JSC - 26098

Design Mass Properties II

Mass Estimating And Forecasting For Aerospace Vehicles Based On Historical Data

Systems Definition Branch
Technology and Project Implementation Office
Engineering Directorate

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National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
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DESIGN MASS PROPERTIES II

MASS ESTIMATING AND FORECASTING FOR AEROSPACE VEHICLES

BASED ON HISTORICAL DATA

by

Willie Heineman, Jr.

Approved by:

Charles Teixeira
Chief, Systems Definition Branch

and

Elric N. McHenry
Manager, Technology & Project Implementation Office

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

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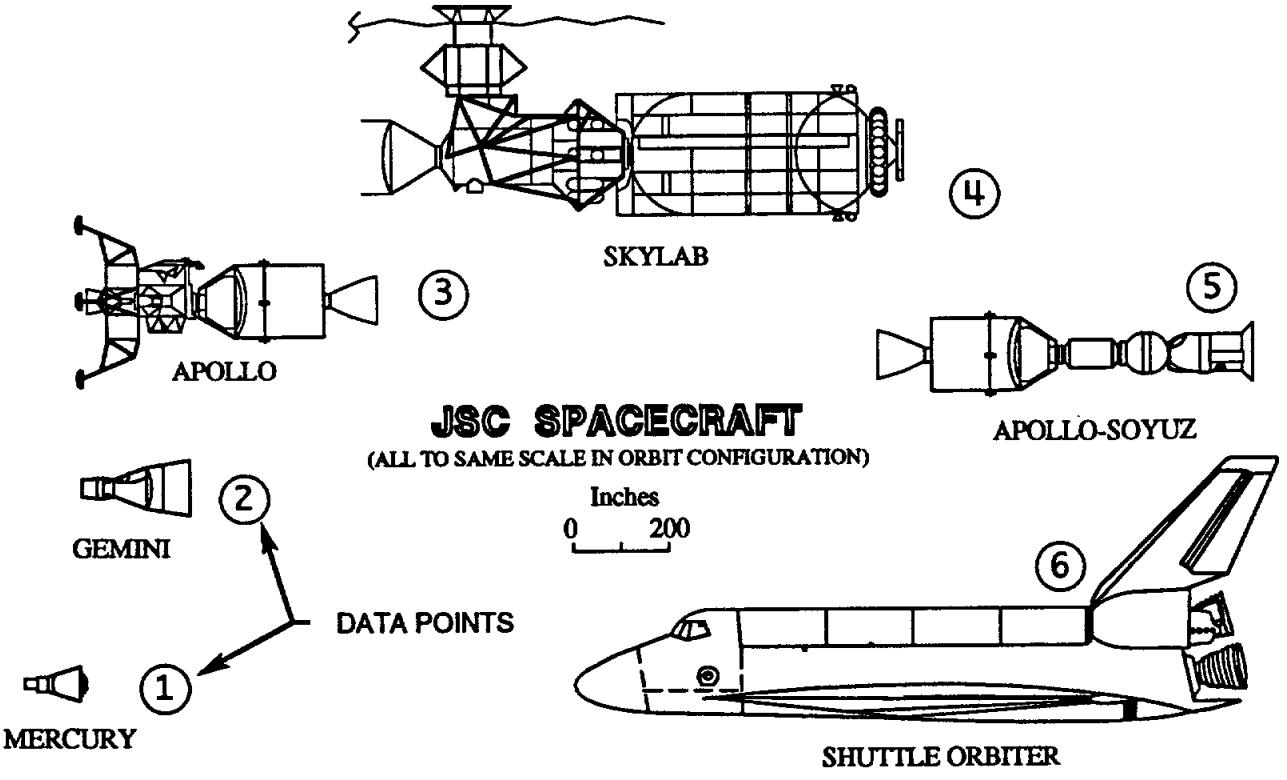

USING THIS REPORT

This report is intended to be used primarily for conceptual design efforts where time is not normally available for rigorous detailed analysis. A cross check with the tools, techniques, and data in this report is suggested along with an awareness of the rapidly advancing technologies.

This report, for the most part, is based on JSC spacecraft hardware data beginning with Mercury and ending with the Space Shuttle Vehicle. As illustrated above, Mercury is data point 1 and so on through data point 6 which is the Space Shuttle Vehicle. Data point 1 is broken down into data point 1A, 1B, 1C, and 1D representing the Mercury Launch Escape System, the Mercury Reentry Module, the Mercury Retro Pack, and the Mercury Adapter Section respectively. This approach is used throughout the report. Several other points are used following data point 6. Appendix D of the report should be referred to for a complete data point listing along with the accompanying data.

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A_b	body wetted area
A_{de}	design-envelope area with a volume, V_{de}
A_{pr}	pressurized area
A_t	tail wetted area
A_w	wing wetted area
A_{wet}	total wetted area
D_b	body diameter
L_b	body length
M_b	mass of body structure
M_c	mass of crew
M_{pl}	mass of payload
M_{cpf}	mass of crew and passengers that is fixed
M_{cpu}	mass of crew, payload, unusable fluids and gases, etc.
M_{cpv}	mass of crew and passengers that varies
M_{ec}	mass of expendables and consumables
M_D	dry mass
M_{fl}	mass of usable fluids
M_{fo}	mass of usable food
M_G	gross mass
M_{ga}	mass of usable gases
M_I	inert mass
M_{ldg}	landing mass
M_{lg}	mass of landing gear
M_p	mass of usable propellant
M_{pu}	mass of unusable propellant
M_s	mass of structure system
M_{sys}	mass of dry systems except for M_s and M_{tps}
M_{tps}	mass of thermal protection system
N_c	number of crew
N_{cp}	number of crew and passengers
N_d	number of days of design mission

LIST OF SYMBOLS (Continued)

Rho_G	gross density
Rho_b	density of body structure
Rho_{sys}	density of dry systems except for structure and TPS
Rho_{tps}	density of thermal protection system
S_w	wing theoretical, aerodynamic area
V_{de}	design-envelope volume with a surface area, A_{de}
V_{pr}	pressurized volume

DESIGN MASS PROPERTIES II

Mass Estimating and Forecasting for Aerospace Vehicles Based On Historical Data

SUMMARY

Mass estimating and forecasting techniques are presented which are based on the fewest and most inclusive design parameters that occur at the earliest time in the design life of a newly evolving aerospace vehicle.

