.8	11567.	1.50	123.4	1046.4	1324.7	1464.	1.0	.7	-11.0	.43	8
668.0	10067.	1.49	124.7	1043.3	1797.4	2151.	4.9	2.4	-5.5	.43	5

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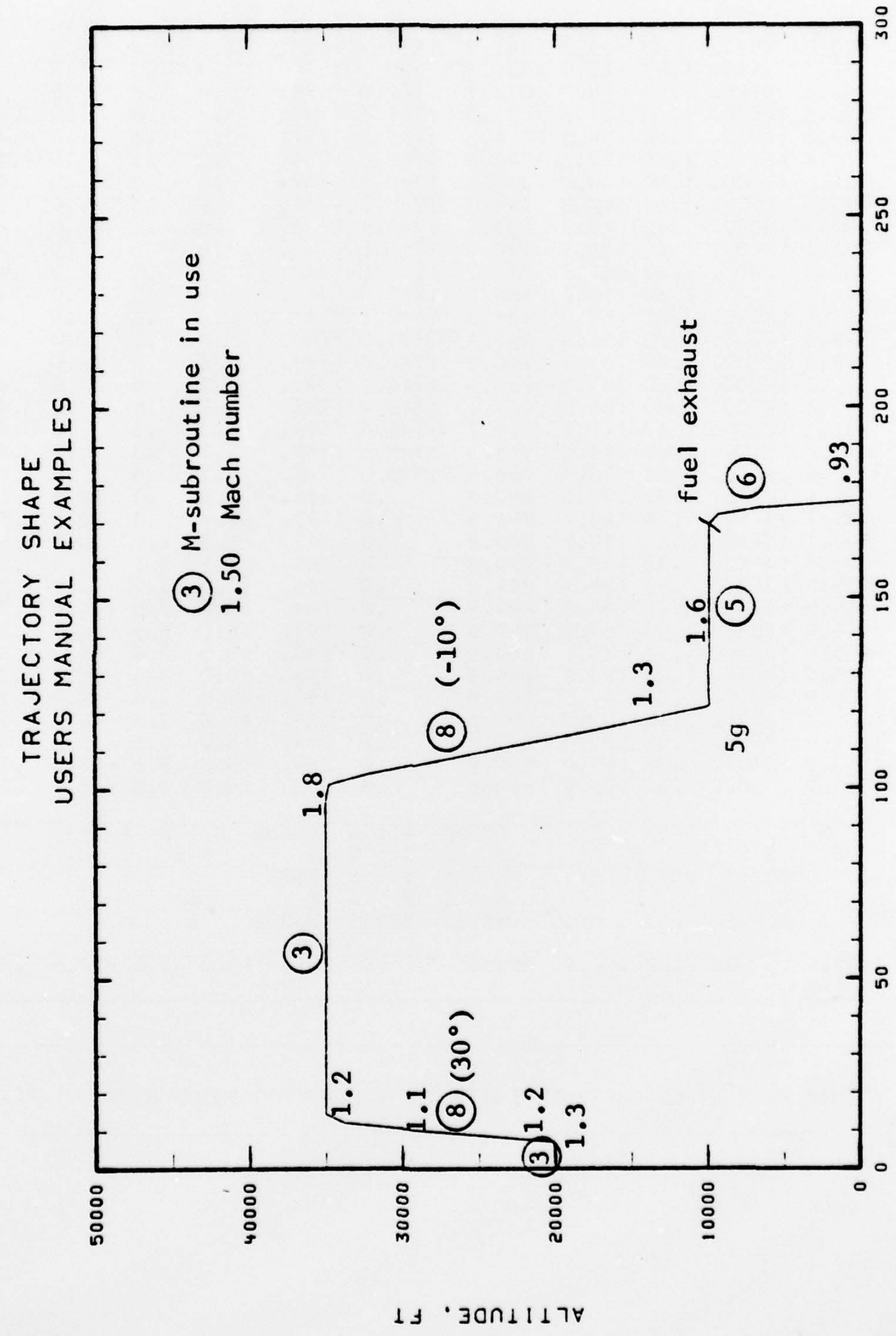
TIME	ALT	MACH	RANGE	WEIGHT	THRUST	DRAG	ALPHA	L/D	FPA	CDX	M
670.0	9947.	1.48	125.3	1041.7	1811.4	1606.	1.8	1.2	-.3	.43	5
672.6	9960.	1.50	125.9	1039.7	1827.1	1579.	.9	.6	.3	.43	5
682.6	9996.	1.56	128.7	1031.7	1862.6	1685.	.9	.6	.0	.42	5
692.6	10000.	1.60	131.5	1023.8	1791.6	1747.	.8	.6	.0	.42	5
702.6	10000.	1.60	134.3	1016.3	1745.8	1751.	.8	.6	.0	.42	5
712.6	10000.	[illegible]	137.1	1008.9	1748.6	1749.	.8	.6	.0	.42	5
722.6	10000.	1.60	140.0	1001.5	1749.1	1749.	.8	.6	.0	.42	5
732.6	10000.	1.60	142.8	994.0	1748.7	1749.	.8	.6	.0	.42	5
742.6	10000.	1.60	145.7	986.6	1748.4	1748.	.8	.6	.0	.42	5
752.6	10000.	1.60	148.5	979.1	1748.1	1748.	.8	.5	.0	.42	5
762.6	10000.	1.60	151.3	971.7	1747.8	1748.	.8	.5	.0	.42	5
772.6	10000.	1.60	154.2	964.3	1747.4	1747.	.8	.5	.0	.42	5
782.6	10000.	1.60	157.0	956.8	1747.1	1747.	.8	.5	.0	.42	5
792.6	10000.	1.60	159.8	949.4	1746.8	1747.	.8	.5	.0	.42	5
802.6	10000.	1.60	162.7	942.0	1746.5	1746.	.8	.5	.0	.42	5
812.6	10000.	1.60	165.5	934.5	1746.2	1746.	.7	.5	.0	.42	5
822.6	10000.	1.60	168.3	927.1	1745.9	1746.	.7	.5	.0	.42	5
832.6	10000.	1.60	171.2	919.7	1745.6	1745.	.7	.5	.0	.42	5
842.6	10000.	1.60	174.0	912.3	1745.3	1745.	.7	.5	.0	.42	5
852.6	10000.	1.60	176.9	904.8	1745.0	1745.	.7	.5	.0	.42	5
861.1	10473.	1.39	179.2	899.8	.0	1565.	.0	.0	12.4	.51	4
865.1	11490.	1.19	180.1	899.8	.0	1157.	1.4	.8	10.0	.52	4
869.1	12318.	1.04	180.9	899.8	.0	842.	1.9	1.1	10.0	.50	4
885.9	14992.	.72	183.4	899.8	.0	285.	4.2	3.1	10.0	.33	4
905.9	17147.	.46	185.4	899.8	.0	226.	11.2	3.9	10.0	.35	4
925.9	17497.	.31	186.6	899.8	.0	144.	15.0	3.6	-17.6	.36	4
945.9	14086.	.42	187.8	899.8	.0	297.	15.0	3.6	-22.0	.35	4
965.9	12219.	.36	189.1	899.8	.0	240.	15.0	3.6	-7.5	.35	4
985.9	10615.	.34	190.3	899.8	.0	226.	15.0	3.6	-18.1	.35	4
1005.9	8399.	.35	191.5	899.8	.0	257.	15.0	3.6	-14.0	.35	4
1025.9	6751.	.32	192.7	899.8	.0	232.	15.0	3.6	-14.1	.34	4
1045.9	4894.	.32	193.8	899.8	.0	244.	15.0	3.6	-15.4	.34	4
1065.9	3162.	.31	194.9	899.8	.0	239.	15.0	3.6	-14.2	.34	4
1085.9	1469.	.30	195.9	899.8	.0	240.	15.0	3.6	-15.1	.34	4

```
S   S     S    SSSS    S        SSSSS   SSSSS   SSSSS  S    S  !
S  S     S S   S   S   S        S    S  S    S  S        S S   !
SSS     SSSSS  SSSS    S        S    S  S    S  SSSS      S    !
S  S    S   S  S   S   S        S    S  S    S  S         S    !
S   S   S   S  SSSS    SSSSS    SSSSS   SSSSS   SSSSS     S    0
```

