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ELLIPTICAL ORBIT PERFORMANCE COMPUTER PROGRAM

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ELLIPTICAL ORBIT-PERFORMANCE COMPUTER PROGRAM

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SUMMARY

This report describes and presents a FORTRAN coded computer program which generates and plots elliptical orbit performance capability of space boosters for presentation purposes. The program requires input data from a trajectory simulation which defines the booster's velocity capability as a function of insertion altitude and payload weight. The Elliptical Orbit Performance computer program manipulates the velocity-altitude-payload weight data to obtain apogee altitude-perigee altitude-payload weight data and generates a computer plot. Included in this report are program theory, user instructions, output definitions, subroutine descriptions and detailed FORTRAN coding information.

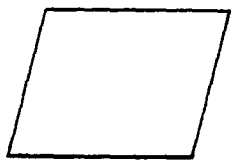
1.0 INTRODUCTION

A common method of presentation of orbital performance capability of space boosters is to show apogee and perigee altitude as a function of payload weight. Typically, apogee and perigee altitude data are calculated from parametric data of altitude and velocity at orbit insertion. The booster's velocity capability as a function of altitude and payload weight at orbit insertion are commonly calculated by a computer program which simulates the booster flight. Thus, based upon the parametric results of a trajectory program which simulates a specific space booster, the orbit insertion data can be manipulated to produce parametric data of apogee and perigee altitude as a function of payload weight. The mechanization of this manipulating process resulted in computer program Elliptical Orbit Performance (acronym ELOPE) and is described herein.

2.0 DEFINITIONS

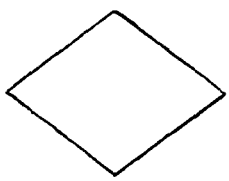
Flowchart conventions used in this report are as follows:

Process

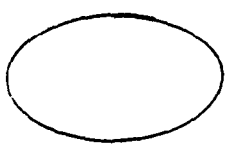


Input/Output

Subroutine



Decision



Subroutine Call

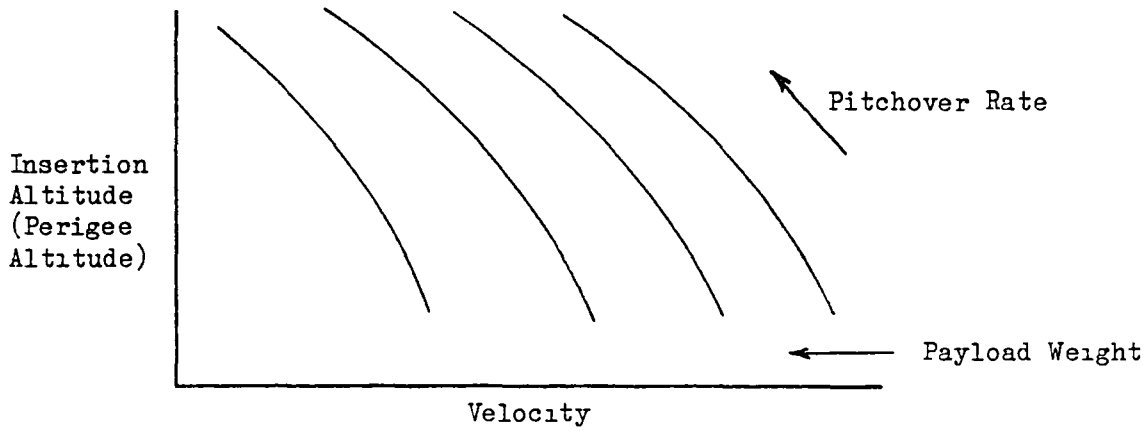
3.0 PROGRAM DESCRIPTION

This section describes program theory, input instructions and output definitions.

3.1 Program Theory

The purpose of computer program ELOPE is to calculate parametric data in apogee altitude, perigee altitude and payload weight and generate a computer plot. The technique used in ELOPE to obtain this plot includes interpolation of data and the solution of a two body energy equation.

Parametric data in altitude, velocity and payload weight at orbit insertion must be input to ELOPE. These data can be obtained by use of a trajectory program, such as NEMAR of Reference (1), which simulates booster flight. By calculating trajectories with various values of payload weight and vehicle pitchover rate, the data map depicted below can be obtained.



The above information is interpolated at the perigee altitudes of interest for each payload weight. Perigee is assumed to be at the point of insertion since insertion at perigee results in maximum vehicle performance and since orbiting vehicles commonly insert at perigee. The interpolated velocity-payload weight at each specific perigee is itself interpolated for the range of payloads weights defined by input. The resulting values of perigee velocities are converted to apogee altitudes by the following relationship:

$$h_a = \frac{2}{\frac{2}{r_p} - \frac{V_p^2}{GM}} - r_p - r_e$$

where r_p = perigee radius = $h_p + r_e$
V_p = perigee velocity
r_e = Earth radius
GM = Earth's gravitational constant
= $1.4076576 \times 10^{16} ft^3/sec^2$

The parametric orbital performance plot is defined by repeating the above described process for the range of perigee altitudes defined by input.

Following the payload weight calculation cycle for a specific perigee altitude, payload weights are calculated which correspond to circular and Earth escape orbits. Circular orbit velocity is obtained from:

$$V_c = \sqrt{\frac{GM}{r_p}}$$

Earth escape velocity is obtained from:

$$V_e = \sqrt{\frac{2GM}{r_p}}$$

The previously defined velocity-payload weight data are interpolated at the above two velocities to define the circular and escape payload weights.

When the payload weight is desired for a specific orbit, in lieu of parametric performance, the velocity-payload weight data is calculated for the perigee altitude of interest as previously described. The velocity required for the specific orbit is then calculated from:

$$V_p^2 = GM \left(\frac{2}{r_p} - \frac{1}{a}\right)$$

where a = semi-major axis = $\frac{r_a + r_p}{2}$

r_a = apogee radius = $h_a + r_e$

This perigee velocity is used to interpolate the velocity-payload weight data for the payload weight corresponding to the specific orbit.

3.2 User Instructions

ELOPE uses a modified FORTRAN NAMELIST for inputting data which provides the user with readability and simplicity of use.

The following rules apply to NAMELIST used by ELOPE:

1. First card of a data group or case is $INPUTD beginning in column 2. Blanks are not allowed.

2. Last card of a data group or case is $END beginning in column 2. Blanks are not allowed.

3. Blanks may not be used within names but may be used elsewhere.

4. Variable names are followed by an equal sign which is followed by a value which is followed by a comma, e.g., WEIGHT = 323.07,

5. Only columns 2-72, inclusive, are used.

6. Titling information may be input by the appropriate title names, e.g., TITLE1= ELLIPTICAL ORBIT PERFORMANCE - VAFB LAUNCH
TITLE1 must begin in column 2.

7. Any number of names and values may be on a single card or line.

8. Complete data arrays are input in the following form:
name = value, value, value, ...,
Data values may be continued on the next line, but the last character on every line must be a comma, excluding title cards.

9. Repeated data values may be input by using a repetition factor and an asterisk, e.g., V1 = 38050, 36525, 2*31510, 28450,

10. One or more specific elements of an array may be input, e.g., WEIGHT(3) = 200, 300,

Subsequent data cases are allowed by providing additional sets of NAMELIST data. All input data is retained for subsequent cases but can be changed by inputting new values.

A sample data case is included as Appendix A to exemplify data case setup.

Execution of ELOPE requires that the CalComp pen plotting facility be available to the computer job at the time of program load. This facility consists of the CalComp 763 pen plotter hardware and the CalComp Basic Software Package, Reference (2). ELOPE generates three plots per case if selected by input. A non-zero value of IPLOT results in plotting on graph paper which has a perforation size of 11 x 17 inches, a grid size of 9 7/8 x 15 inches and grid type of 10 divisions per centimeter. At the Vought installation, this paper is identified as CAL32. A non-zero value of LPLOT results in plotting on 4 cycle semi-log graph paper which has a perforation size of 11 x 8 1/2, a grid size of 10 x 7 and grid type of 2 1/2 inches per cycle and 10 divisions per inch. At the Vought installation, this paper is identified as CAL44. Additionally, this same data is plotted on no-grid paper and may be scaled down in size for use in vugraphs. This plot is placed on paper identified as CAL36 at the Vought installation.

Definitions of specific NAMELIST inputs to ELOPE are shown below. Default values are shown when they are set by the program prior to reading input data.

NAMELIST Input Definitions

ALTMAX	Maximum perigee altitude used for parametric output. Units according to IOPT. Use when IOPT = 1 or 2.
ALTMIN	Minimum perigee altitude used for parametric output. Units according to IOPT. Use when IOPT = 1 or 2.
APOGEE	Apogee altitude of single orbit case. Units according to IOPT. Use when IOPT = 3 or 4.
DELALT	Increment in perigee altitude for parametric output. Units according to IOPT. Use when IOPT = 1 or 2. Maximum number of altitude points is 50.
DELWT	Increment in payload weight for parametric output. Units according to IOPT. Use when IOPT = 1 or 2.
FACT	Ratio of plot size to normal plot size. When greater than zero but less than or equal to one, the semi-log graph is plotted on no-grid paper. This plot resides on local file name PLT3. (0. built-in)
IOPT	Output data option = 1 Input ALTMIN, ALTMAX, DELALT, WTMIN, WTMAX, DELWT and output parametric data in n.mi. and lbs. (1 built-in) = 2 Input ALTMIN, ALTMAX, DELALT, WTMIN, WTMAX, DELWT and output parametric data in km and kg. = 3 Input APOGEE, PERIGE and output single orbit only in n.mi. and lbs. = 4 Input APOGEE, PERIGE and output single orbit only in km and kg.
IPLOT	Non-zero value produces a CalComp plot of altitude as a function of velocity. Local file name of plot is PLT2. (0 built-in)
IPRNT	Output frequency control. Parametric data is calculated at DELWT intervals from WTMIN and printed at the IPRNT frequency. (1 built-in)
IRAD	Input data option = 1 Input R1 - R15 as radius in feet. (1 built-in) = 2 Input R1 - R15 as radius in n.mi. = 3 Input R1 - R15 as altitude in n.nm.
KASE	Case number.

LPLOT	Non-zero value produces a CalComp semi-log plot of apogee altitude as a function of perigee altitude and payload weight. Local file name of plot is PLOT. (0 built-in)
PERIGE	Perigee altitude of single orbit case. Units according to IOPT. Use when IOPT = 3 or 4.
PLABEL1 - PLABEL9	Labels placed on upper right side of apogee-perigee plot. Maximum of 30 characters each.
PTITLE1 - PTITLE4	Titles placed at top center of apogee-perigee plot. Maximum of 40 characters each.
REARTH	Earth radius used to calculate altitudes, ft. (20925741. built-in)
R1 - R15	Tables of radius or altitude (according to IRAD) for each WEIGHT. Input in increasing order. Minimum of 4 and maximum of 10 values per table. Enter 0. after last value of each table if less than 10 values are input. Minimum of 4 tables.
TITLE1	Title printed at top of each page. Maximum of 72 characters.
TITLE2	Title printed at top of each page. Maximum of 72 characters.
V1 - V15	Tables of inertial velocity in fps for each R1 - R15. Maximum of 10 values per table.
WEIGHT	Table of payload weights in lbs. Corresponding tables of radius and velocity must be input for each WEIGHT. Maximum of 15 values.
WTMAX	Maximum payload weight used for parametric output. Units according to IOPT. Input when IOPT = 1 or 2.
WTMIN	Minimum payload weight used for parametric output. Units according to IOPT. Input when IOPT = 1 or 2.
XINC	Increment value of x axis major divisions of apogee-perigee plot. Units according to IOPT. There are 7 major divisions on the x axis. (100. built-in)

3.3 Output Description

The NAMELIST input data is listed verbatim as read. This list provides a quick check of the input data for format correctness and validity. Additionally, the parametric data of weight, altitude and velocity are output in a different format than input for inspection purposes.

Subsequent pages provide parametric data of perigee altitude, apogee altitude and payload weight. For each perigee altitude, as defined by the input, apogee altitude is calculated at each payload weight increment from the minimum value to the maximum value. The resulting values, in both English and metric units, are output according to the value of the input IPRNT. Following the parametric data of each perigee, the payload weight corresponding to a circular orbit and to escape velocity are shown. A sample data case is included as Appendix A. The plots resulting from this data case are also included in Appendix A.

For single orbit cases, data for the specific orbit are shown in lieu of the payload-apogee altitude parametric data.

4.0 SUBROUTINE DESCRIPTIONS

This section provides a brief explanation of each subroutine of ELOPE.

4.1 ELOPE (Main Program)

The main program initializes the input data defaults; converts input data to internal units; calculates parametric data of apogee altitude, perigee altitude and payload weight; calculates payload weight at circular and escape velocities; writes parametric data on disk units 1 and 2 for subsequent plotting; calculates single orbit payload weights; and outputs the results.

4.2 INPUT

Subroutine INPUT reads input data in a modified NAMELIST format. Titling information on title cards are placed in appropriate arrays for use by the main program. Non-title cards are written on disk unit 8 for a FORTRAN NAMELIST read from the main program.

4.3 INTER

Subroutine INTER is a second-order interpolator of two variables. It selects the four closest data points to the desired value of the independent variable and interpolates or extrapolates for the value of the dependent variable.

4.4 PLOTLG

Subroutine PLOTLG produces a CalComp semi-log plot of apogee altitude as a function of perigee altitude and payload weight. The ordinate is fixed at a four cycle logarithm scale from 100 to 1,000,000 n.mi. or kilometers. The abcissa scale is determined by input data but is limited to seven major divisions in length. Plotted data is taken from disk units 1 and 2, which are written by the main program. The data plotted is scaled according to an input multiplier in order to decrease the physical size of the plot. This multiplier is one when plotting on grid paper.

4.5 PLOTLR

Subroutine PLOTLR produces a CalComp plot of insertion (perigee) altitude as a function of insertion velocity. These data are input values and are plotted for inspection purposes only. The ordinate is a fixed scale from 0 to 1200 nautical miles. The abcissa is a fixed scale from 18000 to 37000 feet per second. Also plotted on this graph are the circular and escape velocity lines.

5.0 PROGRAM CODING

This section presents details about the program coding. Included are flowcharts of each subroutine, FORTRAN listings of each subroutine and definitions of the FORTRAN variables. The information presented in this section is intended to be helpful in developing a thorough understanding of ELOPE and in making modifications to the program.

