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FINAL REPORT

DEVELOPMENT OF A WEIGHT/SIZING DESIGN SYNTHESIS COMPUTER PROGRAM

VOLUME III
USER MANUAL

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY • EAST

MCDONNELL DOUGLAS
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DEVELOPMENT OF A WEIGHT/SIZING DESIGN SYNTHESIS COMPUTER PROGRAM

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VOLUME III
USER MANUAL

SUBMITTED TO
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS 77058

CONTRACT NAS 9-12989

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FOREWORD

The Weight/Sizing Design Synthesis Computer Program was developed by McDonnell Douglas Astronautics Company - East under Contract NAS 9-12989 for the National Aeronautics and Space Administration, Lyndon B. Johnson Space Center, Houston, Texas. The contract involved a study to derive basic weight estimation relationships for those elements of the Space Shuttle vehicle which contribute a significant portion of the inert weight. These relationships measure the pacing parameters of load, geometry, material, and environment. The weight estimation relationships are then combined into the Weight/Sizing Design Synthesis Computer Program.

This report is submitted in three volumes:

- I Program Formulation
- II Program Description
- III User Manual

This volume contains the Program User's Manual, which provides the user verbal description of the processes simulated, data input procedures, output data, and values present in the program.

ACKNOWLEDGEMENTS

The following McDonnell Douglas Astronautics Company - East personnel were the major contributors to the technical contents of this study:

L. M. Gnojewski/R. W. Ridenour	Program Coding/Assembly Integration
B. A. Grob	External Tank and Empirical Equations
J. J. Morgan	Wing
J. M. Garrison	Structure Models

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1. ESPER INPUT DATA SETUP

The input data required to run ESPER is in NAMELIST form. With NAMELIST input, the user can input numeric data without FORTRAN statements. Each input record specifies exactly which variable is being input, rather than requiring the input data to interface with an internal input list. This form of inputting data not only enables the user to make changes to the data file with a minimum effort, but it also provides the ability to input information without knowing in advance which items are going to be processed. The NAMELIST block name (x) is a single variable name that refers to a specific list of variables or array names into which (or from which) the data is transferred. The form of the NAMELIST statement is:

NAMELIST/x/$V_1, V_2, V_3, \ldots, V_M$

where

x = the name of the NAMELIST block,

V_j = the scalars or array names that are to be inputted.

To make the mundane task of inputting data into ESPER more palettable and less cumbersome for the user, the data file required by ESPER has been broken down into FIVE distinct blocks. These blocks of data are a logical attempt to group the data functionally to the various models in the program. A description of these data blocks follows:

1. NAMELIST/PERF/ - This block contains the PERFORMANCE oriented parameters (T/W's, thrust's, ..., etc.)
2. NAMELIST/ORB/ - This block contains the ORBITER oriented parameters (OAMS eng wt., FTU's, ..., etc.)
3. NAMELIST/OAERO/ - This block contains the ORBITER AERO-SURFACE parameters (ASPECT RATIO, AREAS, ..., etc.)
4. NAMELIST/SRM/ - This block contains the SRM oriented parameters (DIAMETER, DENSITIES, ..., etc.)
5. NAMELIST/EXT/ - This block contains the EXTERNAL-TANK oriented parameters (HYDROGEN BIAS, CONE ANGLE, ..., etc.)

A description of a typical set of data follows:

1. b PERF

   The first card specifies the beginning of the PERFORMANCE data. The first column in this card and all remaining cards must be left blank.

2. b PROPBG = 1000000., PROPOG = 500000., BCANT = 8.5

   This line is representative of the data included in the PERFORMANCE data block.

3. b END

   This card signifies the end of the PERFORMANCE data block.

4. b ORB

   This card signifies the beginning of the ORBITER data block.

5. b AOI = 15., HTV = 100., LTV = 155., TMIN = .035

   This line is representative of the data included in the ORBITER data block.

6. b END

   This card signifies the end of the ORBITER data block.

7. b OAERO

   This card signifies the beginning of the ORBITER AERO-SURFACE data block.

8. b AR (1) = 2.19, SG(1) = 3200., LAMB(1) = .21

   This line is representative of the data included in the ORBITER AERO-SURFACE data block.

9. b END

   This card signifies the end of the ORBITER AERO-SURFACE data block.

10. b SRM

    This card signifies the beginning of the SRM data block.

11. b RHOP = .065, DIA = 162., MIAX = 78., MAAX = 78.

    This line is representative of the data included in the SRM data block.

12. b END

    This card signifies the end of the SRM data block.

13. b EXT

    This card signifies the beginning of the EXTERNAL-TANK data block.

14. b DI = 0.0, LI = 1000., LD = 4.98235, NR = 25

    This line is representative of the data included in the EXTERNAL TANK data block.

15. b END

    This card signifies the end of the EXTERNAL TANK data block.

Additional cases may be run by repeating each block name with the changed data. At least one piece of data must appear with each block name. A sample input file is shown on the following page.

```
EXAMPLE
&PERF
PROPBG=1000000.,PROPAG=500000.,BCANT=8.5,BCANTY=3.5
BCANTP=17.0,NAENGA=2.0,NAENGB=3.0,THBSL=3917000.
THBSL=395000.,THBVI=470000.,TE=.6918
FTW=1.0
FIXHRD=0.0,ISPBS=260.9,ISPBV=273.2,ISPBBS=359.5
ISPBBV=451.2,SCD=840.,BTW=1.674
H=0.0,DVCARR=1185.2,INC=28.5,STAGV=4874.9,REL=1.0
DVCBN=.0125,DVCNST=3425360.,MATCH=0.0,MR=6.
BMSDVT=1000.,BMSDVP=950.,BMSISP=310.7,BMR=1.65
SENS=0.0,LONGP=1.0
GROW=0.0,MINGLW=0.0
&END
&ARB
ARI=15.,HTV=100.,LTV=155.,HB=110.,LB=235.,LT=747.,NX=.8
NZ=.3,FS=1.4,HF=288.,HL=145.
X=0.0,K1=2.8,SFW=.278.,VC=2912.,PC=14.7,Q=650.,SND=30.6
LNG=77.,FAL=69000.,TMIN=.035,RHBL=.1,RHBS=.1
TAUS=22300.,FF=10300000.,LFS=20.,DELP=1.4,FAB=69000.
RHBB=.1,TAUB=22300.,RHBF=.1,K2=4.,SW=61.,K7=0.,K3=2.,K4=0.
ACO=1764.,FAF=69000.,SAW=809.,FAPB=69000.,TAUPB=22300.
DFAC=1.3,FT=10300000.,RHBTP=.1,RHBPB=.1,K6=120.
NCTPS=4.74,NCA=54.,FWDTPS=1.75,FWDA=1442.,CTTPS=0.0,CTA=0.0
CSTPS=0.0,CSA=0.0,CBTPS=0.0,CBA=0.0,ATTPS=1.22,ATA=1750.
ASTPS=1.22,ASA=1600.,ABTPS=2.97,ABA=2079.,BASTPS=6.6
BASA=371.,TPSCON=275.,WGTPS=1.895,WGPLE=.059
WLETPS=9.3,TLTPS=1.23,TLPLE=.099,TLETPS=6.61
MCSTPS=0.0,MCSA=0.0,WACON=2.02,TACON=2.02,IBA=0.0,IBTPS=0.0
IBC=3476.,LDA=300.,LDTPS=1.0,PRBA=0.0,PRBTPS=0.0,PRBC=1382.
PPC=89.,HYC=77.,SCA=118.,SCTPS=1.0,SWI=4280.,SWC=0.0,WSI=52.
PAGB=1.,SPI=0.,HHEAD=1350.,BHEAD=2000.,HULL=37.
BULL=22.,FTU=95000.,RHB=.286,MATL=1,HCLEN=20.,BCLEN=20.
HELEN=77.,BELEN=172.,CPLGT=1.
DENSF=56.7,DENSB=80.2,RHBT=.16,FTUT=135000.,PRESBM=8160.
RHBP=.16,FTUP=135000.,BMSENG=390.,PROPSY=647.,MODULF=1071.
PRESF=545.,PRESB=545.,ACSPRB=7280.,ACSDEN=61.3,ACSPRS=870.
ACSENG=1310.,ACSSYS=300.,ACSMAD=910.,BRBMTS=0.0
LGFTU=280000.,LGVSL=150.,LGLC=95.,LGLS=117.,BRCF=315000.
LGDIA=33.,AX2=1068.,AX3=1200.,LNDKK=0.0
FIXDWT=00.,BUNC1=.1,PERSON=1250.,BRESD=2985.,BRESV=878.
PLOADU=51612.9,PLOADD=40000.
FIXBRB=0.0,FIXWAR=0.0
PPWR=3912.,HYDRK=0.0,ELECK=0.,SURFK=0.0,AVIONB=4455.0
ECLSB=4093.,PPRBV=1742.,BRIFL=3872.,TABPRB=0.0
&END
&AERB
AR(1)=2.19,SG(1)=3220.,LAMB(1)=.21,TOCR(1)=.09,TOCT(1)=.12
BCT(1)=17.5,THETA(1)=10.,NZ(1)=3.75,DELP(1)=296.,LH(1)=0.0
PTBXC(1)=.43,PTBXE(1)=.894,CB(1)=.67,RHB(1)=.10,FA(1)=64394.
CS(1)=.0005,TAU(1)=22320.,TEMP(1)=70.,UWW(1)=0.0,CSR(1)=.67
TMIN(1)=.03,ULE(1)=1.60,WLF(1)=0.0,CLE(1)=.1,AICP=.306,AILP=1.
EMODU(1)=10000000.,WC1(1)=0.0,WC2(1)=0.0,CM1(1)=0.0
BLP1(1)=0.0,BLP2(1)=0.0,BCM1(1)=0.0
KFAS=.68,UWAIL=1.75,WWOS=0.,WINGK=0.0,SMGDR=190.
AR(2)=1.44,SG(2)=435.,LAMB(2)=.44,TOCR(2)=.107,TOCT(2)=.09

BCT(2)=0.,THETA(2)=33.,NZ(2)=0.,DELP(2)=447.,LH(2)=0.
PTBXC(2)=0.,PTBXE(2)=.42,CB(2)=.47,RHB(2)=.1,FA(2)=64394.
CS(2)=.0005,TAU(2)=22320.,TEMP(2)=70.,UWW(2)=0.,CSR(2)=.67
TMIN(2)=.03,ULE(2)=1.6,WLF(2)=0.0,CLE(2)=.1,RDC=.48,URS=1.75
EMODU(2)=10000000.,WC1(2)=0.0,WC2(2)=0.0,CM1(2)=0.0
BLP1(2)=0.0,BLP2(2)=0.0,BCM1(2)=0.0
RUDUL=3.1,VTVC=0.0,LVT=0.0,SPRUC=1.0,TAILK=0.0
&END
&SRM
RHBP=.064,DIA=142.,MIAX=81.,MAAX=81.,MEBP=1000.
FS=1.4,FTU=254000.,AT=2884.,RHAM=.283,INY=.1,NP=.76397
NJ=5.0,WNAZ=1.0,NER=11.2,AP=3780.,CF=1.58
PC=833.3,NDHA=15.,TC=5775.,TDFS=250.,VRI=141.,VSD=141.
AABE=10.,LF=200.,RUNC1=0.035,FIXDWT=0.0,RRISP=235.,WEI=0.0
BSRMC=0.0,SRMIC=0.0,SRMRC=3500.
FIXBBB=0.0,SIMPBB=0.0
&END
&EXT
DI=0.,LI=1000.,LD=0.,NR=0.,ND=41.,THETA=30.,HHI=100.
MRI=6.,UPERB=1.0297,LA=1.01,FBPRES=37.,BPRES=22.,FUPRES=35.
BUPRES=20.,LF=0.,DF=304.,LCON=30.,BLKHD=3.,BX=1.,K=.15
HBIAS=1500.,FS=1.4,NXL=1.4,NXS=3.3,FTU=64000.,E=10500000.
RHB=.102,TMIN=.025,NCTPS=1.101,UCTPS=.8464,LCTPS=.7365
CYTPS=.6826,INTPS=.8969,DMTPS=.5149,FIXDWT=0.,GUP=.075
RFTDV=200.,RETISP=260.,AVIONT=800.,MISCT=0.,AFT=0.,HRI=.6496
RX1=0.,RX2=0.,RXL=0.,UPERF=1.03
SIMPTK=0.0
&END
```

1ST CASE WHICH IS THE BASELINE CASE

```
&PERF
STAGV=5000.
&END
&ARB
ARI=15.
&END
&AERB
AR(1)=2.19
&END
&SRM
RHBP=.064
&END
&EXT
DI=0.0
&END
```

2ND CASE WHICH CHANGES STAGING VELOCITY FROM 4874 FT/SEC TO 5000 FT/SEC

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2. ESPER INPUT VARIABLES

Following is a complete listing of all the input parameters, together with their reference sources and their symbols for the ESPER program. These reference sources are an interface of ESPER with the Design Data Summary and the Group Weight Statements listed in the appendix. A page, column, line description is used as follows:

DDS 01, 2, 39

where

1. DDS = Design Data Summary
   GWS = Group Weight Summary
   FLUID INV = Fluid Inventory Table of Weight Report
2. 01 = Orbiter page no. 1
   B1 = Booster page no. 1
   ET1 = External tank page no. 1
3. 2 = Column no. or sequence of data entry on line
4. 39 = line number

Proper use of these terms will assure consistency when using and/or generating data.

INPUT DATA SHEET

Input Definition	Units	Reference Source Shuttle	Symbol	Data
PERF PERFORMANCE DATA				
Booster Usable Propellant Weight Initial Guess (1000000 lbs)	Lb		PROPBG	
Orbiter Usable Propellant Weight Initial Guess (500000 lbs)	Lb		PROPOG	
Yaw Angle, Booster to Vehicle Centerline	Deg		BCANT	
Yaw Angle, Outboard Engine to Orbiter Centerline	Deg	DDS 041	OCANTY	
Pitch Angle, Composite Thrust Vector	Deg	DDS 03106	OCANTP	
@ Launch to Orbiter Centerline		Launch c.g.		
Number of Engines, Booster	ND		NOENGB	
Number of Engines, Orbiter	ND	DDS 04130	NOENGO	
Thrust of Booster per Engine @ sea level	Lb		THBSL	
Thrust of Orbiter per Engine @ sea level	Lb	DDS 04230	THOSL	
Thrust of Orbiter per Engine, vacuum	Lb	DDS 04330	THOVI	
Throttle Factor (calculate using BBT)	ND	DDS 04138	TF	
Counter to Determine Thrust 1.0-Fix T/W and float THRUST 0.0-Fix THRUST and float T/W	ND		FTW	
Counter to run Fixed Hardware (payload flots) 1.0-Fixed Hardware 0.0-Option Specified by User	ND ND		FIXHRD	
Specific Impulse Booster, sea level	Sec		ISPBS	
Specific Impulse Booster, vacuum	Sec		ISPBV	
Specific Impulse Orbiter, sea level	Sec	DDS 04530	ISPOBS	
Specific Impulse Orbiter, vacuum	Sec	DDS 04630	ISPOBV	

INPUT DATA SHEET (Cont.)

Input Definition	Units	Reference Source Shuttle	Symbol	Data
Ascent Ballistic Drag Coefficient	ND	DDS 01120	SCD	
Booster T/W at sea level	ND		BTW	
Launch Site Altitude	Ft	DDS 01221	H	
Drag Losses (obtained from fixed hardware run)	Ft/Sec	DDS 01119	DVCORR	
Angle of Inclination, launch	Deg	DDS 01121	INC	
Staging Velocity (see REL)	Ft/Sec	DDS 01220	STAGV	
Counter to use Relative or Ideal Staging Velocity 1.0-Relative Staging Velocity 0.0-Ideal Staging Velocity	ND		REL	
% of Total Velocity required for Flight Performance Reserves	%	DDS 01118	DVCON	
Velocity Correlation Factor (obtained from fixed hardware run)	ND		DVCNST	
Counter to use unknown baseline to solve for DVCORR and DVCNST 1.0-Velocity Correlation Const. Solution 0.0-Option Specified by User	ND		MATCH	
Total Velocity losses used by the program to obtain the correct velocity correlation constants	Ft/Sec		TLSSR	
Oxidizer/fuel ratio, ascent propellant -nominal value	ND	DDS 07141	MR	
OMS Propulsion Delta V for tank sizing	Ft/Sec	DDS 01122	OMSDVT	
OMS Propulsion Delta V for propellant	Ft/Sec		OMSDVP	
OMS Propulsion Specific Impulse	Sec	DDS 05804	OMSISP	
OMS Oxidizer/Fuel Ratio	ND	DDS 07441	OMR	

INPUT DATA SHEET (Cont.)

Input Definition	Units	Reference Source Shuttle	Symbol	Data
Counter to solve for Fixed Hardware Sensitivities 1.0-Fixed Hardware sensitivities 0.0-Option specified by user	ND		SENS	
Counter for Detailed Print Out 1.0-Detail Print Out 0.0-Short Print Out	ND		LONGP	
Counter for Vehicle Growth 0.0-Option Specified by user 1.0-Booster Growth 2.0-Orbiter Growth 3.0-Booster & Orbiter Growth 4.0-External Tank Growth	ND		GROW	
Incremental Booster Growth/Uncertainty	Lb		GROWB	
Incremental Orbiter Growth/Uncertainty	Lb		GROWO	
Two plus the number of one per-cent Growth/Uncertainty Increments to be added	ND		NI	
SRM Dry Weight	Lb		BBOWT	
Orbiter Lift Off Weight less OMS Propellant less Payload	Lb		OLLPLO	
External Tank Inert Weight	Lb		INERT	
External Tank Dry Weight	Lb		DRYWT	
External Tank Residual Propellant Wt	Lb		RESIDT	
Counter for running Minimum Glow 1.0-Minimum Glow 0.0-Option Specified by User			MINGLW	

INPUT DATA SHEET (Cont.)

Input Definition	Units	Reference Source Shuttle	Symbol	Data
ORB ORBITER DATA (BODY)				
Angle of Intersection Composite Thrust Vector and Centerline of Tank	Deg	DDS 03115	AOI	
Height Composite Thrust Vector above Aft Interstage Attach Point	In	DDS 03305 DDS 03306	HTV	
Length of Intersection between Composite Thrust Vector Gimbal and Aft Interstage Attach Point	In	DDS 03105 DDS 03106	LTV	
Height of Orbiter Lift Off CG above Aft Interstage Attach	In	DDS 01305 DDS 03306	HO	
Length of Orbiter Lift Off CG forward of Aft Interstage Attach	In	DDS 01105 DDS 03106	LO	
Length between forward and aft Interface Attach	In	DDS 01105(-) DDS 03104	LI	
Axial Limit Load Factor on Orbiter at critical condition	ND	DDS 01105 DDS 01110	NX	
Vertical limit load factor on Orbiter at critical condition	ND	DDS 01305 DDS 01110	NZ	
Factor of Safety	ND	DDS 0110	FS	
Average Height of Center Fuselage	In	DDS 02248	HF	
Average Height of Cargo Door Sill above Fuselage Bottom	In	DDS 03309 DDS 03310 and axis dia.	HL	
Length forward Interstage Attach and forward Cargo Compt Bulkhead	In	DDS 03104 DDS 03109	X	
Unit weight of forward fuselage shell (calculate outside program)	PSF		K1	
Wetted Area Forward Fuselage	Ft^2	DDS 02141	SFW	
Volume of Pressurized Crew Cabin	Ft^3	DDS 02251	VC	

INPUT DATA SHEET (Cont.)

Input Definition	Units	Reference Source Shuttle	Symbol	Data
Limit Pressure, Crew Compt.	Lb/In^2	DDS 02351	PC	
Max Dynamic Pressure, Orbiter	Lb/Ft^2	DDS 01111	Q	
Area of NLG Doors		DDS 03113 DDS 03114	SND	
Extended Length of Nose Gear Struct	In	DDS 04307	LNG	
Artificial Allowable	Lb/In^2	DDS 02X49 and shell routine	FAL	
Minimum Thickness (calculate outside program)	In		TMIN	
Density Material, Longerons	Lb/In^3	DDS 02X49 and shell routine	RHOL	
Density Material, shell	Lb/In^3	DDS 02X49 and shell routine	RHOS	
Material Shear Allowable, shell	Lb/In^2	DDS 02X49 and shell routine	TAUS	
Modulus Elasticity, frames	Lb/In^2	DDS 02X49 and shell routine	EF	
Average Frame Spacing (calculate outside program)	In		LFS	
Ultimate Design Pressure Differential in center section	Lb/In^2		DELP	
Material Allowable, bulkheads	Lb/In^2	DDS 02X49 and shell routine	FAB	
Density Material, bulkheads	Lb/In^3	DDS 02X49 and shell routine	RHOB	
Shear Allowable, bulkheads	Lb/In^2	DDS 02X49 and shell routine	TAUB	

INPUT DATA SHEET (Cont.)

Input Definition	Units	Reference Source Shuttle	Symbol	Data
Density Material, frames	Lb/In^3	DDS 02X49 and shell routine	RHOF	
Number of Payload Attach Points	ND		K2	
Windshield Area	Ft^2	DDS 02153	SW	
Forward Fuselage Misc. Weight	Lb		K7	
Number of Cargo Door Hinges	ND	DDS 03272	K3	
Center Section Misc. Weight	Lb		K4	
Area Cargo Door	Ft^2	DDS 03122	ACD	
Artificial Allowable, frames	Lb/In^2	DDS 02X49 and shell routine	FAF	
Wetted Area Aft Fuselage	Ft^2	DDS 02341	SAW	
Artifical Allowable Gimbal Plan Bulkhead	Lb/In^2	DDS 02X49 and shell routine	FAPB	
Shear Allowable, Gimbal Bulkhead	Lb/In^2	DDS 02X49 and shell routine	TAUPB	
Dynamic Factor, Ascent Engines	ND		DFAC	
Modulus of Elasticity, thrust struct	Lb/In^2	DDS 02X49	ET	
Density Material, thrust structure	Lb/In^3	DDS 02X49	RHOTP	
Density Material, gimbal bulkhead	Lb/In^3	DDS 02X49	RHOPB	
Aft Section Misc Weight	Lb		K6	
(THERMO)				
Nose Cap TPS Unit Weight	Lb/Ft^2	DDS 03130	NCTPS	
Nose Cap Area	Ft^2	DDS 03830	NCA	
Fwd Crew Compt TPS Unit Weight	Lb/Ft^2	DDS 03132	FWDTPS	

INPUT DATA SHEET (Cont.)