TIME	ALT	MACH	RANGE	WEIGHT	THRUST	DRAG	ALPHA	L/D	FPA	CDX	M
1103.4	0.	.29	196.9	899.8	.0	241.	15.0	3.6	-14.6	.34	4

IT HAS BEEN A PLEASURE SERVING YOU. I HOPE YOU ENJOY YOUR ! FRAMES OF FR-80
UT.
>

80


TRAJECTORY SHAPE
USERS MANUAL EXAMPLES
③ M-subroutine in use
1.50 Mach number
ALTITUDE, FT
RANGE, NM
50000
40000
30000
20000
10000
0
0
50
100
150
200
250
300
③
⑧ (30°)
1.1
1.2
1.2
1.3
③
1.8
⑧ (-10°)
1.3
5g
1.6
⑤
fuel exhaust
⑥
.93

18

2383856000 1 0 15 0 1 5 0 0
1200. 900. 1.58 15. .47 1.00 5.020.00 .80 .0
20.0 1.30 30.0-10.035.00 1.40 100. 10.0 1.3010.00 1.60
STANDARD ATMOSPHERE

TIME SEC.	ALT FT.	MACH NO	RANGE NM	WEIGHT LB	THRUST LB	DRAG LB	ALPHA DEG	L/D	FPA DEG	CDX	M
4.4	20010.	.88	.6	1198.4	980.4	260.3	4.6	4.3	-.1	.23	3
8.4	20006.	.95	1.2	1196.9	1027.4	310.1	3.9	3.6	-.0	.25	3
19.2	20002.	1.11	3.1	1192.3	1130.2	667.2	2.9	1.7	-.0	.00	3
38.0	20123.	1.23	7.0	1183.0	1245.3	3514.7	15.0	2.1	9.4	.02	8
48.0	24966.	1.13	8.8	1178.6	1018.6	607.4	2.9	1.6	27.1	.01	8
58.0	30063.	1.11	10.4	1175.0	862.7	424.4	.0	.0	26.2	.01	8
68.0	33792.	1.13	12.1	1172.0	765.5	364.5	.0	.0	13.0	.01	8
79.7	35004.	1.21	14.3	1168.6	767.8	645.2	6.7	2.5	-.5	.01	3
99.7	35001.	1.35	18.4	1162.5	840.1	587.7	3.8	1.9	.0	.01	3
119.7	35000.	1.49	22.9	1155.7	907.7	671.0	3.1	1.6	-.0	.01	3
139.7	35000.	1.61	27.9	1148.4	958.5	751.3	2.6	1.5	-.0	.01	3
159.7	35000.	1.72	33.2	1140.7	985.1	827.1	2.3	1.3	-.0	.01	3
179.7	35000.	1.79	38.9	1132.7	952.4	881.4	2.1	1.2	-.0	.01	3
199.7	35000.	1.80	44.6	1125.3	886.2	890.7	2.1	1.2	-.0	.01	3
219.7	35000.	1.80	50.4	1118.2	885.8	887.6	2.1	1.2	.0	.01	3
239.7	35000.	1.80	56.2	1111.1	887.3	886.5	2.0	1.2	.0	.01	3
259.7	35000.	1.80	61.9	1103.9	886.3	885.6	2.0	1.2	.0	.01	3
279.7	35000.	1.80	67.7	1096.8	885.3	884.8	2.0	1.2	.0	.01	3
299.7	35000.	1.80	73.5	1089.7	884.4	883.9	2.0	1.2	.0	.01	3
319.7	35000.	1.80	79.2	1082.5	883.5	883.0	2.0	1.2	.0	.01	3
339.7	35000.	1.80	85.0	1075.4	882.6	882.1	2.0	1.2	.0	.01	3
359.7	35000.	1.80	90.8	1068.3	881.8	881.2	2.0	1.2	.0	.01	3
379.7	35000.	1.80	96.5	1061.2	880.9	880.4	1.9	1.2	.0	.01	3
396.0	34790.	1.76	101.2	1056.2	368.8	785.6	.0	.0	-3.9	.01	8
406.0	32255.	1.63	103.9	1055.1	431.4	814.9	1.9	1.2	-11.9	.01	8
416.0	29002.	1.51	106.4	1053.9	235.9	824.2	2.1	1.2	-12.1	.01	8
426.0	25945.	1.40	108.7	1052.7	242.1	811.9	2.1	1.2	-12.1	.01	8
436.0	23081.	1.29	110.9	1051.5	419.8	779.1	2.2	1.3	-12.2	.01	8
446.0	20321.	1.28	113.0	1049.2	729.7	841.2	2.0	1.2	-12.0	.01	8
456.0	17569.	1.30	115.2	1046.1	814.9	946.8	1.7	1.1	-11.7	.01	8
466.0	14821.	1.30	117.4	1042.8	874.8	1043.5	1.5	1.0	-11.5	.01	8
476.0	12087.	1.30	119.6	1039.1	981.2	1141.9	1.4	.9	-11.4	.01	8
483.4	10096.	1.29	121.3	1035.8	1639.7	1970.0	6.4	2.5	-7.9	.01	5
485.4	9920.	1.29	121.7	1034.4	1653.2	1382.7	3.1	1.8	-.7	.01	5
487.4	9927.	1.31	122.2	1033.0	1678.8	1278.7	1.2	.8	.4	.01	5
495.8	9984.	1.40	124.2	1026.8	1751.1	1441.1	1.0	.7	.1	.01	5
505.8	9998.	1.48	126.8	1019.2	1809.1	1579.3	.9	.6	.0	.01	5
515.8	10000.	1.54	129.4	1011.3	1845.9	1683.3	.9	.6	.0	.01	5
525.8	10000.	1.58	132.2	1003.3	1867.4	1757.3	.8	.6	.0	.01	5
535.8	10000.	1.60	135.0	995.3	1832.4	1801.2	.8	.5	-.0	.01	5
545.8	10000.	1.60	137.8	987.5	1802.8	1805.4	.8	.5	-.0	.01	5
555.8	10000.	1.60	140.7	979.8	1803.6	1804.0	.8	.5	-.0	.01	5
565.8	10000.	1.60	143.5	972.1	1803.8	1803.6	.8	.5	-.0	.01	5
575.8	10000.	1.60	146.3	964.4	1803.5	1803.3	.8	.5	-.0	.01	5
585.8	10000.	1.60	149.2	956.7	1803.1	1803.0	.8	.5	-.0	.01	5
595.8	10000.	1.60	152.0	948.9	1802.8	1802.7	.8	.5	.0	.01	5
605.8	10000.	1.60	154.9	941.2	1802.5	1802.3	.8	.5	.0	.01	5
615.8	10000.	1.60	157.7	933.5	1802.2	1802.0	.7	.5	.0	.01	5
625.8	10000.	1.60	160.5	925.8	1801.9	1801.7	.7	.5	.0	.01	5
635.8	10000.	1.60	163.4	918.1	1801.6	1801.4	.7	.5	.0	.01	5

TIME	ALT	MACH	RANGE	WEIGHT	THRUST	DRAG	ALPHA	L/D	FPA	CDX	M
645.8	10000.	1.60	166.2	910.4	1801.3	1801.1	.7	.5	.0	.01	5
655.8	10000.	1.60	169.0	902.7	1801.0	1800.8	.7	.5	.0	.01	5
665.8	9435.	1.26	171.7	900.0	.0	1330.1	.0	.0	-7.5	.01	6
675.8	6447.	1.00	173.6	900.0	.0	745.0	.0	.0	-22.6	.01	6
685.8	1194.	.95	175.0	900.0	.0	516.9	.0	.0	-37.8	.01	6

```
S   S    S    SSSS  S      SSSSS  SSSSS  SSSSS  S   S  !
S  S    S S   S   S S      S   S  S   S  S       S S   !
SSS    SSSSS  SSSS  S      S   S  S   S  SSSS     S    !
S  S   S   S  S   S S      S   S  S   S  S        S    !
S   S  S   S  SSSS  SSSSS  SSSSS  SSSSS  SSSSS    S    0
```

687.5	0.	.93	175.3	900.0	.0	567.4	.0	.0	-40.6	.01	6

IT HAS BEEN A PLEASURE SERVING YOU. I HOPE YOU ENJOY YOUR 1 FRAMES OF FR-80
UT.