5.1 Subroutine Flowcharts

Flowcharts are presented in Figures 5.1 through 5.5. Flowchart conventions used in these figures are defined in Section 2.0 of this report.

5.2 FORTRAN Listings

ELOPE is coded in FORTRAN IV, Reference (3), on the CDC CYBER 175 computer with the NOS/BE 1.4 operating system. Listings of the FORTRAN coding are presented in Appendix B.

5.3 FORTRAN Variable Definition

Definitions of the FORTRAN variables are shown below. This information is usually used only when making modifications to the program.

Variable	Definition
A	Semi-major axis, n.mi.
ALTMAX	Input value
ALTMIN	Input value
APOGEE	Input value
DELALT	Input value
DELWT	Input valve
DH	Perigee altitude increment, n.mi.
DW	Payload weight increment, lb.
FACT	Input value

Variable	Definition
FTNM	Feet per n.mi., 6076.11549
GM	Earth's gravitational constant, 1.4076576 x 10^{16} ft^3/sec^2
H	Table of altitudes from R1 - R15, n.mi.
HA	Apogee altitude of single orbit case, n.mi.
HAMAX	Maximum apogee altitude plotted - 1,000,000 - n.mi. or km
HAMET	Apogee altitude, km
HF	Perigee altitude, n.mi.
HH	Table of perigee altitudes of parametric output, n.mi.
HHMET	Current perigee altitude, km
HMAX	Maximum perigee altitude of parametric output, n.mi.
HMIN	Minimum perigee altitude of parametric output, n.mi.
HNEW	Current perigee altitude, n.mi.
HP	Perigee altitude of single orbit case, n.mi.
HPMET	Perigee altitude, km
IOPT	Input value
IPAGE	Page number
IPLOT	Input value
IPRNT	Input value
IRAD	Input value
KASE	Case number
LABEL	Character data of information input via LABEL1 - LABEL9
LPLOT	Input value

Variable	Definition
NC	Tables of number of non-zero values in the R1 - R15 tables
NDIM	Number of permissable values in R1 - R15 and V1 - V15 tables, set to 10
NH	Number of perigee altitudes of parametric output
NNW	Number of payload weights of parametric output
NREC	Number of records of data written on disk unit 1
NWT	Number of non-zero values of the WEIGHT table
PERIGE	Input value
PL	Current payload weight, lb
PLM	Current payload weight, kg
R	Array of R1 - R15, input units
RBAR	Circular orbit radius, ft
RE	Earth radius, n.mi.
REARTH	Input value
RF	Perigee radius, ft
R1 - R15	Input values
TITLE	Character data of information input via PTITLE1 - PTITLE4
TITLE1	Input value
TITLE2	Input value
V	Array of V1 - V15, ft/sec
VEL	Current velocity, ft/sec
VELC	Circular orbit velocity, ft/sec
VELE	Escape orbit velocity, ft/sec

Variable	Definition
VI	Table of velocities at the current perigee altitude, ft/sec
VMAX	Velocity corresponding to an apogee of 1,000,000 - ft/sec
VV	Tables of velocities for each perigee altitude of paremetric output, ft/sec
V1 - V10	Input values
WEIGHT	Input value
WI	Table of payload weights at the current perigee altitude, lb
WMAX	Maximum payload weight of parametric output, lb
WMIN	Minimum payload weight of parametric output, lb
WNEW	Current payload weight of parametric output, lb
WTC	Circular orbit payload weight, lb
WTCMET	Circular orbit payload weight, kg
WTE	Escape orbit payload weight, lb
WTEMET	Escape orbit payload weight, kg
WTMAX	Input value
WTMIN	Input value
WW	Tables of payload weights for each perigee altitude of parametric output, lb
XINC	Input value
XKG	Kilograms per lb, 0.45359
XKM	Kilometers per n.mi., 1.852