Input Definition	Units	Reference Source Shuttle	Symbol	Data
Fwd Crew Compt Area	Ft^2	DDS 03932	FWDA	
Center Top TPS Unit Weight	Lb/Ft^2	DDS 03136	CTTPS	
Center Top Area	Ft^2	DDS 03936	CTA	
Center Side TPS unit Weight	Lb/Ft^2	DDS 03133	CSTPS	
Center Side Area	Ft^2	DDS 03933	CSA	
Center Bottom TPS Unit Weight	Lb/Ft^2	DDS 03132	CBTPS	
Center Bottom Area	Ft^2	DDS 03933	CBA	
Aft Top TPS Unit Weight	Lb/Ft^2	DDS 03136	ATTPS	
Aft Top Area	Ft^2	DDS 031036	ATA	
Aft Side TPS Unit Weight	Lb/Ft^2	DDS 03133	ASTPS	
Aft Side Area	Ft^2	DDS 031033	ASA	
Aft Bottom TPS Unit Weight	Lb/Ft^2	DDS 03132	ABTPS	
Aft Bottom Area	Ft^2	DDS 031032	ABA	
Base TPS Unit Weight	Lb/Ft^2	DDS 03137	BASTPS	
Base Area	Ft^2	DDS 031037	BASA	
TPS Constant Weight	Lb		TPSCON	
Wing TPS Unit Weight	Lb/Ft^2	DDS 03532	WGTPS	
Leading Edge % Wing Wetted Area	%		WGPLE	
Wing Leading Edge TPS Unit Weight	Lb/Ft^2	DDS 03X28	WLETPS	
Tail TPS Unit Weight	Lb/Ft^2	DDS 03X34	TLTPS	
Leading Edge % Tail Wetted Area	%	DDS 02106	TLPLE	
Tail Leading Edge TPS Unit Weight	Lb/Ft^2	DDS 03X29	TLETPS	
Misc Control Surface TPS Unit Weight	Lb/Ft^2		MCSTPS	
Misc Control Surface Area	Ft^2		MCSA	

INPUT DATA SHEET (Cont.)

Input Definition	Units	Reference Source Shuttle	Symbol	Data
Airfoil Perimeter/Projected Length Wing	ND	DDS 01142	WACON	
Airfoil Perimeter/Projected Length Tail	ND		TACON	
Internal Body TPS Area	Ft^2	DDS 03455	IBA	
Internal Body TPS Unit Weight	Lb/Ft^2		IBTPS	
Internal Body TPS Constant	Lb		IBC	
Landing Docking Compt. TPS Area	Ft^2	DDS 03446	LDA	
Landing Docking Compt TPS Unit Weight	Lb/Ft^2		LDTPS	
Propulsion Compt TPS Area	Ft^2	DDS 03447	PROA	
Propulsion Compt TPS Unit Area	Lb/Ft^2		PROTPS	
Propulsion Compt TPS Constant	Lb		PROC	
Prime Power TPS Weight	Lb		PPC	
Hydraulic TPS Weight	Lb		HYC	
Surface Control Compt TPS Unit Weight	Lb/Ft^3		SCTPS	
Surface Control Compt Area	Ft^2	DDS 03448	SCA	
Initial Baseline Vehicle Projected Area	Ft^2	DDS 01127	SWI	
Change to Initial Baseline Vehicle Projected Area	Ft^2		SWC	
Baseline W/S	Lb/Ft^2		WSI	

INPUT DATA SHEET (Cont.)

Input Definition	Units	Reference Source Shuttle	Symbol	Data
(ASCENT PROPULSION)				
POGO Supression Indicator 1.0-Positive 0.0-Negative	ND		POGO	
Series/Parallel Indicator 1.0-Series Burn 0.0-Parallel Burn	ND		SPI	
Height from top of H_2 Tank to Engine Interface	In		HHEAD	
Height from top of O_2 Tank to Engine Interface	In		OHEAD	
Hydrogen Tank Ullage Pressure	Lb/In^2		HULL	
Oxygen Tank Ullage Pressure	Lb/In^2		OULL	
Ultimate Strength of Duct Material	Lb/In^2		FTU	
Density of Duct Material	Lb/In^3		RHO	
Minimum Gage Indicator 0.0-None 1.0-ARP735 & MDA CW-STL 2.0-MDACW-AL 3.0-MSFC-AL 4.0-MSFC-STL	ND		MATL	
Hydrogen combined flow-length of ducts	In		HCLEN	
Oxidizer combined flow-length of ducts	In		OCLEN	
Hydrogen engine hook-up-(ave/eng) length of ducts	In		HELEN	
Oxygen engine hook-up-(ave/eng) length of ducts	In		OELEN	
Coupling type indicator 1.0-Bolted 0.0-Vee-Band	ND		CPLGI	

INPUT DATA SHEET (Cont.)

Input Definition	Units	Reference Source Shuttle	Symbol	Data
(OMS SYSTEM)				
Density of Fuel	Lb/Ft^3	Fluid Inv.	DENSF	
Density of Oxidizer	Lb/Ft^3	Fluid Inv.	DENSO	
Ullage Pressure in Fuel Tank	Lb/In^2	DDS 05415 DDS 05515	PRESF	
Ullage Pressure in Oxidizer Tank	Lb/In^2	DDS 05416 DDS 05516	PRESO	
Material Allowable, tank	Lb/In^2	DDS 05416	FTUT	
Material Density, tank	Lb/In^3	DDS 04516	RHOT	
Ultimate Pressure, tank pressurization system	Lb/In^2	DDS 05417 DDS 05517	PRESOM	
Pressurization Tank Material Density	Lb/In^3	DDS 05317	RHOP	
Pressurization Tank Material Allowable	Lb/In^2	DDS 05317	FTUP	
Input OMS Module Weight	Lb	GWS 03239	MODULE	
Input OMS Engine Weight	Lb	GWS 03226	OMSENG	
Input OMS System Weight	Lb	GWS 03228	PROPSY	
(ACS SYSTEM)				
Input ACS Propellant Weight	Lb		ACSPRO	
Ullage Pressure, ACS tank	Lb/In^2	DDS 05411 DDS 05511	ACSPRS	
Input ACS System Weight	Lb	GWS 03128	ACSSYS	
Input ACS Engine Weight	Lb	GWS 03126	ACSENG	
Input ACS Module Weight	Lb	GWS 03139	ACSMOD	
Density of the ACS Propellant	Lb/Ft^3	Fluid Inv.	ACSDEN	
(LANDING & DOCKING SYSTEM)				
Ultimate Strength of Strut Material	Lb/In^2		LGFTU	

INPUT DATA SHEET (Cont.)

Input Definition	Units	Reference Source Shuttle	Symbol	Data
Landing Touchdown Speed	Knots		LGVSL	
Extended Strut Length of Main Gear	In		LGLC	
Length from Ground Length to Trunion of Main Gear	In		LGLS	
Landing Break Coefficient	Ft/Sec		BRCF	
Landing Parachute Diameter	Ft		LGDIA	
Auxiliary Sys. Deceleration System	Lb		AX2	
Auxiliary Sys. Separation System	Lb		AX3	
Landing Gear Miscellaneous Constant Weight	Lb		LNDDKK	
(MISC & SUBSYSTEMS)				
Misc Orbiter Subsystem Weight	Lb		ORBMIS	
Percent Orbiter Growth Uncertainty	%		OUNC1	
Orbiter Total Crew Weight	Lb		PERSON	
Optional Fixed Dry Weight GT.0.0-Floating Growth Uncertainty keeping total dry weight equal to number inputted. 0.0-Growth Uncertainty calculated as % of inert wt			FIXDWT	
Orbiter Residual Propellant Weight	Lb		ORESD	
Orbiter Reserve Propellant Weight	Lb		ORESV	
Payload delivered to Orbit	Lb		PLOADU	
Payload delivered at Landing	Lb		PLOADD	
Prime Power Weight	Lb		PPWR	
Hydraulic Weight Constant	Lb		HYDRK	
Electrical Weight Constant	Lb		ELECK	

INPUT DATA SHEET (Cont.)

Input Definition	Units	Reference Source Shuttle	Symbol	Data
Surface Control Weight Constant	Lb		SURFK	
Avionics Weight	Lb		AVIONO	
ECLS Weight	Lb		ECLSO	
Personnel Provision Weight	Lb		PPROV	
In Flight Losses	Lb		ORIFL	
Air-Breathing Propul. System Wt.	Lb		TABPRO	
Counter for Fixed Weight Orbiter 1.0-Fixed Weight Orbiter 0.0-User Specified Option	ND		FIXWOR	
Counter for Fixed Weight Orbiter and External Tank 1.0-Fixed System of Orbiter and External Tank 0.0-User Specified Option	ND		FIXORB	

INPUT DATA SHEET (Cont.)

Input Definition	Units	Reference Source Shuttle	Symbol	Data
OAERO ORBITER AERO-SURFACE DATA				
(WING)				
Aspect Ratio	ND	DDS 01130 DDS 01539	AR(1)	
Aero Ref. Gross Wing Area	Ft^2	DDS 01130	SG(1)	
Planform Taper Ratio	ND	DDS 01540( ) DDS 01240	LAMB(1)	
Thickness Ratio at Root	ND	DDS 01241( ) DDS 01240	TOCR(1)	
Thickness Ratio at Tip	ND	DDS 01541( ) DDS 01540	TOCT(1)	
Span of Carrythrough	Ft	DDS 01339	BCT(1)	
Sweepback Angle @ 50% Chord	Deg	DDS 01145	THETA(1)	
Ultimate Vertical Load Factor	ND	DDS 01608	NZ(1)	
Equivalent Δp of Critical Loading		DDS 01146( ) Exposed Area	DELP(1)	
Horizontal Tail Load	Lb	DDS 02226	LH(1)	
Area of Carrythrough/Area Buried (THEOR.)	%		PTBXC(1)	
Area of Torque Box/Area Exposed	%		PTBXE(1)	
Shell Material Intercept	Lb/Ft^2	DDS 01431 and shell routine	CB(1)	
Density Material, torque box	Lb/In^3	DDS 01431 and shell routine	RHO(1)	
Artificial Allowable Covers	Lb/In^2	DDS 01431 and shell routine	FA(1)	
Shear Web Material Intercept	ND	DDS 01431 and shell routine	CS(1)	

INPUT DATA SHEET (Cont.)

Input Definition	Units	Reference Source Shuttle	Symbol	Data
Shear Allowable	Lb/In^2	DDS 01431 and shell routine	TAU(1)	
Design Temperature, torque box	°F	DDS 01531	TEMP(1)	
Unit Wing Weight	Lb/Ft^2		UWW(1)	
Unit Rib Weight	Lb/Ft^2	Use CB	CSR(1)	
Maximum Thickness of Material	In		TMIN(1)	
Unit Weight of Leading Edge	Lb/Ft^2		ULE(1)	
Area of Leading Edge	Ft^2	DDS 01X32	WLE(1)	
Control Surface HL Fraction of Chord	ND		AICP(1)	
Control Surface Fraction of Exposed Span	ND		AILP(1)	
Leading Edge Fraction of Chord	ND		CLE(1)	
Modulus of Elasticity of Torque Box Material	Lb/Ft^2		EMODU(1)	
Concentrated Weight Input (2)	Lb		WC1(1)	
Concentrated Weight Input (2)	Lb		WC2(1)	
Concentrated Moment Input	Lb		CM1(1)	
Location of Concentrated Weight Input (1) to Orbiter Centerline	In		BLP1(1)	
Location of Concentrated Weight Input (2) to Orbiter Centerline	In		BLP2(1)	
Location of Concentrated Moment Input to Orbiter Centerline	In		BCM1(1)	
Unit Pressure on Elevon	Lb/Ft^2		KEAS	
Unit Weight, control surface shell	Lb/Ft^2		UWAIL	

INPUT DATA SHEET (Cont.)

Input Definition	Units	Reference Source Shuttle	Symbol	Data
Counter for Calculating Wing Area GT.0.0-Size Wing Area using inputted W/S 0.0-Fixed inputted area	ND		WWOS	
Wing Weight Constant	Lb		WINGK	
Area of Main Landing Gear Door	Ft^2		SMGDR	
(TAIL)				
Aspect Ratio	ND	DDS 02110 DDS 02103	AR(2)	
Aero Ref. Gross Tail Area	Ft^2	DDS 02103	SG(2)	
Planform Taper Ratio	ND	DDS 02119( ) DDS 02116	LAMB(2)	
Thickness Ratio at Root	ND	DDS 02121( ) DDS 02116	TOCR(2)	
Thickness Ratio at Tip	ND	DDS 02123( ) DDS 02119	TOCT(2)	
Span of Carrythrough	Ft	DDS 02109( ) DDS 02110	BCT(2)	
Sweepback Angle @ 50% Chord	Deg	DDS 02125	THETA(2)	
Ultimate Vertical Load Factor	ND		NZ(2)	
Equivalent Normal Pressure	Lb/Ft^2	DDS 02126( ) DDS 02104	DELP(2)	
Horizontal Tail Load	Lb		LH(2)	
Torque Box Fraction of Chord	%	DDS 02105( ) DDS 02104	PTBXE(2)	
Torque Box Fraction of Chord-Carrythrough	%		PTBXC(2)	
Shell Material Intercept	Lb/Ft^2	DDS 02112 and shell routine	CB(2)	

INPUT DATA SHEET (Cont.)

Input Definition	Units	Reference Source Shuttle	Symbol	Data
Shell Material Density	Lb/In^3	DDS 02112 and shell routine	RHO(2)	
Artificial Allowable of Shell Material	Lb/In^2	DDS 02112 and shell routine	FA(2)	
Shear Material Intercept	ND	DDS 02112 and shell routine	CS(2)	
Artificial Shear Allowable	Lb/In^2	DDS 02112 and shell routine	TAU(2)	
Temperature @ Design Load	°F	DDS 02113	TEMP(2)	
Unit Tail Weight	Lb/Ft^2		UWW(2)	
Unit Rib Weight	Lb/Ft^2		CSR(2)	
Maximum Thickness of Material	In		TMIN(2)	
Unit Weight of Leading Edge	Lb/Ft^2		ULE (2)	
Area of Leading Edge	Ft^2	DDS 021106	WLE(2)	
Leading EDGE Fraction of Chord	ND		CLE(2)	
Modulus of Elasticity of Torque Box Material	ND		EMODU(2)	
Concentrated Weight Input (1)	Lb		WC1(2)	
Concentrated Weight Input (2)	Lb		WC2(2)	
Concentrated Moment Input	Ft-Lb		CM1(2)	
Location of Concentrated Weight Input (1) to Orbiter Centerline	In		BLP1(2)	
Location of Concentrated Weight Input (2) to Orbiter Centerline	In		BLP2(2)	
Location of Concentrated Weight Input to Orbiter Centerline	In		BCM1(2)	

INPUT DATA SHEET (Cont.)

Input Definition	Units	Reference Source Shuttle	Symbol	Data
Rudder Fraction of Chord	ND	DDS 02107( ) DDS 02104	RDC	
Unit Weight Rudder Shell	Lb/Ft^2		URS	
Rudder Unit Loading/1000	Lb/In^2	DDS 06206	RUDUL	
Counter for Calculating Tail Area GT0.0-Size Tail Area using inputted vertical tail volume coefficient 0.0-Fixed inputted area	ND		UTVC	
Length V Tail C/4 to wing C/4	In		LVT	
Counter for Split Rudder 1.0-Split Rudder 0.0-Single Rudder	ND		SPRUD	
Tail Weight Constant	Lb		TAILK	

INPUT DATA SHEET (Cont.)

Input Definition	Units	Reference Source Shuttle	Symbol	Data
EXT EXTERNAL TANK DATA				
Initial Guess at Tank Diameter	In		DI	
Initial Guess at Tank Length	In		LI	
Required L/D-Output is Resultant Length and Diameter	ND		LD	
Nose Cap Radius	In	DDS ET1128	NR	
Nose Cap Diameter	In	DDS ET1125	ND	
Forward Cone Angle	Deg		THETA	
Initial Guess at Fuel Tank Length	In		HHI	
Mixture Ratio, Oxidizer/Fuel	ND	DDS 07141	MRI	
Percent Oxidizer Ullage (1+Dec.%)	ND	DDS ET1132	UPERO	
Load Allowance (1+Dec.%)	ND	DDS ET1133	LA	
Fuel Operating Pressure	Lb/In^2	DDS ET1237	FOPRES	
Fuel Ullage Pressure	Lb/In^2	DDS ET1238	FUPRES	
Oxidizer Operating Pressure	Lb/In^2	DDS ET1137	OPRES	
Oxidizer Ullage Pressure	Lb/In^2	DDS ET1138	OUPRES	
Required Fixed Length-Output is Resultant Diameter	Lb/In^2		LF	
Required Fixed Diameter-Output is Resultant Length	In		DF	
Minimum Propellant Load	Lb	VOL I p.4-32	PROMIN	

INPUT DATA SHEET (Cont.)

Input Definition	Units	Reference Source Shuttle	Symbol	Data
Clearance Between Bulkheads	In	Cal. from station data	LCON	
Bulkhead Counter 1.0-Common Bulkhead 2.0-Separate Bulkhead 3.0-Alternate Bulkhead	ND		BLKHD	
Dummy Counter to test series burn point design 1.0-Parallel Burn 0.0-Series Burn	ND		BX	
Structural Space Allowance	In		K	
Percent Fuel Ullage(1+Dec %)	ND	DDS ET1232	UPERF	
Optional Fixed Fuel Bias	Lb		HBIAS	
Factor of Safety	ND	DDS ET1107	FS	
Lift Off Vertical Load Factor	ND	DDS ET1105	NXL	
Staging Vertical Load Factor	ND	DDS ET1106	NXS	
Material Tensile Strength	Lb/In^2	DDS ET1X34	FTU	
Material Modulus	Lb/In^2	DDS ET1X34	E	
Material Density	Lb/In^3	DDS ET1X34	RHO	
Material Minimum Gauge	In		TMIN	
Nose Cap TPS Unit Weight	Lb/Ft^2		NCTPS	
Upper Cone TPS Unit Weight	Lb/Ft^2		UCTPS	
Lower Cone TPS Unit Weight	Lb/Ft^2		LCTPS	
Cylinder (fuel tanks) TPS Unit Weight	Lb/Ft^2		CYTPS	

INPUT DATA SHEET (Cont.)

Input Definition	Units	Reference Source Shuttle	Symbol	Data
Interstage TPS Unit Weight	Lb/Ft^2		INTPS	
Aft Dome TPS Unit Weight	Lb/Ft^2		DMTPS	
Optional Fixed Dry Weight GT.0.0-Floating Growth Uncertainty keeping total dry weight equal to number inputted. 0.0-Growth Uncertainty calculated as a % of inert wt	Lb		FIXDWT	
Growth/Uncertainty (Dec %)	ND		GUP	
Retro Delta Velocity	Ft/Sec	DDS ET1148	RETDV	
Retro Rocket Isp	Sec	DDS ET1248	RTISP	
Avionics Constant Weight	Lb		AVOINT	
Misc. Constant Weight	Lb		MISCT	
Counter for LOX Tank 1.0-Aft 0.0-Forward	ND		AFT	
Ratio of Blkhd Height to Blkhd Hemispherical Radius-HR/R	ND	DDS ET1X49 DDS ET1X50	HRI	
Orbiter Interstage Reaction Loads from Orbiter Module	Lb		RX1	
Orbiter Interstage Reaction Loads from Orbiter Module	Lb		RX2	
Orbiter Interstage Reaction Loads from Orbiter Module	Lb		RXL	
Simplified Tank Equation Counter 1.0-Simplified Equation 0.0-Detail Equation	ND		SIMPTK	
External Tank Inert Weight	Lb		INERT	
External Tank Dry Weight	Lb		DRYWT	
External Tank Residual Propellant Weight	Lb		RESIDT	

INPUT DATA SHEET (Cont.)

Input Definition	Units	Reference Source Shuttle	Symbol	Data
SRM SRM DATA				
Propellant Density	Lb/In^3	DDS B1110	RHOP	
Case Diameter	In	DDS B1X23	DIA	
Minor Axis of Elliposidal Dome	In	DDS B1226 DDS B1227	MIAX	
Major Axis of Elliposidal Dome	In	DDS B1X23	MAAX	
Maximum Expected Operating Pressure	Lb/In^2	DDS B1129	MEOP	
Factor of Safety	ND	DDS B1130	FS	
Ultimate Tensile Strength	Lb/In^2	DDS B1132	FTU	
Nozzle Throat Area	In^2	DDS B1153	AT	
Case Material Density	Lb/In^3	DDS B1131	RHOM	
Insulation Thickness	In	DDS B1139	INT	
Propellant Loading Fraction	ND	DDS B1210	NP	
Number of Segment Points	ND	DDS B1139	NJ	
Counter for Nozzle Type 1.0-Gimballed 0.0-Fixed	ND		WNOZ	
Nozzle Expansion Ratio	ND	DDS B1452	NER	
Propellant Grain Port	In^2	DDS B1154	AP	
Thrust Coefficient		DDS B1155	CF	
Average Operating Chamber Pressure	Lb/In^2	DDS B1230	PC	
Nozzle Divergence Half Angle	Deg	DDS B1253	NDHA	
Combustion Temperature	°F	DDS B1156	TC	
Case Design Temperature	°F	DDS B1133	TDES	

INPUT DATA SHEET (Cont.)

Input Definition	Units	Reference Source Shuttle	Symbol	Data
Velocity @ Retro Rocket Ignition	Ft/Sec	DDS B1343	VRI	
Velocity @ Water Impact	Ft/Sec	DDS B1243	VSD	
Average Angle of Orbiter Engines with X axis in X-Z plane	Deg		AAOE	
Distance from edge of Aft Skirt End to Orbiter Thrust Line	In		LF	
Percent Uncertainty	%		BUNC1	
Optional Fixed Dry Weight GT.0.0-Floating Growth uncertainty keeping total dry weight constant 0.0-Growth Uncertainty calculated as a % * Weight	Lb		FIXDWT	
Average Specific Impulse of Retro Rocket Propellant	Sec	DDS B1247	RRISP	
Counter for Joint Type 1.0-Neither end inhibited 0.0-One end inhibited	ND		WEI	
Basic SRM Weight Constant	Lb		BSRMC	
SRM Adapter Weight Constant	Lb		SRMIC	
SRM Recovery Weight Constant	Lb		SRMRC	
Counter to run Fixed Booster 1.0-Fix Booster Total Wt 0.0-Specified Option	ND		FIXBOO	
Simplified Booster Equation Indicator 1.0-Simplified Equation 0.0-Detail Equations	ND		SIMPBO	
SRM Burn Out Weight	Lb		BBOWT	
SRM Dry Weight	Lb		BDRYWT	

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3. ESPER PROGRAM DESCRIPTION AND OPTIONS

This section describes the method of exercising the various options of the ESPER program.