Estimating techniques are based on design-envelope area and volume. While both of these parameters usually change with the design process over time, the presented estimating techniques account for this change through generalized sizing variations. Accurate sizing during conceptual design is crucial to accurate mass estimation. Additional design parameters for mass estimating, sizing, and systems derivations are introduced in the first part of this report.

Forecasting techniques are also presented in the second part of this report. After a weight estimate is made in conceptual design, a compatible mass-growth forecast is made. This forecast accounts for the inexorable mass growth that affects aerospace vehicles before they become operational.

INTRODUCTION

The estimating and forecasting techniques in this report are intended to be used for aerospace vehicles in the early phases of design, particularly in conceptual design.

There are many approaches to estimating and forecasting the mass of newly evolving vehicle designs throughout Government and industry. Most of these approaches require many design parameters that cannot be used with reasonable assurance of applicability. Not knowing what the final designing parameters turn out to be is the true nature of conceptual design.

Therefore, the need exists for mass estimating and forecasting techniques that are reasonably reliable, depend on the minimum number of design parameters, and are applicable over a wide range of vehicle designs. The techniques in this report are intended to fill this need to the extent that design hardware data are available. Considerable use is made of a systematized computer data base from which to retrieve mass and design data.

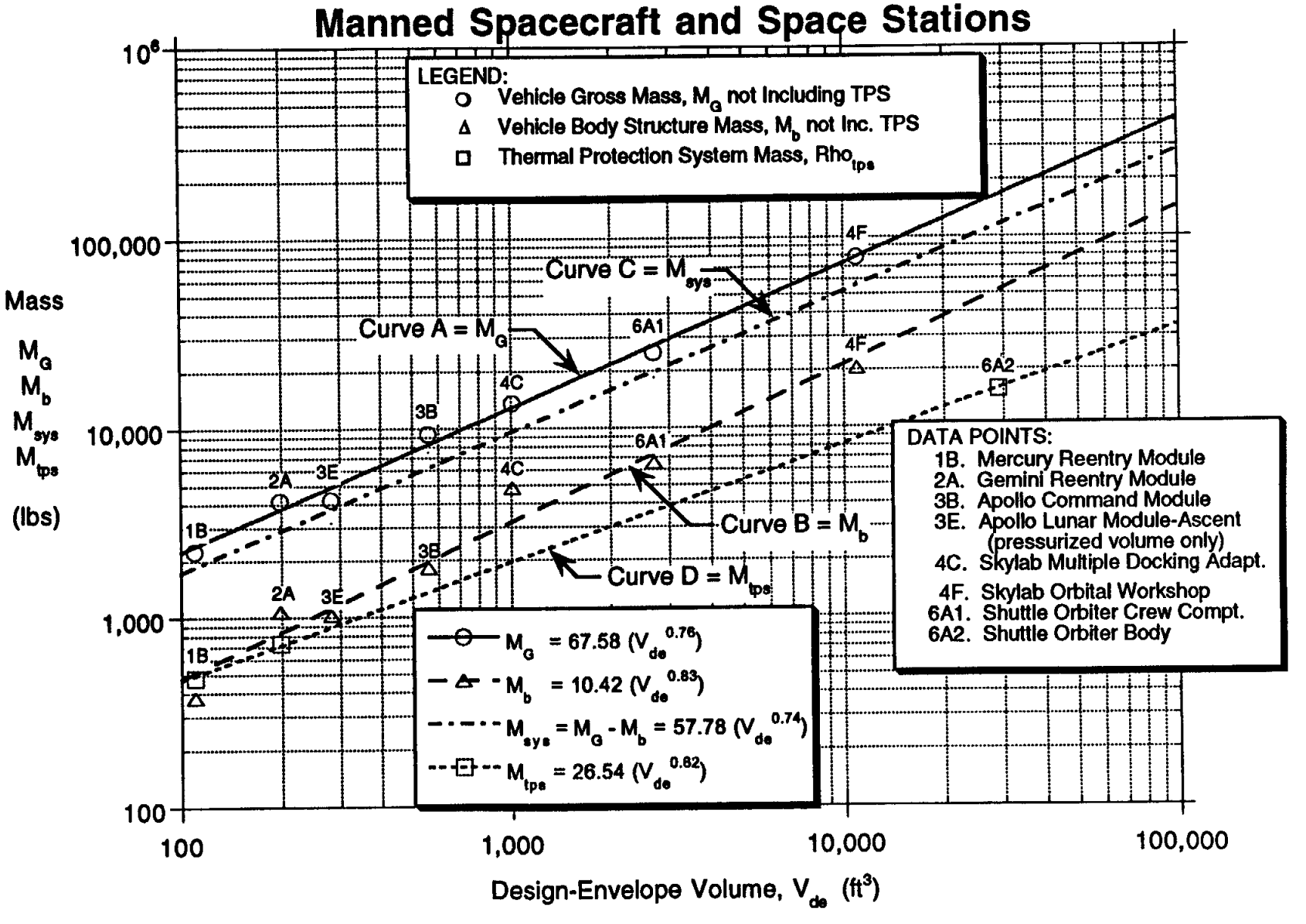
This report is in two parts; part one, which presents the estimating techniques; and part two, which presents the forecasting techniques. This is done to emphasize the distinction, that although related, the estimate should be treated separate from the forecast. This report emphasizes that regardless of the mass estimate that is made in conceptual design, a mass forecast should also be made. This is in recognition of vehicle mass growth that occurs throughout the program life of any aerospace vehicle.

BACKGROUND

Mass estimation, like other estimation processes involving complex vehicles, is difficult to achieve with accuracy. With the rapidly improving technologies, it is becoming increasingly more difficult to derive estimates during conceptual phases of design. It is felt that there are three major areas of consideration that must be explored in order to achieve reasonable estimating accuracy in conceptual design: (1) consistently recorded and reported mass and design data; (2) fundamentally derived estimating and forecasting techniques based on hardware data; and (3) relentlessly researched and applied data pertaining to the advancing technologies.