Figure 5.1

FLOWCHART OF MAIN PROGRAM ELOPE

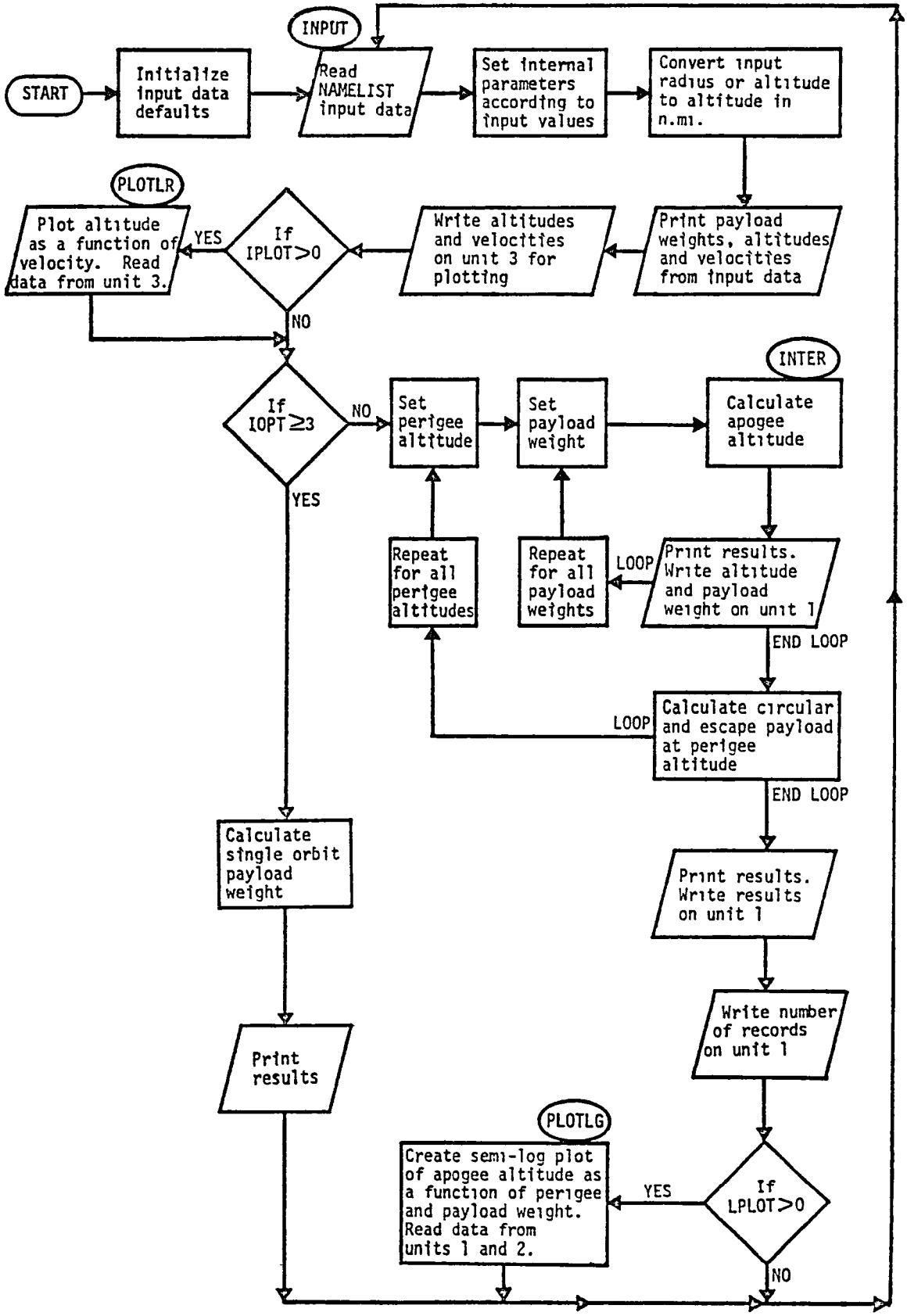


Figure 5.2

FLOWCHART OF SUBROUTINE INPUT

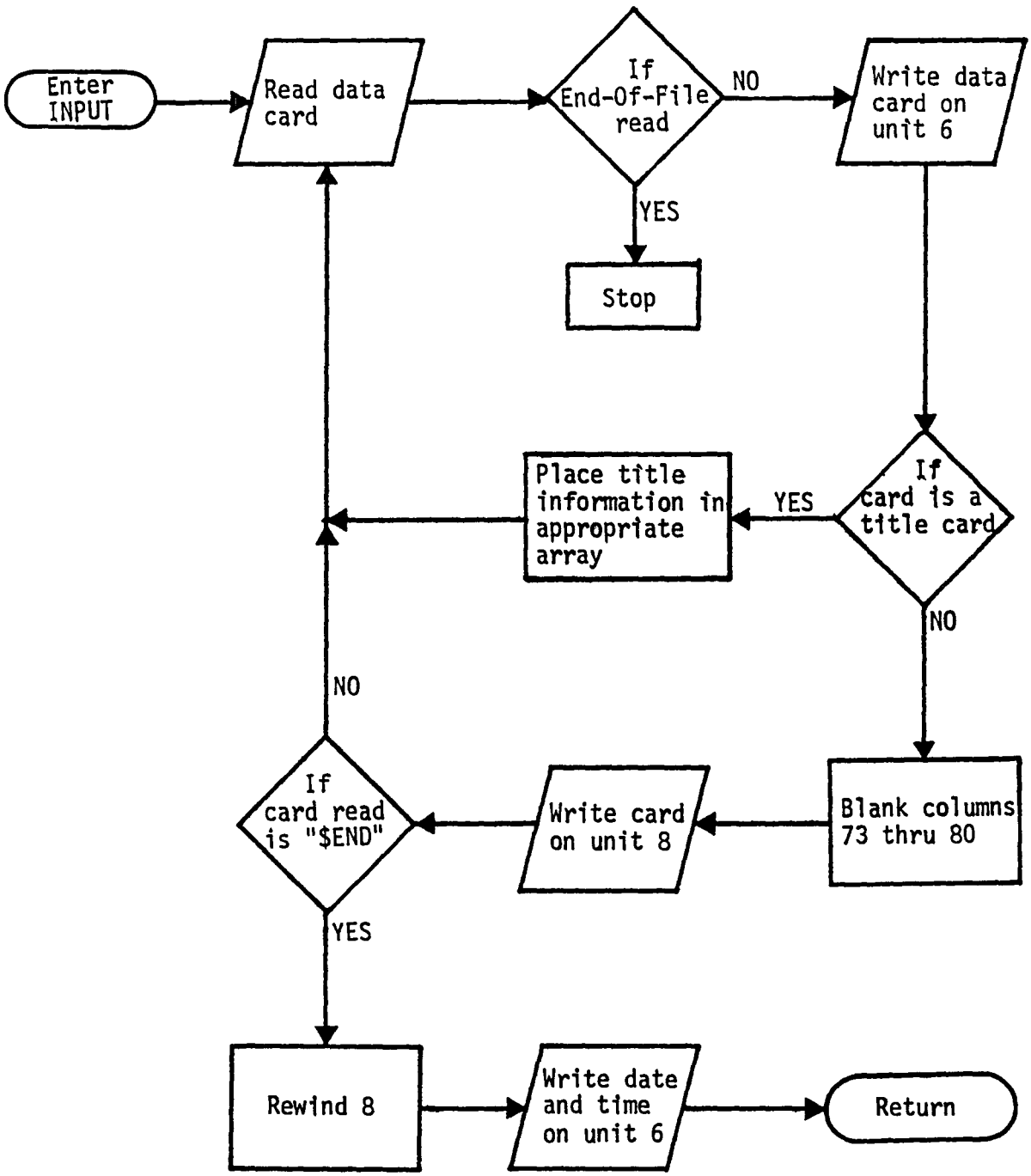


Figure 5.3

FLOWCHART OF SUBROUTINE INTER

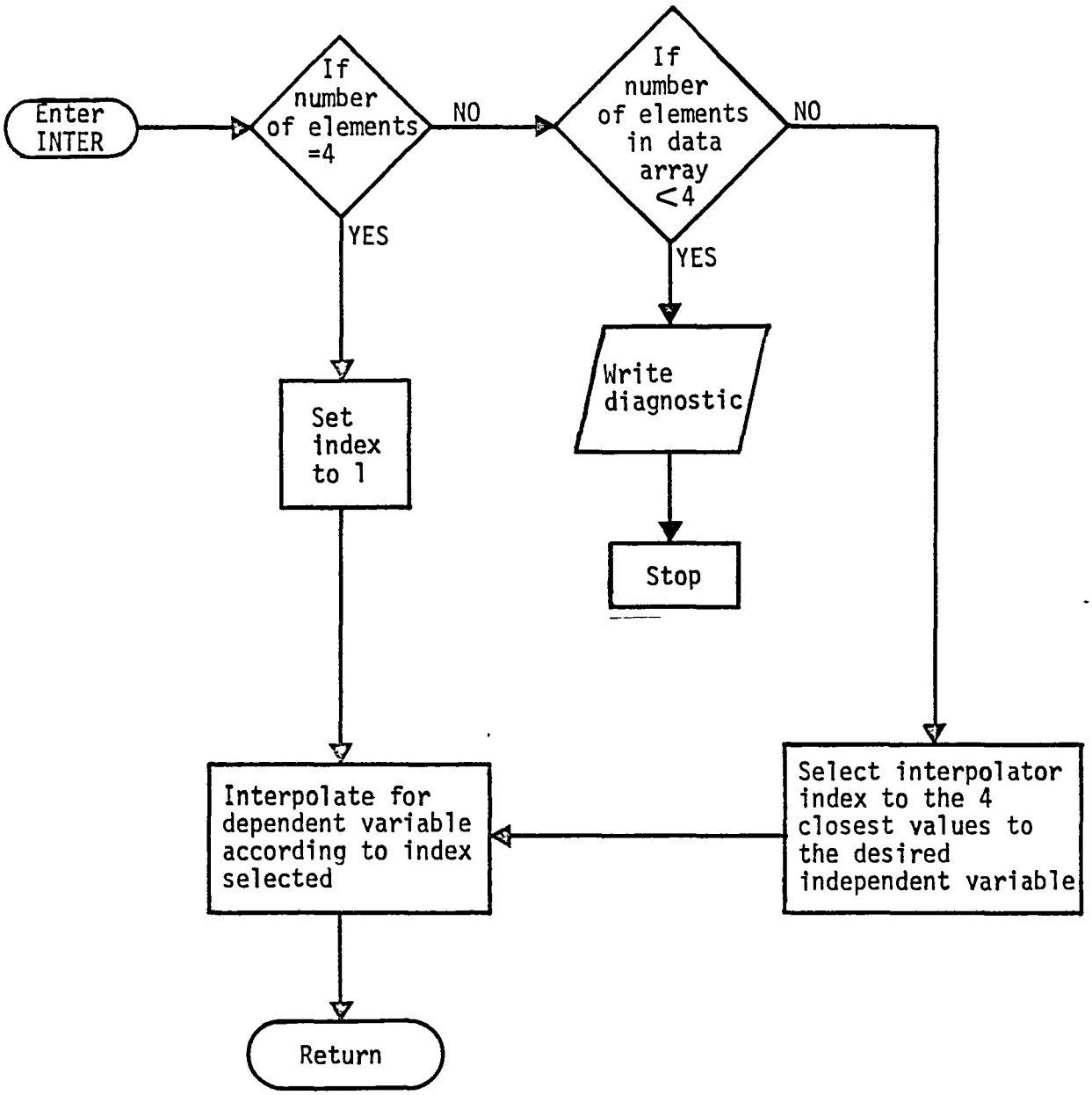


Figure 5.4

FLOWCHART OF SUBROUTINE PLOTLG

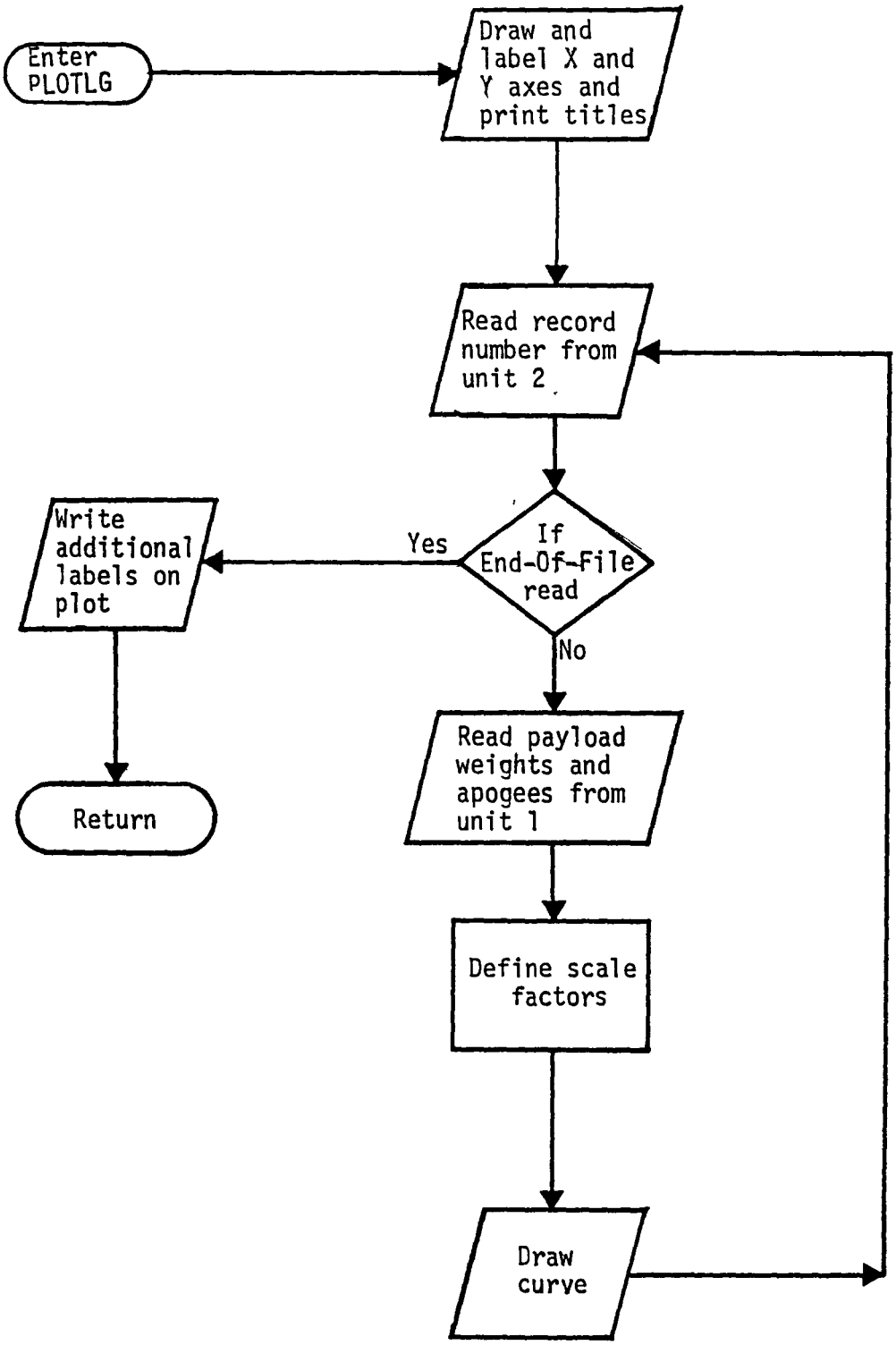
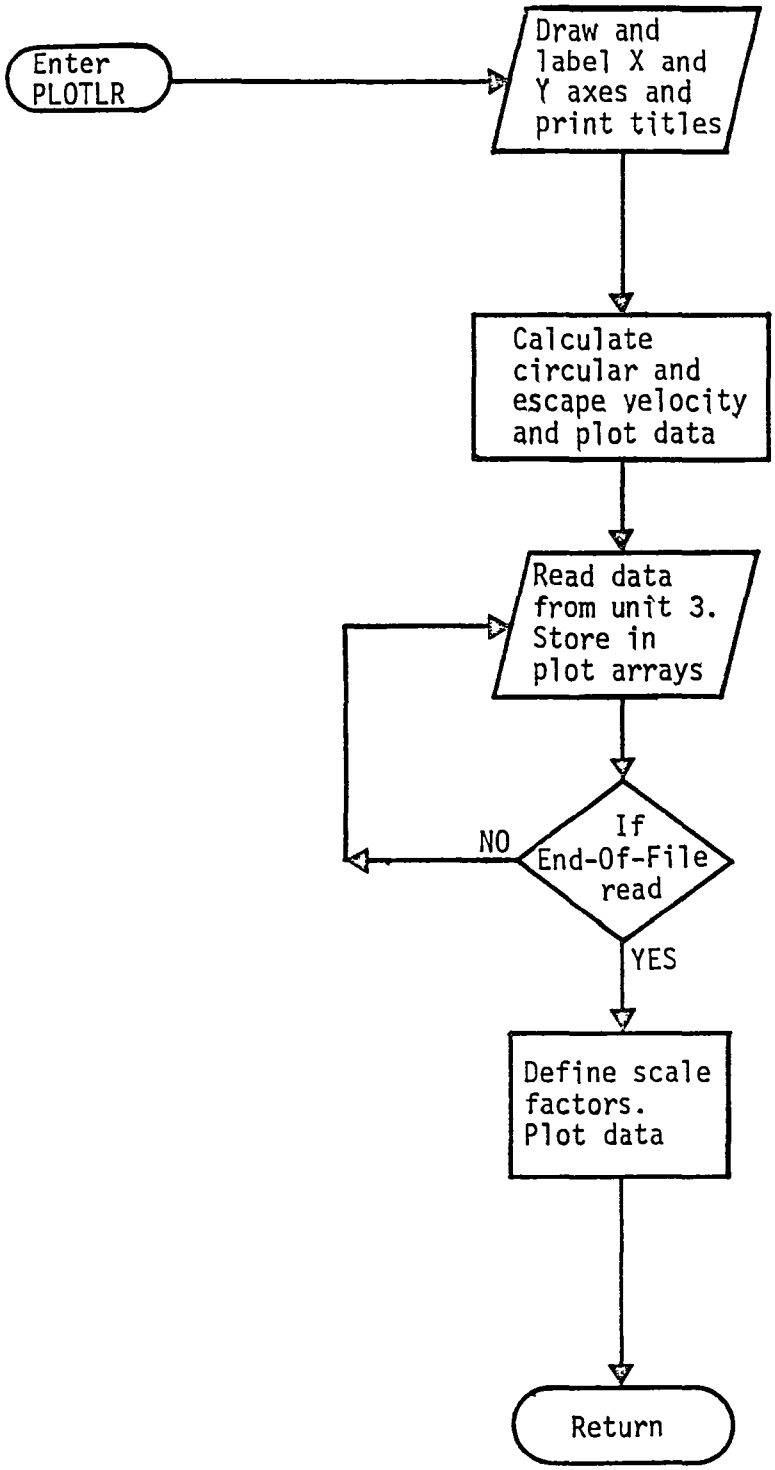


Figure 5.5

FLOWCHART OF SUBROUTINE PLOTLR



REFERENCES

1. Vought Corporation Report No. 00.1371, Revision C, "The Near-Earth Mission Analysis Routine" dated 15 September 1978.

2. CalComp Software Reference Manual, No. 1005, dated 1 June 1968.

3. Control Data Corporation, "FORTRAN Extended Version 4 Reference Manual", Revision C, dated 15 April 1977.

APPENDIX A

Sample Data Case

```
$INPUT
TITLE1=SCOUT LAUNCH VEHICLE
TITLE2=ELLIPTICAL ORBIT PERFORMANCE     ENGLISH UNITS
IPRT=1,ITAPT=1,
ALTMIN=100.,ALTMAX=1000.,DELALT=100.,
XMMIN=5.,XMMAX=7.,DELXM=2.,
IPLOT=1.,PLOT=1.,
IPRNT=1.,
ETA=.01,
V1(1)=4.,9.,15.,22.,300.,4 .5.,55.,
V1(1)=209. 225.,2 .4.8.,25574837.,2 966.62,
V2(1)=3 .. 1.51.44457.67,32125.00.29813.32,
V2(1)=22701. 7 .,23 .223.252944 .,2 39C2.,
V (1)=33 .4. 9,31985.56,29687.93,27330.99,
V3(1)=3224 .84,23554.01,24984476,26322950,
V3(1)=31 .15,29978.97,27701.34,25405.09,
V4(1)=22257802,23290021,246 8739,25963441,
V4(1)=299.6. 3,2 315.42,2 076.78,23795.67,
V5(1)=22 39720,23026757,24343773,25604394,26379123,
V5(1)=2345 .12,26927.94,24737.00,22476.05,20942.29,
V6(1)=21 12617,22733920,23988254,25201906,25953995,
V6(1)=27144.40,25656.73,23515.19,21283.79,19758.15,
V7(1)=21625477,22474795,23679104,24847715,25578461,
V7(1)=2611 .48,24701.66,22599.68,20400.88,18885.68,
V8(1)=2149 812,22293749,23459406,24593411,25307775,
V8(1)=25424.27,24080.20,22011.82,19840.33,18334.05,
PTITLE1=
PTITLE2=    SCOUT LAUNCH VEHICLE
PTITLE3=ELLIPTICAL ORBIT PERFORMANCE
PTITLE4=    WALLOPS FLIGHT CENTER
PLABEL1=LAUNCH AZIMUTH = 90 DEG
PLABEL2=ORBIT INCL = 37.7 DEG
PLABEL3=SCOUT CONFIGURATION
PLABEL4=    ALGOL IIIA
PLABEL5=    CASTOR IIA
PLABEL6=    ANTARES IIIA
PLABEL7=    ALTAIR IIIA
PLABEL8=42/-48 IN. HEATSHIELD
$END
```

```
DATE IS  04/12/71
TIME IS  11.10.25
```

WEIGHT(LBS.)= 4[illegible].0
ALTITUDE(N.MI.)

260.[illegible]3	4[illegible].536	667.1[illegible]5	92[illegible].[illegible]77	1164.129
1302.949	0.000	0.000	0.000	0.000

VELOCITY(FPS)

38473.3	36610.9	35005.3	32669.6	30385.4
29[illegible]75.2	0.0	0.0	0.0	0.0

WEIGHT(LBS.)= 9[illegible].0
ALTITUDE(N.MI.)

222.559	436.53[illegible]	[illegible]15.740	[illegible]71.047	1103.1[illegible]
1239.428	0.000	0.000	0.000	0.000

VELOCITY(FPS)

35664.5	33832.3	32249.3	29924.2	27640.0
26124.5	0.0	0.0	0.0	0.0

WEIGHT(LBS.)= 150.0
ALTITUDE(N.MI.)

184.339	389.080	560.796	808.407	1034.815
1169.873	0.000	0.000	0.000	0.000

VELOCITY(FPS)

33415.1	31625.0	30073.5	27766.4	25484.4
23965.1	0.0	0.0	0.0	0.0

WEIGHT(LBS.)= 220.0
ALTITUDE(N.MI.)

147.609	338.852	504.508	743.319	964.100
1096.665	0.000	0.000	0.000	0.000

VELOCITY(FPS)

31572.1	29857.7	28324.9	26045.1	23769.0
22247.8	0.0	0.0	0.0	0.0

WEIGHT(LBS.)= 300.0
ALTITUDE(N.MI.)

113.[illegible]5	288.918	448.765	677.[illegible]4	892.197
1021.855	0.000	0.000	0.000	0.000

VELOCITY(FPS)

30025.0	28408.0	26596.7	24651.7	223[illegible].2
20967.4	0.0	0.0	0.0	0.0

WEIGHT(LBS.)= 400.0
ALTITUDE(N.MI.)

236.857	389.331	606.463	813.270	939.44[illegible]
0.000	0.000	0.000	0.000	0.000

VELOCITY(FPS)

27076.8	25596.8	23401.8	21157.8	19640.6
0.0	0.0	0.0	0.0	0.0

WEIGHT(LBS.)= [illegible]
ALTITUDE(N.MI.)

193.769	339.139	544.966	744.349	867.116
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

VELOCITY(FPS)

26061.1	24619.0	22474.6	20257.5	18746.1
0.0	0.0	[illegible]	[illegible]	[illegible]

WEIGHT(LBS.)= [illegible]
ALTITUDE(N.MI.)