3.0.1 ESPER Program - The ESPER program is a multi option sizing/synthesis program geared to the Solid Rocket Motor (SRM) booster, in parallel with an external hydrogen/oxygen tank Orbiter for either the easterly (28-1/2-degree inclination), polar (90-degree inclination), or resupply (55 degree inclination) missions.

The program has two primary options:

(a) fixed hardware

(b) iterative vehicle sizing

The fixed hardware option determines the payload capability of a given configuration. This allows the user to determine the effect on performance of configuration and/or criteria changes, either real or proposed.

The iterative vehicle sizing option physically sizes the vehicles for a given payload. It determines the size of the SRM and its propellant load and the size of the external tank and its corresponding propellant load. The iterative procedure will size the vehicle to the sizing criteria of a fixed-staging velocity or it will size the vehicle to a minimum Gross Lift Off Weight (GLOW). The minimimum GLOW option is provided as it is generally associated with a minimum cost operation.

In turn, either of the sizing requirements can be run with a fixed-thrust option in which both the booster and Orbiter thrust are set at given values and the propellant requirements are determined,or the Orbiter thrust can be fixed and the first stage thrust to weight ratio input. The fixed-thrust-to-weight option determines booster engine size plus the propellant requirements.

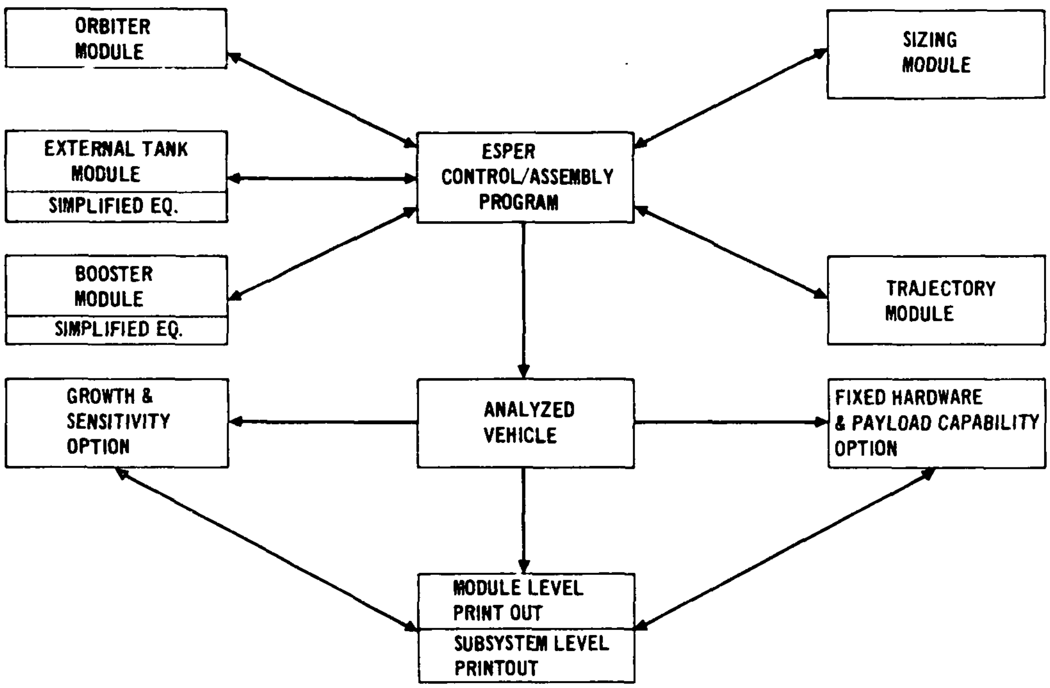
Each of the vehicles has several modes of analysis available. The Orbiter, external tank, and booster weight can be determined by the detail analysis, by detail analysis while maintaining a user input dry weight, or by no analysis, by simply utilizing an input weight to represent the vehicle. In addition, the external tank and the booster are represented by simplified equations in which the parameter of interest is curve-fit to determine the vehicle weight.

In addition to printing out the performance parameter, the option is available to print out the detail subsystems weights of each vehicle, providing a line-item comparison with the current Shuttle vehicle. The other option would be a simplified printout, containing only the vehicle dry or burnout weight as listed in the performance parameter.

Two performance subroutines are tied into the ESPER program to allow the user to determine growth characteristics or vehicle sensitivities.

Figure 3-1 presents a simplified flow chart of the ESPER program. The analytical program consists of three vehicle modules, two functional modules and three performance subroutines.

FIGURE 3-1 ESPER FLOW CHART



3.1 Option 1 - Fixed Hardware - This option determines the payload capability for a given configuration and physical characteristics through the use of the rocket equation (ΔV = gISP ln (MASS FRACTION)). In this option, the configuration weights and propellant loadings, as well as the ascent engine characteristics, are input into ESPER. To complete the analysis, the configuration velocity losses ($\Delta V_{CONFIG} = \Delta V_{ORB} + \Delta V_{SRM} + \Delta V_{LOSSES}$) are determined from an empirical relationship derived from parametric-ascent trajectory shaping studies. These velocity losses were curve fit for ease of interpolation when running ESPER. When the configuration velocity correlation constants needed for the interpolation routine (DVCORR and DVCNST) are known, the velocity losses are calculated by ESPER. This option gives the user an invaluable tool by which the user can measure the impact on payload due to changes to a FIXED HARDWARE DESIGN. (For example, what is the change to the deliverable payload due to a 1-sec increase in orbiter ascent ISP.) An example data file is given as follows:

```
EXAMPLE1
&PERF
PRØPBG=2812334.,PRØPØG=1259273.,BCANT=8.5,BCANTY=3.5
BCANTP=17.0,NØENGB=2.0,NØENGØ=3.0,THBSL=3917000.
THBVI=470000.,THØSL=375000.,TF=.6918
FIXHRD=1.0,ISPBS=240.9,ISPBV=273.2,ISPØBS=359.5
ISPØBV=451.2,SCD=840.,H=0.0,DVCØRR=600.
INC=28.5,DVCAN=.0125,DVCNST=3427166.
RFL=1.0,BBØWT=463780.,BLLPLB=186267.,DRYWT=72260.,RFSIDT=9580.
BDRYWT=463780.,ØMSISP=310.7,ØMSDVP=950.,MR=6.0
SFNS=0.0,LØNGP=0.0
MATCH=0.0
&END
```

In this data file, it is important to note the following

1. PROPGB is the actual SRM usable propellant weight.
2. PROPOG is the actual Orbiter usable propellant weight burned in the 2nd stage.
3. FIXHRD must be equal to 1.0.
4. MATCH must be equal to 0.0.
5. LONGP must be equal to 0.0.

Generally, however, these velocity correlation constants (DVCORR and DVCNST) are not known, but the staging velocity and the total losses are usually readily available. A matching routine, based on a simplified newtonian iteration technique, is provided in the FIXED HARDWARE OPTION that will internally modify the existing velocity loss curve fits. This routine solves for the correct DVCORR and DVCNST that will satisfy the total losses and staging velocity constraints. Since DVCORR and DVCNST are required input parameters, this solution serves a dual purpose for the user, it not only allows ESPER to compute the velocity losses, but it also opens the door to the other options offered by ESPER. An example data file utilizing this matching routine is as follows:

```
EXAMPLE2
&PERF
PRØPBG=2812334.,PRØPØG=1259273.,BCANT=8.5,BCANTY=3.5
BCANTP=17.0,NØENGB=2.0,NØENGØ=3.0,THBSL=3917000.
THBVI=470000.,THØSL=375000.,TF=.6918
FIXHRD=1.0,ISPBS=240.9,ISPBV=273.2,ISPØBS=359.5
ISPØBV=451.2,SCD=840.,H=0.0,DVCØRR=600.
INC=28.5,DVCAN=.0125,DVCNST=3427166.
RFL=1.0,BBØWT=463780.,BLLPLB=186267.,DRYWT=72260.,RFSIDT=9580.
BDRYWT=463780.,ØMSISP=310.7,ØMSDVP=950.,MR=6.0
SFNS=0.0,LØNGP=0.0
MATCH=1.0,STAGV=4874.,TLSSR=6360.
&END
```

This data file is exactly the same as the previous one with the following exceptions:

1. MATCH must now equal 1.0.
2. TLSSR and STAGV must be added. Where
   A. TLSSR is the total velocity losses, and
   B. STAGV is the relative staging velocity.
3. DUCØRR and DVCNST are required inputs, but merely serve as initial guesses to start the iteration.

3.1.2 Option 2 - Orbiter - This option contains the analytical and empirical weight estimation relationships necessary to completely define the Orbiter. These relationships are combined into separate models, each model fully describing a weight group from the NASA functional coding. The NASA weight report and design data, coupled with a three-view drawing of the Orbiter, supplies all the inputs necessary to analyze the configuration. To run a point design, it is necessary to determine the velocity correlation coefficients as described in Option 1, if they are not already known. The Orbiter option is then ready to be executed in its iterative mode. The primary purpose of this option is to provide the capability of analyzing an iterative vehicle to determine performance trades, and to lend direction to the overall design effort by answering such questions as:

1. what happens if the engine characteristics, such as orbiter thrust, booster thrust, or specific impulse are varied?
2. is the staging velocity optimized?
3. what is the minimum gross-weight vehicle for the users constraints?
4. what is the effect of changes, to the primary construction material?
5. how do geometric changes, such as aspect ratio, payload bay length, or width, effect the configuration?

The inputted parameters start the Orbiter Module iteration, for which liftoff weight, injected weight, etc. are calculated. These calculated weights modify the aerodynamic surfaces, which in turn modify the surface controls and hydraulics as well as the thermal protection system. The auxiliary propulsion system is affected by injected weight, and the landing gear by the landing loads. The body is modified by reactions from the above systems, which in turn changes the interstage loads which ripple changes back through the body. The entire module continues the iteration until a completely balanced system exists. This Orbiter option not only contains input constants, which allow the user to input weight changes without modifying the program, but also has three distinct modes of operation which are as follows:

1. Iterative Analysis
2. Iterative Analysis (Fixed Dry Weight)
3. Fixed Weight Orbiter

The iterative analysis mode is the primary mode of the Orbiter option. A typical data file for the mode is as follows:

EXAMPLE3

```
&ARB
AOI=15.,HTV=100.,LTV=155.,HO=110.,LO=235.,LI=747.,NX=.8
NZ=.3,FS=1.4,HF=258.,HL=145.
X=0.0,K1=2.8,SFW=1278.,VC=2912.,PC=14.7,Q=650.,SND=30.6
LNG=77.,FAL=69000.,TMIN=.035,RHOL=.1,RHOS=.1
TAUS=22300.,FF=10300000.,LFS=20.,DELP=1.4,FAB=69000.
RHOB=.1,TAUB=22300.,RHOF=.1,K2=4.,SW=41.,K7=0.,K3=2.,K4=0.
ACD=1764.,FAF=69000.,SAW=809.,FAPB=69000.,TAUPB=22300.
DFAC=1.3,FT=10300000.,RHOTP=.1,RHAPB=.1,K6=120.
NCTPS=4.74,NCA=54.,FWDTPS=1.75,FWDA=1442.,CTTPS=0.0,CTA=0.0
CSTPS=0.0,CSA=0.0,CBTPS=0.0,CBA=0.0,ATTPS=1.22,ATA=1750.
ASTPS=1.22,ASA=1600.,ABTPS=2.97,ABA=2079.,BASTPS=6.6
BASA=371.,TPSCON=275.,WGTPS=1.895,WGPLE=.059
WLETPS=9.3,TLTPS=1.23,TLPLE=.099,TLETPS=4.61
MCSTPS=0.0,MCSA=0.0,WACAN=2.02,TACON=2.02,IBA=0.0,IBTPS=0.0
IBC=3476.,LDA=300.,LDTPS=1.0,PROA=0.0,PROTPS=0.0,PROC=1382.
PPC=89.,HYC=77.,SCA=118.,SCTPS=1.0,SWI=4280.,SWC=0.0,WSI=52.
PAGO=1.,SPI=0.,HHEAD=1350.,OHEAD=2000.,HULL=37.
OULL=22.,FTU=95000.,RHO=.286,MATL=1,HCLEN=20.,OCLEN=20.
HFLEN=77.,OELEN=172.,CPLGI=1.
DENSF=54.7,DENSA=90.2,RHOT=.16,FTUT=135000.,PRESOM=8160.
RHOP=.16,FTUP=135000.,OMSENG=390.,PROPSY=647.,MODULF=1071.
PRESF=545.,PRESA=545.,ACSPRO=7280.,ACSDEN=61.3,ACSPRS=870.
ACSENG=1310.,ACSSYS=300.,ACSMOD=910.,ORBMIS=0.0
LGFTU=280000.,LGVSL=150.,LGLC=95.,LGLS=117.,BRCF=315000.
LGDIA=33.,AX2=1068.,AX3=1200.,LNDDKK=0.0
FIXDWT=00.,OUNC1=.1,PERSON=1250.,ARESD=2985.,ARESV=878.
PLOADU=51612.9,PLAADD=40000.
FIXORB=0.0,FIXWAR=0.0
PPWR=3912.,HYDRK=0.0,ELECK=0.,SURFK=0.0,AVIONO=4455.0
ECLSO=4093.,PPROV=1742.,ORIFL=3872.,TABPRA=0.0
&END
&AAERO
AR(1)=2.19,SG(1)=3220.,LAMB(1)=.21,TOCR(1)=.09,TOCT(1)=.12
BCT(1)=17.5,THETA(1)=10.,NZ(1)=3.75,DELP(1)=296.,LH(1)=0.0
PTBXC(1)=.43,PTBXE(1)=.594,CB(1)=.67,RHO(1)=.10,FA(1)=64394.
CS(1)=.0005,TAU(1)=22320.,TEMP(1)=70.,UWW(1)=0.0,CSR(1)=.67
TMIN(1)=.03,ULE(1)=1.60,WLE(1)=0.0,CLE(1)=.1,AICP=.306,AILP=1.
EMODU(1)=10000000.,WC1(1)=0.0,WC2(1)=0.0,CM1(1)=0.0
BLP1(1)=0.0,BLP2(1)=0.0,BCM1(1)=0.0
KFAS=.68,UWAIL=1.75,WWOS=0.,WINGK=0.0,SMGDR=190.
AR(2)=1.44,SG(2)=435.,LAMB(2)=.44,TOCR(2)=.107,TOCT(2)=.09
BCT(2)=0.,THETA(2)=33.,NZ(2)=0.,DELP(2)=447.,LH(2)=0.
PTBXC(2)=0.,PTBXE(2)=.42,CB(2)=.67,RHO(2)=.1,FA(2)=64394.
CS(2)=.0005,TAU(2)=22320.,TEMP(2)=70.,UWW(2)=0.,CSR(2)=.67
TMIN(2)=.03,ULE(2)=1.6,WLE(2)=0.0,CLE(2)=.1,RDC=.48,URS=1.75
EMODU(2)=10000000.,WC1(2)=0.0,WC2(2)=0.0,CM1(2)=0.0
BLP1(2)=0.0,BLP2(2)=0.0,BCM1(2)=0.0
RUDUL=3.1,VTVC=0.0,LVT=0.0,SPRUD=1.0,TAILK=0.0
&END
```

In this data file, it is important to note the following:

1. FIXWØR must be 0.0
2. FIXØRB must be 0.0
3. WWØS must be contained in data set equal to either 0.0 or a value
4. VTVC must be contained in data set equal to either 0.0 or a value
5. SPRUD must be contained in data set equal to either 0.0 or a value
6. FIXDWT must be contained in data set and equal to 0.0

The (Fixed Dry Weight) Iterative Analysis mode of the Orbiter allows the user to run a point design. The growth/uncertainty of the Orbiter module is allowed to "float," i.e., vary either up or down to maintain a constant dry weight, physically sizing each system to the point design loads. A typical data file for this mode is as follows:

EXAMPLE4

```
&ARB
AAI=15.,HTV=100.,LTV=155.,HB=110.,LB=235.,LI=747.,NX=.8
N7=.3,FS=1.4,HF=258.,HL=145.
X=0.0,K1=2.8,SFW=1278.,VC=2912.,PC=14.7,Q=650.,SND=30.6
LNG=77.,FAL=49000.,TMIN=.035,RHOL=.1,RHOS=.1
TAUS=22300.,FF=10300000.,LFS=20.,DELP=1.4,FAB=69000.
RHOB=.1,TAUB=22300.,RHOF=.1,K2=4.,SW=41.,K7=0.,K3=2.,K4=0.
ACD=1764.,FAF=69000.,SAW=809.,FAPB=69000.,TAUPB=22300.
DFAC=1.3,FT=10300000.,RHOTP=.1,RHAPB=.1,K6=120.
NCTPS=4.74,NCA=54.,FWDTPS=1.75,FWDA=1442.,CTTPS=0.0,CTA=0.0
CSTPS=0.0,CSA=0.0,CBTPS=0.0,CBA=0.0,ATTPS=1.22,ATA=1750.
ASTPS=1.22,ASA=1600.,ABTPS=2.97,ABA=2079.,BASTPS=6.6
BASA=371.,TPSCON=275.,WGTPS=1.895,WGPLE=.059
WLETPS=9.3,TLTPS=1.23,TLPLE=.099,TLETPS=4.61
MCSTPS=0.0,MCSA=0.0,WACON=2.02,TACON=2.02,IBA=0.0,IBTPS=0.0
IBC=3476.,LDA=300.,LDTPS=1.0,PROA=0.0,PROTPS=0.0,PROC=1382.
PPC=89.,HYC=77.,SCA=118.,SCTPS=1.0,SWI=4280.,SWC=0.0,WSI=52.
PAGO=1.,SPI=0.,HHEAD=1350.,OHEAD=2000.,HULL=37.
OULL=22.,FTU=95000.,RHO=.286,MATL=1,HCLEN=20.,OCLEN=20.
HELEN=77.,OELEN=172.,CPLGI=1.
DENSF=54.7,DENSO=90.2,RHOT=.16,FTUT=135000.,PRESOM=8160.
RHOP=.16,FTUP=135000.,OMSENG=390.,PROPSY=647.,MODULE=1071.
PRESF=545.,PRESO=545.,ACSPRO=7280.,ACSDEN=61.3,ACSPRS=870.
ACSENG=1310.,ACSSYS=300.,ACSMOD=910.,ORBMIS=0.0
LGFTU=280000.,LGVSL=150.,LGLC=95.,LGLS=117.,BRCF=315000.
LGDIA=33.,AX2=1068.,AX3=1200.,LNDDKK=0.0
FIXDWT=17266.,AUNC1=0.0,PERSON=1250.,ORESD=2985.,ORESV=878.
PLOADU=51612.9,PLOADD=40000.
FIXORB=0.0,FIXWAR=0.0
PPWR=3912.,HYDRK=0.0,ELECK=0.,SURFK=0.0,AVIONB=4455.0
FCLSO=4093.,PPRAV=1742.,ORIFL=3872.,TABPRA=0.0
&END
&AAERO
AR(1)=2.19,SG(1)=3220.,LAMB(1)=.21,TOCR(1)=.09,TOCT(1)=.12
BCT(1)=17.5,THETA(1)=10.,NZ(1)=3.75,DELP(1)=296.,LH(1)=0.0
PTBXC(1)=.43,PTBXE(1)=.594,CB(1)=.67,RHO(1)=.10,FA(1)=64394.
CS(1)=.0005,TAU(1)=22320.,TEMP(1)=70.,UWW(1)=0.0,CSR(1)=.67
TMIN(1)=.03,ULE(1)=1.60,WLE(1)=0.0,CLE(1)=.1,AICP=.306,AILP=1.
EMODU(1)=10000000.,WC1(1)=0.0,WC2(1)=0.0,CM1(1)=0.0
BLP1(1)=0.0,BLP2(1)=0.0,BCM1(1)=0.0
KEAS=.68,UWAIL=1.75,WWOS=0.,WINGK=0.0,SMGDR=190.
AR(2)=1.44,SG(2)=435.,LAMB(2)=.44,TOCR(2)=.107,TOCT(2)=.09
BCT(2)=0.,THETA(2)=33.,NZ(2)=0.,DELP(2)=447.,LH(2)=0.
PTBXC(2)=0.,PTBXE(2)=.42,CB(2)=.67,RHO(2)=.1,FA(2)=64394.
CS(2)=.0005,TAU(2)=22320.,TEMP(2)=70.,UWW(2)=0.,CSR(2)=.67
TMIN(2)=.03,ULE(2)=1.6,WLE(2)=0.0,CLE(2)=.1,RDC=.48,URS=1.75
EMODU(2)=10000000.,WC1(2)=0.0,WC2(2)=0.0,CM1(2)=0.0
BLP1(2)=0.0,BLP2(2)=0.0,BCM1(2)=0.0
RUDUL=3.1,VTVC=0.0,LVT=0.0,SPRUD=1.0,TAILK=0.0
&END
```

This file is exactly the same as the previous one except that FIXDWT must be equal to the desired Orbiter dry weight.

The Fixed-Weight Orbiter mode does exactly what the name implies. This option fixes the liftoff weight of the Orbiter, allowing the propellant and external tank to iterate. A typical data file for this mode is as follows:

```
EXAMPLF5
1.000  $ORB
2.000  FIXWØR=1.0,FIXØRB=0.0,ØLLPLØ=188778.31,WØPRØP=23965.85
3.000  PLØADU=51612.90
4.000  $END
```

In this data file it is important to note the following:

1. FIXWØR must be equal to 1.0
2. FIXØRB must be equal to 0.0
3. OLLPLØ must be equal to the Orbiter liftoff weight, less OMS propellant weight, and less payload.
4. WØPRØP is the OMS propellant weight.
5. PLØADU is the Orbiter payload
6. RX1, RX2, RXL-In the External Tank data block "EXT" must have values

3.1.3 Option 3 - External Tank - This option contains the analytical and empirical weight estimation relationships necessary to completely define the external tank. These relationships consist of many elements, the first of which is the basic sizing logic which consists of three basic general arrangement options and three separate iteration techniques, i.e., solve for specific tank dimensions as a function of volume requirements with either input or fixed length, fixed diameter, or fixed L/D design features, such as separate and common bulkhead and an alternate forward section design. A LOX aft option, which simply uses the generalized baseline LOX forward method, and sets mixture ratio to its inverse and switches the hydrogen and oxygen densities is also available.