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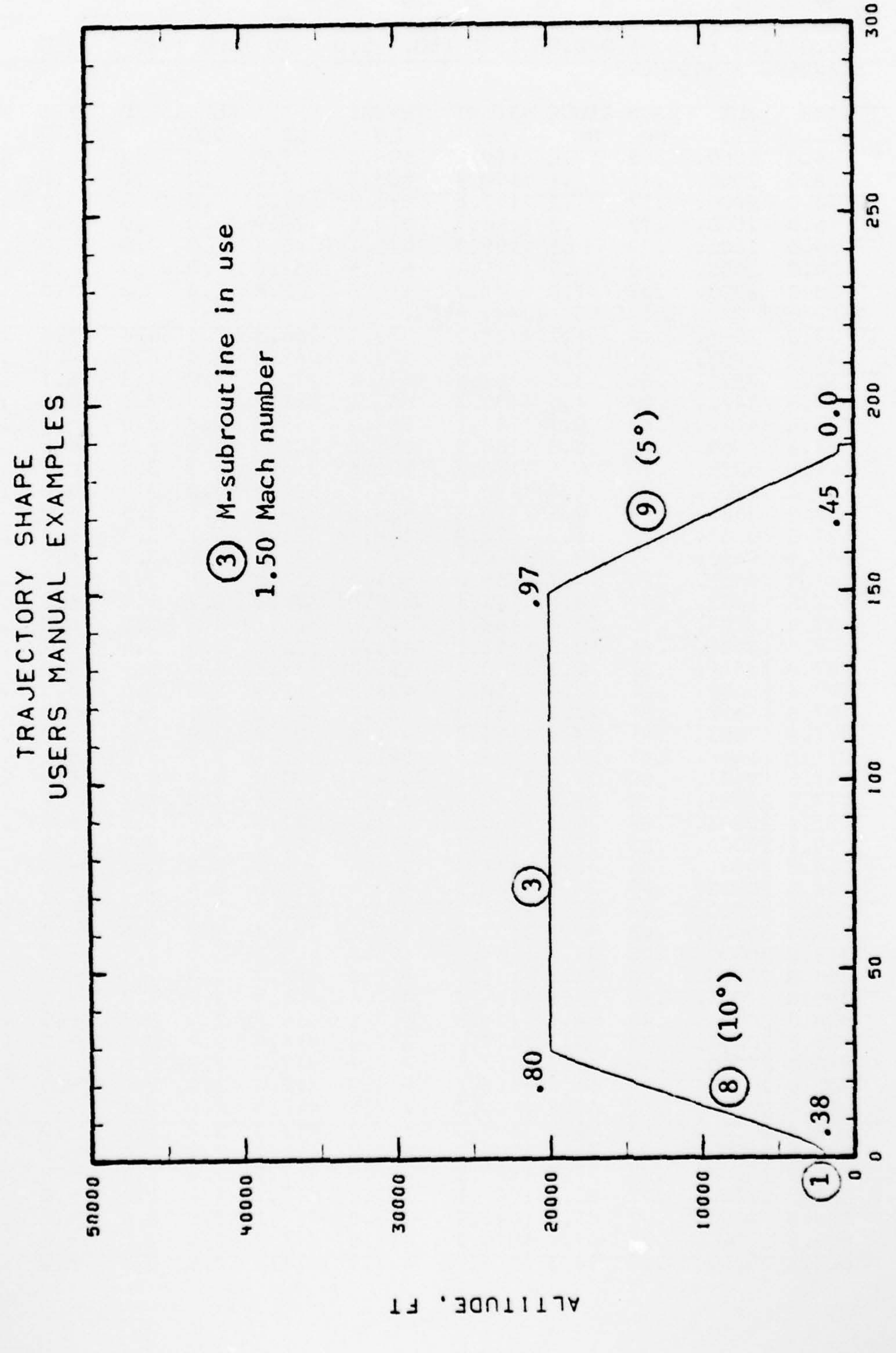
TRAJECTORY SHAPE
USERS MANUAL EXAMPLES
③ M-subroutine in use
1.50 Mach number
ALTITUDE, FT
RANGE, NM
0
10000
20000
30000
40000
50000
0
50
100
150
200
250
300
①
.38
⑧ (10°)
.80
③
.97
⑨ (5°)
.45
0.0