187.424	296.231	481.410	683.743	803.172
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

VELOCITY(FPS)

25247.4	23843.0	21757.3	19565.1	18062.2
0.0	0.0	0.0	0.0	0.0

PERIGEE ALT.= 100.0 N.MI. = 185.2 KM

INTERPOLATION DATA (CHECK FOR ACCURACY)

PAYLOAD WT.,LBS	INJECTION VEL.,FPS
40.0	39779.7
90.0	36688.5
150.0	34031.8
200.0	31989.1
300.0	30148.6
400.0	28385.1
500.0	26962.9
600.0	25817.6

PERIGEE ALT.,N.MI.	PAYLOAD WT.,LBS	APOGEE ALT.,N.MI.	PERIGEE VEL.,FPS	PAYLOAD WT.,KG	APOGEE ALT.,KM
100.0	120.0	67097.0	35282.8	54.4	124263.6
100.0	140.0	32381.5	34492.5	63.5	59970.6
100.0	160.0	20856.2	33778.9	72.6	38625.7
100.0	180.0	15056.8	33124.6	81.6	27885.2
100.0	200.0	11609.1	32531.1	90.7	21500.0
100.0	220.0	9320.1	31989.1	99.8	17260.8
100.0	240.0	7646.5	31477.1	108.9	14161.3
100.0	260.0	6392.9	31002.4	117.9	11839.7
100.0	280.0	5419.0	30560.9	127.0	10036.1
100.0	300.0	4639.7	30148.6	136.1	8592.7
100.0	320.0	3990.9	29755.4	145.1	7391.1
100.0	340.0	3446.7	29384.7	154.2	6387.0
100.0	360.0	2988.6	29034.2	163.3	5534.9
100.0	380.0	2592.6	28701.8	172.4	4801.6
100.0	400.0	2247.5	28385.1	181.4	4162.3
100.0	420.0	1936.4	28075.4	190.5	3586.3
100.0	440.0	1660.5	27778.9	199.6	3075.3
100.0	460.0	1414.4	27495.0	208.7	2619.5
100.0	480.0	1193.7	27223.1	217.7	2210.8
100.0	500.0	994.9	26962.9	226.8	1842.6
100.0	520.0	815.1	26713.7	235.9	1509.7
100.0	540.0	651.9	26475.1	244.9	1207.3
100.0	560.0	503.1	26246.5	254.0	931.7
100.0	580.0	366.9	26027.6	263.1	679.6
100.0	600.0	242.0	25817.6	272.2	448.2
100.0	620.0	127.0	25616.2	281.2	235.1

CIRCULAR PAYLOAD= 624.7 LBS= 283.3 KG CIRCULAR VEL.= 25567.8 FPS

ESCAPE PAYLOAD = 100.6 LBS= 45.7 KG ESCAPE VEL. = 36158.3 FPS

PERIGEE ALT.= [illegible] N.MI. = 370.4 KM

INTERPOLATION DATA (CHECK FOR ACCURACY)

PAYLOAD T.,LBS	INJECTION VEL.,FPS
4 .	[illegible]
[illegible]	[illegible]
150.0	33283.6
220.0	31108.7
300.0	29232.6
400.0	27430.2
500.0	25999.4
600.0	24865.5

PERIGEE ALT.,N.MI.	PAYLOAD WT.,LBS	APOGEE ALT.,N.MI.	PERIGEE VEL.,FPS	PAYLOAD WT.,KG	APOGEE ALT.,KM
200.0	100.0	204998.4	35351.0	45.4	379657.0
210.0	120.0	47256.0	34442.6	54.4	87536.7
200.0	140.0	26113.5	33645.0	63.5	48362.2
200.0	160.0	17614.8	32923.8	72.6	32622.6
200.0	180.0	12991.7	32261.3	81.6	24060.7
200.0	200.0	10122.1	31659.3	90.7	18746.2
200.0	220.0	8164.0	31108.7	99.8	15119.8
200.0	240.0	6705.1	30597.8	108.9	12417.8
200.0	260.0	5590.6	30104.1	117.9	10364.0
200.0	280.0	4726.0	29653.7	127.0	8752.6
200.0	300.0	4023.5	29232.6	136.1	7451.5
200.0	320.0	3434.4	28830.5	145.1	6360.4
200.0	340.0	2938.6	28451.2	154.2	5444.1
200.0	360.0	2518.2	28092.7	163.3	4668.7
200.0	380.0	2154.7	27753.1	172.4	3990.5
200.0	400.0	1837.6	27430.2	181.4	3403.2
200.0	420.0	1554.1	27118.0	190.5	2879.1
200.0	440.0	1302.3	26819.7	199.6	2411.9
200.0	460.0	1077.3	26534.5	208.7	1996.1
200.0	480.0	874.0	26261.4	217.7	1620.4
200.0	500.0	691.9	25999.4	226.8	1281.4
200.0	520.0	525.4	25747.9	235.9	973.1
200.0	540.0	373.2	25505.5	244.9	691.1
200.0	560.0	233.2	25271.6	254.0	431.9

CIRCULAR PAYLOAD= 564.9 LBS= 256.2 KG CIRCULAR VEL.= 25214.5 FPS

ESCAPE PAYLOAD = 98.8 LBS= 42.6 KG ESCAPE VEL. = 35653.7 FPS

PERIGEE ALT.= 300.0 N.MI. = 555.6 KM

INTEGRATION DATA (CHECK FOR ACCURACY)

PAYLOAD WT.,LBS	INJECTION VEL.,FPS
[illegible]	34541.[illegible]
[illegible]	33009.0
157.1	32412.2
200.0	31211.0
300.0	29304.5
400.0	26463.0
500.0	25012.4
600.0	23803.9

PERIGEE ALT.,N.MI.	PAYLOAD WT.,LBS	APOGEE ALT.,N.MI.	PERIGEE VEL.,FPS	PAYLOAD WT.,KG	APOGEE ALT.,KM
300.0	100.0	91048.1	34502.4	45.4	168621.1
300.0	120.0	35107.0	33586.2	54.4	65019.3
300.0	140.0	21236.2	32780.6	63.5	39329.3
300.0	150.0	14844.6	32051.2	72.6	27492.2
300.0	180.0	11136.5	31380.3	81.6	20624.9
300.0	200.0	8746.1	30776.0	90.7	16197.9
300.0	220.0	7074.3	30211.0	99.8	13101.5
300.0	240.0	5807.5	29682.2	108.9	10755.5
300.0	260.0	4832.2	29190.9	117.9	8949.3
300.0	280.0	4058.3	28732.9	127.0	7516.0
300.0	300.0	3428.6	28304.5	136.1	6349.9
300.0	320.0	2907.0	27905.1	145.1	5385.2
300.0	340.0	2448.0	27518.7	154.2	4533.7
300.0	360.0	2063.8	27143.3	163.3	3822.2
300.0	380.0	1731.2	26797.1	172.4	3206.2
300.0	400.0	1440.1	26466.0	181.4	2667.1
300.0	420.0	1180.0	26150.7	190.5	2185.3
300.0	440.0	948.3	25847.0	199.6	1756.3
300.0	460.0	740.7	25557.5	208.7	1371.8
300.0	480.0	553.5	25279.6	217.7	1025.1
300.0	500.0	383.6	25012.4	226.8	710.4

CIRCULAR PAYLOAD= 510.5 LBS= 231.6 KG CIRCULAR VEL.= 24875.5 FPS

ESCAPE PAYLOAD = 86.8 LBS= 39.4 KG ESCAPE VEL. = 35179.2 FPS

PERIGEE ALT.= 400.0 N.MI. = 740.8 KM

INTERPOLATION DATA (CHECK FOR ACCURACY)

PAYLOAD WT.,LBS	INJECTION VEL.,FPS
[illegible]	37304.0
[illegible]	34149.8
150.0	31527.6
220.0	29296.9
300.0	27362.1
400.0	25491.8
500.0	23998.6
600.0	22750.4

PERIGEE ALT.,N.MI.	PAYLOAD WT.,LBS	APOGEE ALT.,N.MI.	PERIGEE VEL.,FPS	PAYLOAD WT.,KG	APOGEE ALT.,KM
400.0	100.0	55485.3	33638.8	45.4	102758.8
400.0	120.0	26991.5	32714.2	54.4	49988.2
400.0	140.0	17389.2	31900.2	63.5	32204.9
400.0	160.0	12488.0	31162.3	72.6	23127.7
400.0	180.0	9488.8	30482.8	81.6	17573.2
400.0	200.0	7490.7	29864.0	90.7	13872.8
400.0	220.0	6061.9	29296.9	99.8	11226.7
400.0	240.0	4963.1	28760.7	108.9	9191.7
400.0	260.0	4108.7	28262.1	117.9	7605.6
400.0	280.0	3420.4	27797.3	127.0	6334.6
400.0	300.0	2857.6	27362.1	136.1	5292.2
400.0	320.0	2379.2	26945.9	145.1	4406.2
400.0	340.0	1972.8	26552.8	154.2	3653.6
400.0	360.0	1623.3	26180.7	163.3	3006.4
400.0	380.0	1319.4	25827.7	172.4	2443.6
400.0	400.0	1052.3	25491.8	181.4	1948.9
400.0	420.0	812.6	25167.2	190.5	1504.9
400.0	440.0	598.4	24856.6	199.6	1108.2
400.0	460.0	405.8	24559.0	208.7	751.6

CIRCULAR PAYLOAD= 460.8 LBS= 209.0 KG CIRCULAR VEL.= 24549.8 FPS

ESCAPE PAYLOAD = 79.5 LBS= 36.1 KG ESCAPE VEL. = 34718.6 FPS

PERIGEE ALT.= 500.0 N.MI. = 926.0 KM

INTERPOLATION DATA (CHECK FOR ACCURACY)

PAYLOAD WT.,LBS	INJECTION VEL.,FPS
[illegible]	34453.9
[illegible]	33275.5
150.0	32627.7
200.0	28997.1
300.0	26404.9
400.0	24484.4
500.0	22954.7
600.0	21663.5

PERIGEE ALT.,N.MI.	PAYLOAD WT.,LBS	APOGEE ALT.,N.MI.	PERIGEE VEL.,FPS	PAYLOAD WT.,KG	APOGEE ALT.,KM
500.0	80.0	144675.2	33828.2	36.3	267938.4
500.0	100.0	38247.9	32761.1	45.4	70835.1
500.0	120.0	21248.1	31827.5	54.4	39342.3
500.0	140.0	14311.1	31004.6	63.5	26504.1
500.0	160.0	10482.6	30257.9	72.6	19413.7
500.0	180.0	8033.6	29569.7	81.6	14878.3
500.0	200.0	6354.9	28942.5	90.7	11769.2
500.0	220.0	5130.6	28367.1	99.8	9501.9
500.0	240.0	4174.7	27833.8	108.9	7735.3
500.0	260.0	3424.7	27318.5	117.9	6342.8
500.0	280.0	2816.4	26846.9	127.0	5216.0
500.0	300.0	2313.6	26404.0	136.1	4284.8
500.0	320.0	1882.8	25991.3	145.1	3486.9
500.0	340.0	1514.6	25598.4	154.2	2805.0
500.0	360.0	1199.2	25230.3	163.3	2218.4
500.0	380.0	928.9	24838.9	172.4	1720.2
500.0	400.0	672.5	24494.4	181.4	1245.4

CIRCULAR PAYLOAD= 415.4 LBS= 188.4 KG CIRCULAR VEL.= 24234.5 FPS

ESCAPE PAYLOAD = 72.2 LBS= 32.7 KG ESCAPE VEL. = 34275.4 FPS

PERIGEE ALT.= 600.0 N.MI. =1111.2 KM

INTERPOLATION DATA (CHECK FOR ACCURACY)

PAYLOAD WT.,LBS	INJECTION VEL.,FPS
4..0	35581.4
80.0	32946.0
150.0	29716.2
220.0	27428.5
300.0	25428.9
400.0	23469.2
500.0	21984.1
600.0	20547.0

PERIGEE ALT.,N.MI.	PAYLOAD WT.,LBS	APOGEE ALT.,N.MI.	PERIGEE VEL.,FPS	PAYLOAD WT.,KG	APOGEE ALT.,KM
600.0	80.0	69328.5	32946.2	36.3	128396.4
600.0	100.0	28136.5	31870.1	45.4	52108.8
600.0	120.0	16998.6	30928.1	54.4	31481.4
600.0	140.0	11823.6	30097.1	63.5	21897.3
600.0	160.0	8782.3	29342.6	72.6	16264.8
600.0	180.0	6763.0	28646.8	81.6	12525.1
600.0	200.0	5343.2	28011.8	90.7	9895.7
600.0	220.0	4288.7	27428.5	99.8	7942.6
600.0	240.0	3454.6	26876.3	108.9	6398.0
600.0	260.0	2789.7	26361.7	117.9	5166.4
600.0	280.0	2246.0	25880.6	127.0	4161.3
600.0	300.0	1794.9	25429.9	136.1	3324.2
600.0	320.0	1405.5	24995.4	145.1	2602.9
600.0	340.0	1070.0	24584.6	154.2	1983.3
600.0	360.0	780.3	24194.6	163.3	1445.2

CIRCULAR PAYLOAD= 374.0 LBS= 169.7 KG CIRCULAR VEL.= 23935.0 FPS

ESCAPE PAYLOAD = 64.9 LBS= 29.4 KG ESCAPE VEL. = 33849.2 FPS

PERIGEE ALT.= 700.0 N.MI. =1296.4 KM

INTERPOLATION DATA (CHECK FOR ACCURACY)

PAYLOAD WT.,LBS	INJECTION VEL.,FPS
40.0	34719.2
80.0	31406.5
150.0	28793.4
220.0	26469.3
300.0	24426.7
400.0	22416.0
500.0	20771.8
600.0	19368.2

PERIGEE ALT.,N.MI.	PAYLOAD WT.,LBS	APOGEE ALT.,N.MI.	PERIGEE VEL.,FPS	PAYLOAD WT.,KG	APOGEE ALT.,KM
700.0	60.0	489735.2	33298.7	27.2	906989.6
700.0	80.0	43635.5	32057.2	36.3	80812.9
700.0	100.0	21579.5	30972.0	45.4	39965.3
700.0	120.0	13774.0	30020.3	54.4	25509.4
700.0	140.0	9786.5	29179.4	63.5	18124.5
700.0	160.0	7323.8	28414.7	72.6	13563.7
700.0	180.0	5637.1	27708.6	81.6	10439.9
700.0	200.0	4425.0	27063.2	90.7	8195.1
700.0	220.0	3510.3	26469.3	99.8	6501.0
700.0	240.0	2778.2	25926.4	108.9	5145.2
700.0	260.0	2188.8	25381.0	117.9	4053.7
700.0	280.0	1704.0	24889.1	127.0	3155.8
700.0	300.0	1297.7	24426.7	136.1	2403.3
700.0	320.0	946.2	23983.1	145.1	1752.4