The external tank module also includes a design loads model which considers ullage and head pressure, interstage reactions, and axial load factors. For simplicity as well as optimization, the external loads induced by tank attachment to Orbiters and boosters are considered located at major existing hard points, such as bulkhead attach rings.

Also, a multi station analysis method is included, whereby a number of body station cuts are examined to determine the effective unit load and corresponding material thickness required for pure unstiffened monocoque structure. Alternate material allowables may be input to handle variations in design temperature and other candidate construction techniques. The resultant material thicknesses are integrated over the total body area using the dimensional data from the sizing routine, to determine the total sidewall weight. The bulkheads are sized to their representative loads, i.e., internal or external pressure, and meridional and hoop forces. Splice rings and attachment structure are treated as discrete items, with major attention given to the redistributions of point loads and manufacturing processes such as welding.

The external tank thermal protection system is based on detailed MDAC point design data with input unit weights for alternate design concepts.

Other external tank subsystems are expressed as either input constants for such systems as avionics, or simplified sizing equations, where, for example, plumbing weight is a function of engine flow rate and overall tank length/diameter.

Detail loads and strength and weight analyses have been documented for the MDAC parallel burn, 1,530,800-lb propellant, load-point-design external tank. Therefore, this tank is used as the basis for the general methodology.

The basic structure and subsystems are correlated to the Phase B extension point-design studies of external tanks as well as the latest NR point-design tank. The Three external tank general-arrangement options used in the basic tank sizing routine are shown in Section 4 of this volume. This option, like the Orbiter option, has the capability of inputting constants, which allows the user to input weight changes without modifying the program. This option also contains four distinct modes of operation which are as follows:

1. Iterative Analysis
2. Iterative Analysis (Fixed Dry Weight)
3. Simplified Equation
4. Fixed Weight Tank

The Iterative Analysis mode is the primary mode of the external tank option, and a typical data file for this mode is as follows:

```
EXAMPLE6
&EXT
DI=0.,LI=1000.,LD=0.,NR=0.,ND=41.,THETA=30.,HHI=100.
MRI=6.,UPFRB=1.0297,LA=1.01,FBPRFS=37.,BPRFS=22.,FUPRFS=35.
BUPRFS=20.,LF=0.,DF=304.,LCBN=30.,BLKHD=3.,BX=1.,K=.15
HBIAS=1500.,FS=1.4,NXL=1.4,NXS=3.3,FTU=64000.,E=10500000.
RHB=.102,TMIN=.025,NCTPS=1.101,UCTPS=.8444,LCTPS=.7365
CYTPS=.6526,TNTPS=.8969,DMTPS=.5149,FIXDWT=0.,GUP=.075
RETDV=200.,RETISP=260.,AVIBNT=800.,MISCT=0.,AFT=0.,HRI=.6496
RX1=0.,RX2=0.,RXL=0.,UPFRF=1.03
SIMPTK=0.0
&END
```

In this data file, it is important to note the following:

1. SIMPTK must be equal to 0.0.
2. FIXDWT must be contained in the data set, and equal to 0.0.
3. LD - Fixed L/D case DI must be installed to start iteration LF and DF must equal 0.
4. LF - Fixed length case DI must be initialized to start iteration DF and LD must equal 0.
5. DF - Fixed diameter case LI must be initialized to start iteration LF and LD must equal 0.
6. PROMIN - Minimum propellant load for tank iteration (see figure 4.18-1, Page 4-32 Volume 1) - required input for fixed length or fixed L/D cases.

The iterative analysis (Fixed Dry Weight) mode of the external tank allows the user to run a point design. The growth/uncertainty of the external tank module is allowed to "float," i.e., vary either up or down to maintain a constant dry weight, physically sizing to a point design. A typical data file for this mode is as follows:

```
EXAMPLE7
&EXT
DI=0.,LI=1000.,LD=0.,NR=0.,ND=41.,THETA=30.,HHI=100.
MRI=6.,UPFRB=1.0297,LA=1.01,FBPRFS=37.,BPRFS=22.,FUPRFS=35.
BUPRES=20.,LF=0.,DF=304.,LCBN=30.,BLKHD=3.,BX=1.,K=.15
HBIAS=1500.,FS=1.4,NXL=1.4,NXS=3.3,FTU=64000.,E=10500000.
RHB=.102,TMIN=.025,NCTPS=1.101,UCTPS=.8444,LCTPS=.7365
CYTPS=.6526,TNTPS=.8969,DMTPS=.5149,FIXDWT=73011.,GUP=.075
RETDV=200.,RETISP=260.,AVIBNT=800.,MISCT=0.,AFT=0.,HRI=.6496
RX1=0.,RX2=0.,RXL=0.,UPFRF=1.03
SIMPTK=0.0
&END
```

3.1.4 Option 4 (SRM) - This option contains the analytical and empirical weight estimation relationships necessary to completely define the solid rocket motor (SRM) booster system. The NASA weight report and design data, coupled with a three-view drawing of the SRM, supplies all inputs necessary to analyze the configuration. Here again, it is important to note that the velocity correlation coefficients described in Option 1 must be calculated or known before this option can be executed. The primary purpose of this option is to provide the capability of optimizing the SRM by inputting a diameter and iterating on propellant load and engine characteristics. The iteration calculates SRM burnout weight and dry weight, which in turn modifies retro and parachute system weights, which in turn is rippled through the other weights. This entire module continues the iteration until a completely balanced system exists. If retro rockets are not used, the velocity at ignition (VRI) should be set equal to the velocity at water impact (VSI). This option also has the capability of inputting constants, which allows the user to input weight changes without modifying the program. The SRM option contains four distinct modes of operation which are as follows:

1. Iterative Analysis
2. Iterative Analysis (Fixed Day Weight)
3. Simplified Equation
4. Fixed Booster

The iterative analysis mode is the primary mode of the SRM option. A typical data file for this mode is as follows:

```
EXAMPLE10

&SRM
RHBP=.064,DIA=162.,MIAX=81.,MAAX=81.,MEBP=1000.
FS=1.4,FTU=254000.,AT=2884.,RHAM=.283,INT=.1,NP=.76397
NJ=5.0,WNAZ=1.0,NER=11.2,AP=3750.,CF=1.58
PC=833.3,NDHA=15.,TC=5775.,TDFS=250.,VRI=141.,VSD=141.
AABE=10.,LF=200.,BUNC1=0.035,FIXDWT=0.0,RRISP=235.,WFI=0.0
BSRMC=0.0,SRMIC=0.0,SRMRC=3500.
FIXB88=0.0,SIMPB8=0.0
&END
```

This file is exactly the same as the previous one except that FIXDWT must be equal to the desired external tank dry weight.

The simplified equation mode of the external tank greatly reduces computer run time as well as eliminating the 48 input variables required to run an iterative tank. A typical data file for this option is as follows:

```
EXAMPLE8
        1.000   &EXT
        2.000   SIMPTK=1.0,DF=304.,GUP=.075
        3.000   &END
```

In this data file, it is important to note the following:

1. FIXØRB - In the Orbiter data block 'ORB' must be equal to 0.0
2. SIMPTK must be equal to 1.0
3. DF - External Tank Diameter
4. GUP - Growth Uncertainty (Dec %)

The Fixed Weight Tank mode fixes the weight of the Orbiter, the external tank and their ascent propellants. A typical data file for this mode is as follows:

```
EXAMPLE9
        1.000   &EXT
        2.000   DRYWT=73011.,RESIDT=5248.,SIMPTK = 0.0
        3.000   &END
```

In this data file, it is important to note the following:

1. PRØPØG - In the performance data block, 'PERF' must be equal to the total Orbiter ascent propellant (1st stage plus 2nd stage).
2. FIXØRB - In the Orbiter data block, 'ORB' must be equal to 1.0.
3. FIXWØR - In the Orbiter data block, 'ORB' must be equal to 0.0.
4. DRYWT - External Tank Dry Weight
5. RESIDT - External Tank Residual Propellant Weight.
6. SIMPTK must be equal to 0.0.
7. Since this mode fixes both the Orbiter and External Tank, the 'ØRB' data block must be similar to Example 5 which is as follows:

```
EXAMPLE5
        1.000   &ØRB
        2.000   FIXWØR=0.0,FIXØRB=1.0,ØLLPLØ=188778.31,WØPRØP=23965.85
        3.000   PLØADU=51612.90
        4.000   &END
```

In this data file, it is important to note the following:

1. FIXBØØ must be equal to 0.0.
2. SIMPBØ must be equal to 0.0.
3. FIXDWT must be equal to 0.0.

The iterative analysis (Fixed Dry Weight) mode of the SRM allows the user to run a point design. The growth/uncertainty of the external tank module is allowed to "float," i.e., vary either up or down to maintain a constant dry weight, physically sizing to a point design. A typical data file for this mode is as follows:

```
EXAMPLE11
1.000  &SRM
2.000  RHBP=.064,DIA=162.,MIAX=81.,MAAX=81.,MEBP=1000.
3.000  FS=1.4,FTU=254000.,AT=2884.,RHAM=.283,INT=.1,NP=.76397
4.000  NJ=5.0,WNBZ=1.0,NFR=11.2,AP=3750.,CF=1.58
5.000  PC=833.3,NDHA=15.,TC=5775.,TDES=250.,VRI=141.,VSD=141.
6.000  AABE=10.,LF=200.,BUNC1=0.0,FIXDWT=435185.12,RRISP=235.,WFI=0.0
7.000  BSRMC=0.0,SRMIC=0.0,SRMRC=3500.
8.000  FIXB00=0.0,SIMPB0=0.0
9.000  &END
```

This file is exactly the same as the previous one except FIXDWT must be equal to the desired SRM dry weight.

The simplified equation mode of the SRM greatly reduces computer run time as well as eliminating the 39 input variables required to run an iterative booster. A typical data file for this option is as follows:

```
EXAMPLE12
        1.000  &SRM
        2.000  FIXB00=0.0,SIMPB0=1.0,BUNC1=.035
        3.000  &END
```

In this file, it is important to note the following:

1. SIMPBØ must be equal to 1.0
2. FIXBØØ must be equal to 0.0.
3. BYNC1 is the Growth Uncertainty (Dec %)

The fixed booster mode fixes the burnout weight of the SRM as well as its ascent propellant. A typical data file for this mode is as follows:

```
EXAMPLE13
        1.000   &SRM
        2.000   FIXB00=0.0,SIMPBO = 0.0,BB0WT=421586.5,BDRYWT=435185.12
        3.000   &END
```

In this data file, it is important to note the following:

1. PRØPBG - In the performance data block 'PERF' must be equal to the total SRM ascent propellant.
2. FIXBØØ must be equal to 0.0.
3. BBØWT SRM Burnout Weight.
4. BDRYWT is the SRM Dry Weight.
5. SIMPBO must be equal to 0.0.

3.1.5 Option 5 - Fixed Hardware Sensitivities - This option was developed for the specific purpose of automating the task of assessing vehicle sensitivities. Theoretically, any sensitivity evaluation can be made by simply making two back-to-back runs through ESPER with the individual sensitivity element adjusted by the desired increment for the second case, and simply subtracting the resulting payloads and/or gross liftoff weights, and dividing by this increment.

Since this option is a part of ESPER, it utilizes the same ascent performance logic and ascent velocity equations. Thus, any output case from ESPER can take advantage of this option. The basic equations within this part of ESPER, however, are modified to contain discrete sensitivity increments (i.e., delta booster inert weight, delta Orbiter inert weight, delta booster ISP, etc).

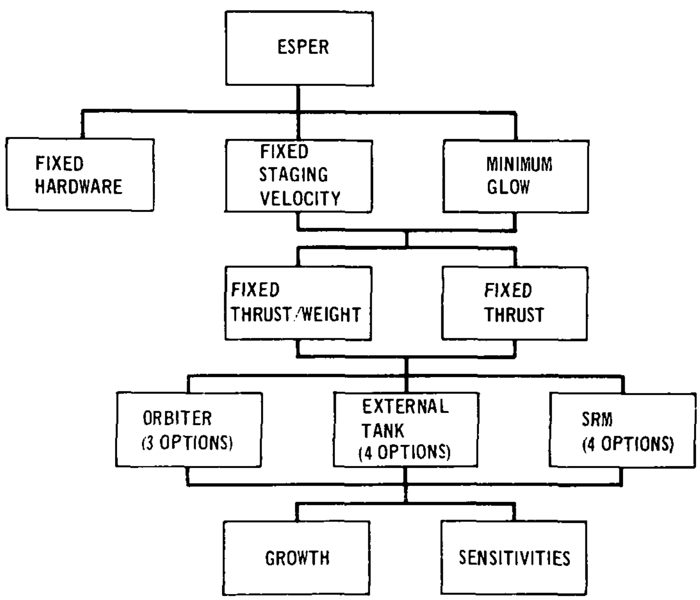
The first input case is treated as a fixed hardware configuration and initializes and varies the basic configuration performance capability. The various sensitivity increments are applied one by one, and each sensitivity is calculated separately against the initial case. To save the user the time and money involved in inputting, these sensitivity increments have been fixed in the program. Since this option can be run with any ESPER option, the user need only set SENS in the 'PERF' data file equal to 1.0.

3.1.6 Option 6 - Growth - This option enables the user to increase the reference configuration in four ways, increase the Orbiter only, increase the Booster only, increase Orbiter and Booster or increase the External Tank. An incremental weight is added per specified option and the configuration is resized. Since this option can also be run with any ESPER option, the user need only set GRØW equal to the option desired and input the following in the performance data block 'PERF'.

1. GRØWB (Incremental booster growth desired)
2. GRØWØ (Incremental orbiter growth desired)
3. NI (Two plus the number of one percent uncertainty/growth increments to be added to the desired option)

This discussion has tried to familiarize the user with the versatility of ESPER. In essence, however, with combinations of its options, the versatility of ESPER is only limited to the ingenuity and imagination of the user.

A representation of the gamet of cases that can be executed by ESPER is shown by the following chart.



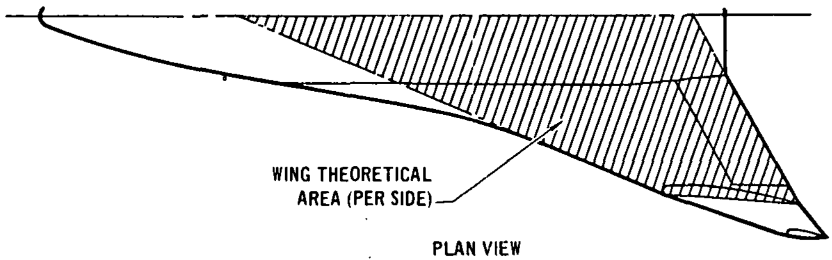
ORBITER OPTIONS	EXT TANK OPTIONS	SRM OPTIONS
1. ITERATIVE	1. ITERATIVE	1. ITERATIVE
2. ITERATIVE (FIXED DRY WT)	2. ITERATIVE (FIXED DRY WT)	2. ITERATIVE (FIXED DRY WT)
3. FIXED ORBITER	3. SIMPLIFIED EQ	3. SIMPLIFIED EQ
	4. FIXED EXT TANK	4. FIXED SRM

4. CONFIGURATION DATA AND GEOMETRY DEFINITIONS

The definitions and the development of various areas and other geometric orientated data used in ESPER are illustrated in the following:

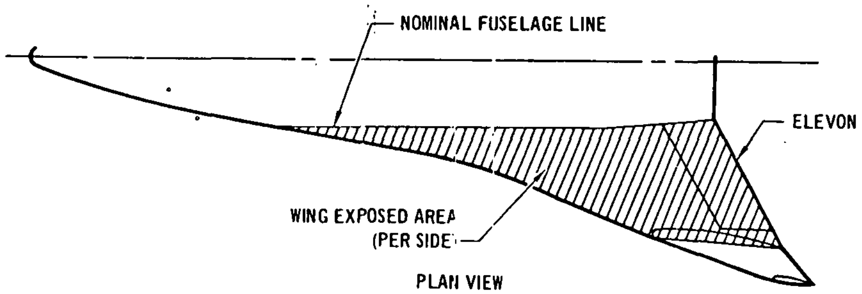
1. Orbiter Definitions - Wing

(a) The wing theoretical area is the projected plan view area shown below:



PLAN VIEW

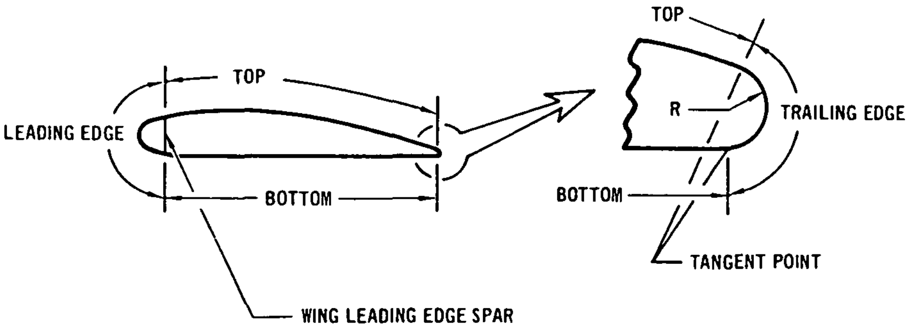
(b) The wing exposed area is the projected plan view area shown below:



PLAN VIEW

(c) Total wing wetted area is the summation of the following:

- o Wing Top Area
- o Wing Bottom Area
- o Wing Leading Edge Area
- o Wing Trailing Edge Area

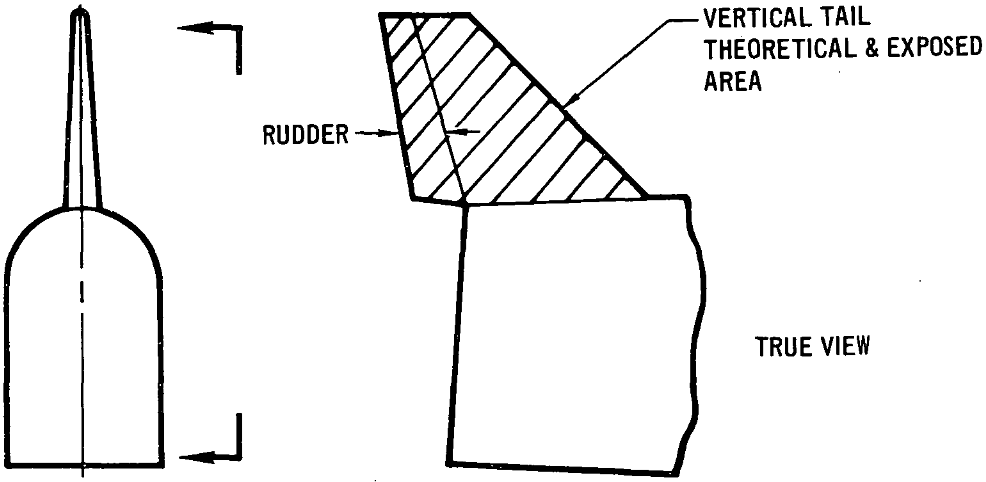


(d) FLAP AND AILERON AREAS ARE PROJECTED PLAN VIEW AREAS AND ARE PART OF THE WING EXPOSED AREA.

(d) Flap and aileron areas are projected plan view areas and are part of the wing exposed area.

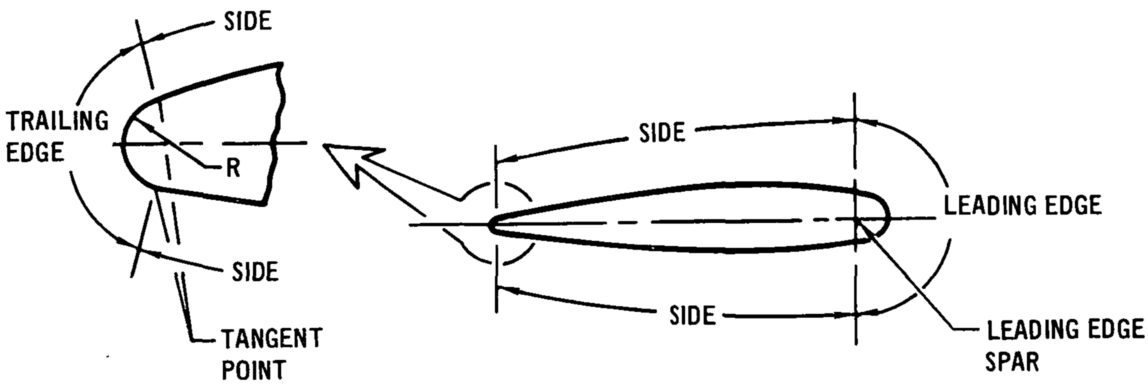
(Vertical Tail)

(a) The theoretical and exposed vertical tail areas are identical. They are defined by taking a true area projection at the tail ℄ as shown below. The rudder area is defined in the same manner.