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1839000000    1    0   15    0   13    5    0    0
1200. 900. 2.00  15.  .47 1.00  5.0 2.00  .80   .0
 20.0 1.50 10.0 -5.020.00 1.70 150.  5.0  .40 1.00 1.50
```

STANDARD ATMOSPHERE

TIME SEC.	ALT FT.	MACH NO	RANGE NM	WEIGHT LB	THRUST LB	DRAG LB	ALPHA DEG	L/D	FPA DEG	CDX	M
4.0	2000.	.06	.0	1199.2	598.3	1.9	.0	.0	.0	.22	1
8.0	2000.	.11	.1	1198.4	586.3	7.8	.0	.0	.0	.22	1
12.0	2000.	.17	.2	1197.6	576.9	17.3	.0	.0	.0	.22	1
16.0	2000.	.22	.3	1196.7	572.5	29.9	.0	.0	.0	.22	1
20.0	2000.	.28	.5	1195.9	573.1	45.4	.0	.0	.0	.22	1
24.0	2000.	.33	.7	1195.1	571.5	63.6	.0	.0	.0	.22	1
28.0	2000.	.37	1.0	1194.2	570.8	83.8	.0	.0	.0	.22	1
TAKE-OFF ROLL REQUIRED 6044. FEET.											
37.8	2098.	.44	1.7	1192.0	572.0	266.5	7.6	4.4	2.5	.22	8
47.8	2403.	.50	2.6	1189.8	572.9	262.5	5.9	4.5	4.1	.22	8
57.8	2872.	.55	3.5	1187.6	571.7	270.1	4.9	4.3	5.1	.22	8
67.8	3473.	.59	4.6	1185.3	568.6	282.2	4.3	4.1	5.8	.22	8
77.8	4179.	.63	5.7	1183.1	564.9	295.0	3.8	3.9	6.2	.22	8
87.8	4969.	.67	6.8	1180.9	559.6	306.8	3.5	3.8	6.5	.22	8
97.8	5825.	.70	8.1	1178.6	552.6	316.5	3.3	3.6	6.7	.22	8
107.8	6733.	.72	9.3	1176.4	544.3	323.8	3.2	3.5	6.8	.22	8
117.8	7681.	.74	10.6	1174.3	534.8	328.7	3.1	3.5	6.9	.22	8
127.8	8657.	.76	11.9	1172.2	524.4	331.5	3.1	3.4	6.9	.22	8
137.8	9653.	.77	13.3	1170.1	513.1	332.3	3.1	3.4	6.9	.22	8
147.8	10661.	.78	14.7	1168.0	501.3	331.5	3.1	3.4	6.9	.22	3
157.8	11673.	.79	16.1	1166.1	489.0	329.3	3.2	3.4	6.8	.22	8
167.8	12684.	.80	17.4	1164.1	476.5	326.1	3.2	3.5	6.8	.22	8
177.8	13688.	.81	18.8	1162.2	463.9	322.0	3.3	3.5	6.7	.23	8
187.8	14681.	.81	20.2	1160.4	451.2	317.4	3.4	3.5	6.6	.23	8
197.8	15659.	.81	21.6	1158.7	438.5	312.4	3.5	3.6	6.5	.23	8
207.8	16617.	.81	23.0	1157.0	425.9	307.2	3.6	3.6	6.4	.23	8
217.8	17553.	.81	24.4	1155.3	411.5	301.8	3.8	3.7	6.2	.23	8
227.8	18461.	.81	25.8	1153.7	395.4	296.1	3.9	3.8	6.1	.23	8
237.8	19337.	.80	27.2	1152.2	379.7	290.4	4.1	3.8	5.9	.23	8
247.2	20005.	.81	28.5	1150.8	368.8	234.6	2.4	2.7	.1	.23	3
251.2	20003.	.82	29.0	1150.3	371.7	292.8	4.2	3.8	-.0	.23	3
255.2	20002.	.83	29.6	1149.7	374.6	295.2	4.1	3.8	-.0	.23	3
268.8	20001.	.86	31.5	1147.6	384.6	304.1	3.8	3.7	-.0	.23	3
288.8	20000.	.90	34.5	1144.5	400.4	319.0	3.4	3.5	-.0	.23	3
308.8	20000.	.94	37.7	1141.3	410.8	350.6	3.1	3.2	-.0	.24	3
328.8	20000.	.96	40.9	1137.9	416.2	394.4	3.0	2.8	-.0	.26	3
348.8	20000.	.96	44.2	1134.5	417.4	415.2	3.0	2.7	-.0	.28	3
368.8	20000.	.96	47.5	1131.1	417.6	416.7	3.0	2.7	-.0	.28	3
388.8	20000.	.96	50.8	1127.7	417.6	416.9	2.9	2.7	-.0	.28	3
408.8	20000.	.96	54.1	1124.3	417.6	416.9	2.9	2.6	-.0	.28	3
428.8	20000.	.96	57.4	1120.9	417.6	416.9	2.9	2.6	-.0	.28	3
448.8	20000.	.96	60.7	1117.5	417.7	417.0	2.9	2.6	-.0	.28	3
468.8	20000.	.97	64.0	1114.1	417.7	417.0	2.9	2.6	-.0	.28	3
488.8	20000.	.97	67.3	1110.7	417.7	417.0	2.9	2.6	-.0	.28	3
508.8	20000.	.97	70.5	1107.3	417.7	417.0	2.9	2.6	-.0	.28	3