CIRCULAR PAYLOAD= 336.2 LBS= 152.5 KG CIRCULAR VEL.= 23644.4 FPS

ESCAPE PAYLOAD = 57.7 LBS= 26.2 KG ESCAPE VEL. = 33438.3 FPS

PERIGEE ALT.= 800.0 N.MI. =1481.6 KM

INTERPOLATION DATA (CHECK FOR ACCURACY)

PAYLOAD WT.,LBS	INJECTION VEL.,FPS
40.0	33937.9
90.0	30986.3
150.0	27847.3
220.0	25493.8
300.0	23391.9
400.0	21309.7
500.0	19589.7
600.0	18103.9

PERIGEE ALT.,N.MI.	PAYLOAD WT.,LBS	APOGEE ALT.,N.MI.	PERIGEE VEL.,FPS	PAYLOAD WT.,KG	APOGEE ALT.,KM
800.0	60.0	103653.0	32406.1	27.2	191965.3
800.0	80.0	30521.5	31153.0	36.3	56525.9
800.0	100.0	16903.2	30055.9	45.4	31304.8
800.0	120.0	11191.6	29092.1	54.4	20726.8
800.0	140.0	8054.9	28239.2	63.5	14917.7
800.0	160.0	6038.2	27462.9	72.6	11182.7
800.0	180.0	4620.3	26745.5	81.6	8556.8
800.0	200.0	3581.8	26088.9	90.7	6633.4
800.0	220.0	2786.7	25483.8	99.8	5160.9
800.0	240.0	2143.0	24909.0	108.9	3968.8
800.0	260.0	1619.0	24371.5	117.9	3000.0
800.0	280.0	1186.2	23867.2	127.0	2196.8
800.0	300.0	820.2	23391.9	136.1	1519.0

CIRCULAR PAYLOAD= 301.2 LBS= 136.0 KG CIRCULAR VEL.= 23364.2 FPS

ESCAPE PAYLOAD = 50.6 LBS= 23.0 KG ESCAPE VEL. = 33042.0 FPS

PERIGEE ALT.= 900.0 N.MI. =1666.8 KM

INTERPOLATION DATA (CHECK FOR ACCURACY)

PAYLOAD WT.,LBS	INJECTION VEL.,FPS
4[illegible].0	32935.4
[illegible].0	29651.5
150.0	26874.3
220.0	24457.5
300.0	22300.4
400.0	20130.2
500.0	18315.6
600.0	16730.8

PERIGEE ALT.,N.MI.	PAYLOAD WT.,LBS	APOGEE ALT.,N.MI.	PERIGEE VEL.,FPS	PAYLOAD WT.,KG	APOGEE ALT.,KM
900.0	60.0	53990.7	31490.3	27.2	99990.9
900.0	80.0	22470.9	30224.4	36.3	41616.1
900.0	100.0	13372.1	29114.8	45.4	24765.1
900.0	120.0	9069.3	28138.5	54.4	16796.3
900.0	140.0	6564.5	27272.8	63.5	12157.4
900.0	160.0	4895.8	26482.7	72.6	9067.1
900.0	180.0	3693.8	25750.5	81.6	6840.9
900.0	200.0	2797.7	25078.5	90.7	5181.4
900.0	220.0	2102.6	24457.5	99.8	3894.1
900.0	240.0	1534.7	23886.9	108.9	2842.2
900.0	260.0	1069.2	23313.2	117.9	1980.1

CIRCULAR PAYLOAD= 268.5 LBS= 121.8 KG CIRCULAR VEL.= 23093.7 FPS

ESCAPE PAYLOAD = 43.5 LBS= 19.7 KG ESCAPE VEL. = 32659.5 FPS

PERIGEE ALT.=1000.0 N.MI. =1852.0 KM

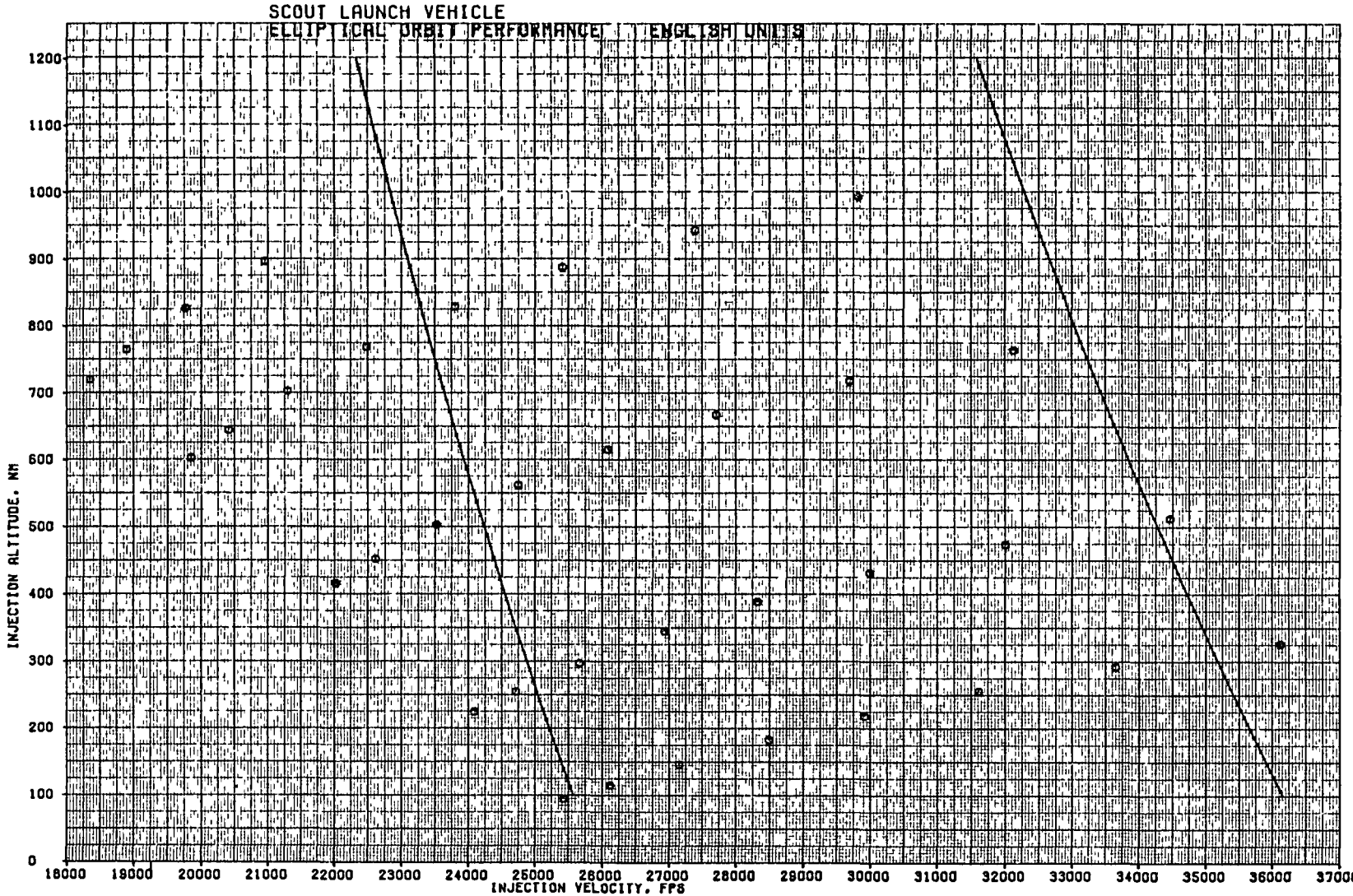
INTERPOLATION DATA (CHECK FOR ACCURACY)

PAYLOAD WT.,LBS	INJECTION VEL.,FPS
40.0	32007.4
60.0	29693.2
100.0	25953.9
220.0	23371.0
300.0	21134.1
400.0	18858.2
500.0	16927.3
600.0	15225.5

PERIGEE ALT.,N.MI.	PAYLOAD WT.,LBS	APOGEE ALT.,N.MI.	PERIGEE VEL.,FPS	PAYLOAD WT.,KG	APOGEE ALT.,KM
1000.0	40.0	247190.0	32007.4	18.1	457795.8
1000.0	60.0	34408.4	30546.5	27.2	63724.3
1000.0	80.0	16991.8	29264.4	36.3	31468.9
1000.0	100.0	10580.3	28138.1	45.4	19594.8
1000.0	120.0	7263.8	27144.7	54.4	13452.5
1000.0	140.0	5238.8	26261.4	63.5	9702.3
1000.0	160.0	3849.0	25453.2	72.6	7128.4
1000.0	180.0	2827.0	24702.4	81.6	5235.5
1000.0	200.0	2052.1	24011.3	90.7	3802.3
1000.0	220.0	1445.5	23371.0	99.8	2677.1

CIRCULAR PAYLOAD= 237.7 LBS= 107.8 KG CIRCULAR VEL.= 22832.4 FPS

ESCAPE PAYLOAD = 36.5 LBS= 16.6 KG ESCAPE VEL. = 32289.9 FPS


SCOUT LAUNCH VEHICLE
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INJECTION ALTITUDE, NM
INJECTION VELOCITY, FPS
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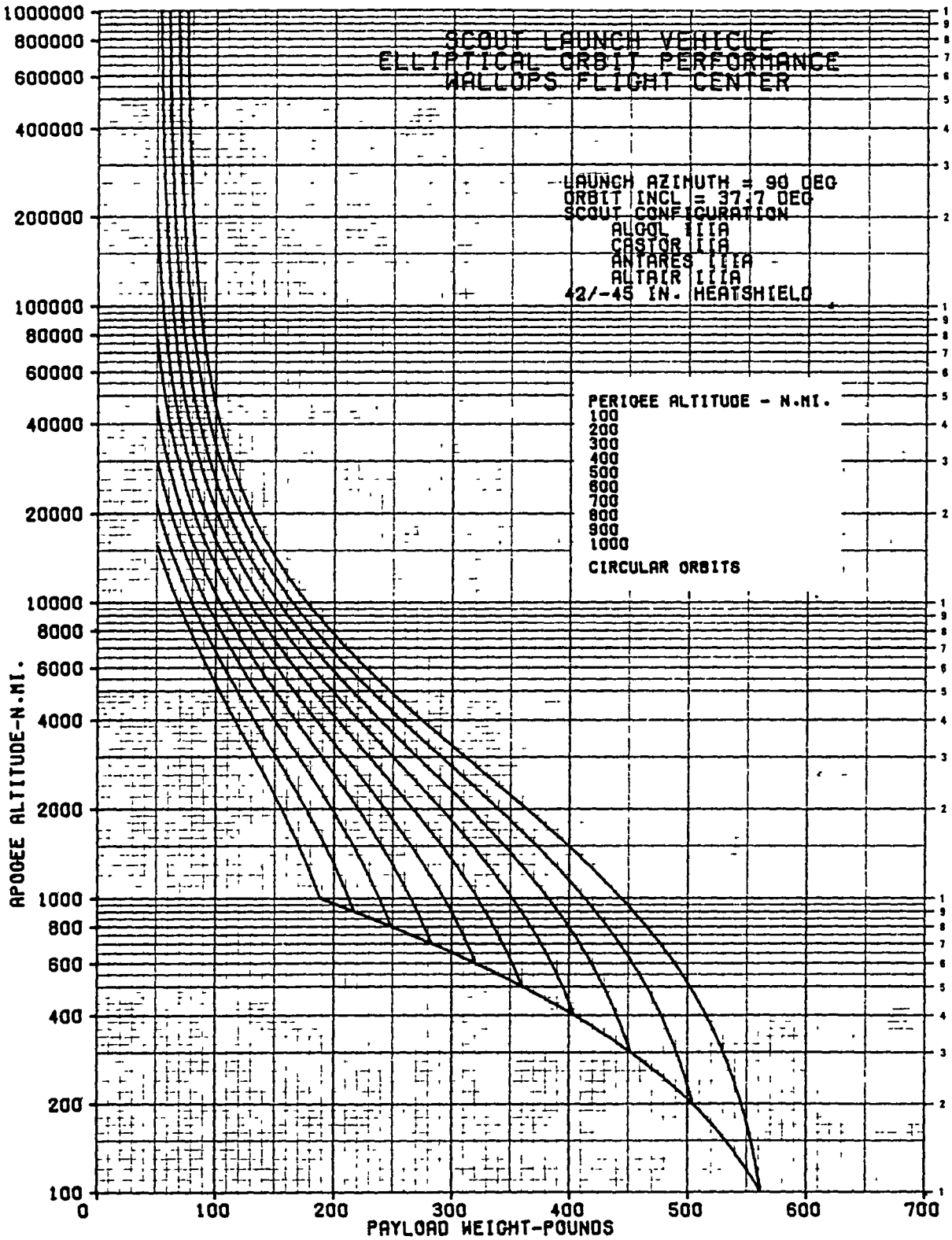
SCOUT LAUNCH VEHICLE
ELLIPTICAL ORBIT PERFORMANCE
WALLOPS FLIGHT CENTER
LAUNCH AZIMUTH = 90 DEG
ORBIT INCL = 37.7 DEG
SCOUT CONFIGURATION
ALGOL IIIA
CASTOR IIA
ANTARES IIIA
ALTAIR IIIA
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PERIGEE ALTITUDE - N.MI.
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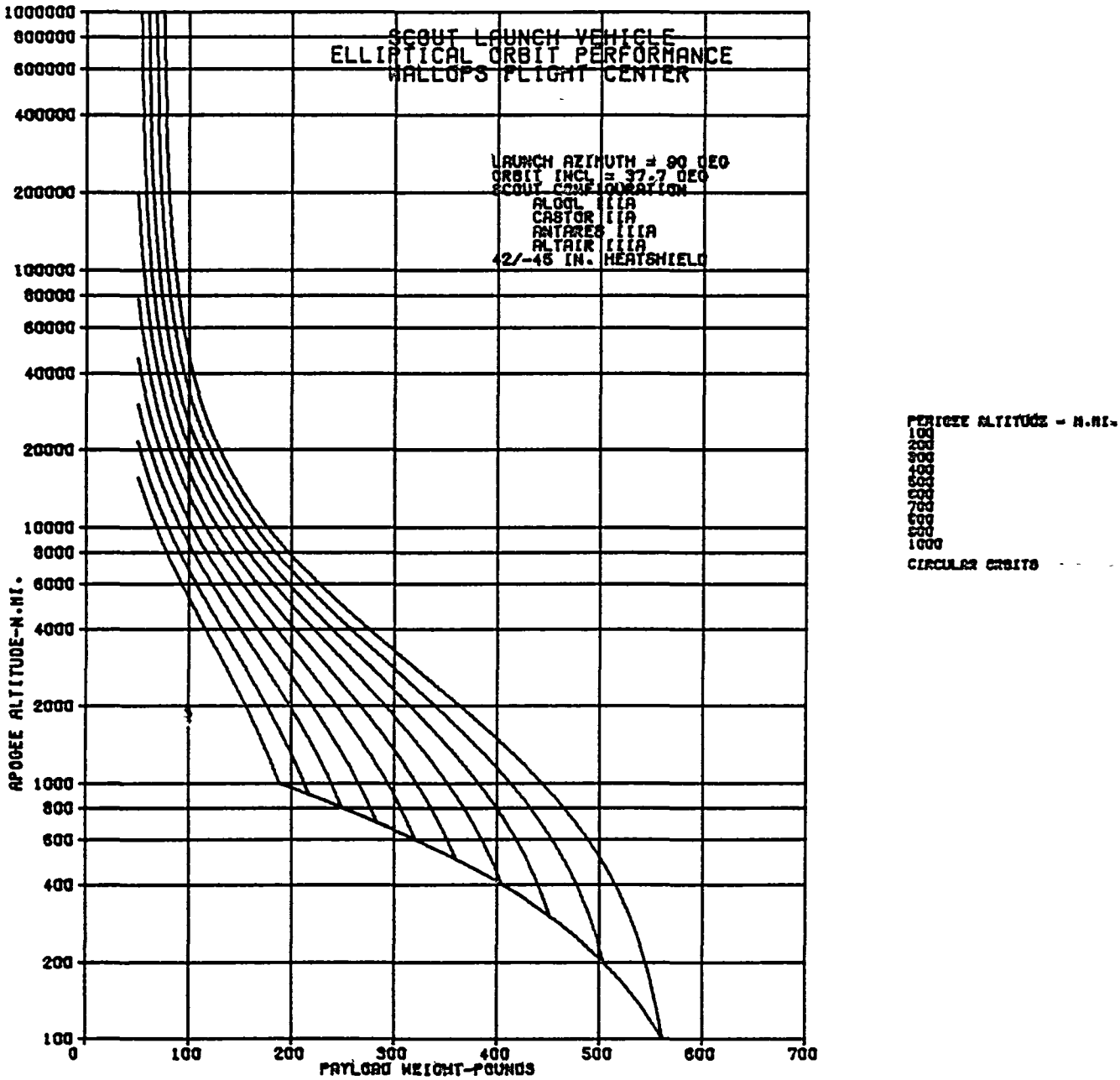
900
1000
CIRCULAR ORBITS
APOGEE ALTITUDE-N.MI.
PAYLOAD WEIGHT-POUNDS
1000000
800000
600000
400000
200000
100000
80000
60000
40000
20000
10000
8000
6000
4000
2000
1000
800
600
400
200
100
0
100
200
300
400
500
600
700