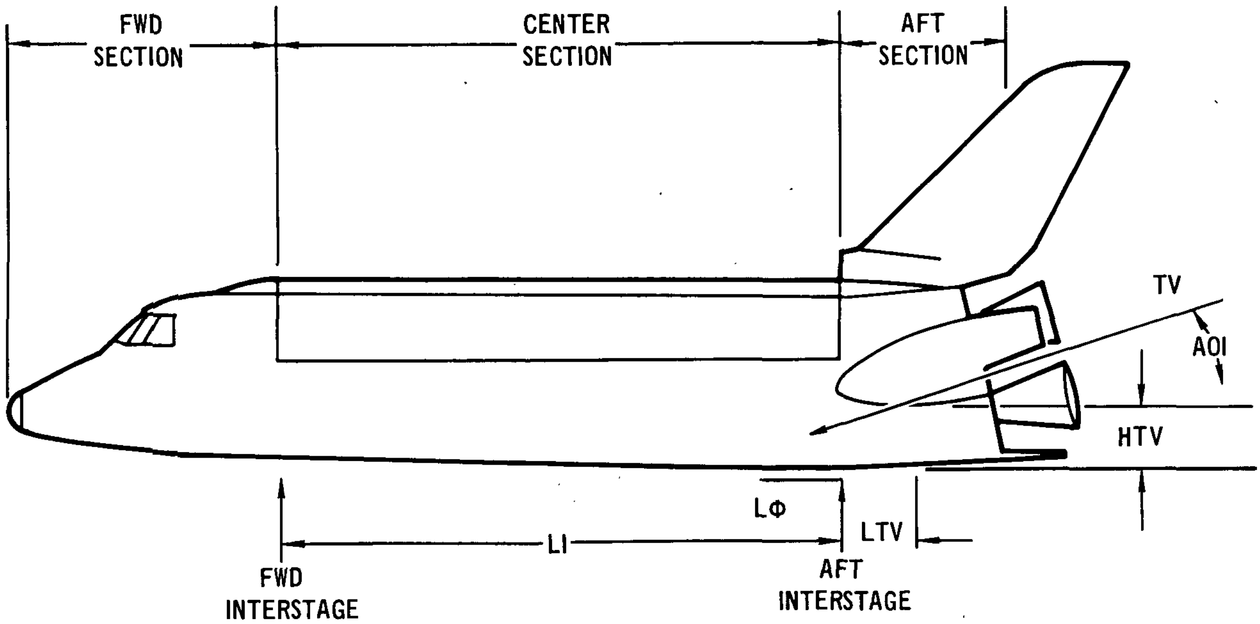
(b) Total vertical tail wetted area for each tail is the summation of the following:

- o Vertical Tail Side Area (total)
- o Vertical Tail Leading Edge Area
- o Vertical Tail Trailing Edge Area



(Body)

(a) The location of the fuselage sections and some of the primary symbols used in ESPER are shown below:

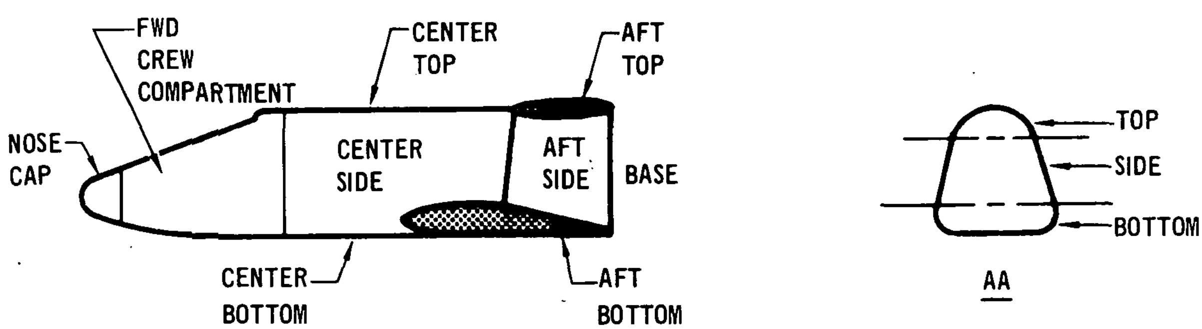


LOCATION OF FUSELAGE SECTIONS

(TPS)

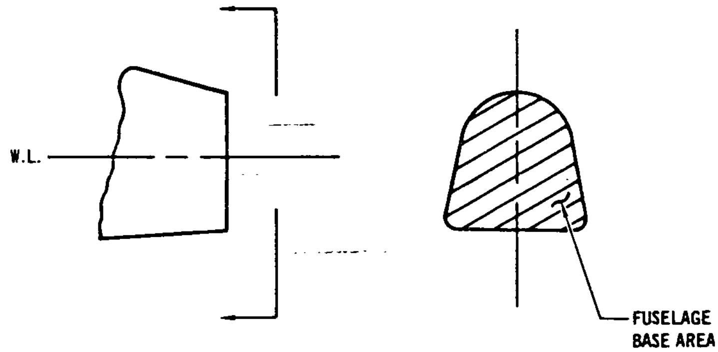
(a) Total fuselage wetted area is the summation of the following:

- o fuselage forward area
- o fuselage center area
- o fuselage aft area
- o fuselage nose cap area

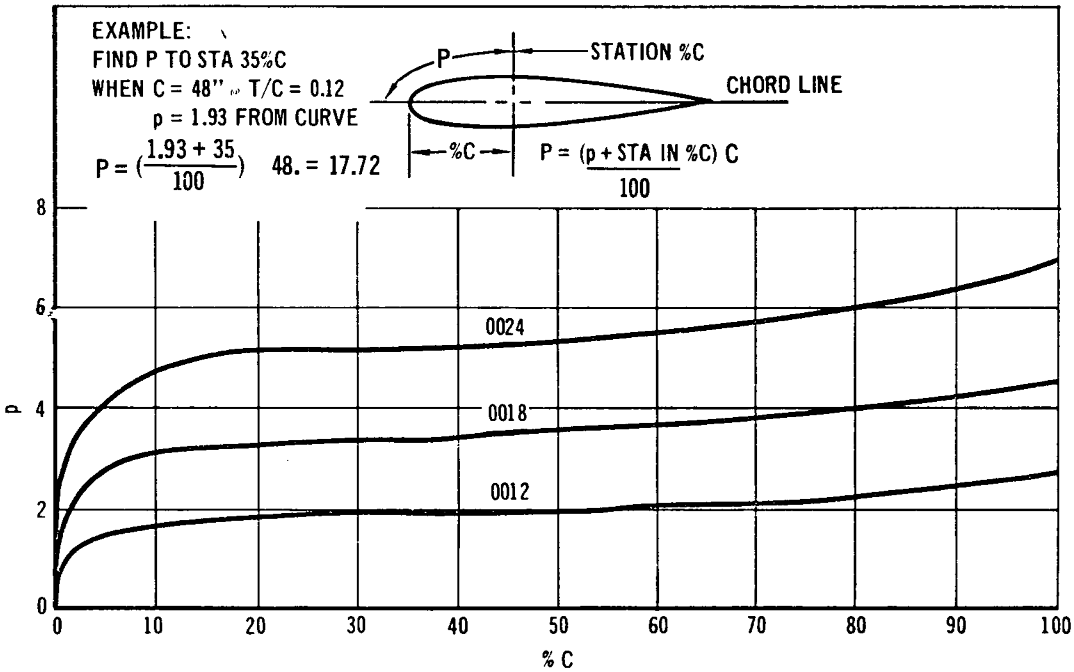


(SHADED AREA NOT COVERED BY TPS)

(b) The fuselage base area is the projected end view area shown below:

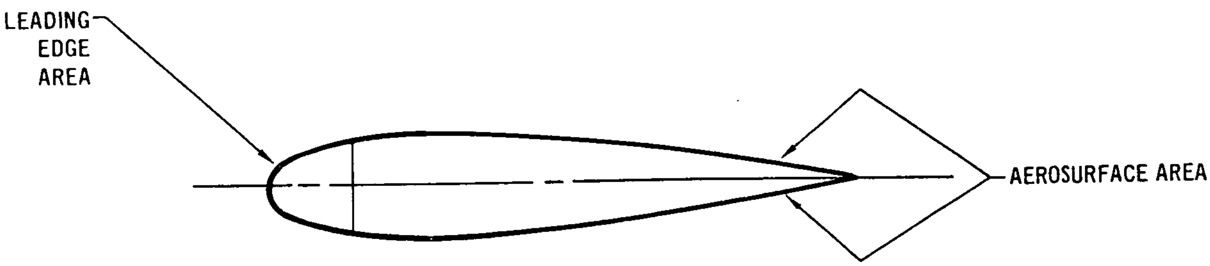


(c) All aerosurface areas are calculated outside the module, and are inputted as total projected areas along with their appropriate airfoil constants. These airfoil constants can be obtained from the following graph.



AIRFOIL PERIMETERS

(d) Aerosurface area sections considered in ESPER are as follows:

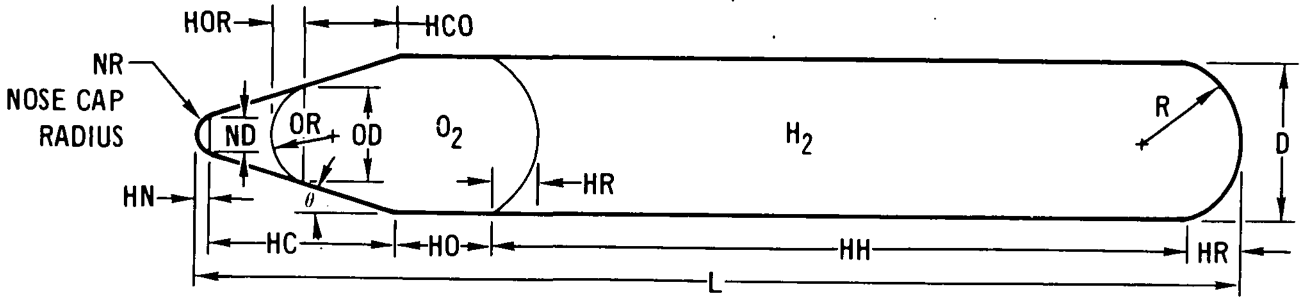


TPS AEROSURFACE BREAKDOWN

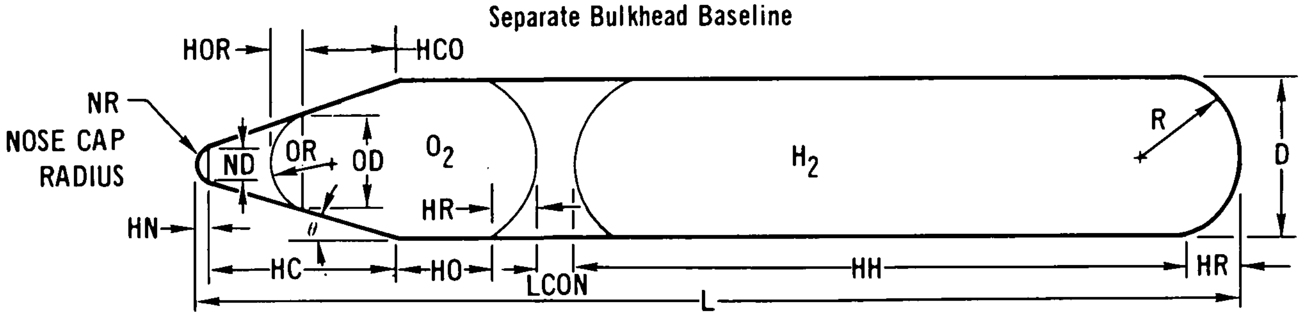
2. External Tank Definitions

(a) The three external tank general arrangement options, used in the basic tank sizing routine, are illustrated below. It should be noted that most of the basic dimensional parameters have the same variable name for each of the three arrangements. Therefore, most of the sizing equations are identical for each option and only a few ESPER input variables need be changed.

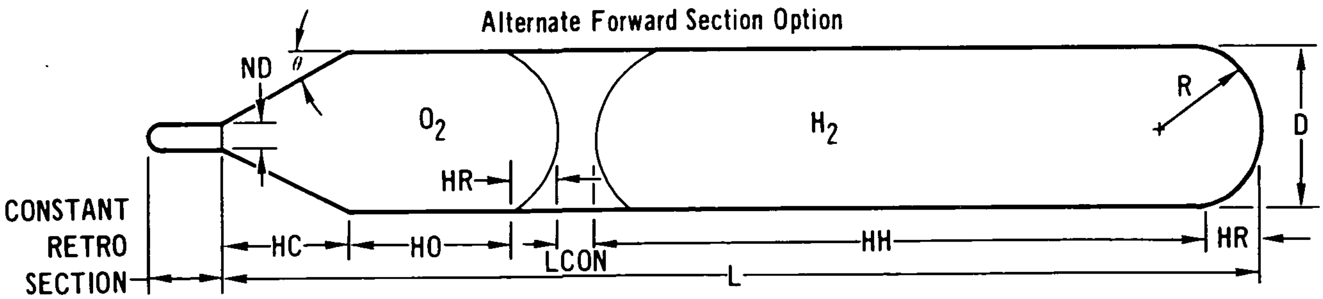
Common Bulkhead Option



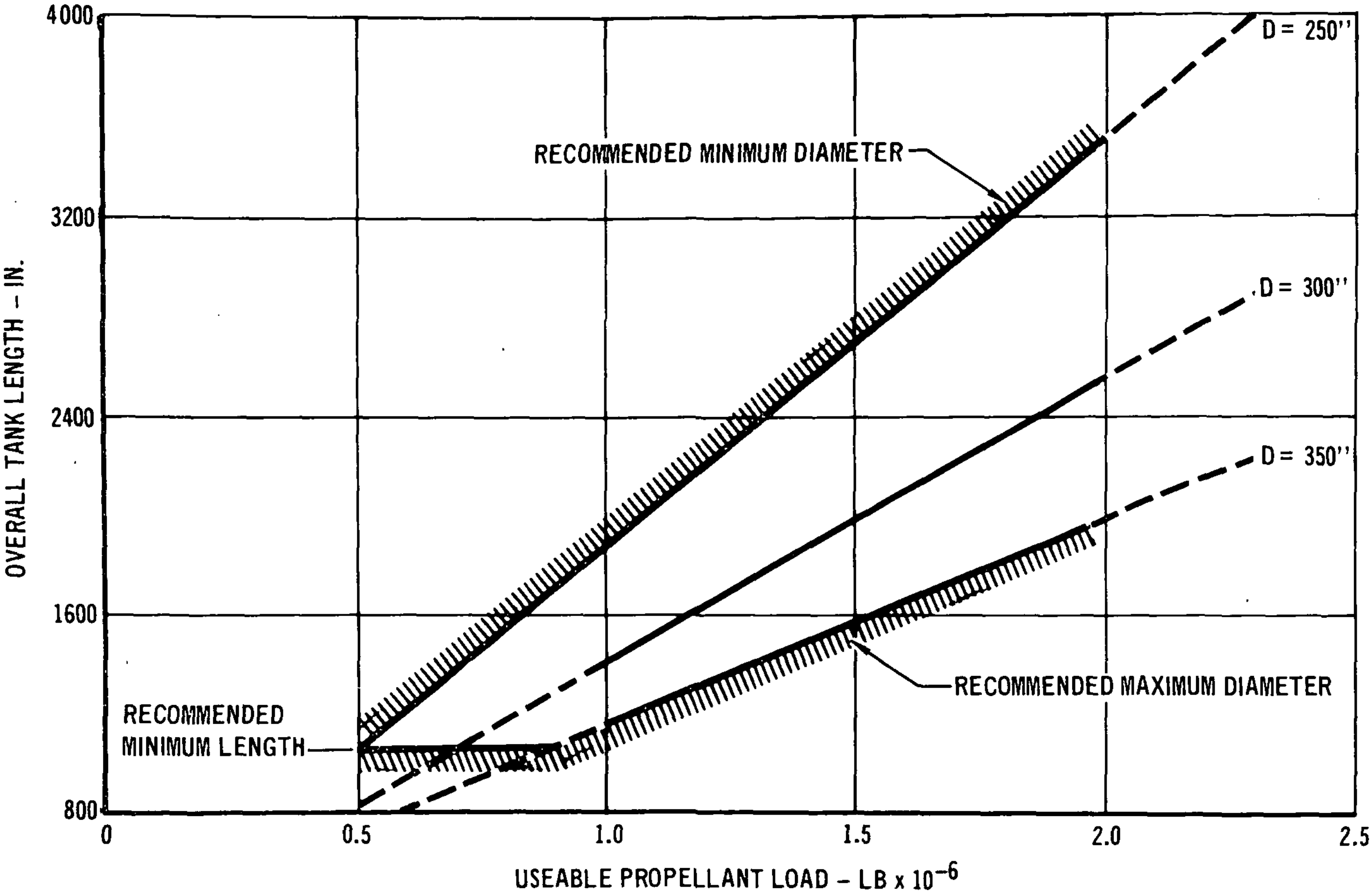
Separate Bulkhead Baseline



Alternate Forward Section Option



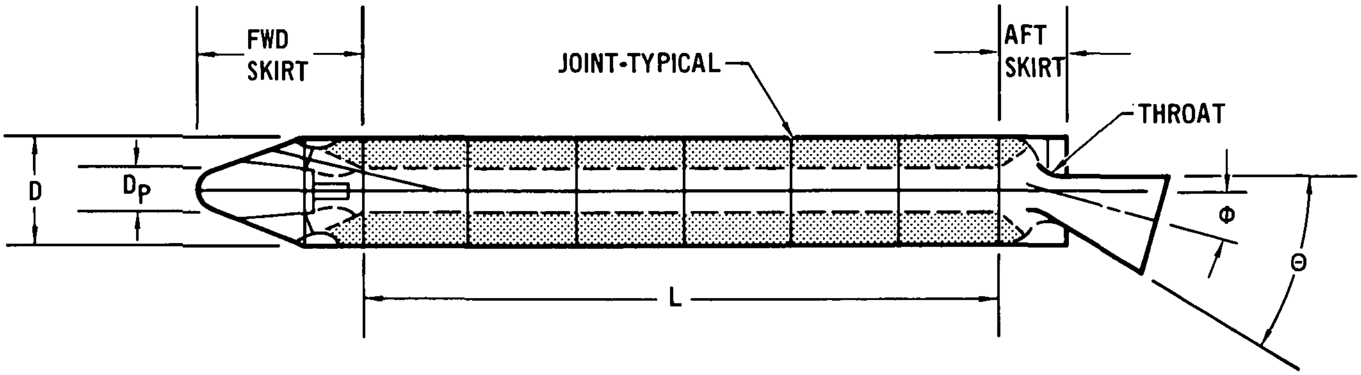
The following figure depicts the recommended limits for tank geometry and propellant loading



EXTERNAL TANK OVERALL LENGTH vs USEABLE PROPELLANT LOAD
MR = 6. LOX/LH_2 – LOX Fwd Separate Bulkhead Design

3. SRM Definitions

(a) Illustrated below is a SRM depicting typical sectional cuts with various input parameters used in ESPER.



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5. ESPER OUTPUT PARAMETERS

Following is a complete listing of all the output parameters calculated and printed by ESPER.

OUTPUT DATA SHEET

Output Definition	Units	Symbol
(SHORT PRINT OUT)		
Inclination of Vehicle Orbit	Deg	INC
Total Ascent Velocity Losses	Ft/Sec	TOTLSS
Drag Velocity Losses	Ft/Sec	DVCORR
Velocity Correlation Factor	ND	DVCNST
Reference Ascent Velocity Losses up to Staging	Ft/Sec	X3
Effect of Inclination on Trajectory Shaping	Ft/Sec	X2
Altitude Adjustment Parameter to vary Velocity Losses from Sea Level to other Altitudes	Ft/Sec	DVALT
Gross Lift Off Weight/Ascent Ballistic Drag Coefficient	ND	WOSCD
Ascent Ballistic Drag Coefficient	ND	SCD
Yaw Angle, Booster to Vehicle Centerline	Deg	BCANT
SRM Burn Out Weight	Lb	BBOWT
SRM Dry Weight	Lb	BDRYWT
SRM Usable Ascent Propellant	Lb	PROPB
SRM Usable Ascent Propellant less Insulation	Lb	PWOI
SRM Lambda=SRM Usable Ascent Propellant/SRM Gross Lift Off Wt	ND	LAMB
Specific Impulse Booster, vacuum	Sec	ISPBV
Specific Impulse Orbiter, vacuum	Sec	ISPOBV
Weighted Average Specific Impulse of the SRM	Sec	ISPB
ISPB=(PROB * ISPBV + PROPO1 * ISPOBV)/PROPOT		
Total Canted Sea Level Thrust SRM + Orbiter	Lb	THBTC
Total SRM Sea Level Thrust	Lb	THBSLT
SRM Burn Time	Sec	BBT
Yaw Angle, Outboard Engine to Orbiter Centerline	Deg	OCANTY
Pitch Angle, Composite Thrust Vector	Deg	OCANTP
Orbiter Liftoff Weight less Payload less OMS Propellant Wt	Lb	OLLPLO
Payload Carried to Orbit	Lb	PLOADU
OMS Propellant Weight	Lb	WOPROP
External Tank Inert Weight	Lb	DRYWT

OUTPUT DATA SHEET (Cont.)

Output Definition	Units	Symbol
External Residual Propellant Weight	Lb	RESIDT
Total Orbiter Usable Ascent Propellant	Lb	PROPOT
Orbiter Usable Ascent Propellant burned in the 1st stage	Lb	PROPO1
Orbiter Usable Ascent Propellant burned in the 2nd stage	Lb	PROPO2
External Tank Lambda = Total Orbiter Usable Ascent Propellant/Propellant/External Tank Gross Weight	ND	TLAMB
Total Orbiter canted thrust, vacuum	Lb	THOTC
Orbiter Flow Rate	Lb/Sec	FLOWR
Orbiter Gross Lift Off Weight	Lb	OGLOW
SRM Gross Lift Off Weight	Lb	BGLOW
Total Gross Lift Off Weight less Hold Down Propellant	Lb	GLOW
Hold Down Propellant Weight	Lb	OHOLD
Total Gross Lift Off Weight	Lb	TOTAL
Thrust/Weight of the Booster	ND	TOWB
Thrust/Weight of the Orbiter	ND	TOWO
Ideal Booster Staging Velocity	Ft/Sec	DVB
Relative Booster Staging Velocity	Ft/Sec	DVBRP
Delta V obtained from Flight Performance Reserves	Ft/Sec	DVFPR
Flight Performance Reserve Propellant Weight	Lb	FPRP
Nominal Required Delta V	Ft/Sec	DVR
Total Required Delta V	Ft/Sec	DVT
Total Calculated Delta V	Ft/Sec	DVTOTC
Required Orbiter Delta V	Ft/Sec	DVOWR
Calculated Orbiter Delta V	Ft/Sec	DVONC

OUTPUT DATA SHEET (Cont.)