In relation to 1, above, DESIGN MASS PROPERTIES, Guidelines and Formats for Aerospace Vehicles, JSC-23303, March 1989, should provide a significant contribution to consistent recording and reporting (reference 1). This document on estimating and forecasting is intended to supply the needs expressed by 2, above. A substantial effort is devoted to developing fundamental estimating relationships based on early known design parameters as they apply to conceptual design. This provides direct tools for conceptual design as well as check points for later phases of design. At the least, good estimating and forecasting tools should be based on hardware proven data to provide credence and a firm baseline from which to project the advancing technologies.

FIGURE 1
ESTIMATING CURVES



PART 1 - MASS ESTIMATING

Techniques for developing mass estimates for aerospace vehicles have been developed for use in conceptual design. The mass estimating techniques are based on design-envelope area and volume.

Development of the estimating techniques are based on historical data. The historical data includes existing or previously flown spacecraft and launch vehicles. A least squares regression was applied to the historical data. The least squares method was considered applicable since the data was fairly consistent and did not contain any outliers. A power curve fit of the form $y = a + x^b$ was chosen since the curve appears as a straight line on a log-log plot.

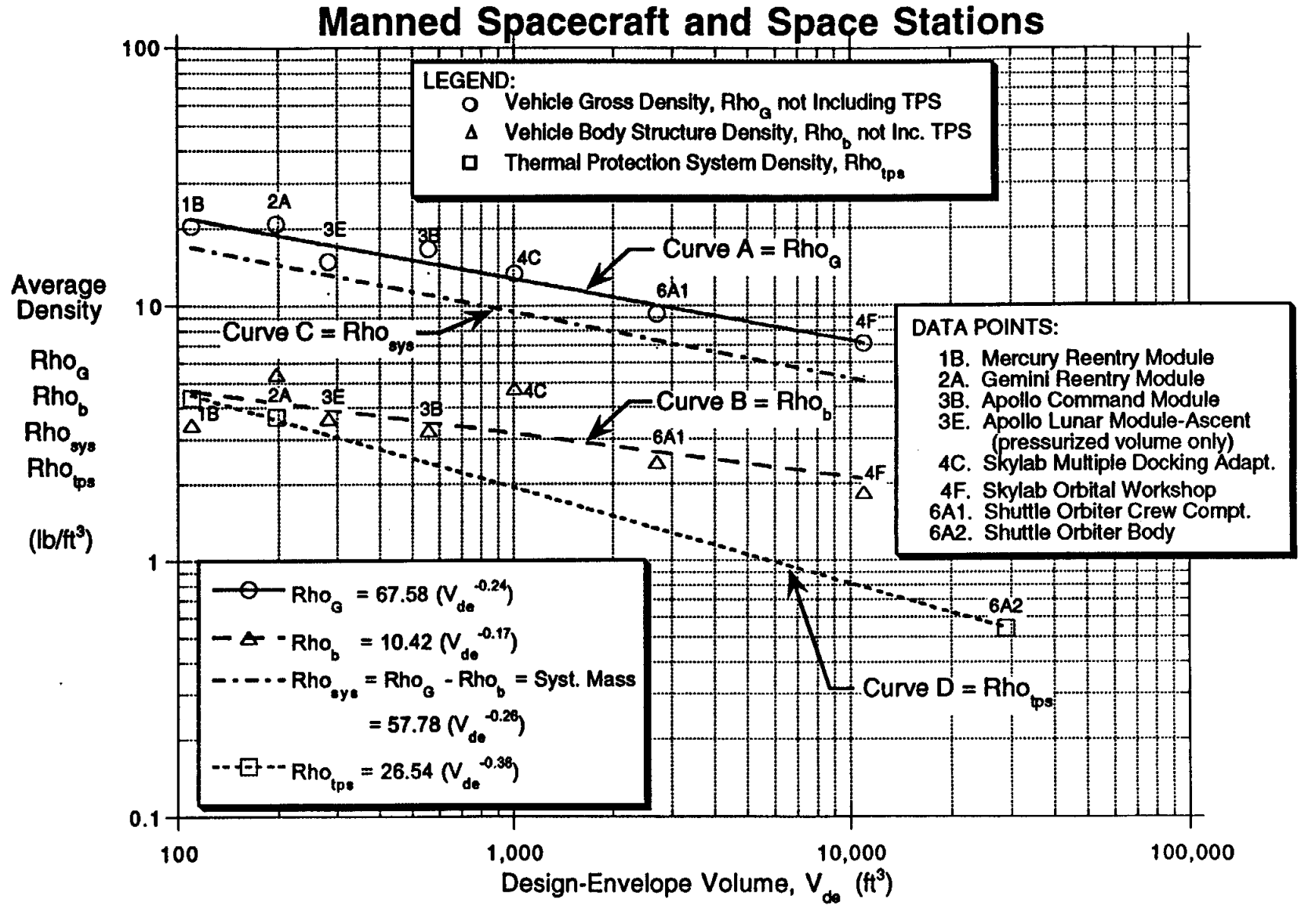
Figure 1 shows a plot of average gross mass, body-structure mass, systems mass, and thermal protection system (TPS) mass versus total design-envelope volume for non-winged, manned vehicles. Vehicle gross mass, M_G, (curve A) represents the total mass of a spacecraft without the mass of the TPS, M_{tps}. M_{tps} is not included due to the differences in the missions performed by the vehicles represented by the data points. For example, the Apollo command module had a TPS sized for lunar return velocities and Skylab only had the TPS required for orbit operations. The variation in M_G is ± 15 % for any given total design-envelope volume, V_{de}.

Curve B shows the body-structure mass, M_b, as a function of the total design-envelope volume, V_{de}. The variation in M_b is ± 35 % for any given V_{de}. M_b has a greater variation (±35 %) than M_G (± 15 %) for a given V_{de}. Also, it should be noted that M_b does not include M_{tps}.

The systems mass, M_{sys}, (curve C) represents the mass of all of the systems that comprise the vehicle except for M_b and M_{tps}. Systems mass, M_{sys}, is the result of subtracting the body-structure mass, M_b, from the gross mass, M_G.