528.8	20000.	.97	73.8	1103.9	417.7	417.1	2.9	2.6	-.0	.28	3
548.8	20000.	.97	77.1	1100.5	417.8	417.1	2.9	2.6	-.0	.28	3
568.8	20000.	.97	80.4	1097.1	417.8	417.1	2.9	2.6	-.0	.28	3
588.8	20000.	.97	83.7	1093.7	417.8	417.1	2.8	2.6	-.0	.28	3
608.8	20000.	.97	87.0	1090.3	417.8	417.2	2.8	2.6	-.0	.28	3
628.8	20000.	.97	90.3	1086.9	417.9	417.2	2.8	2.6	-.0	.28	3

TIME	ALT	MACH	RANGE	WEIGHT	THRUST	DRAG	ALPHA	L/D	FPA	CDX	M
648.8	20000.	.97	93.6	1083.5	417.9	417.2	2.8	2.5	-.0	.28	3
668.8	20000.	.97	96.9	1080.1	417.9	417.3	2.8	2.5	-.0	.28	3
688.8	20000.	.97	100.2	1076.7	417.9	417.3	2.8	2.5	-.0	.28	3
708.8	20000.	.97	103.5	1073.3	417.9	417.3	2.8	2.5	-.0	.28	3
728.8	20000.	.97	106.8	1069.9	418.0	417.3	2.8	2.5	-.0	.28	3
748.8	20000.	.97	110.1	1066.5	418.0	417.4	2.8	2.5	-.0	.28	3
768.8	20000.	.97	113.4	1063.1	418.0	417.4	2.8	2.5	-.0	.28	3
788.8	20000.	.97	116.7	1059.7	418.0	417.4	2.8	2.5	-.0	.28	3
808.8	20000.	.97	120.0	1056.3	418.1	417.4	2.7	2.5	-.0	.28	3
828.8	20000.	.97	123.3	1052.9	418.1	417.5	2.7	2.5	-.0	.28	3
848.8	20000.	.97	126.6	1049.5	418.1	417.5	2.7	2.5	-.0	.28	3
868.8	20000.	.97	129.9	1046.1	418.1	417.5	2.7	2.5	-.0	.28	3
888.8	20000.	.97	133.2	1042.6	418.1	417.5	2.7	2.4	-.0	.28	3
908.8	20000.	.97	136.5	1039.2	418.2	417.6	2.7	2.4	-.0	.28	3
928.8	20000.	.97	139.8	1035.8	418.2	417.6	2.7	2.4	-.0	.29	3
948.8	20000.	.97	143.1	1032.4	418.2	417.6	2.7	2.4	-.0	.29	3
968.8	20000.	.97	146.4	1029.0	418.2	417.6	2.7	2.4	-.0	.29	3
988.8	20000.	.97	149.7	1025.6	418.2	417.7	2.7	2.4	-.0	.29	3
1008.8	18660.	.90	152.8	1024.3	104.9	305.5	3.1	3.3	-5.0	.23	9
1028.8	17100.	.83	155.8	1023.4	107.5	286.9	3.4	3.5	-5.0	.23	9
1048.8	15645.	.77	158.5	1022.5	110.3	273.8	3.7	3.7	-5.0	.23	9
1068.8	14278.	.72	161.1	1021.6	113.3	263.8	4.0	3.8	-5.0	.23	9
1088.8	12982.	.68	163.5	1020.6	115.6	256.0	4.2	3.9	-5.0	.23	9
1108.8	11747.	.65	165.9	1019.6	117.2	249.9	4.4	4.0	-5.0	.23	9
1128.8	10564.	.62	168.1	1018.5	118.3	244.9	4.6	4.1	-5.0	.23	9
1148.8	9425.	.60	170.2	1017.4	119.4	240.8	4.8	4.2	-5.0	.22	9
1168.8	8325.	.58	172.3	1016.3	122.8	237.6	4.9	4.2	-5.0	.22	9
1188.8	7257.	.56	174.3	1015.1	125.4	235.2	5.0	4.3	-5.0	.22	9
1208.8	6215.	.54	176.3	1013.9	127.4	233.3	5.0	4.3	-5.0	.22	9
1228.8	5195.	.53	178.2	1012.6	129.0	231.8	5.1	4.3	-5.0	.22	9
1248.8	4194.	.52	180.1	1011.3	130.1	230.5	5.1	4.3	-5.0	.22	9
1268.8	3208.	.51	181.9	1009.9	131.0	229.5	5.1	4.3	-5.0	.22	9
1288.8	2236.	.50	183.7	1008.5	131.5	228.5	5.0	4.3	-5.0	.22	9
1307.6	1335.	.49	185.4	1007.1	131.8	246.3	5.5	4.4	-4.9	.22	9
1311.6	1174.	.49	185.8	1006.8	131.7	246.5	5.5	4.4	-3.5	.22	9
1315.6	1068.	.48	186.1	1006.5	133.8	245.3	5.6	4.5	-2.1	.22	9
1319.6	1015.	.47	186.5	1006.2	136.7	244.0	5.8	4.5	-.7	.22	9
1323.6	1007.	.46	186.8	1005.9	139.9	223.5	5.5	4.4	-.1	.22	9
1327.9	1006.	.45	187.2	1005.6	142.9	221.9	5.8	4.5	-.0	.22	9

TOUCHDOWN AT FLIGHT PATH ANGLE OF -.04 DEGREES

1345.3	1000.	.21	188.3	1005.0	.0	41.9	.0	.0	.0	.31	9

LANDING COMPLETED TO FULL STOP IN 7159. FEET FROM TOUCHDOWN