Output Definition	Units	Symbol
(DETAILED PRINT OUT-SRM)		
SRM Length	In	SRML
SRM Diameter	In	SRMD
Basic SRM Weight = WOASE + WJOINT + WNOZZ + WTTER + WINST + WIGN + BSRMC	Lb	BASSRM
SRM Unsegmented Case Weight	Lb	WCASE
SRM Case Segment Joint Weight	Lb	WJOINT
SRM Nozzle Weight	Lb	WNOZZ
SRM Thrust Termination Weight	Lb	WTTER
SRM Internal Insulation Weight	Lb	WINST
SRM Igniter Weight	Lb	WIGN
Basic SRM Weight Constant	Lb	BSRMC
SRM Recovery System Weight = PWPAR + PWPI + PWRR + PWRP + PWWR + SRMRC	Lb	WRECOV
SRM Parachute Weight	Lb	PWPAR
SRM Parachute Installation Weight	Lb	PWPI
SRM Retro Rocket (including installation) Weight	LB	PWRR
SRM Retro Rocket Propellant Weight	Lb	PWRP
SRM Water Recovery Hardware Weight	Lb	PWWR
SRM Recovery Weight Constant	Lb	SRMRC
SRM Body Adapter Weight = PWFS + PWASLS + PWAS + PWNF + PWTN + PWAV + WNCTPS + SRM1C	Lb	SRMISS
SRM Forward Skirt Weight	Lb	PWFS
SRM Aft Skirt/Launch Structure Weight	Lb	PWASLS
SRM Attach/Separation Structure Weight	Lb	PWAS
SRM Nose Fairing Weight	Lb	PWNF
SRM Tunnel Weight	Lb	PWTN
SRM Avionics Weight	Lb	PWAV
SRM Nose Cone Thermal Protection Weight	Lb	WNCTPS
SRM Adapter Weight Constant	Lb	SRMIC
SRM Burn Out Weight less Growth Uncert.	Lb	PBOSLU
SRM Growth Uncertainty Weight	Lb	UNCERT
SRM Expendable Propellant Weight	Lb	EXPINS

OUTPUT DATA SHEET (Cont.)

Output Definition	Units	Symbol
(DETAILED PRINT OUT-ORBITER)		
(AERO)		
Wing Gross Area	Ft^2	WSG
Wing Total Weight	Lb	WWT
Wing Basic Structure Weight = WTORBE + WTORBC + LEW + WTE	Lb	WBSTR
Wing Torque Box Exposed Weight	Lb	WTORBE
Wing Torque Box Carrythrough Weight	Lb	WTORBC
Wing Leading Edge Weight	Lb	LEW
Wing Trailing Edge Weight	Lb	WTE
Wing Secondary Structure Weight	Lb	GPROV
Wing Main Landing Gear Provisions Weight	Lb	GPROV
Wing Control Surface Weight = WAS + WADR + WAH + WAP	Lb	WAIL
Wing C.S. Shell Weight	Lb	WAS
Wing C.S. Drive Rib Weight	Lb	WADR
Wing C.S. Hinge Weight	Lb	WAH
Wing C.S. Attach Weight	Lb	WAP
Wing Weight Constant	Lb	PWINGK
Tail Gross Area	Ft^2	TSG
Tail Total Weight	Lb	TAIL
Tail Basic Structure Weight = TTORQB + TLE	Lb	TBSTR
Tail Torque Box Weight	Lb	TTORQB
Tail Leading Edge Weight	Lb	TLE
Tail Control Surface Weight = WRS + WRDR + WRH + WRP	Lb	WRUD
Tail C.S. Shell Weight	Lb	WRS
Tail C.S. Drive Rib Weight	Lb	WRDR
Tail C.S. Hinge Weight	Lb	WRH
Tail C.S. Attach Weight	Lb	WRP
Tail Weight Constant	Lb	PTAILK
(BODY)		
Orbiter Body Group Total Weight	Lb	G37
Orbiter Basic Structure Weight = G1 + G11 + G25 + G10 + G27 + G12 + G26 + G15 + G2 + G3 + G6 + G16 + G17 + G32 + G34		
Body B.S. Fwd Sidewall Weight	Lb	G1
Body B.S. Ctr Sidewall Weight	Lb	G11

OUTPUT DATA SHEET (Cont.)

Output Definitions	Units	Symbol
Body B.S. Aft Sidewall Weight	Lb	G25
Body B.S. Ctr Longer Weight	Lb	G10
Body B.S. Aft Longer Weight	Lb	G27
Body B.S. Ctr Frame Weight	Lb	G12
Body B.S. Aft Frame Weight	Lb	G26
Body B.S. Ctr Bulkheads	Lb	G15
Body B.S. Crew Compt. Provision Weight	Lb	G2
Body B.S. Windshield Provision Weight	Lb	G3
Body B.S. Nose Wheel Well Provision Weight	Lb	G6
Body B.S. Payload Reaction Weight	Lb	G16
Body B.S. Wing Shear Provision Weight	Lb	G17
Body B.S. Thrust Structure Weight	Lb	G32
Body B.S. Tail Provision Weight	Lb	G34
Fwd Subtotal Weight	Lb	G8
Ctr Subtotal Weight	Lb	G18
Aft Subtotal Weight	Lb	G35
Orbiter Secondary Structure Weight = G19 + G22		
Body S.S. Cargo Door Shell	Lb	G19
Body S.S. Cargo Door Mechanism	Lb	G22
Orbiter Body Miscellaneous Weight (fwd)	Lb	G7
Orbiter Body Miscellaneous Weight (Ctr)	Lb	G23
Orbiter Body Miscellaneous Weight (aft)	Lb	G33
Fwd Total Weight	Lb	G9
Ctr Total Weight	Lb	G24
Aft Total Weight	Lb	G36
(THERMO)		
Total TPS Weight	Lb	TOTTPS
Total Wing TPS Weight = WGWT + WGLEWT	Lb	TWGWT
Wing Surface Panel TPS Weight	Lb	WGWT
Wing Leading Edge TPS Weight	Lb	WGLEWT
Total Tail TPS Weight = TWT + TLEWT	Lb	TWT
Tail Surface Panel TPS Weight	Lb	TWT
Tail Leading Edge Weight	Lb	TLEWT

OUTPUT DATA SHEET (Cont.)

Output Definitions	Units	Symbol
Total Body TPS Weight = BLBTPS + BASEWT + IBTWT + PTPSCN	Lb	BTPSWT
Body TPS Panel Weight	Lb	BLBTPS
Body Base TPS Weight	Lb	BASEWT
Body Internal TPS Weight	Lb	IBTWT
Body TPS Constant Weight	Lb	PTPSCN
Miscalleneous Control Surface TPS Weight	Lb	MSCWT
Landing and Docking TPS Weight	Lb	LDTWT
Propulsion TPS Weight	Lb	PROWT
Prime Power TPS Weight	Lb	PPPO
Hydraulics TPS Weight	Lb	PHYC
Surface Controls TPS Weight	Lb	SCWT
(LANDING GEAR)		
Landing and Docking Total Weight	Lb	LNDDK
Nose Gear Weight = NG1 + NG2 + NG3	Lb	NGEAR
Nose Gear Rolling Gear Weight	Lb	NG1
Nose Gear Structure Weight	Lb	NG2
Nose Gear Controls Weight	Lb	NG3
Main Gear Weight = MG1 + MG2 + MG3	Lb	MGEAR
Main Gear Rolling Gear Weight	Lb	MG1
Main Gear Structure Weight	Lb	MG2
Main Gear Controls Weight	Lb	MG3
Auxiliary System Weight = AX1 + AX2 + AX3	Lb	AXGEAR
Aux. Deceleration Chute Weight	Lb	AX1
Aux. Separation System Weight	Lb	AX2
Aux. Handling and Manipulation System Weight	Lb	AX3
Landing and Docking System Constant Weight	Lb	LNDDKK

OUTPUT DATA SHEET (Cont.)

Output Definition	Units	Symbol
(ASCENT PROPULSION)		
Main Ascent Propulsion Weight	Lb	TAPROP
M.A.P.Engine + Acc. Weight = ENG + TVC + CONTR + PRPUTL	Lb	ENGPAC
M.A.P. Engine Weight	Lb	ENG
M.A.P. Gimbal System Weight	Lb	TVC
M.A.P. Control Weight	Lb	CONTR
M.A.P. Propellant Utilization Weight	Lb	PRPUTL
M.A.P. Propellant System Weight = FAD + PRES + CHIL + PREVAL + FEEDS + DISC + MISC	Lb	PROSYS
M.A.P. Fill and Drain System Weight	Lb	FAD
M.A.P. Pressurization System Weight	Lb	PRES
M.A.P. Chill and Dump Line Weight	Lb	CHTL
M.A.P. Pre Valves Weight	Lb	PREVAL
M.A.P. Feed System Weight	Lb	FEEDS
M.A.P. Disconnects Weight	Lb	DISC
M.A.P. Miscellaneous Weight	Lb	MISC
Air Breathing Propulsion System	Lb	TBPRO
(OMS-ACS SYSTEM)		
Total Auxiliary Propulsion System Weight	Lb	WTAUX
Total ACS System Weight = ACSENG + ACSSYS + WTACK + ACSMOD	Lb	WTACS
ACS Thruster Weight	Lb	ACSENG

OUTPUT DATA SHEET (Cont.)

Output Definitions	Units	Symbols
ACS Prop. System Weight	Lb	ACSSYS
ACS Tank Weight	Lb	WTACK
ACS Module Weight	Lb	ACSMOD
Total OMS System Weight = OMSENG + PROPSY + WTOMTK, MODULE	Lb	WTOMS
OMS Thruster Weight	Lb	OMSENG
OMS Propulsion System Weight	Lb	PROPSY
OMS Tank Weight	Lb	WTOMTK
OMS Module Weight	Lb	MODULE
(SUBSYSTEMS)		
Prime Power Weight	Lb	PPWR
Electrical System Weight	Lb	ELEC
Hydraulic System Weight	Lb	HYDR
Surface Controls Weight	Lb	SURFC
Avionics Weight	Lb	AVIONO
Environmental Control Weight	Lb	ECLSO
Personnel Provision Weight	Lb	PPROV
Growth/Uncertainty Weight	Lb	OUNCWT
Orbiter Dry Weight	Lb	ODRYWT
Personnel	Lb	PERSON
Orbiter Residual Propellant Weight	Lb	ORESD
Orbiter Payload delivered to orbit	Lb	PLOADU
Orbiter Inert Weight	Lb	OINWT
Orbiter Reserve Propellant Weight	Lb	ORESU
Orbiter Inflight Losses	Lb	ORFIL
Orbiter ACS Propellant Weight	Lb	ACSPRO
Orbiter OMS Propellant Weight	Lb	WOPROP
Orbiter Trapped Propellant Weight	Lb	OTRAP
Orbiter Lift Off Weight	Lb	OLOWT
Orbiter Payload delivered at landing	Lb	PLOADD
Orbiter Landing Weight	Lb	OLANWT
Orbiter Injected Weight	Lb	OINJWT

OUTPUT DATA SHEET (Cont.)

Output Definitions (Detailed Print Out - Ext. Tank)	Units	Symbol
External Tank Length	In	EXTL
External Tank Diameter	In	EXTD
External Tank Body Group	Lb	BODGRP
External Tank Forward Tank Weight = FWDBLF + CONSCT + CYLSCT + AFTBLF	Lb	FWDTK
Forward Bulkhead Weight	Lb	FWDBLF
Conical Section Weight	Lb	CONSCT
Cylindrical Section Weight	Lb	CYLSCT
Aft Bulkhead Weight	Lb	AFTBLF
Inter Tank Section Weight	Lb	WINT
External Tank Aft Tank Weight = FWDBLAT + AFTCYL + AFTBLA	Lb	AFTNK
Forward Bulkhead Weight	Lb	FWDBLA
Cylindrical Section Weight	Lb	AFTCYL
Aft Bulkhead Weight	Lb	AFTBLA
Orbiter Body Structure Tank Attach Weight	Lb	TWINT
Nose Fairing Weight	Lb	NOSFAR
Umbilical Panel Weight	Lb	UMBPNL
Tunnel Weight	Lb	TUNNEL
Baffle Weight - LOX	Lb	BAFF
Induced Enviornmental Protection Weight = FAIRT + FCCTPS + TPSIN + ACYDM	Lb	TDTPS
Nose Fairing TPS Weight	Lb	FAIRT
Forward Cone and Cylinder TPS Weight	Lb	FCCTPS
Inter Tank TPS Weight	Lb	TPSIN
Aft Cylinder and Dome TPS Weight	Lb	ACYDM
External Tank Propellant System Weight = FEDSYS + PRSVNT + SUMP + PNPU	Lb	PROSY
Feed System Weight	Lb	FEDSYS
Pressurization and Vent Weight	Lb	PRSVNT
Sump and Vortex Control Weight	Lb	SUMP
Pneumatic and PU System Weight	Lb	PNPU
Subtotal Dry Weight	Lb	SUBDRY
Growth/Uncertainty Weight	Lb	GU
Dry Weight of External Tank	Lb	DRYWT
Tank Undrainable Propellant Weight	Lb	UNDRAN

OUTPUT DATA SHEET (Cont.)

Output Definitions	Units	Symbols
Feedline Trapped Propellant Weight	Lb	FEEDTR
Pressurant Propellant Weight	Lb	PRSURT
PU Bias Propellant Weight	Lb	FBIAS
Inert Weight of External Tank	Lb	INERT
Total Usable Ascent Propellant Weight	Lb	PROPOT
Total External Tank Gross Weight	Lb	GROSSW
Lambda = Total Usable Ascent Propellant/Total External Tank Gross Weight	ND	TLAMB

6. ESPER OUTPUT

The output options contained in ESPER are multivariant. This dependency lies with the user and what option of ESPER he has chosen to execute. However, the basic mainline output is either a simplified or detailed weight statement.

The simplified weight statement supplies the user with total vehicle weights and performance parameters, such as, TW, GLOW and ΔV. This option is best utilized in parametric studies where many cases are executed and detailed weights are not of prime importance. This can result in a substantial cost savings by reducing computer printout time.

The detailed weight statement exists in the form of the NASA Phase B functional weight grouping. By coding ESPER's detailed output in this form, the user obtains a direct line-by-line comparison of ESPER's data with the weight status report of the main line Shuttle program. This comparison will identify for NASA either which areas of the program need updating, or which elements of the reported weights require scrutiny.

Combinations of these two mainline options are numerous. (For example, if the user is running a fixed SRM and wishes to see details on the Orbiter, or if the user is running a fixed Orbiter and wishes to see details on the SRM, etc.) Examples of the simplified and detailed weight statements are as follows:

PARALLEL BURN
FIXED T/W BOOSTER
PARAMETRIC STUDY EXTERNAL (H2-O2) ORBITER
BOOSTER - SOLID ROCKET MOTOR

********** WARNING LOOK AT T/W **********

INCLINATION OF ORBITER 28.50 DEGREES

DV TOTAL LOSSES	(6338.7)		
DV CORRECTION	1185.2	DVCNST	3425360.0
DV CURVE LOSSES	5153.5		
DV INC	-46.9		
DV ALT	.0		
W/SCD	6099.4	SCD	840.0

BOOSTER PARAMETERS
(CANT ANGLE= 8.5)

BURN OUT WEIGHT	419908.50		
DRY WEIGHT	433448.50		
PROPELLANT WEIGHT	2721543.00	PROPB WOI	2708002.00
LAMBDA=.8663			
ISP AV (273.2,451.2)	295.53		
SEA LEVEL THRUST	8576672.00	S.L. T BOO	7586996.00
BURN TIME	124.91		

ORBITER PARAMETERS
(CANT ANGLE YAW= 3.5)
(CANT ANGLE PITCH=17.0)

LIFT OFF-PAY-OAMS	188208.75
PAYLOAD	51612.90
OAMS PROP WEIGHT	23909.07

EXT TANK PARAMETERS

EXT. TANK WT (DRY)	72903.75		
EXT. TANK RESID.	5238.03		
PROPELLANT WEIGHT	ORB PROP	1STSTAG PROP	2NDSTAG PROP
	1640239.00	390358.31	1249881.00
LAMBDA=.9546			
ISP	451.20		
VACUUM THRUST	1408245.00	THRUST/ENG 470000.	# ENG 3.
FLOW RATE	1041.67		

OGLOW=	1982010.000	
BGLOW=	3141451.000	
GLOW =	5123461.000	
TOTAL=	5126437.000	(INCLUDES HOLD DOWN PROP= 2976.5)
T/W1 =	1.674	
T/W2 =	.885	

IDEAL STAGING VELOCITY	8889.51	F.P.R. DELTA V	385.46
REAL STAGING VELOCITY	4874.51	F.P.R. PROP	9196.37
NOMINAL REQUIRED VELOCITY	30837.45		
TOTAL VELOCITY(INC 1% FPR)	31222.91		
ORBITER VELOCITY(CALC)	22333.40		
ORBITER VELOCITY(ACT)	22332.59		

SOLID ROCKET MOTOR (SRM) WEIGHT SUMMARY
(PER SRM)

LENGTH= 1191.
DIAMETER= 162.

BASIC SRM WEIGHT	(163580.)
CASE WEIGHT	100187.
JOINT WEIGHT	5569.
NOZZLE WEIGHT	45100.
THRUST TERM WT.	3649.
INSULATION WEIGHT	8537.
IGNITER WEIGHT	538.
BASIC SRM WT.CON.	0.
SRM RECOVERY WEIGHT	(13072.)
PARACHUTE WEIGHT	5434.
PARACHUTE INSTAL.	3758.
RETRO ROCKET	0.
PROPELLANT WEIGHT	0.
WATER REC. HWD.	380.
SRM REC.WT.CONST.	3500.
SRM INTERSTAGE STRU.	(32743.)
FORWARD SKIRT	2211.
AFT SKIRT STRUCT	10962.
ATTACH/SEP STRUCT	17187.
NOSE FAIRING	1593.
TUNNEL WEIGHT	136.
AVIONICS WEIGHT	182.
TPS WEIGHT	472.
SRM INTERS.CONST.	0.
	- - - - - - - -
SUBTOTAL DRY WEIGHT	209395.
GROWTH UNCERTAINTY	7329.
	- - - - - - - -
DRY WEIGHT	216724.
EXPENDABLE PROP.	-6770.
	- - - - - - - -
BURN OUT WEIGHT	209954.
USABLE PROP WEIGHT	1360771.
	- - - - - - - -
TOTAL GROSS WEIGHT	(1570725.)

LAMBDA=WPROP/WGROSS=.86633
TOTAL NO OF SRMS =2.

ORBITER WEIGHT SUMMARY

WING GROUP(AREA=3220.)			(18820.)
BASIC STRUCTURE		13473.	
TORQUE BOX EXPOSE	8822.		
TORQUE BOX CARRY	3876.		
LEADING EDGE	775.		
TRAILING EDGE	0.		
SECONDARY STRUCTURE		1482.	
M.L.G. PROVISIONS	1482.		
CONTROL SURFACE		3864.	
SHELL	1179.		
DRIVE RIB	1628.		
HINGE	284.		
ATTACH	773.		
WING WEIGHT CONSTANT		0.	
TAIL GROUP(AREA= 435.)			(3721.)
BASIC STRUCTURE		1725.	
TORQUE BOX	1571.		
LEADING EDGE	153.		
CONTROL SURFACE		1996.	
SHELL	731.		
DRIVE RIB	737.		
HINGE	129.		
ATTACH	399.		
TAIL WEIGHT CONSTANT		0.	
BODY GROUP			(31187.)
	FWD	CTR	AFT
BASIC STRUCTURE			
SIDEWALLS	3578.	3340.	1354.
LONGERONS		1065.	409.
FRAMES		1488.	1066.
BULKHEADS		774.	
CREW CPT. PROV.	5124.		
WINDSHIELD PROV.	1656.		
NOSE WHL.WEL PROV	226.		
PAYLOAD REACTION		1200.	
WING SHEAR PROV.		556.	
THRUST STRUCTURE			4003.
TAIL PROV.			158.
SUB TOTAL	10584.	8423.	6990.
SECONDARY STRUCTURE			
CARGO DOOR SHELL		2796.	
CARGO DOOR MECH.		2274.	
MISCELLANEOUS WTS.	0.	0.	120.
TOTAL	10584.	13493.	7110.
INDUCED ENVIRON. PROT.			(31033.)
WING		9641.	
SURFACE PANELS	7373.		
LEADING EDGE	2269.		
TAIL		1278.	
SURFACE PANELS	905.		
LEADING EDGE	373.		
BODY		18148.	
BODY PANELS	12121.		
BASE	2276.		
INTERNAL TPS	3476.		
BODY CNST TPS WT.	275.		
MIS CONT. SURFACE		0.	
LAND + DOCKING		300.	
PROPULSION		1382.	
PRIME POWER		89.	
HYDRAULICS		77.	
SURFACE CONTROLS		118.	

LANDING & DOCKING			(11483.)
NOSE GEAR		1333.	
ROLL GEAR	559.		
STRUCTURE	274.		
CONTROLS	500.		
MAIN GEAR		7574.	
ROLL GEAR	4010.		
STRUCTURE	2566.		
CONTROLS	998.		
AUXILIARY SYSTEMS		2576.	
DECELERATION SYS	308.		
SEPARATION SYS	1068.		
HANDLING & MANIP	1200.		
MISCELLANEOUS		0.	
PROPULSION MAIN ASCENT			(27114.)
ENGINES+ACESSORIES		20847.	
ENGINES	18880.		
GIMBAL SYSTEM	1219.		
CONTROLS	738.		
PROPELLANT UTILIZ	10.		
PROPELLANT SYSTEM		6267.	
FILL & DRAIN	773.		
PRESSURIZATION	1095.		
CHILL DUMP LINES	133.		
PRE VALVES	1088.		
FEED SYSTEM	1941.		
DISCONNECTS	488.		
MISCELLANEOUS	749.		
PROPULSION AIR BREATH			(0.)
PROPULSION AUXILIARY			(8190.)
ACS SYSTEM		3963.	
THRUSTERS	1310.		
PROP. SYSTEM	300.		
TANK	1443.		
MODULE	910.		
OAMS SYSTEM		4228.	
THRUSTERS	390.		
PROP. SYSTEM	647.		
TANK	2120.		
MODULE	1071.		
PRIME POWER			(3912.)
ELECTRICAL			(4645.)
HYDRAULIC			(2264.)
SURFACE CONTROLS			(5511.)
AVIONICS			(4455.)
ENVIRONMENTAL CONTROL			(4093.)
PERSONNEL PROVISIONS			(1742.)
MISCELLANEOUS			(0.)
GROWTH/UNCERTAINTY			(13929.)
			- - - - - -
DRY WEIGHT			((172098.))

ORBITER MISSION HISTORY

DRY WEIGHT	(172098.)
PERSONNEL	1250.
ORB RESD PROP WT.	2985.
PAYLOAD UP	51613.
INERT WEIGHT	(227946.)
ORB RESV PROP WT.	878.
ORB INFLIGHT LOSSES	3872.
ACS PROP WT	7280.
OAMS PROP WT	23909.
ORB TRAPED PROP WT	724.
GROSS WT(ORB-ONLY)	(263731.)
(LAND WT PAY=40000.)	
LANDING WEIGHT	(217211.)
(INJE WT PAY=51613.)	
INJECTED WEIGHT	(263007.)