The thermal protection system mass, M_{tps}, (curve D) is derived by using data points 1B, 2A, and 6A2, representing the Mercury reentry module, the Gemini reentry module, and the Shuttle Orbiter body, respectively. These three data points form the M_{tps} relationship for low-Earth-orbit reentry vehicles. Curve D is not applicable for TPS mass estimates of orbiting space stations or vehicles operating under different entry conditions.

FIGURE 2
ESTIMATING CURVES



The plots of figure 1 can also be found in reference 2 which was published in May 1971. At that time, data for the Skylab Program and the Shuttle Program were not available. The slope of the curves were determined from other large bodies such as aircraft.

It is pointed out that variations like $\pm$ 15 % for M_G and $\pm$35 % for M_b are entirely reasonable for first-level estimating during conceptual design. This is substantiated by the fact that some mass estimates of previous vehicles grew more than 50 % from concept to operation despite the benefit of considerable effort in design and analysis. There is more discussion on forecasting mass growth in Part 2 of this report.

Figure 2 shows a plot of mass density versus design-envelope volume for gross vehicle, body-structure, systems, and thermal protection system for non-winged, manned vehicles. This plot is the same as figure 1 except that mass density is plotted directly instead of mass. The overall trend of mass density with changing vehicle size can be seen in this figure.

Figure 3 shows a plot of mass ratio versus gross mass. The mass ratio, M_p/M_G (also known as mass fraction) is defined as the usable propellant, M_p, divided by the vehicle gross mass, M_G. Several estimating curves have been developed from the hardware data points. Significant data points are identified for clarity.

The first number of the data point refers to the project, the following letter refers to the stage or module, the subscript number one (1) refers to the in-flight condition without interstages and adapters, and the subscript number two (2) refers to the ground (or pre-ignition) condition. Additional subscript numbers refer to other identifying conditions. For example, $3K_1$ is the Apollo Program vehicle (3), the Saturn S-II stage (K), in the in-flight condition (1).

Data point 7_1, Centaur, is without insulation panels which are jettisoned during first-stage boost. Since none of the other data points reflect jettisoned insulation, 7_1 is adjusted to 7_3, which includes insulation panels to make the data compatible. The circle symbols represent stages or vehicles propelled by LO_2/LH_2, the squares represent liquid storables, and the triangles represent LO_2/RP-1 propellant. The diamond symbols represent studies of LO_2/Hydrocarbon propelled winged boosters.

Algorithms define Curves A and B, the two most important relationships developed to date. Curve A is applicable for the preliminary sizing of LO_2/LH_2 expendable stages while curve B is more applicable for LO_2/hydrocarbon and liquid storable expendable stages. Note that there is a range of values of propellant bulk density between curves A and B so that different values may be used to estimate the mass ratio of a given stage mass for a given propellant density. Bulk density is the average density of the usable propellant for vehicles with more than one kind of propellant.

Figure 3.1 is included to more completely and clearly identify the data points that were considered in this study.

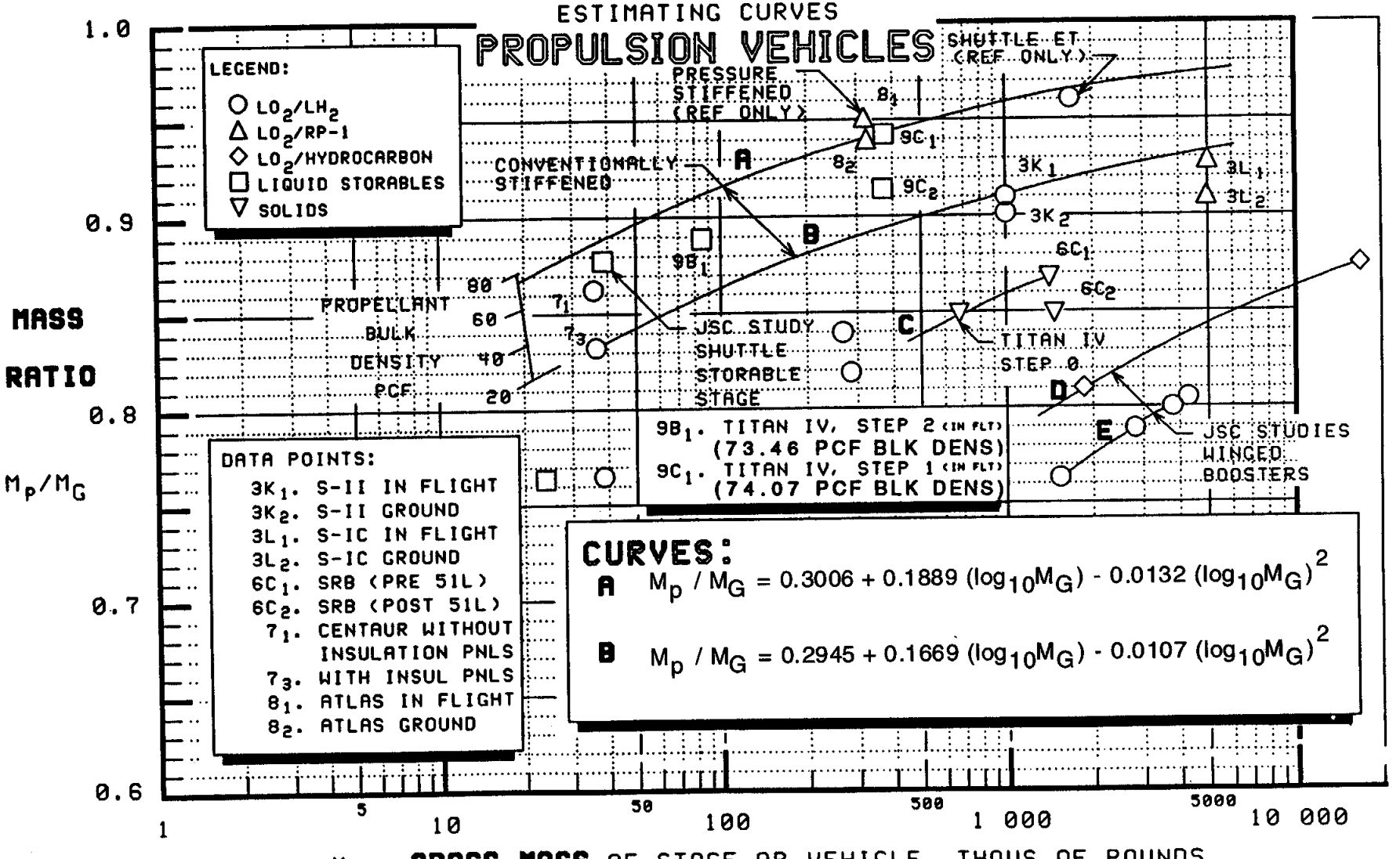
Figure 4 shows a plot of average areal density of body structure versus design-envelope area. Historical pressurized and non pressurized vehicle body structures are used for curve development. There is a general increase in average density with increasing area. Also, the more simple structures are near curve A which represents the minimum unmanned values. Curve B is the minimum, manned values which is represented by the Mercury reentry module, data point 1B. This data point has a design-envelope area of 139 square feet. Curve C is the average, manned values. It should be noted that most of the data points near curve C are pressurized body structures.