SCOUT LAUNCH VEHICLE
ELLIPTICAL ORBIT PERFORMANCE
WALLOPS FLIGHT CENTER
LAUNCH AZIMUTH = 90 DEG
ORBIT INCL = 37.7 DEG
SCOUT CONFIGURATION
ALGOL IIIA
CASTOR IIA
ANTARES IIIA
ALTAIR IIIA
42/-45 IN. HEATSHIELD
PERIGEE ALTITUDE - N.MI.
CIRCULAR ORBITS
APOGEE ALTITUDE-N.MI.
PAYLOAD WEIGHT-POUNDS
1000000
800000
600000
400000
200000
100000
80000
60000
40000
20000
10000
8000
6000
4000
2000
1000
800
600
400
200
100
0
100
200
300
400
500
600
700

```
      PROGRAM ELOPE(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,
     ^                           TAPE1,TAPE2,TAPE3,TAPE8)
C        PROGRAM ELOPE CONVERTS PERIGEE ALTITUDE-VELOCITY-PAYLOAD DATA
C        TO PERIGEE ALTITUDE-APOGEE ALTITUDE-PAYLOAD DATA PARAMETRICALLY
C
C
C        ************************ INPUT DATA ****************************
C        ALTMAX  = MAXIMUM PERIGEE ALTITUDE USED FOR PARAMETRIC
C                  OUTPUT.  UNITS ACCORDING TO IOPT.
C        ALTMIN  = MINIMUM PERIGEE ALTITUDE USED FOR PARAMETRIC
C                  OUTPUT.  UNITS ACCORDING TO IOPT.
C        APOGEE  = APOGEE ALTITUDE OF SINGLE ORBIT.  UNITS ACCORDING
C                  TO IOPT.  INPUT WHEN IOPT=3 OR 4.
C        DELALT  = INCREMENTAL PERIGEE ALTITUDE USED FOR PARAMETRIC
C                  OUTPUT.  UNITS ACCORDING TO IOPT.  MAXIMUM NUMBER OF
C                  ALTITUDE POINTS IS 50.
C        DELWT   = INCREMENTAL PAYLOAD USED FOR PARAMETRIC OUTPUT.
C                  UNITS ACCORDING TO IOPT.
C        FACT    = FACTOR TO INCREASE OR DECREASE SIZE OF LOG PLOT.
C                  PLOT IS PLACED ON FILE PLT3.
C        IOPT    = DATA OPTION
C                  =1 INPUT ALTMAX, ALTMIN, DELALT, DELWT, WTMAX, AND
C                     WTMIN IN N. MI., LBS., AND COMPUTE PARAMETRIC
C                     DATA IN N. MI. AND LBS.  (1 BUILT-IN)
C                  =2 INPUT ALTMAX, ALTMIN, DELALT, DELWT, WTMAX, AND
C                     WTMIN IN KM AND KG AND COMPUTE PARAMETRIC DATA
C                     IN KM AND KG.
C                  =3 INPUT APOGEE AND PERIGEE IN N. MI. AND COMPUTE
C                     SINGLE ORBIT ONLY.
C                  =4 INPUT APOGEE AND PERIGEE IN KM AND COMPUTE
C                     SINGLE ORBIT ONLY.
C        IPLOT   = A NON ZERO VALUE PRODUCES A PLOT OF ALTITUDE VS
C                  VELOCITY.  LOCAL PLOT FILE NAME IS PLT2.  (0 BUILT-IN)
C        IPRNT   = FREQUENCY OF OUTPUT CONTROL.  DATA IS COMPUTED AT
C                  DELWT INTERVALS FROM WTMIN AND PRINTED EVERY IPRNT
C                  DATA POINTS CALCULATED. (1 BUILT-IN)
C        IRAD    = DATA OPTION
C                  =1 INPUT R1-R15 AS RADIUS IN FEET (1 BUILT-IN)
C                  =2 INPUT R1-R15 AS RADIUS IN N. MI.
C                  =3 INPUT R1-R15 AS ALTITUDE IN N. MI.
C        KASE    = CASE NUMBER
C        LPLOT   = NON-ZERO VALUE PRODUCES A SEMI-LOG PLOT OF APOGEE
C                  AND PERIGEE ALTITUDE AS A FUNCTION OF PAYLOAD WEIGHT.
C                  LOCAL PLOT FILE NAME IS PLOT.  (0 BUILT-IN)
C        PERIGE  = PERIGEE ALTITUDE OF SINGLE ORBIT.  UNITS ACCORDING
C                  TO IOPT.  INPUT WHEN IOPT=3 OR 4.
C        PLABEL1 = LABELS PLACED ON UPPER RIGHT SIDE OF APOGEE-PERIGEE
C       -PLABLE9   PLOT.  30 TITLE CHARACTERS EACH.
C        PTITLE1 = TITLES PLACED AT TOP OF SEMI-LOG PLOTS.
C       -PTITLE4 = 40 TITLE CHARACTERS EACH.
C        REARTH  = EARTH RADIUS USED TO COMPUTE ALTITUDES,  FEET.
C                  (20925741. BUILT-IN)
C        R1-R15  = TABLE OF RADIUS OR ALTITUDE (ACCORDING TO IRAD) FOR
C                  EACH WEIGHT.  INPUT IN INCREASING ORDER.  MINIMUM OF
C                  4 AND MAXIMUM OF 10 VALUES PER TABLE.  ENTER 0 AFTER
C                  LAST VALUE IF LESS THAN 10 VALUES ARE INPUT.
C                  MINIMUM OF 4 TABLES.
```

```
C       TITLE1  = TITLE PRINTED AT THE TOP OF EACH PAGE.  72 TITLE
C                 CHARACTERS.
C       TITLE2  = TITLE PRINTED AT THE TOP OF EACH PAGE.  72 TITLE
C                 CHARACTERS.
C       V1-V15  = TABLE OF INERTIAL VSLOCITY FOR EACH WEIGHT.  INPUT IN
C                 ORDER OF R1-R15.  MAXIMUM OF 10 VALUES PER TABLE.
C       WEIGHT  = TABLE OF PAYLOAD WEIGHTS, IN LBS. CORRESPONDING RADIUS
C                 AND VELOCITY MUST BE INPUT FOR EACH WEIGHT.  MINIMUM
C                 OF 4 VALUES AND MAXIMUM OF 15 VALUES.
C       WTMAX   = MAXIMUM PAYLOAD WEIGHT USED FOR PARAMETRIC OUTPUT.
C                 UNITS ACCORDING TO IOPT.
C       WTMIN   = MINIMUM PAYLOAD WEIGHT USED FOR PARAMETRIC OUTPUT.
C                 UNITS ACCORDING TO IOPT.
C       XINC    = INCREMENTAL VALUE OF X AXIS MAJOR DIVISIONS, LBS
C                 OR KG, ON SEMI-LOG PLOT.  THERE ARE SEVEN MAJOR
C                 DIVISIONS ON THE X AXIS.  (100. BUILT-IN)
C
C
C
C
      IMPLICIT REAL(A-H,O-Z)
      COMMON /BLK1/TITLE1(8),TITLE2(8),TITLE(16),LABEL(36)
      DIMENSION NC(15),WW(15,50),WEIGHT(15)
      DIMENSION R(10,15),R1(10),R2(10),R3(10),R4(10),R5(10),
     ^          R6(10),R7(10),R8(10),R9(10),R10(10),R11(10),
     ^          R12(10),R13(10),R14(10),R15(10),VI(10),WI(10),
     ^          V(10,15),V1(10),V2(10),V3(10),V4(10),V5(10),
     ^          V6(10),V7(10),V8(10),V9(10),V10(10),V11(10),
     ^          V12(10),V13(10),V14(10),V15(10),
     ^          H(10,15),HH(50),VV(15,50)
      EQUIVALENCE ( R1(1),R(1, 1)),( R2(1),R(1, 2)),( R3(1),R(1, 3)),
     ^            ( R4(1),R(1, 4)),( R5(1),R(1, 5)),( R6(1),R(1, 6)),
     ^            ( R7(1),R(1, 7)),( R8(1),R(1, 8)),( R9(1),R(1, 9)),
     ^            (R10(1),R(1,10)),(R11(1),R(1,11)),(R12(1),R(1,12)),
     ^            (R13(1),R(1,13)),(R14(1),R(1,14)),(R15(1),R(1,15)),
     ^            ( V1(1),V(1, 1)),( V2(1),V(1, 2)),( V3(1),V(1, 3)),
     ^            ( V4(1),V(1, 4)),( V5(1),V(1, 5)),( V6(1),V(1, 6)),
     ^            ( V7(1),V(1, 7)),( V8(1),V(1, 8)),( V9(1),V(1, 9)),
     ^            (V10(1),V(1,10)),(V11(1),V(1,11)),(V12(1),V(1,12)),
     ^            (V13(1),V(1,13)),(V14(1),V(1,14)),(V15(1),V(1,15))
      DATA TITLE1,TITLE2/16*10H          /
      DATA TITLE,LABEL/52*10H          /
      DATA FTNM/6076.11549/,GM/1.4076576E16/,XKG/.45359/,XKM/1.852/
      DATA NDIM/10/
      NAMELIST /INPUTD/IRAD,IOPT,WEIGHT,ALTMIN,ALTMAX,DELALT,
     ^                 WTMIN,WTMAX,DELWT,REARTH,APOGEE,PERIGE,R1,R2,
     ^                 R3,R4,R5,R6,R7,R8,R9,R10,R11,R12,R13,R14,R15,
     ^                 V1,V2,V3,V4,V5,V6,V7,V8,V9,V10,V11,V12,V13,
     ^                 V14,V15,LPLOT,IPRNT,IPLOT,XINC,KASE,FACT
C
C
C        INITIALIZE DEFAULTS
      APOGEE=0.
      FACT=1.
      IOPT=1
      IPLOT=0
      IPRNT=1
```

```
      IRAD=1
      KASE=1
      LPLOT=0
      PERIGE=0.
      REARTH=20925741.
      XINC=100.
C
C        READ INPUT DATA
   10 CONTINUE
      CALL INPUT
      READ( 8,INPUTD)
C     UNIT 1 USED FOR SEMI-LOG PLOT
C     UNIT 2 USED FOR SEMI-LOG PLOT
C     UNIT 3 USED FOR LINEAR PLOT
      REWIND 1
      REWIND 2
      REWIND 3
C
C        DETERMINE NUMBER OF PAYLOAD WEIGHTS
      DO 20 I=1,15
         IF (WEIGHT(I).EQ.0.) GOTO 30
         NWT=I
   20 CONTINUE
   30 CONTINUE
C
C        DETERMINE NUMBER OF DATA POINTS PER PAYLOAD
      DO 60 I=1,NWT
         DO 40 J=1,NDIM
            IF (R(J,I).EQ.0.) GOTO 50
   40    CONTINUE
         NC(I)=J
         GOTO 60
   50    NC(I)=J-1
   60 CONTINUE
      IPAGE=1
C
C        CONVERT APPROPIATE INPUT TO ENGLISH IF METRIC
      GOTO (70,80,90,100), IOPT
   70 CONTINUE
         HMIN=ALTMIN
         HMAX=ALTMAX
         DH=DELALT
         WMIN=WTMIN
         WMAX=WTMAX
         DW=DELWT
         HAMAX=1.E6
         GOTO 110
   80 CONTINUE
         HMIN=ALTMIN/XKM
         HMAX=ALTMAX/XKM
         DH=DELALT/XKM
         WMIN=WTMIN/XKG
         WMAX=WTMAX/XKG
         DW=DELWT/XKG
         HAMAX=1.E6/XKM
         GOTO 110
   90 CONTINUE
```

```
         HA=APOGEE
         HP=PERIGE
         GOTO 110
  100 CONTINUE
         HA=APOGEE/XKM
         HP=PERIGE/XKM
  110 CONTINUE
      RE=REARTH/FTNM
C
C        CONVERT INPUT ALTITUDES OR RADII TO ALTITUDE, NM
      GOTO (120,150,180), IRAD
  120 CONTINUE
         DO 140 I=1,NWT
            DO 130 J=1,NDIM
               H(J,I)=R(J,I)/FTNM-RE
               IF (R(J,I).EQ.0.) H(J,I)=0.
  130       CONTINUE
  140    CONTINUE
         GOTO 210
  150 CONTINUE
         DO 170 I=1,NWT
            DO 160 J=1,NDIM
               H(J,I)=R(J,I)-RE
               IF (R(J,I).EQ.0.) H(J,I)=0.
  160       CONTINUE
  170    CONTINUE
         GOTO 210
  180 CONTINUE
      DO 200 I=1,NWT
         DO 190 J=1,NDIM
            H(J,I)=R(J,I)
  190    CONTINUE
  200 CONTINUE
C
  210 CONTINUE
      DO 230 I=1,NWT
         IF (I.EQ.1 .OR. I.EQ.7 .OR. I.EQ.13) WRITE (6,400)
         WRITE (6,420) WEIGHT(I)
         WRITE (6,410) (H(J,I),J=1,NDIM)
         WRITE (6,430)
         WRITE (6,440) (V(J,I),J=1,NDIM)
         DO 220 J=1,NDIM
            WRITE (3) H(J,I),V(J,I)
  220    CONTINUE
  230 CONTINUE
      IF (IPLOT.NE.0) CALL PLOTLR(TITLE1,TITLE2,REARTH)
      IF (IOPT.GE.3) GOTO 370
C
C        CALCULATE NUMBER OF PERIGEE ALTITUDES
      NH=INT((HMAX-HMIN)/DH+1.5)
      NH=MIN0(NH,50)
C
C        CALCULATE VELOCITY FOR EACH PERIGEE AND PAYLOAD LINE
      HNEW=HMIN
      DO 250 K=1,NH
         HH(K)=HNEW
         DO 240 I=1,NWT
```

```
            CALL INTER(HNEW,VEL,NC(I),V(1,I),H(1,I))
            VV(I,K)=VEL
            WW(I,K)=WEIGHT(I)
  240     CONTINUE
          HNEW=HNEW+DH
  250 CONTINUE
C
C         CALCULATE ORBIT DATA AT EACH PERIGEE
        DO 330 K=1,NH
          NREC=0
          HHMET=HH(K)*XKM
          WRITE (6,450) TITLE1,TITLE2,KASE,IPAGE
          WRITE (6,460) HH(K),HHMET
          WRITE (6,470)
          WRITE (6,480) (WW(I,K),VV(I,K),I=1,NWT)
          WRITE (6,490)
          HF=HH(K)
          RF=(HF+RE)*FTNM
C
C         REVERSE ORDER OF VELOCITY AND WEIGHT ARRAYS
          J=NWT
          DO 260 I=1,NWT
            VI(I)=VV(J,K)
            WI(I)=WW(J,K)
            J=J-1
  260     CONTINUE
C
C         CALCULATE PAYLOAD AT 1E6 APOGEE ALTITUDE
          A=((HAMAX+RE)*FTNM+RF)/2.
          VMAX=SQRT(GM*(2./RF-1./A))
          CALL INTER(VMAX,PL,NWT,WI,VI)
          IF (PL.LT.WMIN) GOTO 270
            NREC=NREC+1
            WRITE (1) PL,HAMAX
  270     CONTINUE
C
C         CALCULATE NUMBER OF PAYLOAD WEIGHTS
          NNW=INT((WMAX-WMIN)/DW+1.5)
C
C         CALCULATE ORBIT DATA AT PAYLOAD INCREMENT
          WNEW=WMIN
          DO 300 I=1,NNW
            CALL INTER(WNEW,VEL,NWT,VV(1,K),WW(1,K))
            IF (VEL.GT.VMAX) GOTO 290
            HA=(2./(2./RF-VEL**2/GM)-RF)/FTNM-RE
            IF (HA.LT.HF) GOTO 310
            IF (MOD(I-1,IPRNT).NE.0) GOTO 280
            PLM=WNEW*XKG
            HAMET=HA*XKM
            WRITE (6,500) HF,WNEW,HA,VEL,PLM,HAMET
  280       CONTINUE
            IF (LPLOT.EQ.0) GOTO 290
            IF (HA.GT.HAMAX) GOTO 290
              WRITE (1) WNEW,HA
              NREC=NREC+1
  290       CONTINUE
            WNEW=WNEW+DW
```

```
  300    CONTINUE
C
  310    CONTINUE
C        CALCULATE CIRCULAR AND ESCAPE PAYLOAD AT PERIGEE ALTITUDE
         VELC=SQRT(GM/RF)
         CALL INTER(VELC,WTC,NWT,WI,VI)
         WTCMET=WTC*XKG
         VELE=SQRT(2.)*VELC
         CALL INTER(VELE,WTE,NWT,WI,VI)
         WTEMET=WTE*XKG
         WRITE (6,510) WTC,WTCMET,VELC,WTE,WTEMET,VELE
         IPAGE=IPAGE+1
         IF (LPLOT.EQ.0) GOTO 330
         IF (WTC.GT.WMAX) GOTO 320
            WRITE (1) WTC,HF
            NREC=NREC+1
  320    CONTINUE
C
         WRITE (2) NREC
  330 CONTINUE
      IF (LPLOT.EQ.0) GOTO 390
C
C        CALCULATE CIRCULAR ORBIT LINE
      HP=HMIN
      HA=HMIN
      NREC=0
  340 CONTINUE
         J=NWT
         DO 350 I=1,NWT
            CALL INTER(HP,VEL,NC(I),V(1,I),H(1,I))
            VI(J)=VEL
            WI(J)=WEIGHT(I)
            J=J-1
  350    CONTINUE
         RBAR=(HP+RE)*FTNM
         A=(2.*RE+HP+HA)/2.*FTNM
         VEL=SQRT(GM*(2./RBAR-1./A))
         CALL INTER(VEL,PL,NWT,WI,VI)