EXTERNAL TANK WEIGHT SUMMARY
ALTERNATE FWD SECTION(WITHOUT NOSE FAIRING)
SEPARATE BULKHEAD-LOX FWD

LENGTH= 2108.
DIAMETER= 304.

	WEIGHT -LB.		WEIGHT -LB.
BODY GROUP	[53356.]	IND. ENVIRN. PROT.	[7103.]
FWD TANK	(12459.)	NOSE FAIRING	0.
FWD BULKHEAD	14.	FWD CONE & CYL.	0.
CONICAL SECTION	2784.	INTER TANK	1534.
CYLINDRICAL SECT.	5385.	AFT CYL & DOME	1761879.
AFT BULKHEAD	4276.		
INTER TANK SECT.	(5326.)	PROPELLANT SYSTEMS	[3953.]
AFT TANK	(24383.)	FEED SYSTEM	1753.
FWD BULKHEAD	2579.	PRES. AND VENT	1742.
CYLINDRICAL SECT.	18827.	SUMPS & VORTEX CTL	220.
AFT BULKHEAD	2976.	PNEUMATIC & PU SYS	237.
ORB/BSTR/TANK ATT.	(10150.)		
NOSE FAIRING	(0.)	AVIONICS	[800.]
UMBILICAL PANEL	(300.)	DEORBIT SYSTEM	[2512.]
TUNNEL	(249.)	MISCELLANEOUS	[0.]
BAFFLES-LOX	(490.)		
		SUBTOTAL DRY WEIGHT	67724.

SUBTOTAL DRY WEIGHT	67724.
GROWTH/UNCERTAINTY	[5079.]
DRY WEIGHT	72804.
RESIDUAL PROPELLANT	[5238.]
TANK UNDRAINABLE	400.
FEEDLINE TRAPPED	103.
PRESSURANT	3235.
PU BIAS	1500.
INERT WEIGHT	78042.
USABLE PROPELLANT	[1640239.]
TOTAL GROSS WEIGHT	1718280.

LAMBDA=WPROP/WGROSS= .9546

VEHICLE SENSITIVITIES

ITEM	INCREMENT	DELTA PAYLOAD	SENSITIVITY
ORBITER INERT WT	10000.00 LB	-10000.3 LB	-1.0 LB/LB
ORBITER INERT WT	-10000.00 LB	10000.0 LB	-1.0 LB/LB
		AVG	-1.0
BOOSTER INERT WT	20000.00 LB	-1595.2 LB	-.07976 LB/LB
BOOSTER INERT WT	-20000.00 LB	1619.3 LB	-.08097 LB/LB
		AVG	-.08036
BSTR ISP(CONST THRUST)	3.00 SEC	2344.7 LB	781.6 LB/SEC
BSTR ISP(CONST THRUST)	-3.00 SEC	-2332.0 LB	777.3 LB/SEC
		AVG	779.5
ORBT ISP(CONST THRUST)	3.00 SEC	4056.7 LB	1352.2 LB/SEC
ORBT ISP(CONST THRUST)	-3.00 SEC	-4057.2 LB	1352.4 LB/SEC
		AVG	1352.3
BOOSTER ISP(CONST FLOW)	3.00 SEC	2270.7 LB	756.9 LB/SEC
BOOSTER ISP(CONST FLOW)	-3.00 SEC	-2261.7 LB	753.9 LB/SEC
		AVG	755.4
ORBITER ISP(CONST FLOW)	3.00 SEC	4820.3 LB	1606.8 LB/SEC
ORBITER ISP(CONST FLOW)	-3.00 SEC	-4814.9 LB	1605.0 LB/SEC
		AVG	1605.9
BOOSTER THRUST	2.00 %	-118.0 LB	-59.0 LB/%
BOOSTER THRUST	-2.00 %	110.2 LB	-55.1 LB/%
		AVG	-57.0
ORBITER THRUST	3.00 %	3165.4 LB	1055.1 LB/%
ORBITER THRUST	-3.00 %	-3717.1 LB	1239.0 LB/%
		AVG	1147.1
ORBITER PROPELLANT	10000.00 LB	820.8 LB	.08208 LB/LB
ORBITER PROPELLANT	-10000.00 LB	-844.0 LB	.08440 LB/LB
		AVG	.08324
BOOSTER PROPELLANT	10000.00 LB	509.1 LB	.05091 LB/LB
BOOSTER PROPELLANT	-10000.00 LB	-511.5 LB	.05115 LB/LB
		AVG	.05103
ORBITER TANK LAMBDA	.01 LB/LB	17692.4 LB	17692.4 LB/.01
ORBITER TANK LAMBDA	-.01 LB/LB	-18066.0 LB	18066.0 LB/.01
		AVG	17879.2
BOOSTER LAMBDA	.01 LB/LB	2921.5 LB	2921.5 LB/.01
BOOSTER LAMBDA	-.01 LB/LB	-2906.1 LB	2906.1 LB/.01
		AVG	2913.8
ORBITER PROP+INERT WT	10.00 %	2900.3 LB	290.0 LB/%
ORBITER PROP+INERT WT	-10.00 %	-8741.0 LB	874.1 LB/%
		AVG	582.1
BOOSTER PROP+INERT WT	10.00 %	9958.0 LB	995.8 LB/%
BOOSTER PROP+INERT WT	-10.00 %	-11076.1 LB	1107.6 LB/%
		AVG	1051.7
TOTAL DELTA V	93.59 FPS	-2563.8 LB	-27.4 LB/FPS
TOTAL DELTA V	-93.52 FPS	2582.3 LB	-27.6 LB/FPS
		AVG	-27.5
ORBITER MANUEV DELTA V	41.95 FPS	-1000.0 LB	-23.8 LB/FPS
ORBITER MANUEV DELTA V	-41.80 FPS	1000.0 LB	-23.9 LB/FPS
		AVG	-23.9
ORBITER GROWTH/UNCER.	- 1. %	1392.9 LB	-1392.9 LB/%
HO-TANK GROWTH/UNCER.	- 1. %	677.2 LB	-677.2 LB/%
BOOSTER GROWTH/UNCER.	- 1. %	328.1 LB	-328.1 LB/%

SENSITIVITY OUTPUT STATEMENT

GLOW SENSITIVITIES

	ORBITER/TANK	BOOSTER
+ DELTA GLOW (LB) DUE TO:		
+ DELTA INERT WT (LB)	59.8	5.7
- DELTA ISP (SEC)	79548.	45724.
- DELTA THRUST (%)	72880.	-3240.
+ DELTA V TOTAL (FPS)	1611.	----
+ DELTA V MANUEVER (FPS)	1402.	----

DELTA GLOW/DELTA PAYLOAD (LB/LB)	59.8
DELTA HO-PROP/DELTA PAYLOAD	56.1
DELTA HO-TANK(DRY)/DELTA PAYLOAD	2.510

GROWTH STUDY
ORBITER GROWTH

%	ORB PROP	DRY-WT	CORE-WT	TNK-WT	VALID	STAGE	T/W(2)
.000	1560423.	398520.	265310.	62738.	YES	4897.	.951
.010	1580716.	398520.	266728.	63316.	YES	4830.	.937
.020	1602653.	398520.	268146.	63950.	YES	4752.	.922
.030	1626684.	398520.	269564.	64654.	YES	4677.	.906
.040	1653595.	398520.	270982.	65459.	YES	4593.	.890
.050	1684695.	398520.	272400.	66410.	YES	4499.	.871
.060	1722965.	398520.	273818.	67613.	YES	4378.	.849
.070	1777665.	398520.	275236.	69404.	YES	4226.	.821
.080	1863729.	398520.	276654.	72412.	YES	3991.	.779

GROWTH OUTPUT STATEMENT

GROWTH STUDY
BOOSTER GROWTH

%	ORB PROP	DRY-WT	CORE-WT	TNK-WT	VALID	STAGE	T/W(2)
.000	1560423.	398520.	265310.	62738.	YES	4897.	.951
.010	1565343.	402505.	265310.	62878.	YES	4872.	.948
.020	1570333.	406490.	265310.	63019.	YES	4843.	.944
.030	1575318.	410475.	265310.	63162.	YES	4824.	.941
.040	1580364.	414461.	265310.	63305.	YES	4793.	.938
.050	1585433.	418446.	265310.	63451.	YES	4763.	.935
.060	1590580.	422431.	265310.	63600.	YES	4742.	.931
.070	1595745.	426416.	265310.	63750.	YES	4718.	.928
.080	1600971.	430402.	265310.	63900.	YES	4690.	.925
.090	1606257.	434386.	265310.	64054.	YES	4662.	.921
.100	1611594.	438372.	265310.	64211.	YES	4634.	.918

GROWTH STUDY
FIXED HO TANK GROWTH

%	BOO GLOW	DRY-WT	CORE-WT	TNK-WT	VALID	STAGE	T/W(2)
.000	3044594.	398531.	265310.	62737.	YES	4898.	.951
.010	3084468.	402690.	266728.	62737.	YES	4945.	.951
.020	3125134.	406951.	268146.	62737.	YES	4996.	.951
.030	3166136.	411247.	269564.	62737.	YES	5050.	.951
.040	3207450.	415575.	270982.	62737.	YES	5092.	.951
.050	3248580.	419864.	272400.	62737.	YES	5144.	.951
.060	3290532.	424258.	273818.	62737.	YES	5189.	.951
.070	3332836.	428688.	275236.	62737.	YES	5245.	.951
.080	3375472.	433153.	276654.	62737.	YES	5287.	.951
.090	3418444.	437653.	278072.	62737.	YES	5344.	.951
.100	3461786.	442190.	279490.	62737.	YES	5384.	.951

APPENDIX A

GROUP WEIGHT STATEMENT

AND

DESIGN DATA SUMMARY

GROUP WEIGHT STATEMENT

CONFIGURATION		BY		DATE		PAGE E01
1		CARRY	INTERM	OUTER		
2	WING GROUP	THROUGH	PANEL	PANEL		
3	BASIC STRUCTURE					
4	TORQUE BOX	(INCL FUSE)				
5	LEADING EDGE					
6	TRAILING EDGE					
7	TIP					
8	M.G. BAY					
9	M.G. BAY-STRUCTURE					
10	-DOORS					
11	GLOVE					
12	SECONDARY STRUCTURE					
13	FAIRINGS, FINISH, MISC.					
14	ACCESS DOORS					
15	ELEVON		INNER	OUTER		
16	STRUCTURE					
17	MECHANISM					
18	BALANCE WEIGHT					
19	SUPPORTS					
20	TAIL GROUP			VERTICAL		
21	BASIC STRUCTURE					
22	TORQUE BOX					
23	LEADING EDGE					
24	TRAILING EDGE					
25	TIP					
26	SECONDARY STRUCTURE					
27	DOORS					
28	FAIRINGS, FINISH, MISC.					
29	RUDDER					
30	STRUCTURE					
31	MECHANISM					
32	BALANCE WEIGHT					
33	SUPPORTS					
34	BODY GROUP	FWD	CTR	AFT		
35	BASIC STRUCTURE					
36	SKIN/STRINGERS					
37	LONGERONS					
38	FRAMES					
39	WING ATTACH-CARRY THRU					
40	BULKHEADS					
41	THRUST STRUCTURE					
42	CREW CABIN					
43	WINDOWS/FRAMES					
44	STRUCTURE					
45	AIRLOCK					
46	HATCH					
47	PAYLOAD DOOR					
48	STRUCTURE					
49	HINGES/MECHANISM					
50	BODY FLAP/SPEED BRAKE					
51	N. GEAR BAY					
52	SECONDARY STRUCTURE/MISC.					
53	ACCESS DOORS					
54	EQUIPMENT COMPTS					
55						
56	FAIRINGS, FINISH, MISC.					

GROUP WEIGHT STATEMENT

CONFIGURATION		BY		DATE		PAGE 02

Line	Item				
1					
2	4 INDUCED ENVIRONMENT PROTECTION	WING	TAIL	BODY	
3	THERMAL PROTECTION	( )	( )	( )	
4	LEADING EDGE/NOSE CAP				
5	SURFACE PNL-UPPER				
6	-SIDE				
7	-LOWER				
8	-CONT. SURF.				
9	BASE PROTECTION				
10	PRESSURE VENT PURGE SY				
11	INTERNAL THERMAL CONTROL (PASSIVE)				
12	CABIN				
13	NOSE GEAR BAY				
14	FORWARD BODY				
15	CENTER BODY				
16	RADIATOR				
17	AVIONICS BAY				
18	MAIN GEAR BAY				
19	PODS - OMS				
20	- RCS				
21	APU COMPARTMENT				
22	HYDRAULIC BAY				
23					
24	NOISE PROTECTION				
25	METEOROID PROTECTION				
26					
27	5 LANDING DOCKING	ROLLING	STRUCTURE	CONTROLS	
28	ALIGHTING GEAR	( )	( )	( )	
29	MAIN				
30	NOSE				
31	DOCKING				
32	AUXILIARY SYSTEMS				
33	DECELERATION CHUTES				
34	SEPARATION SYSTEM				
35	HANDLING GEAR-CARGO & MANIPULATOR				
36					
37	6 PROPULSION - MAIN ASCENT				
38	ENGINE & ACCESSORIES				
39	ENGINE (AS SUPPLIED)				
40	GIMBAL SYSTEM				
41	PROPELLANT UTILIZATION SYSTEM				
42	ACCESSORIES				
43	INSTALLATION - DUCTS, SHROUDS				
44	PROPELLANT SYSTEM		FUEL	OXIDIZER	
45	FILL/DRAIN				
46	PRESSURIZATION				
47	VENT SYSTEM				
48	INSTRUMENTATION				
49	PRE-VALVES				
50	FEED SYSTEM				
51	PROPELLANT MANAGEMENT				
52	SUPPORTS AND INSTALL				
53					
54					
55					
56					
57					

GROUP WEIGHT STATEMENT

CONFIGURATION		BY		DATE		PAGE 03
7 PROPULSION - AIR BREATHING						
ENGINE ACCESSORIES						
ENGINE (AS SUPPLIED)						
IGNITION & CONTROL SYS						
LUBRICATION SY (DRY)						
ACCESSORIES						
INSTALLATION, DUCTS, SHROUDS						
AIR INDUCTION						
ENGINE MOUNTING						
NACELLES, PYLON (INCL ___ LB MECH)						
EXHAUST SYSTEM						
PROPELLANT SYSTEM						
FILL/DRAIN						
PRESSURIZATION/VENT						
PUMP						
FEED						
TRANSFER						
SUPPORTS/INSTALLATION						
TANKAGE-NON-INTEGRAL TANK		INSUL	SUPTS			
FUEL						
8 PROPULSION - AUXILIARY			ATT CONTROL		MANEUVER	
THRUSTER INSTALLATION						
THRUSTERS						
SUPPORTS, INSTALL						
PROPELLANTS SY						
FILL/DRAIN						
PRESSURIZATION						
VENT						
FEED SYSTEM						
INSTRUMENTATION						
GIMBALLING						
PROP CONDITION & GAUGE						
TANKS						
OXIDIZER						
FUEL						
INSULATION						
STRUCTURAL SUPPORTS						
9 PRIME POWER	POWER UNITS	MTG/ INSTAL	PROPEL TANK SY	TEMP CONTROL	PLUMB/ SUPPORT	TOTAL
BATTERIES						( )
ENGINE/TURBINE						( )
FUEL CELL						( )
10 ELECTRICAL		SUPPLY	CONVERSION	CONTROL UNITS		
EQUIPMENT POWER SY						
PRIMARY DISTRIBUTION CIRCUITRY						
UTILITY SYSTEMS						
SYSTEM CIRCUITRY						
AVIONICS						
MISSION SEQUENCING						
ENVIRONMENTAL CONTROL						
PROPULSION						
SUPPORTS/INSTALLATION						

G R O U P   W E I G H T   S T A T E M E N T

CONFIGURATION			BY		DATE		PAGE 04
11	HYDRAULIC		SY#	SY#			
	POWER SUPPLY						
	CONTROL CENTER						
	DISTRIBUTION SY						
	TEMPERATURE CONTROL						
	AUXILIARY SYSTEMS						
	SUPTS/INSTAL						
12	SURFACE CONTROLS						
	COCKPIT CONTROLS						
	FLIGHT CONTROL SY					SEE AVIONICS	
		PLUMB	ACTUATOR	FEEL SY	MECH		
	ELEVON						
	RUDDER						
	BODY FLAP						
13	AVIONICS	UNITS	CIRCUITRY	ANTENNAS	INSTAL		
		( )	( )	( )	( )		
	GUID & NAV		SEE ELECTRICAL				
	COMMUNICATE						
	INSTRUMENTATION						
	DISPLAYS						
	MISSION SPECIAL STAT						
14	ENVIRONMENTAL CONTROL (DRY)						
	GAS SUPPLY SYSTEM						
	GAS MANAGEMENT/PURIFICATION						
	HEAT TRANSPORT SYSTEM						
	WATER MANAGEMENT SYSTEM						
	INSTRUMENTATION						
	SUPPORTS/INSTALLATION						
15	PERSONNEL PROVISIONS						
	SEATS/RESTRAINT SYSTEM						
	FIXED LIFE SUPPORT EQUIPMENT						
	EMERGENCY EQUIPMENT						
	FURNISHINGS						
	SUPPORT/INSTALLATION						
16	RANGE SAFETY AND ABORT						
17	BALLAST						
18	GROWTH/UNCERTAINTY						
19	OPEN						
	SUBTOTAL - DRY WEIGHT						

GROUP WEIGHT STATEMENT

CONFIGURATION	BY	DATE	PAGE 05	
USEFUL LOAD AND GROSS WEIGHT				
MISSION				
20 PERSONNEL	( )	( )	( )	( )
CREW (NO.)				
PASSENGERS (NO.)				
PERSONAL GEAR/ACCESSORIES				
LIFE SUPPORT				
21 CARGO				
22 ORDNANCE				
23 RESIDUAL & UNUSABLE FLUIDS	( )	( )	( )	( )
ASCENT				
CRUISE				
MANEUVER				
ATTITUDE CONTROL				
ECS				
EPS				
HYDRAULIC				
24 OPEN				
SUBTOTAL - INERT WEIGHT	( )	( )	( )	( )
25 RESERVE FLUIDS				
ASCENT				
CRUISE				
MANEUVER				
ATTITUDE CONTROL				
ECS				
EPS				
HYDRAULIC				
26 IN FLIGHT LOSSES				
ASCENT				
CRUISE				
MANEUVER				
ATTITUDE CONTROL				
ECS				
EPS				
HYDRAULIC				
27 ASCENT PROPELLANT				
28 CRUISE PROPELLANT				
29 MANEUV/ATT PROPELLANT				
MANEUVER				
ATTITUDE CONTROL				
GROSS WEIGHT @ LAUNCH-ORBITER				
EXTERNAL TANK @ LAUNCH				
SRM @ LAUNCH				
ABORT ROCKETS @ LAUNCH				
GROSS LIFT OFF WEIGHT				

DESIGN DATA SUMMARY

CONFIGURATION		BY		DATE		PAGE	01

GENERAL

STRUCTURAL DATA

DESIGN CONDITION	GROSS WEIGHT	CENTER OF GRAVITY X	Y	Z	ULTIMATE LOAD FACTOR NX	NY	NZ
ASCENT							
ABORT							
ENTRY							
CRUISE							
LANDING							

FACTOR OF SAFETY ______ MAX. DYNAMIC PRES: PSF ______
MAX. Q, PSF DEGREE ______

PERFORMANCE DATA	BOOSTER	ORBITER
S.L. THRUST		
VACUUM THRUST		
LIFT-OFF WEIGHT		
BURN-OUT WEIGHT		
MAXIMUM T/W		

INERT WEIGHT FRACTION - EXTERNAL TANK ______ BOOSTER ______
TOTAL ASCENT ΔV REQ. fps ______ STAGING ΔV: fps ______
ON ORBIT MANEUVER ΔV fps ______ FLIGHT PERF RESERVE fps ______
ASCENT $^{S}C_{D}$ ______ ORBITAL ALTITUDE, n mi ______
LAUNCH INCLINATION, DEG. ______ LAUNCH SITE ATL. FT. ______

GEOMETRY DATA	ORBITER	EXT. TANK	BOOSTER
AERODYNAMIC REF. WING AREA			
WETTED AREA, SQ. FT. (EXCLUDE NOZZLE)			
MOLDLINE VOLUME, CU. FT. (EXCLUDE NOZZLE)			
PLANFORM PROJECTED AREA SQ. FT.			

WING

AREA-PROJECTED-SQ. FT	CARRY THROUGH	INTERM PANEL	OUTER PANEL	STRUCTURAL MATERIAL/ALLOY	DESIGN TEMP °F
TORQUE BOX					
LEADING EDGE					
TRAILING EDGE					
CONTROL SURFACE					
GLOVE, FAIRING					

VOLUME - MOLDLINE CU. FT. ______

	M.A.C.	ROOT THEOR	BODY JUNCT	PLANFORM BREAK	TIP
SPAN BETWEEN CHORDS					
CHORD - LENGTH - FT					
- THICKNESS - FT.					