It should be pointed out that curves A and B define the minimum of density per design-envelope area for unmanned and manned body structure respectively. Therefore, data points can be above these lines, but additional scrutiny should be applied if a point falls below these curves.

Figure 4.1 shows a plot of average areal density of body structure versus design-envelope area for launch vehicle shrouds and adapters. This plot indicates the same slope as found for figure 4. In fact, curves A and B of figure 4.1 are the same curves A and B of figure 4. Curve A' is the average of curves A and B and is also shown as a formula in figure 4.1.

Figure 4.2 shows a plot of propellant tank body-structure mass versus volume for a number of different vehicles with a variety of propellant types, tank sizes, and shapes. While there appears to be a considerable scatter of values is should be remembered that this does not necessarily mean that the data are not applicable to conceptual design where there is a constant change of input parameters. Solid lines paralleling the curve fit for M_{TNK} bound the $\pm$ 30 % variation for the larger volume tanks.

FIGURE 3
ESTIMATING CURVES



NOTE: M_p IS USABLE (MAIN IMPULSE) PROPELLANT MASS.
PAYLOAD IS NOT INCLUDED IN STAGE OR VEHICLE MASS.

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FIGURE 3.1
ESTIMATING BASIS

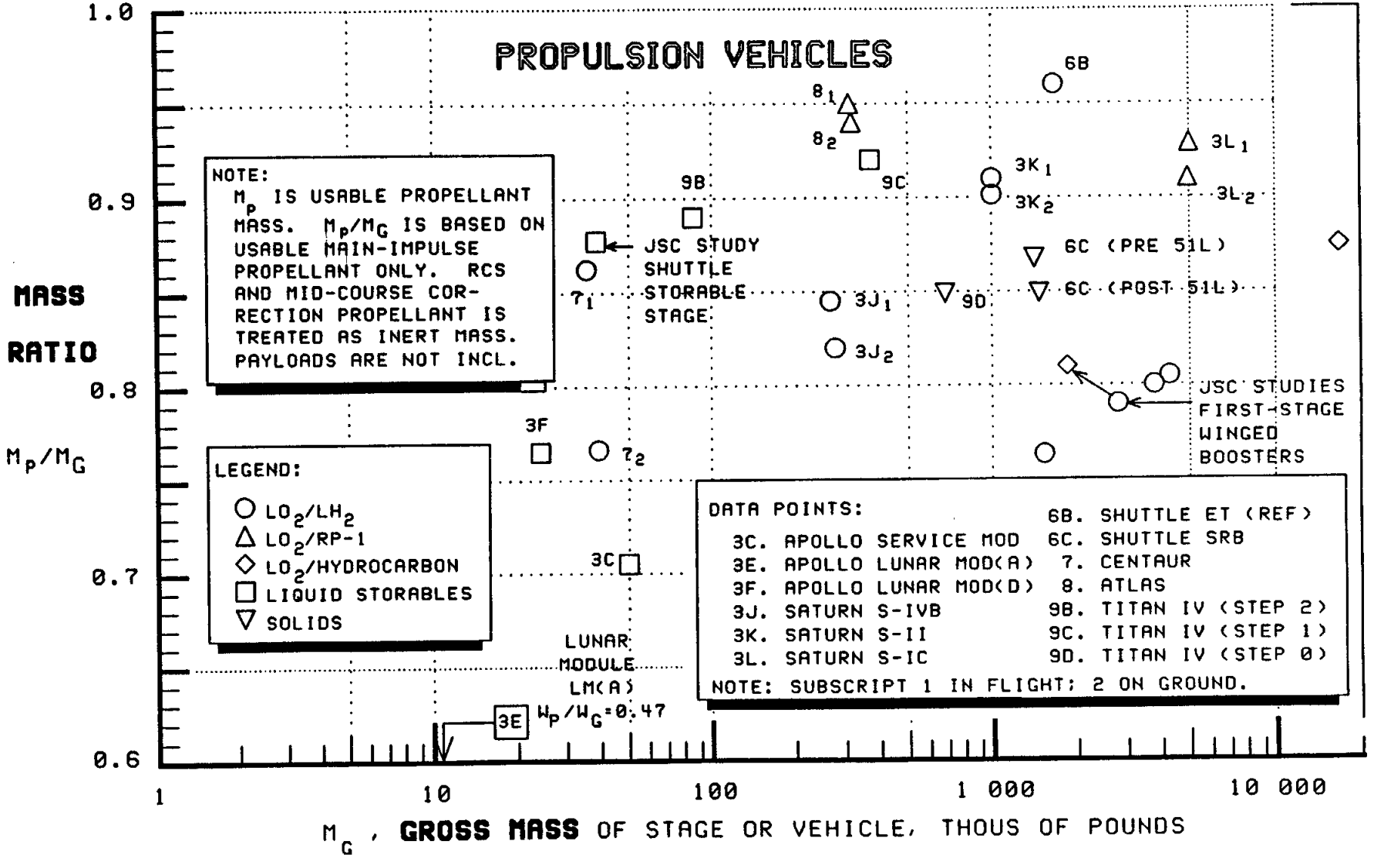

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FIGURE 4

ESTIMATING CURVES

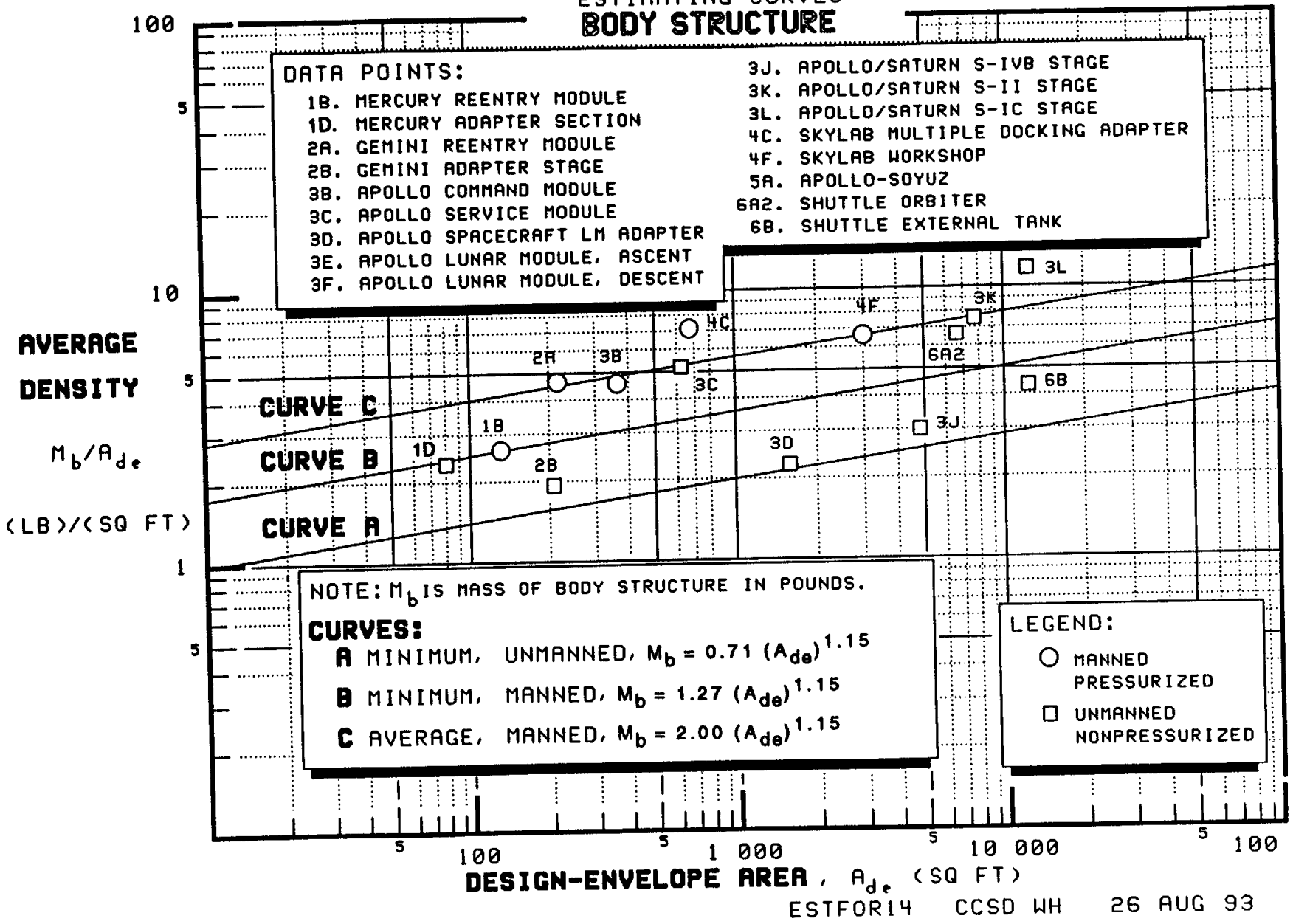

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FIGURE 4.1
ESTIMATING CURVES