         IF (PL.LE.WMIN .OR. PL.GT.WMAX) GOTO 360
            NREC=NREC+1
            WRITE (1) PL,HA
  360    CONTINUE
         HA=HA+DH/10.
         HP=HA
      IF (HP.LE.HMAX) GOTO 340
      WRITE (2) NREC
      CALL PLOTLG (IOPT,XINC,ALTMIN,DELALT,NH,1.,44,4HPLOT)
      CALL PLOTLG (IOPT,XINC,ALTMIN,DELALT,NH,FACT,36,4HPLT3)
      GOTO 390
C
C         CALCULATE SINGLE ORBIT
  370 CONTINUE
      J=NWT
      DO 380 I=1,NWT
         CALL INTER(HP,VEL,NC(I),V(1,I),H(1,I))
         VI(J)=VEL
         WI(J)=WEIGHT(I)
```

```
        J=J-1
  380 CONTINUE
      RBAR=(HP+RE)*FTNM
      A=(2.*RE+HP+HA)/2.*FTNM
      VEL=SQRT(GM*(2./RBAR-1./A))
      CALL INTER(VEL,PL,NWT,WI,VI)
      HPMET=HP*XKM
      HAMET=HA*XKM
      PLM=PL*XKG
      WRITE (6,450) TITLE1,TITLE2,KASE,IPAGE
      WRITE (6,460) HP,HPMET
      WRITE (6,490)
      WRITE (6,500) HP,PL,HA,VEL,PLM,HAMET
C
  390 CONTINUE
      KASE=KASE+1
      GOTO 10
C
  400 FORMAT (1H1)
  410 FORMAT ((15X,5(F10.3)))
  420 FORMAT (//,15X,*WEIGHT(LBS.)=*,F8.1/15X,*ALTITUDE(N.MI.)*)
  430 FORMAT (15X,*VELOCITY(FPS)*)
  440 FORMAT ((15X,5(F10.1)))
  450 FORMAT (*1*, 8X,8A10,T68,*VOUGHT CORPORATION*,/
     ^             9X,8A10,T73,*PROGRAM ELOPE*,/
     ^                     T68,*CASE  *,I2,
     ^                     T79,*PAGE *,I2//)
  460 FORMAT (25X,*PERIGEE ALT.=*,F6.1,* N.MI. =*,F6.1,* KM*//)
  470 FORMAT (15X,*INTERPOLATION DATA (CHECK FOR ACCURACY)*,//
     ^         13X,*PAYLOAD*,6X,*INJECTION*,/
     ^         13X,*WT.,LBS*,7X,*VEL.,FPS*,/)
  480 FORMAT (5X,2F15.1)
  490 FORMAT (///13X,*PERIGEE*,9X,*PAYLOAD*,8X,*APOGEE*,8X,*PERIGEE*,
     ^            3X,*PAYLOAD*,4X,*APOGEE*,/
     ^           13X,*ALT.,N.MI.*,6X,*WT.,LBS*,6X,*ALT.,N.MI.*,
     ^            5X,*VEL.,FPS*,4X,*WT.,KG*,3X,*ALT.,KM*,/)
  500 FORMAT (5X,4F15.1,2F10.1)
  510 FORMAT (///13X,*CIRCULAR PAYLOAD=*,F6.1,* LBS=*,F6.1,* KG*,
     ^            5X,*CIRCULAR VEL.=*,F8.1,* FPS*,//
     ^           13X,*ESCAPE PAYLOAD  =*,F6.1,* LBS=*,F6.1,* KG*,
     ^            5X,*ESCAPE VEL.  =*,F8.1,* FPS*)
      END
```

```
      SUBROUTINE INPUT
C        THIS SUBROUTINE READS MODIFIED NAMELIST FORMATTED DATA.
C        IT READS A CARD ON UNIT 5,WRITES THE CARD ON UNIT 6,
C        WRITES THE CARD ON UNIT 8 (FIRST 72 CHARACTERS ONLY).
C        THE TITLE CARDS AS DEFINED IN THE DATA STATEMENT BELOW
C        ARE NOT WRITTEN ON UNIT 8 BUT THE DATA IS PLACED IN
C        THE APPROPRIATE ARRAYS FOR TRANSFER BACK TO THE CALLING
C        PROGRAM.  THE TITLE CARDS MUST BEGIN IN COLUMN 2 WITH
C        NO SPACES.  THE CALLING PROGRAM MUST BLANK THE TITLE
C        ARRAYS, CALL INPUT AND READ(8,INPUTD).  NAMELIST DATA
C        MUST BEGIN WITH $INPUTD AND END WITH $END, BOTH
C        BEGINNING IN COLUMN 2.
      IMPLICIT INTEGER (A-Z)
      COMMON /BLK1/ TITLE(68)
      DIMENSION CARD(8), LINE(15)
      DATA LINE/10H TITLE1=  ,10H TITLE2=  ,10H PTITLE1  ,10H PTITLE2
     ^         ,10H PTITLE3  ,10H PTITLE4  ,10H PLABEL1  ,10H PLABEL2
     ^         ,10H PLABEL3  ,10H PLABEL4  ,10H PLABEL5  ,10H PLABEL6
     ^         ,10H PLABEL7  ,10H PLABEL8  ,10H PLABEL9  /
      DATA BLANK/10H          /
C
C
      REWIND 8
      WRITE (6,70)
   10 CONTINUE
         READ (5,110) CARD
         IF (EOF(5).NE.0) STOP
         WRITE (6,90) CARD
C           BLANK COLUMNS 9 AND 10
         ENCODE (10,80,WORD) CARD(1),BLANK
         DO 30 I=1,15
            IF (WORD.NE.LINE(I)) GOTO 30
C           CARD READ IS A TITLE CARD
            IF (I.EQ.1) J=1
            IF (I.EQ.2) J=9
            IF (I.GE.3) GOTO 20
            ENCODE(72,60,TITLE(J))CARD
            GOTO 10
C
   20       CONTINUE
            J=17+4*(I-3)
            ENCODE(30,50,TITLE(J)) CARD(1), CARD(2), CARD(3), CARD(4)
            GOTO 10
   30    CONTINUE
C
C           BLANK COLUMNS 73-80 OF DATA CARD
         ENCODE (10,100,CARD(8)) CARD(8), BLANK
         WRITE (8,110) CARD
      IF (CARD(1).NE.10H $END     ) GOTO 10
C
      REWIND 8
      CALL DATE(DAT)
      CALL TIME(TIM)
      WRITE (6,40) DAT,TIM
      RETURN
C
C
```

```
   40 FORMAT (/////,10X,*DATE IS *,A9/
     ^              10X,*TIME IS *,A9)
   50 FORMAT (R1,A10,A10,A9)
   60 FORMAT (R2,7A10)
   70 FORMAT (1H )
   80 FORMAT (AP,A2)
   90 FORMAT (10X,8A10)
  100 FORMAT (A2,A8)
  110 FORMAT (8A10)
      END
```

```
      SUBROUTINE INTER (X,Y,NUM,B,A)
C        SECOND ORDER INTERPOLATOR
C        SELECT FOUR DATA POINTS CLOSEST TO X TO INTERPOLATE FOR Y.
C        X=INDEPENDENT VARIABLE VALUE
C        Y=RESULTING DEPENDENT VARIABLE VALUE
C        LMT=NO. OF ELEMENTS IN A AND B
C        B=ARRAY OF DEPENDENT VARIABLES
C        A=ARRAY OF INDEPENDENT VARIABLES
      DIMENSION A(15),B(15)
C
      I=1
      IF (NUM.EQ.4) GOTO 30
      IF (NUM.LT.4) WRITE (6,40) NUM
      IF (NUM.LT.4) STOP
C
      IF (X.LT.A(3)) I=1
      IF (X.GT.A(NUM-2)) I=NUM-3
      IF (X.LT.A(3) .OR. X.GT.A(NUM-2)) GOTO 30
C
      LMT=NUM-2
      DO 10 K=4,LMT
         IF (X.LT.A(K)) GOTO 20
   10 CONTINUE
   20 CONTINUE
      I=K-2
C
   30 CONTINUE
      X0=A(I)
      X1=A(I+1)
      X2=A(I+2)
      X3=A(I+3)
      Y11=((X1-X)*B(I)-(X0-X)*B(I+1))/(X1-X0)
      Y21=((X2-X)*B(I)-(X0-X)*B(I+2))/(X2-X0)
      Y31=((X3-X)*B(I)-(X0-X)*B(I+3))/(X3-X0)
      Y22=((X2-X)*Y11-(X1-X)*Y21)/(X2-X1)
      Y32=((X3-X)*Y11-(X1-X)*Y31)/(X3-X1)
      Y=((X3-X)*Y22-(X2-X)*Y32)/(X3-X2)
      RETURN
C
   40 FORMAT (//10X,*SUBROUTINE INTER - VALUES IN INTERPOLATION TABLE =*
     ^               I3*   MUST BE .GE. 4*)
      END
```

```
      SUBROUTINE PLOTLG (IOPT,XINC,HMIN,DH,NUMH,FACT,ICAL,PFILE)
C        THIS SUBROUTINE GENERATES A SEMI-LOG PLOT OF APOGEE
C        ALTITUDE AS A FUNCTION OF PERIGEE ALTITUDE AND
C        PAYLOAD WEIGHT.
C
C     ******************** INPUT DATA ************************
C     DH      = PERIGEE ALTITUDE INCREMENT
C     FACT    = FACTOR FOR RELATIVE SIZE OF PLOT PRODUCED.
C     HMIN    = MINIMUM PERIGEE ALTITUDE
C     ICAL    = TWO DIGIT CALCODE.
C     IOPT    = 1 IF ENGLISH UNITS
C             = 2 IF METRIC UNITS
C     NUMH    = NUMBER OF PERIGEE ALTITUDES
C     PFILE   = LOCAL FILE NAME OF PLOT FILE.
C     XINC    = ABCISSA MAJOR DIVISION INCREMENT
C
      IMPLICIT REAL(A-H,O-S,U-Z),
     ^     INTEGER(I-N,T)
      COMMON /BLK1/TITLE1(8),TITLE2(8),TITLE(16),LABEL(36)
      DIMENSION X(1000), Y(1000)
      DIMENSION A(5), LABELY(20)
      DATA LABELY/10H100       ,10H200       ,10H400       ,
     ^           10H600       ,10H800       ,10H1000      ,
     ^           10H2000      ,10H4000      ,10H6000      ,
     ^           10H8000      ,10H10000     ,10H20000     ,
     ^           10H40000     ,10H60000     ,10H80000     ,
     ^           10H100000    ,10H200000    ,10H400000    ,
     ^           10H600000    ,10H800000    /
C
      DATA XKG/0.45359/,XKM/1.852/
C
      ENCODE(5,5,CALCODE) ICAL
    5 FORMAT(3HCAL,I2)
      CALL PLOTS (CALCODE,0,PFILE)
      CALL FACTOR(FACT)
      REWIND 1
      REWIND 2
      NCYCLE=4
      A(1)=0.
      A(2)=ALOG10(2.)
      A(3)=ALOG10(4.)
      A(4)=ALOG10(6.)
      A(5)=ALOG10(8.)
      XINT=0.
C
C     DRAW TICK MARKS ON Y AXIS AND ANNOTATE
      DO 20 J=1,NCYCLE
         DO 10 I=1,5
            Y1=(FLOAT(J-1)+A(I))*2.5
            CALL PLOT (0.,Y1,3)
            CALL PLOT (-.05,Y1,2)
            X1=-.1*(3.+FLOAT(J))
            Y1=Y1-.05
            IBCD=LABELY(5*J-5+I)
            NCHAR=2+J
            CALL SYMBOL (X1,Y1,.1,IBCD,0.,+NCHAR)
   10    CONTINUE
```

```
   20 CONTINUE
      Y1=(FLOAT(NCYCLE)+A(1))*2.5
      CALL PLOT (0.,Y1,3)
      CALL PLOT (-.05,Y1,2)
      Y1=-.1*(3.+FLOAT(NCYCLE+1))
      Y1=Y1-.05
      CALL SYMBOL (X1,Y1,.1,7H1000000,0.,+7)
C
C     DRAW TICK MARKS ON X AXIS AND ANNOTATE
      DO 30 J=1,8
         X1=FLOAT(J-1)
         CALL PLOT (X1,0.,3)
         CALL PLOT (X1,-.05,2)
         X1=X1-.15
         FPN=XINT+(J-1)*XINC
         CALL NUMBER(X1,-.2,.1,FPN,0.,-1)
   30 CONTINUE
C
C     LABEL X AND Y AXIS
      IF (IOPT.EQ.1)
     ^  CALL SYMBOL(-.64,2.45,.1,21HAPOGEE ALTITUDE-N.MI.,90.,+23)
      IF (IOPT.EQ.1)
     ^  CALL SYMBOL(2.3,-.35,.1,21HPAYLOAD WEIGHT-POUNDS,0.,+23)
      IF (IOPT.EQ.2)
     ^  CALL SYMBOL(-.64,2.45,.1,18HAPOGEE ALTITUDE-KM,90.,+20)
      IF (IOPT.EQ.2)
     ^  CALL SYMBOL(2.3,-.35,.1,24HPAYLOAD WEIGHT-KILOGRAMS,0.,+23)
C
C     WRITE 4 LINES OF TITLE AND 9 LINES OF LABEL
      K=1
      X1=7./2.-8.*.14
      Y1=10.-.14
      DO 40 I=1,4
         CALL SYMBOL (X1,Y1,.14,TITLE(K),0.,30)
         Y1=Y1-.14-.035
         K=K+4
   40 CONTINUE
      K=1
      X1=7.-.10*30.5
      Y1=8.5
      DO 50 I=1,9
         CALL SYMBOL (X1,Y1,.10,LABEL(K),0.,30)
         Y1=Y1-.10-.035
         K=K+4
   50 CONTINUE
C
C     FILL ARRAYS FOR PLOTTING
   60 CONTINUE
         READ(2) NREC
         IF (EOF(2).NE.0) GOTO 80
         DO 70 I=1,NREC
            READ(1) WT,HA
            IF (IOPT.EQ.1) X(I)=WT
            IF (IOPT.EQ.1) Y(I)=ALOG10(HA)-2.
            IF (IOPT.EQ.2) X(I)=WT*XKG
            IF (IOPT.EQ.2) Y(I)=ALOG10(HA*XKM)-2.
   70    CONTINUE
```

```
C
C     DEFINE SCALE FACTORS
         X(NREC+1)=XINT
         X(NREC+2)=XINC
         Y(NREC+1)=0.
         Y(NREC+2)=1./2.5
C
C     DRAW CURVE
         CALL LINE (X,Y,NREC,1,0,0)
         GOTO 60
   80 CONTINUE
C
C     WRITE ADDITIONAL LABELS IN RIGHT BORDER OF PLOT
      X1=8.
      Y1=6.
      HGT=.085
      IF (IOPT.EQ.1)
     ^   CALL SYMBOL (X1,Y1,HGT,24HPERIGEE ALTITUDE - N.MI.,0.,+24)
      IF (IOPT.EQ.2)
     ^   CALL SYMBOL (X1,Y1,HGT,21HPERIGEE ALTITUDE - KM,0.,+21)
      DO 90 I=1,NUMH
         Y1=Y1-HGT-.035
         FPN=HMIN+DH*(I-1)
         CALL NUMBER(X1,Y1,HGT,FPN,0.,-1)
   90 CONTINUE
      Y1=Y1-.2
      CALL SYMBOL (X1,Y1,HGT,15HCIRCULAR ORBITS,0.,+15)
      CALL PLOT (12.,0.,999)
      RETURN
      END
```

```
      SUBROUTINE PLOTLP(TITLE1,TITLE2,REARTH)
C        THIS SUBROUTINE GENERATES A LINEAR PLOT OF PERIGEE ALTITUDE
C        AS A FUNCTION OF VELOCITY AND PAYLOAD WEIGHT.
      IMPLICIT REAL(A-H,O-S,V-Z),
     ^      INTEGER(I-N,T)
      DIMENSION  TITLE1(8), TITLE2(8)
      DIMENSION X(152), Y(152), Z(150)
      DATA CM/2.54/,GM/1.4076576E16/
C
C
      CALL PLOTS(5HCAL32,0,4HPLT2)
      REWIND 3
      SQ2=SQRT(2.)
C
C        ANNOTATE X-AXIS
      NCHAR=5
      DO 10 J=1,20
         X1=FLOAT(J-1)*2./CM
         CALL PLOT(X1,0.,3)
         CALL PLOT(X1,-.05,2)
         X1=X1-.1*NCHAR/2.
         FPN=18000.+1000.*(J-1)
         CALL NUMBER(X1,-.2,.1,FPN,0.,-1)
   10 CONTINUE
      CALL SYMBOL(5.,-.35,.1,23HINJECTION VELOCITY, FPS,0.,23)
C
C         ANNOTATE Y-AXIS
      NCHAR=4
      DO 20 J=1,13
         Y1=FLOAT(J-1)*2./CM
         CALL PLOT(0.,Y1,3)
         CALL PLOT(-.05,Y1,2)
         Y1=Y1-.05
         X1=-.05-.1*NCHAR
         FPN=0.+100.*(J-1)
         CALL NUMBER(X1,Y1,.1,FPN,0.,-1)
   20 CONTINUE
      CALL SYMBOL(-.6,2.5,.1,22HINJECTION ALTITUDE, NM,90.,22)
C
C     WRITE TITLES
      X1=8.-.14*40.
      Y1=10.-.07
      CALL SYMBOL(X1,Y1,.14, TITLE1,0.,80)
      Y1=Y1-.21
      CALL SYMBOL(X1,Y1,.14, TITLE2,0.,80)
C
C     DRAW CIRCULAR AND ESCAPE VELOCITY LINES
      H=100.
      I=1
   30 CONTINUE
         X(I)=H
         Y(I)=SQRT(GM/(X(I)*6076.11549+REARTH))
         Z(I)=SQ2*Y(I)
         IF (H.EQ.1200.) GOTO 40
         I=I+1
         H=H+20.
      GOTO 30
```

```
   40 CONTINUE
      X(I+1)=0.
      X(I+2)=100./2.*CM
      Y(I+1)=18000.
      Y(I+2)=1000./2.*CM
      Z(I+1)=18000.
      Z(I+2)=1000./2.*CM
      CALL LINE(Y,X,I,1,0,0)
      CALL LINE(Z,X,I,1,0,0)
C
C     PLOT DATA
      I=1
   50 CONTINUE
         READ(3) Y(I),X(I)
         IF (EOF(3).NE.0) GOTO 60
         IF (Y(I).LT.0 .OR. Y(I).GT.1200. .OR.
     ^     X(I).LT.18000. .OR. X(I).GT.37000.) GOTO 50
         I=I+1
      GOTO 50
   60 CONTINUE
      I=I-1
      Y(I+1)=0.
      Y(I+2)=100./2.*CM
      X(I+1)=18000.
      X(I+2)=1000./2.*CM
      CALL LINE(X,Y,I,1,-1,1)
      CALL PLOT(17.,0.,999)
      RETURN
      END
```