AIRFOIL ______ LEADING EDGE M.A.C. (STA) ______
DIHEDRAL ANGLE DEGREES; ______ SPAN @ DIHEDRAL BASE ______
SWEEPBACK ANGLE 50%C ______

DESIGN LOAD POUNDS ______ REF ______
CRITICAL LOAD CONDITION ______ REF ______

CONTROL SURFACE

SURFACE	NO.	TYPE	AREA	HL CHORD	HL THICK	HL SPAN	LOAD LB
ELEVON-IN							
-OUT							

DESIGN DATA SUMMARY

CONFIGURATION		BY		DATE		PAGE 02

		VERTICAL	HORIZ
1	TAIL GROUP	VERTICAL	HORIZ
2	AREA - SQ. FT		
3	AERODYNAMIC REFERENCE		
4	EXPOSED		
5	TORQUE BOX		
6	LEADING EDGE		
7	TRAILING EDGE		
8	CONTROL SURFACE		
9	SPAN - AERODYNAMIC REF.		
10	SPAN - EXPOSED		
11	VOLUME - CU. FT.		
12	PRIMARY STRUCT. - MATERIAL		
13	- DESIGN TEMP		
14	AIRFOIL DESCRIPTION		
15	CHORD LENGTH - FT.		
16	ROOT (AERO REF)		
17	MAC		
18	BODY JUNCTION		
19	TIP		
20	CHORD THICKNESS - FT		
21	ROOT		
22	BREAK		
23	TIP		
24	DIHEDRAL ANGLE		
25	SWEEP BACK ANGLE 50%		
26	DESIGN LOAD - ULTIMATE		
27	DESIGN LOAD CONDITION		
28	LEMAC		
29	TAIL LENGTH 25% MAC WING TO 25% MAC TAIL		
30			

31 CONTROL SURFACE

	SURFACE	NO.	TYPE	AREA	HL CHORD	HL THICK	HL SPAN	LOAD LB
32	SURFACE	NO.	TYPE	AREA	HL CHORD	HL THICK	HL SPAN	LOAD LB
33	RUDDER							
34								

35 STRUCTURAL MATERIAL RUDDER ________

36

37

		FWD	CENTER	AFT	BASE	TOTAL
38	BODY GROUP	FWD	CENTER	AFT	BASE	TOTAL
39	STATION - FORWARD					
40	STATION - AFT					
41	AREA - STRUCTURE - WETTED					
42	- PODS/FAIRING					
43	VOLUME - PRESSURIZED CU FT					
44	- STRUCTURE TOTAL					
45	- PODS/FAIRINGS					
46	LENGTH - FT					
47	WIDTH - MAX - FT					
48	HEIGHT - MAX - FT					
49	PRIMARY STRUCTURAL MATERIAL					

	PRESSURIZED COMPT	AREA	VOLUME	ULT PRESS	PRIMARY MATERIAL
50	PRESSURIZED COMPT	AREA	VOLUME	ULT PRESS	PRIMARY MATERIAL
51	CREW CABIN				
52	SIDEWALLS				
53	TRANSPARENT AREA				
54					
55					

DESIGN DATA SUMMARY

CONFIGURATION	BY	DATE	PAGE 03

BODY (CONTINUED)

LOCATION - STATION	X	Y	Z
FORWARD INTERSTAGE ATTACH			
AFT INTERSTAGE ATTACH			
COMPOSITE THRUST VECTOR GIMBAL			
NOSE GEAR ATTACH			
MAIN GEAR ATTACH			
CARGO DOOR SILL - FORWARD			
- AFT			
N.G. BAY - FWD			
- AFT			
CREW COMPT - FWD BLKHD			
- AFT			

ANGLE - COMPOSITE THRUST VECTOR TO CL PAYLOAD BAY LAUNCH CONFIG. - DEGREES ____

CONTROL SURFACE

SURFACE	NO.	TYPE	AREA	HL CHORD	HL THICK	HL SPAN	LOAD, LB

PAYLOAD BAY DOOR: AREA ________ SQ. FT; NO. HINGES ________ MATERIAL

INDUCED ENVIRONMENT PROTECT

EXTERNAL	MAX T °F	MATERIAL	WING FIXED	WING CNT SRF	TAIL FIXED	TAIL CNT SRF	BODY	
L. EDGE								
N. CAP								
PANELS LWR								
SIDE								
UPR								
BASE								
W/S CYR								
UNPROTECT								
TOTAL					( )	( )	( )	( )

VEHICLE WETTED AREA

INTERNAL TPS COMPARTMENT	MATERIAL	COMPT TEMP °F	AREA INSULATED - SQ. FT.

DESIGN DATA SUMMARY

CONFIGURATION	BY	DATE	PAGE 04

LANDING, RECOVERY, DOCKING

ALIGHTING GEAR	NO/ VEH	GEAR LENGTH EXT FT.	STRUT LGTH-FT	STROKE FT	PRIMARY MATERIAL/ALLOY	BRAKE MATERIAL
MAIN GEAR						
NOSE GEAR						

	TIRES NO VEH	TIRES SIZE	STATIC RADIUS	GROUND CONTACT PT X	GROUND CONTACT PT Y	GROUND CONTACT PT Z	
MAIN							
NOSE							

LOADS - CRITERIA REF ______ LANDING SINK SPEED CPS ______
STALL SPEED, LDG., KNOTS ______ ANGLE OF ATTACK, LDG ______
NOSE GEAR STEERING INCL. ______ ANTI SKID INCL. ______

DOCKING

SEPARATION SYSTEM
MAXIMUM SEPARATION FORCE - FWD ______ AFT ______ LBS

DECELERATION CHUTE
NO./VEHICLE ______ DIAMETER EACH FT. ______

PROPULSION - MAIN ASCENT

	NO/VEH	THRUST SL	THRUST VAC	SPECIFIC IMPULSE S.L.	SPECIFIC IMPULSE VAC	EXP RATIO	CHAMB PRESS
ENGINE, EA							

GIMBAL ANGLE ______ GIMBAL RATE °/SEC ______
BURN TIME @ STAGE SEC ______ THRUST RANGE ______ % TO ______ %
@ INJECT SEC ______ MIXTURE RATIO O/F ______
FEED LINE DIA, LH2 IN. ______ PRESSURANT LH2 ______
FEED LINE DIA, LO2 IN. ______ PRESSURANT LO2 ______

LOCATION	X	Y	Z
FEED LINE DISCONNECT			
GIMBAL ENG #1			
GIMBAL ENG #2			
GIMBAL ENG #3			

PROPULSION - CRUISE BACK

	NO/VEH	THRUST SL STATIC	SFC NOM CRUIS	FUEL TYPE	BYPASS RATIO
ENGINE - EA					

	ALTITUDE	SPEED, M	RANGE REQD	L/D RATIO
CRUISE - NOMINAL				
- ENGINE				

ENG THRUST SIZED TO ______ CL FOR THRUST DESIGN COND ______

TANKAGE	NO/ VEH: TYPE: SHAPE	VOL CU FT	MATERIAL	PRESSURE	BURST FACTOR	
FUEL SY						
PRESSURE SY						

AIR INTAKE DUCT LENGTH FT ______ NACELLE WETTED AREA (EA) ______
AIR INTAKE DUCT DIA FT. ______

DESIGN DATA SUMMARY

CONFIGURATION	BY	DATE	PAGE 05

8 PROPULSION - AUXILIARY

THRUSTERS SY/NO. ENG	LOCATION X	Y	Z	THRUST VAC	ISP STD/PLSE	EXPANSION RATIO	CHAMB PRESS

PROPELLANT SY ACS	TYPE	TANK VOL CU FT	TANK MATL	TANK PRES-PSI	BURST FACTOR	NO OF TANKS
FUEL						
OXIDIZER						
PRESSURANT						
MANEUVER						
FUEL						
OXIDIZER						
PRESSURANT						

9 PRIME POWER

	NO. UNITS	SPECIFIC POWER		TOTAL POWER		TYPE
BATTERIES			WATT-HRS/LB		WATT-HRS	
ENGINE/TURBINE			HP-HR LB FUEL		HP-HR	
			HP-LB OF ENGINE		HP	
FUEL CELL			WATT-HR/LB FUEL		WATT HRS	
			WATT-LB OF CELL		WATTS	

FUEL STORAGE SYSTEMS	TYPE	TANK VOL CU FT	TANK MATL	TANK PRESS	BURST FACTOR	NO OF TANKS

10 ELECTRICAL POWER CONVERSION/DISTRIBUTION

SYSTEM VOLTAGE ____________
PEAK POWER (WATTS) ____________; TOTAL ENERGY WATT-HRS.____

LOCATION	X	Y	Z
PRIME POWER COMPT			
POWER DISTRIBUTION COMPT			

11 HYDRAULIC POWER CONVERSION/DISTRIBUTION

SYSTEM NOMINAL OPER PRESSURE ____________ PSI
PEAK HORSEPOWER ____________
SYSTEM OPERATING TEMPERATURE ____________;

SYSTEM	NO. PUMPS	PUMP GPM	SUBSYSTEMS SERVICED

LOCATION	X	Y	Z
PUMP COMPARTMENT			
SERVICE CENTER			

DESIGN DATA SUMMARY

CONFIGURATION		BY		DATE		PAGE	06

12 SURFACE CONTROLS

SURFACE	MAX DEFL DEG	DESIGN HINGE MOM FT/LB	ACTUATOR NO./VEHICLE	ACTUATOR LOCATION (C.G.) X	Y	Z
ELEVONS						
RUDDER						
SPEED BRAKE						

13 AVIONICS

14 ENVIRONMENTAL CONTROL

GAS STORAGE	TYPE	TANK VOL CU FT	TANK MATL	TANK PRESS	BURST FACTOR	NO. OF TANKS
PRIMARY O_2						
SECONDARY O_2						
DILUENT - N_2						

GAS REQUIREMENT AVERAGE RATES

METABOLIC ________ LB MAN-DAY

LEAKAGE ________ LB DAY;

PRESSURIZED VOLUME ________ CU. FT. FOR REPRESSURIZATION

HEAT TRANSPORT SYSTEM CAPACITY ________ BTU HR PEAK

________ BTU HR AVE

RADIATOR AREA ________ SQ. FT: ________ MATERIAL

WATER MANAGEMENT SYSTEM CAPACITY

DRINKING WATER ________ LB/MAN DAY * ________ MAN DAYS

WASH/WASTE WATER ________

COOLING WATER ________

15 PERSONNEL PROVISIONS

16 RANGE SAFETY AND ABORT

D E S I G N   D A T A   S U M M A R Y

CONFIGURATION		BY		DATE		PAGE	07

17 BALLAST

DESIGN CONDITION

______________ WEIGHTS = ______ LBS @ ______ % L

DESIGN C.G. ENVELOPE FWD ______ %L AFT ______ %L

NOMINAL C.G. WITHOUT BALLAST ______ %L

NOMINAL C.G. WITH ______ LB BALLAST = ______ %L

18 GROWTH

CURRENT ALLOWANCE ______ LB

CONTRACTORS EST OF ALLOWANCE NEEDED TO GUARANTEE
CURRENT PAYLOAD AND GROSS WEIGHT ______ LB*

* FOR SYSTEM REQUIREMENTS AS DEFINED BY

19 OPEN

20 PERSONNEL

NO. OF CREW ______ ; ______ PERCENTILE

NO. OF PERSONNEL ______ ; ______ PERCENTILE

21 CARGO

BAY DIA ______ FT CARGO VOLUME ______ CU FT

BAY LENGTH ______ FT

22 ORDNANCE

23 RESIDUAL FLUIDS - DEFINE WEIGHT ESTIMATING RATIONAL

24 OPEN

25 RESERVE FLUIDS

26 IN-FLIGHT LOSSES

27 - 29 PROPELLANTS EXPENDED

	ASCENT	CRUISE	MANEUVER	ATTITUDE
OXIDIZER FUEL RATIO (BY WEIGHT)	____	____	____	____
ASCENT VELOCITY REQ'D	(____)			
INERTIAL	____			
LOSSES	(____)			
MANEUVER	____			
GRAVITY	____			
DRAG	____			
BACK PRESSURE	____			
ANGLE OF ATTACK	____			
FLIGHT PERF RESERVE	____			

EXTERNAL TANK
GROUP WEIGHT SUMMARY

CONFIGURATION		BY		DATE		PAGE	ET1

1 WING GROUP						NOT APP
2 TAIL GROUP						NOT APP
3 BODY GROUP						
		FWD	INTER	AFT		
BASIC STRUCTURE	NOSE	TANK	STAGE	TANK		
SIDEWALL						
BULKHEAD - FWD						
- AFT						
BAFFLING						
SKIRT						
ORBITER/TANK ATTACH						
TUNNELS						
UMBILICAL STRUCTURE						
SECONDARY STRUCTURE						
4 INDUCED ENVIRONMENT PROTECTION						
		FWD	INTER	AFT		
	NOSE	TANK	STAGE	TANK		
SURFACE TPS						
ABLATOR						
INSULATOR						
INSTALLATION						
BASE PROTECT						
5 LANDING, DOCKING						NOT APP
6 PROPULSION - MAIN ASCENT						
ENGINE SYSTEM						
RECIRCULATION SY						
UTILIZATION SY						
PNEUMATICS						
PROPELLANT FEED SY			FUEL	OXIDIZER		
FILL & DRAIN						
PRESSURIZATION						
VENT SY						
VORTEX, FLOW CONTROL						
SUPPORTS, INSTALLATION						
7 PROPULSION - CRUISE						NOT APP
8 PROPULSION - AUXILIARY						
9 PRIME POWER						NOT APP
10 ELECTRICAL						
CONTROL UNITS						
CIRCUITRY						
11 HYDRAULIC						NOT APP
12 SURFACE CONTROLS						NOT APP

EXTERNAL TANK GROUP WEIGHT SUMMARY

CONFIGURATION		BY		DATE		PAGE	ET2

13	AVIONICS	UNITS	COOLING	ANTENNA	INSTAL		____
14	ENVIRONMENTAL CONTROL						NOT APP
15	PERSONNEL PROV						NOT APP
16	RANGE SAFETY, ABORT						NOT APP
17	BALLAST						NOT APP
18	GROWTH/UNCERTAINTY						____
19	OPEN						
	SUBTOTAL - DRY WEIGHTS						(____)
20	PERSONNEL						NOT APP
21	CARGO						NOT APP
22	ORDNANCE						NOT APP
23	RESIDUAL FLUIDS						____
	ASCENT PROPELLANT					____	
	PRESSURANT					____	
24	OPEN						
	SUBTOTAL - INERT WEIGHT						(____)
25	RESERVE FLUIDS						____
26	INFLIGHT LOSSES						____
27	PROPELLANT ASCENT						____
28	PROPELLANT - CRUISE						
29	PROPELLANT - AUX						____
	EXTERNAL TANK GROSS WEIGHT @ LAUNCH						(____)

EXTERNAL TANK

DESIGN DATA SUMMARY

CONFIGURATION ____ BY ____ DATE ____ PAGE ET1

0 GENERAL

STRUCTURAL DESIGN CONDITION	ULTIMATE LOAD FACTOR NX	NY	NZ	GROSS WEIGHT
ASCENT-LIFT OFF				
-STAGE				

FACTOR OF SAFETY ____
MAX DYNAMIC PRESSURE ____
MAX ∝ q, PSF DEGREE ____

EXTERNAL TANK INERT FRACTION ____

1 WINGS NOT APPLICABLE

2 TAIL NOT APPLICABLE

3 BODY GROUP

LOCATION	NOSE	FWD TANK	INTER STAGE	AFT TANK	SKIRT
STATION-FORWARD	____	____	____	____	____
-CONTOUR BREAK	____	____			
-AFT	____	____	____	____	____
FORWARD ATTACH POINT		____		____	
AFT ATTACH POINT		____		____	
DIAMETER-FORWARD	____	____	____	____	____
-CONTOUR BREAK	____	____			
-AFT	____				____
SPHERICAL RADIUS-CAP	____				
BULKHEAD-FWD-HT/RADIUS		____		____	
-AFT-HT/RADIUS		____		____	
VOLUMETRIC					
ULLAGE		____		____	
LOAD ALLOWANCE		____		____	
STRUCTURE/ALLOWANCE		____		____	
EXTERNAL TANK ML		____		____	
STRUCTURAL ALLOY	____	____	____	____	____
OPERATING PRESSURE		____		____	
ULLAGE PRESSURE				____	

4 INDUCED ENVIRONMENT

	NOSE	FWD TANK	INTER STAGE	AFT TANK	SKIRT
PROTECTED AREA	____	____	____	____	____
INSULATION TYPE	____	____	____	____	____

5 LANDING RECOVERY DOCKING

	Δ V, fps	ISP	THRUST
RETRO ROCKET	____	____	____

6 PROPULSION - MAIN ASCENT
FEED LINE DIA. LH2, IN
FEED LINE DIA LOX, IN

EXTERNAL TANK

DESIGN DATA SUMMARY

CONFIGURATION		BY		DATE		PAGE	ET2

7 PROPULSION - CRUISE ... NOT APPLICABLE

8 PROPULSION - AUXILIARY

9 PRIME POWER

10 ELECTRICAL CONV & DISTRIBUTION
SUBSYSTEMS SUPPLIED:

11 HYDRAULIC CONV & DISTRIBUTION ... NOT APPLICABLE

12 SURFACE CONTROLS ... NOT APPLICABLE

13 AVIONICS

14 ENVIRONMENTAL CONTROL ... NOT APPLICABLE

15 PERSONNEL PROV ... NOT APPLICABLE

16 RANGE SAFETY, ABORT ... NOT APPLICABLE

17 BALLAST ... NOT APPLICABLE

18 GROWTH/UNCERTAINTY

19 OPEN

SOLID ROCKET MOTOR BOOSTER GROUP WEIGHT SUMMARY

CONFIGURATION | BY | DATE | PAGE B1

1 WING	NOT APP
2 TAIL	NOT APP
3 BODY GROUP	
CASE	
STRUCTURE	
JOINTS	
FORWARD SKIRT	
AFT SKIRT	
ATTACH/SEPARATION STRUCT	
NOSE FAIRING	
TUNNEL	
INSTALLATION	
4 INDUCED ENVIRONMENT PROTECTION	
CASE	
JOINTS	
EXPENDED	
5 LANDING, DOCKING	
PARACHUTE SYSTEM	
PARACHUTE	
CONTROLS	
INSTALLATION	
RETRO ROCKETS	
CASES	
PROPELLANT	
CONTROLS	
INSTALLATION	
RECOVERY HARDWARE	
6 PROPULSION ASCENT	
NOZZLE	
GIMBAL	
IGNITER	
THRUST TERMINATION SY	
7 PROPULSION - CRUISE	NOT APP
8 PROPULSION - AUXILIARY	
9 PRIME POWER	NOT APP
10 ELECTRICAL CONV & DIST	
11 HYDRAULIC CONV & DIST	
12 SURFACE CONTROLS	NOT APP

SOLID ROCKET MOTOR BOOSTER GROUP WEIGHT SUMMARY

CONFIGURATION		BY		DATE		PAGE B2

13	AVIONICS	UNITS COOLING ANTENNA INSTL	______
14	ENVIRONMENTAL CONTROL		NOT APP
15	PERSONNEL PROV		NOT APP
16	RANGE SAFETY, ABORT		NOT APP
17	BALLAST		NOT APP
18	GROWTH/UNCERTAINTY		______
19	OPEN		
	SUB TOTAL	DRY WEIGHT	(____)
20	PERSONNEL		NOT APP
21	CARGO		NOT APP
22	ORDNANCE		NOT APP
23	RESIDUAL FLUIDS		NOT APP
24	OPEN		NOT APP
	SUB TOTAL	INERT WEIGHT	(____)
25	RESERVE FLUIDS		NOT APP
26	INFLIGHT LOSSES		NOT APP
27	PROPELLANT - ASCENT		______
28	PROPELLANT - CRUISE		NOT APP
29	PROPELLANT		NOT APP
	SRM BOOSTER GROSS WEIGHT @ LAUNCH		(____)

SOLID ROCKET MOTOR BOOSTER
DESIGN DATA SUMMARY

CONFIGURATION		BY		DATE		PAGE	B1

0.0 GENERAL

STRUCTURAL DESIGN CONDITION	ULTIMATE LOAD FACTOR NX	NY	NZ	WEIGHT
ASCENT – LAUNCH				
– STAGING (MAX NX)				

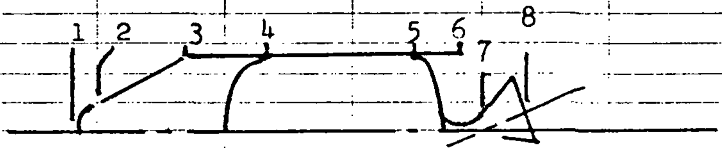
	DENSITY	LOADING FRACTION	WEIGHT FRACTION
SRM PROPELLANT			

1.0 WING — NOT APPL

2.0 TAIL — NOT APPL

3.0 BODY

GEOMETRY



LOCATION	1	2	3	4	5	6	7	8
STATION								
DIA								

	FWD SKIRT	CASE	AFT SKIRT
FWD BULKHEAD HEIGHT			
AFT BULKHEAD HEIGHT			
WETTED AREA			

STRUCTURAL
- CASE OPERATING PRESSURE – MAXIMUM ________ AVERAGE ________
- CASE MATERIAL ________
- ULTIMATE TENSILE STRENGTH ALLOWABLE ________
- CASE DESIGN TEMPERATURE °F ________
- NO. OF SEGMENT JOINTS ________
- FACTOR OF SAFETY ________
- EXTERNAL MOLD LINE VOLUME ________
- INTERNAL CASE VOLUME ________

4.0 INDUCED ENVIRONMENT PROTECTION
- INSULATION THICKNESS ________ ;

5.0 LANDING DOCKING

PARACHUTE SYSTEM	OPEN	IMPACT	RETRO-ROCKET IGNITION
VELOCITY			
ALTITUDE			

	TYPE	NO./SRM	DIA.
MAIN			
STABILIZATION			
PILOT			

6.0 ASCENT PROPULSION

	NO./VEHICLE	THRUST S.L.	THRUST VAC.	EXP RATIO	I_{SP} S.L.	I_{SP} VAC.	CHAMB PRESSURE
SRM = Ea							

- NOZZLE-THROAT AREA ________ SQ. IN, DIVERGENCE HALF ANGLE ________
- PROPELLANT GRAIN PORT AREA ________ SQ. IN.
- THRUST COEFFICIENT ________
- COMBUSTION TEMPERATURE ________ °F
- GIMBALLED OR FIXED NOZZLE ________

SOLID ROCKET MOTOR BOOSTER
DESIGN DATA SUMMARY

CONFIGURATION		BY		DATE		PAGE	B2

7.0 PROPULSION CRUISE — NOT APPLICABLE

8.0 PROPULSION AUXILIARY

	ΔV fps	I_{SP} AVE	THRUST LB	NO. MOTORS
RETRO ROCKET/SRM				

9.0 PRIME POWER — NOT APPL.

10. ELECTRICAL CONV & DIST
SYSTEMS SERVED ____________

11. HYDRAULIC CONV & DIST
SYSTEMS SERVED: ____________

12. SURFACE CONTROLS — NOT APPL.

13. AVIONICS

14. ENVIRONMENTAL CONTROL — NOT APPL.

15. PERSONNEL PROV — NOT APPL.

16. RANGE SAFETY, ABORT — NOT APPL.

17. BALLAST — NOT APPL.

18. GROWTH/UNCERTAINTY
ALLOWANCE FOR GFE ____________
ALLOWANCE FOR CFE ____________

19. THRU 26. — NOT APPL.

27. ASCENT PROPELLANT

	LOADED	EXPENDED
PROPELLANT - MAIN		
INSULATION		

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