```
S   S    S    SSSS   S        SSSSS  SSSSS  SSSSS  S   S  !
S   S   S S   S   S  S        S   S  S   S  S        S S  !
SSS    SSSSS  SSSS   S        S   S  S   S  SSSS      S   !
S  S   S   S  S   S  S        S   S  S   S  S         S   !
S   S  S   S  SSSS   SSSSS    SSSSS  SSSSS  SSSSS     S   0
```

1359.8	0.	.01	188.6	1005.0	.0	.0	.0	.0	.0	.22	9

IT HAS BEEN A PLEASURE SERVING YOU. I HOPE YOU ENJOY YOUR 1 FRAMES OF FR-80 UT.

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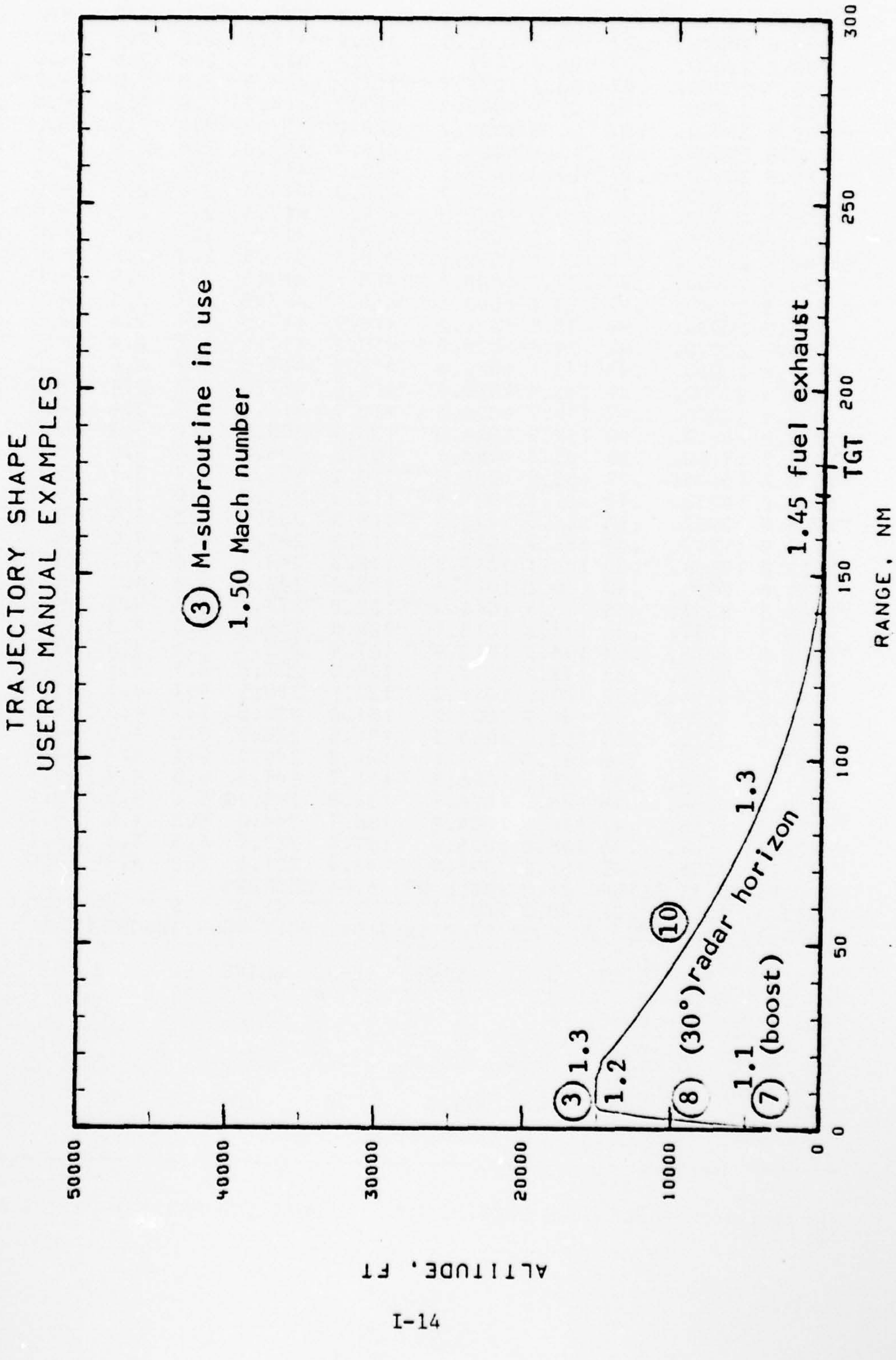
TRAJECTORY SHAPE
USERS MANUAL EXAMPLES
(3) M-subroutine in use
1.50 Mach number
1.45 fuel exhaust
TGT
(10) radar horizon
(8) (30°)
(7) (boost)
1.1
1.2
1.3
(3) 1.3
ALTITUDE, FT
RANGE, NM
0
10000
20000
30000
40000
50000
50
100
150
200
250
300

87