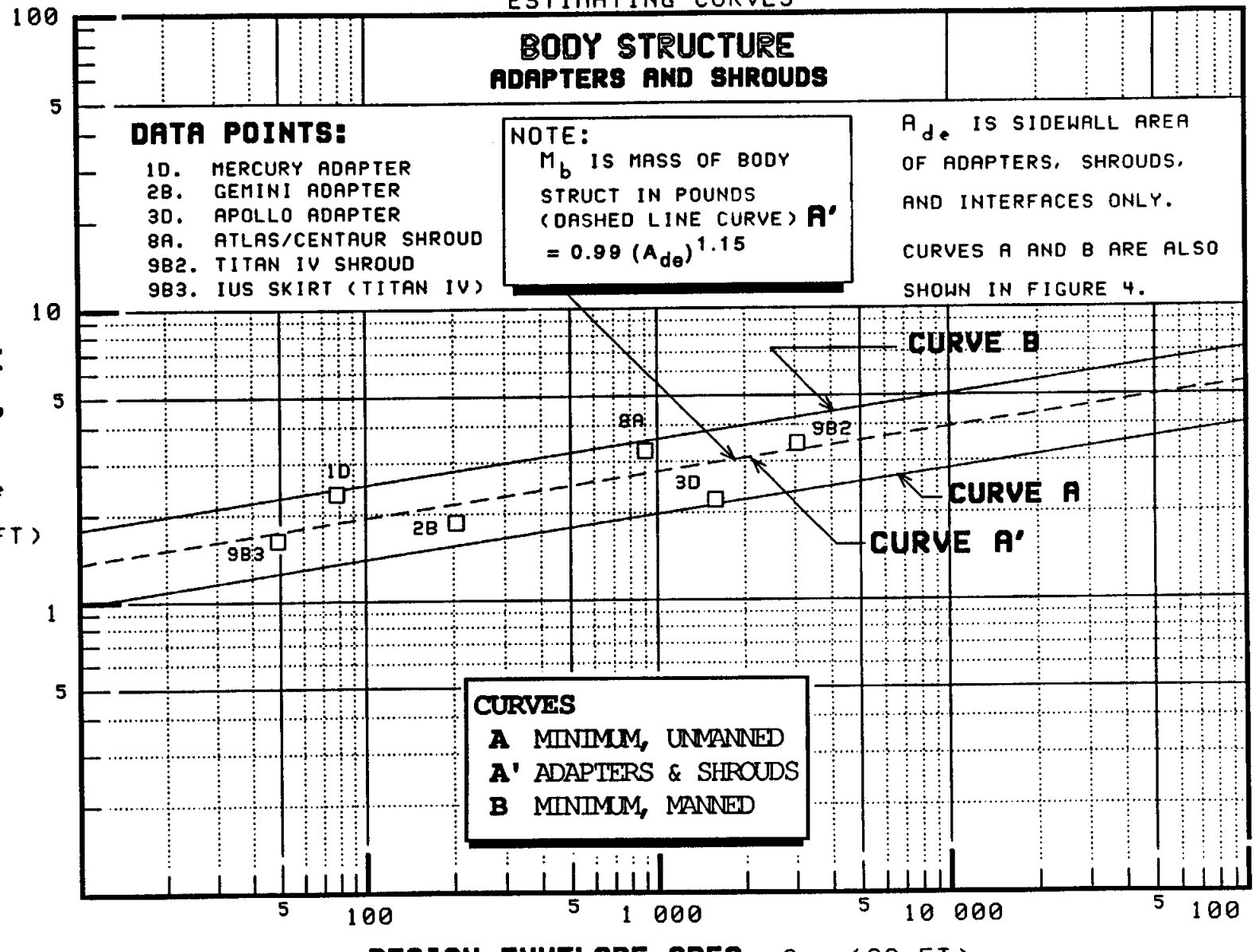

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FIGURE 4.2

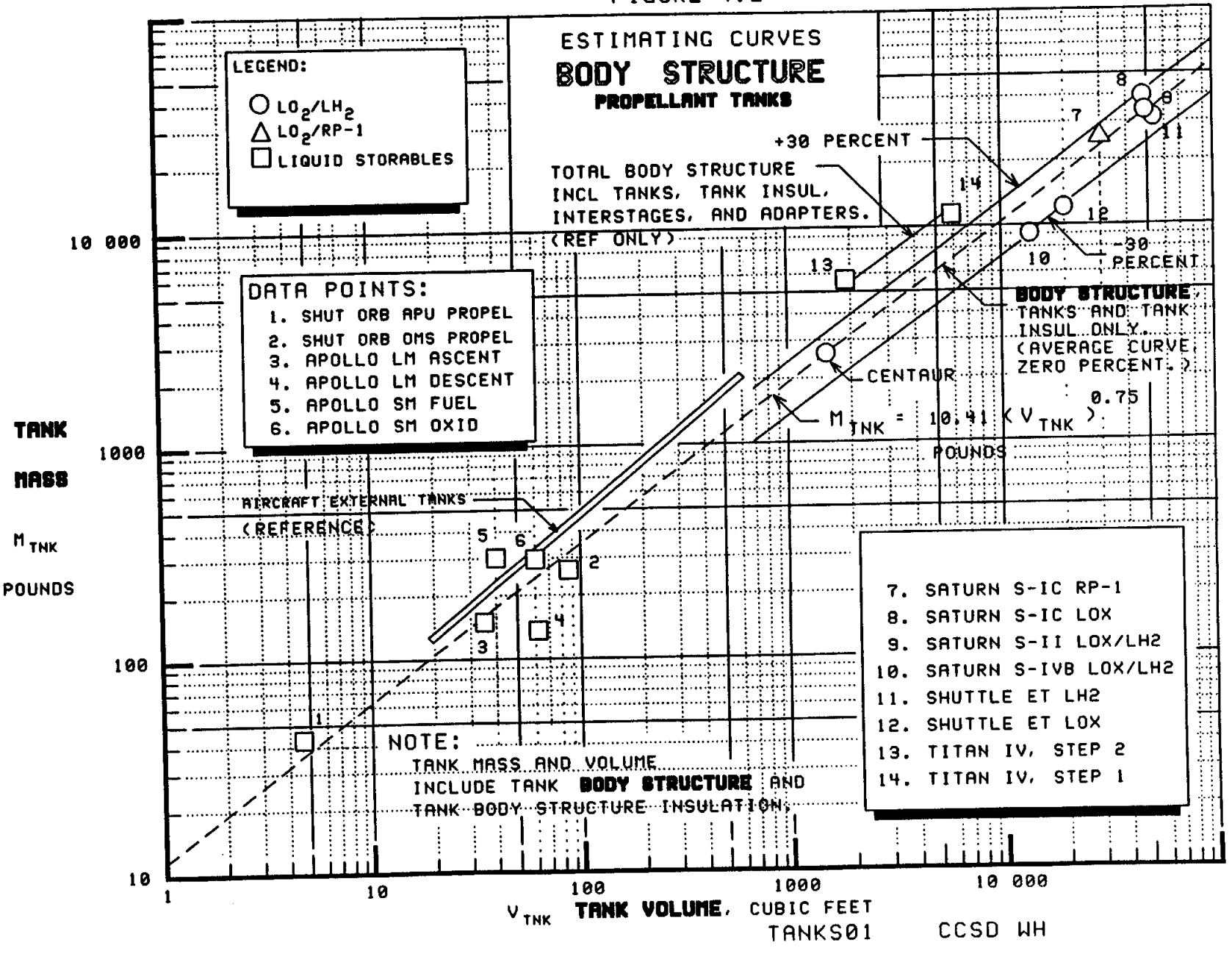
ESTIMATING CURVES
BODY STRUCTURE
PROPELLANT TANKS
LEGEND:
LO2/LH2
LO2/RP-1
LIQUID STORABLES
+30 PERCENT
TOTAL BODY STRUCTURE
INCL TANKS, TANK INSUL,
INTERSTAGES, AND ADAPTERS.
(REF ONLY)
-30 PERCENT
BODY STRUCTURE
TANKS AND TANK
INSUL ONLY.
(AVERAGE CURVE
ZERO PERCENT.)
DATA POINTS:
1. SHUT ORB APU PROPEL
2. SHUT ORB OMS PROPEL
3. APOLLO LM ASCENT
4. APOLLO LM DESCENT
5. APOLLO SM FUEL
6. APOLLO SM OXID
CENTAUR
M TNK = 10.41 (V TNK) 0.75
POUNDS
AIRCRAFT EXTERNAL TANKS
(REFERENCE)
7. SATURN S-IC RP-1
8. SATURN S-IC LOX
9. SATURN S-II LOX/LH2
10. SATURN S-IVB LOX/LH2
11. SHUTTLE ET LH2
12. SHUTTLE ET LOX
13. TITAN IV, STEP 2
14. TITAN IV, STEP 1
NOTE:
TANK MASS AND VOLUME
INCLUDE TANK BODY STRUCTURE AND
TANK BODY STRUCTURE INSULATION.
TANK MASS
M TNK
POUNDS
10 000
1000
100
10
1
10
100
1000
10 000
V TNK TANK VOLUME, CUBIC FEET
TANKS01 CCSD WH