APPENDIX C

SCIENTIFIC DATA PROCESSING ROUTINE
SUMMARY DOCUMENTATION

IDENTIFICATION

Title Elliptical Orbit Performance

Routine No. 7031 Date Filed March 72 Security Class. U

Responsible Engineer T. R. Myler

Date Completed March 1972 Source Language: FORTRAN IV Other

Key Words Orbit parameters, interpolation, CalComp plot

RESOURCE REQUIREMENTS

Typical CPU 5 sec Machine(s) CDC CYBER 175 No. Source Cards 710

Core 60k (octal) Tape none Plot yes Graphics none

DESCRIPTION

Purpose: To calculate elliptical orbit altitudes as a function of payload weight and generate a CALCOMP plot.

Input: Parametric data of insertion velocity as a function of insertion altitude and payload weight. Also selectors on desired plot.

Output: A table of apogee altitude and payload weight for each perigee altitude selected. Also the payload weight at the circular and escape condition. All data output in both English and metric units. CalComp plot.

Functional Description: Uses a 2-body orbit equation for orbit determination and a second order curve fit to interpolate for velocity and payload weight.

DOCUMENTATION

Vought Report 2-53030/1R-52643, "Elliptical Orbit Performance Computer Program" dated 1 June 1981.

1 Report No	2 Government Accession No	3 Recipient's Catalog No
NASA CR-165832		

4 Title and Subtitle	5 Report Date
Elliptical Orbit Performance Computer Program	December 1981
	6 Performing Organization Code

7 Author(s)	8 Performing Organization Report No
T. R. Myler	
	10 Work Unit No

9 Performing Organization Name and Address	11 Contract or Grant No
Vought Corporation P. O. Box 225907 Dallas, TX 75265	NAS1-15000
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12 Sponsoring Agency Name and Address	Contractor Report
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15 Supplementary Notes

Langley Technical Monitor: R. J. Keynton

16 Abstract

This report describes and presents a FORTRAN coded computer program which generates and plots elliptical orbit performance capability of space boosters for presentation purposes.

Orbital performance capability of space boosters is typically presented as payload weight as a function of perigee and apogee altitudes.

The parameters are derived from a parametric computer simulation of the booster flight which yields the payload weight as a function of velocity and altitude at insertion (i.e., flight path angle = 0 deg.). The process of converting from velocity and altitude to apogee and perigee altitude and plotting the results as a function of payload weight has been mechanized with the ELOPE program. Included in this report are the program theory, user instruction, input/output definitions, subroutine descriptions and detailed FORTRAN coding information.

17 Key Words (Suggested by Author(s))	18 Distribution Statement
Subprograms, Apogee Plots, Perigee Plots, Performance Plots	FEDD Distribution Subject Category 61

19 Security Classif (of this report)	20 Security Classif (of this page)	21 No of Pages	22 Price
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