```
7831000000    1    0   15    6    1    5    0    0
1763. 900. 1.58  15.  .47 1.00 5.0 2.00  .00 40.0
 20.0  .90 30.0-10.015.00 1.40 180. 10.0 1.3010.00 1.60
STANDARD ATMOSPHERE
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TIME SEC.	ALT FT.	MACH NO	RANGE NM	WEIGHT LB	THRUST LB	DRAG LB	ALPHA DEG	L/D	FPA DEG	CDX	M
1.0	2043.	.23	.0	1707.2	13575.9	80.5	9.7	3.9	20.4	.36	8
2.0	2182.	.43	.1	1658.6	12105.7	222.9	7.1	3.8	22.9	.36	8
3.0	2419.	.62	.2	1614.8	11208.8	386.4	5.4	3.4	24.6	.35	8
4.0	2757.	.80	.3	1574.5	10591.9	556.7	4.1	2.9	26.0	.35	8
5.0	3194.	.97	.4	1537.5	9297.8	833.6	3.0	2.0	27.1	.39	8
6.0	3717.	1.07	.6	1513.7	4964.2	1425.0	2.3	1.1	27.7	.02	8
7.0	4277.	1.10	.8	1505.4	2439.1	1490.6	2.0	.9	28.0	.02	8
11.6	6891.	1.10	1.6	1396.1	1618.3	1056.1	1.8	1.1	28.2	.02	8
21.6	11922.	1.11	3.3	1389.8	1434.5	863.9	.0	.0	19.3	.02	8
31.6	14733.	1.16	5.3	1384.1	1364.4	844.1	.0	.0	6.6	.02	8
37.2	15045.	1.22	6.4	1380.9	1396.8	983.1	2.2	1.3	-.4	.02	3
41.2	15019.	1.25	7.3	1378.6	1425.3	1043.0	2.2	1.3	-.2	.02	3
48.8	15004.	1.31	9.0	1374.0	1475.4	1131.6	2.0	1.2	-.0	.03	3
68.8	15000.	1.40	13.7	1362.2	1327.8	1284.3	1.7	1.0	-.0	.03	3
88.8	14656.	1.39	18.6	1352.1	966.1	1629.1	4.6	2.1	-4.1	.03	10
108.8	13679.	1.30	23.3	1344.0	1072.1	1170.7	1.9	1.1	-1.8	.03	10
128.8	12827.	1.30	27.8	1334.9	1161.4	1188.8	1.8	1.1	-1.8	.03	10
148.8	11992.	1.30	32.4	1325.3	1194.1	1223.6	1.7	1.1	-1.7	.03	10
168.8	11183.	1.30	37.0	1315.3	1226.8	1256.0	1.7	1.0	-1.6	.03	10
188.8	10400.	1.30	41.5	1305.1	1260.1	1287.9	1.6	1.0	-1.6	.03	10
208.8	9644.	1.30	46.1	1294.5	1293.1	1319.6	1.6	1.0	-1.5	.03	10
228.8	8914.	1.30	50.8	1283.7	1325.6	1350.9	1.5	.9	-1.5	.03	10
248.8	8212.	1.30	55.4	1272.5	1357.6	1381.7	1.4	.9	-1.4	.03	10
268.8	7537.	1.30	60.0	1260.9	1389.1	1411.9	1.4	.9	-1.3	.03	10
288.8	6890.	1.30	64.7	1249.1	1419.9	1441.4	1.4	.8	-1.3	.03	10
308.8	6271.	1.30	69.3	1237.0	1449.9	1470.3	1.3	.8	-1.2	.03	10
328.8	5680.	1.30	74.0	1224.6	1479.1	1498.2	1.3	.8	-1.2	.03	10
348.8	5118.	1.30	78.7	1211.9	1507.4	1525.3	1.2	.8	-1.1	.03	10
368.8	4584.	1.30	83.4	1198.9	1534.7	1551.4	1.2	.8	-1.0	.03	10
388.8	4080.	1.30	88.1	1185.6	1560.9	1576.5	1.2	.7	-1.0	.03	10
408.8	3605.	1.30	92.8	1172.1	1586.0	1600.4	1.1	.7	-.9	.03	10
428.8	3159.	1.30	97.5	1158.4	1609.8	1623.2	1.1	.7	-.9	.03	10
448.8	2742.	1.30	102.2	1144.4	1632.5	1644.7	1.1	.7	-.8	.03	10
468.8	2355.	1.30	107.0	1130.2	1653.7	1664.9	1.0	.7	-.7	.03	10
488.8	1997.	1.30	111.7	1115.7	1673.6	1683.8	1.0	.6	-.7	.03	10
508.8	1670.	1.30	116.5	1101.1	1692.1	1701.2	1.0	.6	-.6	.03	10
528.8	1371.	1.30	121.2	1086.3	1709.1	1717.2	1.0	.6	-.6	.03	10
548.8	1102.	1.30	126.0	1071.3	1724.6	1731.7	.9	.6	-.5	.03	10
568.8	863.	1.30	130.7	1056.2	1738.5	1744.7	.9	.6	-.4	.03	10
588.8	654.	1.30	135.5	1041.0	1750.9	1756.1	.9	.6	-.4	.03	10
608.8	473.	1.30	140.2	1025.6	1761.6	1765.9	.9	.6	-.3	.03	10
628.8	322.	1.30	145.0	1010.1	1770.7	1774.2	.9	.6	-.3	.03	10
648.8	201.	1.30	149.8	994.5	1778.2	1780.8	.8	.5	-.2	.03	10
668.8	108.	1.30	154.6	978.9	1784.0	1785.8	.8	.5	-.2	.03	10
674.4	92.	1.31	155.9	974.3	2090.4	1821.7	.8	.5	.0	.03	5
680.6	98.	1.35	157.4	968.5	2130.8	1940.0	.7	.5	.0	.03	5
690.6	100.	1.40	159.9	958.9	2170.5	2068.4	.7	.5	.0	.03	5
700.6	100.	1.42	162.5	949.1	2191.1	2132.4	.7	.4	.0	.03	5
710.6	100.	1.43	165.2	939.2	2202.7	2169.1	.6	.4	-.0	.03	5
720.6	100.	1.44	167.8	929.3	2209.2	2190.1	.6	.4	-.0	.03	5

TIME	ALT	MACH	RANGE	WEIGHT	THRUST	DRAG	ALPHA	L/D	FPA	CDX	M
730.6	100.	1.45	170.4	919.4	2212.8	2202.0	.6	.4	-.0	.03	5
740.6	100.	1.45	173.1	909.5	2214.9	2208.7	.6	.4	-.0	.03	5
750.6	100.	1.44	175.8	899.8	.0	2388.4	.6	.4	-.0	.03	5
760.6	98.	.95	177.9	899.8	.0	676.4	1.4	1.3	.0	.03	5
770.6	99.	.77	179.5	899.8	.0	453.0	2.2	2.0	.0	.03	5

TARGET IMPACT AT 180. NM AND TIME 774.6

```
S   S    S    SSSS  S       SSSSS  SSSSS  SSSSS  S   S  !
 S S     S S  S   S S       S   S  S   S  S        S S  !
 SSS    SSSSS SSSS  S       S   S  S   S  SSSS      S   !
 S S    S   S S   S S       S   S  S   S  S         S   !
S   S  S   S  SSSS  SSSSS   SSSSS  SSSSS  SSSSS     S   0
```

TIME	ALT	MACH	RANGE	WEIGHT	THRUST	DRAG	ALPHA	L/D	FPA	CDX	M
774.6	0.	.72	44.9	899.8	.0	404.1	2.5	2.2	.0	.03	10

IT HAS BEEN A PLEASURE SERVING YOU. I HOPE YOU ENJOY YOUR 1 FRAMES OF FR-80 UT.

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