Figure 5 shows a plot of systems mass versus design-envelope area for a number of different types and sizes of vehicles. It is important to point out that the systems mass referred to in figure 5 is the INERT MASS (see appendix B) of systems but not including structure, TPS, main engines, main engine systems, crew and passengers, and crew and passenger systems. The mass for structure, TPS, crew and passengers, and crew and passenger systems are estimated on an individual basis in this report.

By using the data points that are available, curves A, B, and C are developed. Curve A represents the systems mass for non-winged reentry spacecraft sized for one or two crew members. Curve B is similar to curve A, but is used for sizing vehicles with larger crew sizes. Curve C can be used to size the systems mass for winged reentry spacecraft.

Mass allowances for personnel and personnel provisions can be calculated by using the curve in figure 6. Values for fixed and variable items must be accounted for. The fixed value of 310 pounds per crew or passenger is a minimum value that accounts for a person and seat only. Variable mass includes items that are affected by the number of mission days and the number of crew and passengers. Examples of items that are included in the variable mass are food, water, and clothing. The equation shown for variable mass in figure 6 was determined by performing a regression on the six data points noted.

Figure 7 shows a plot of structure and systems mass versus pressurized volume for a number of vehicles. The result is reasonably good when it is considered that there are vast differences in vehicle sizes, shape, type, mission duration, loads, and so on.

Again, it is pointed out that structure and systems do not include thermal protection system, crew and passengers, and expendables for crew and passengers. These excluded systems are estimated on an individual basis in this report.

FIGURE 5

ESTIMATING CURVES

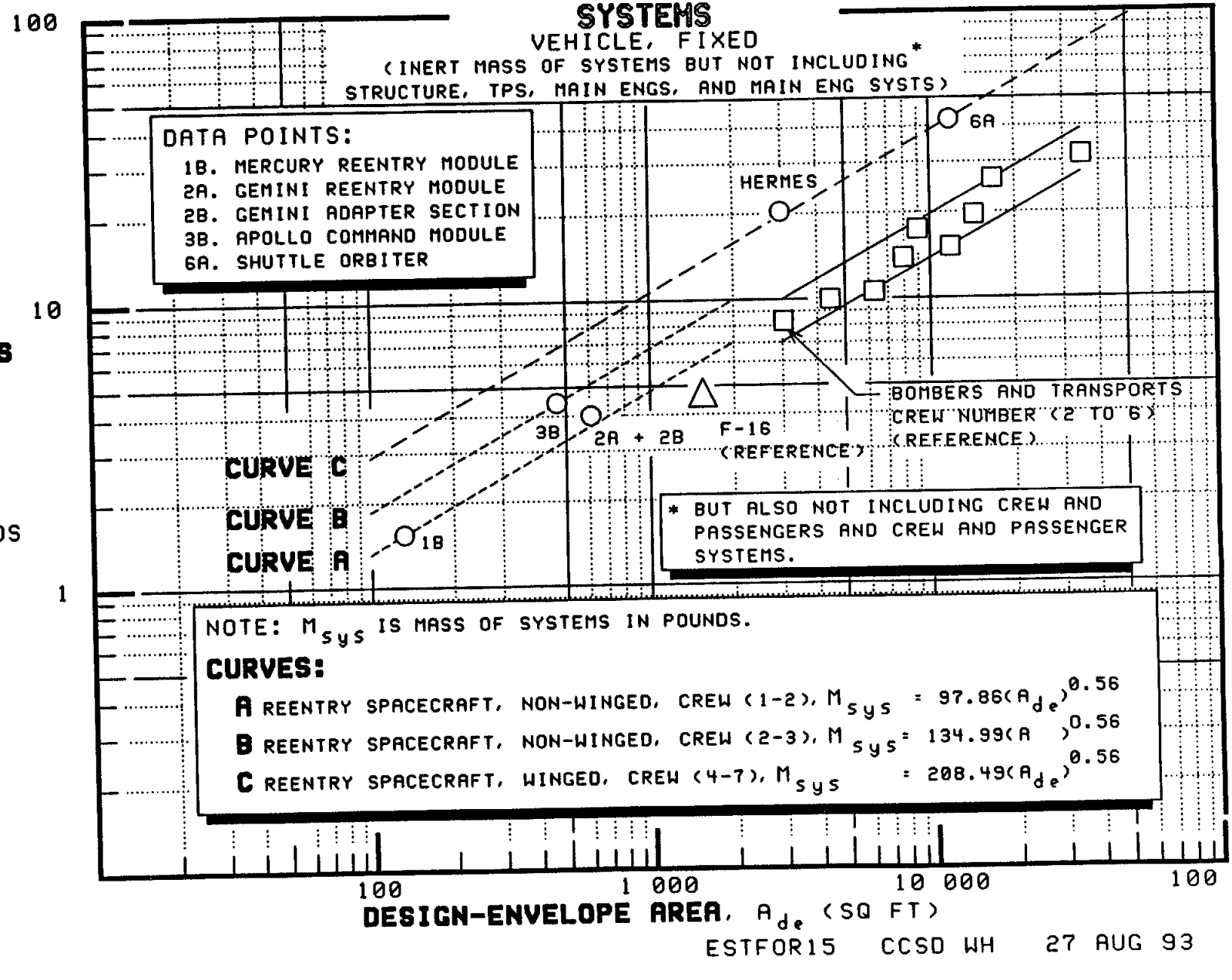

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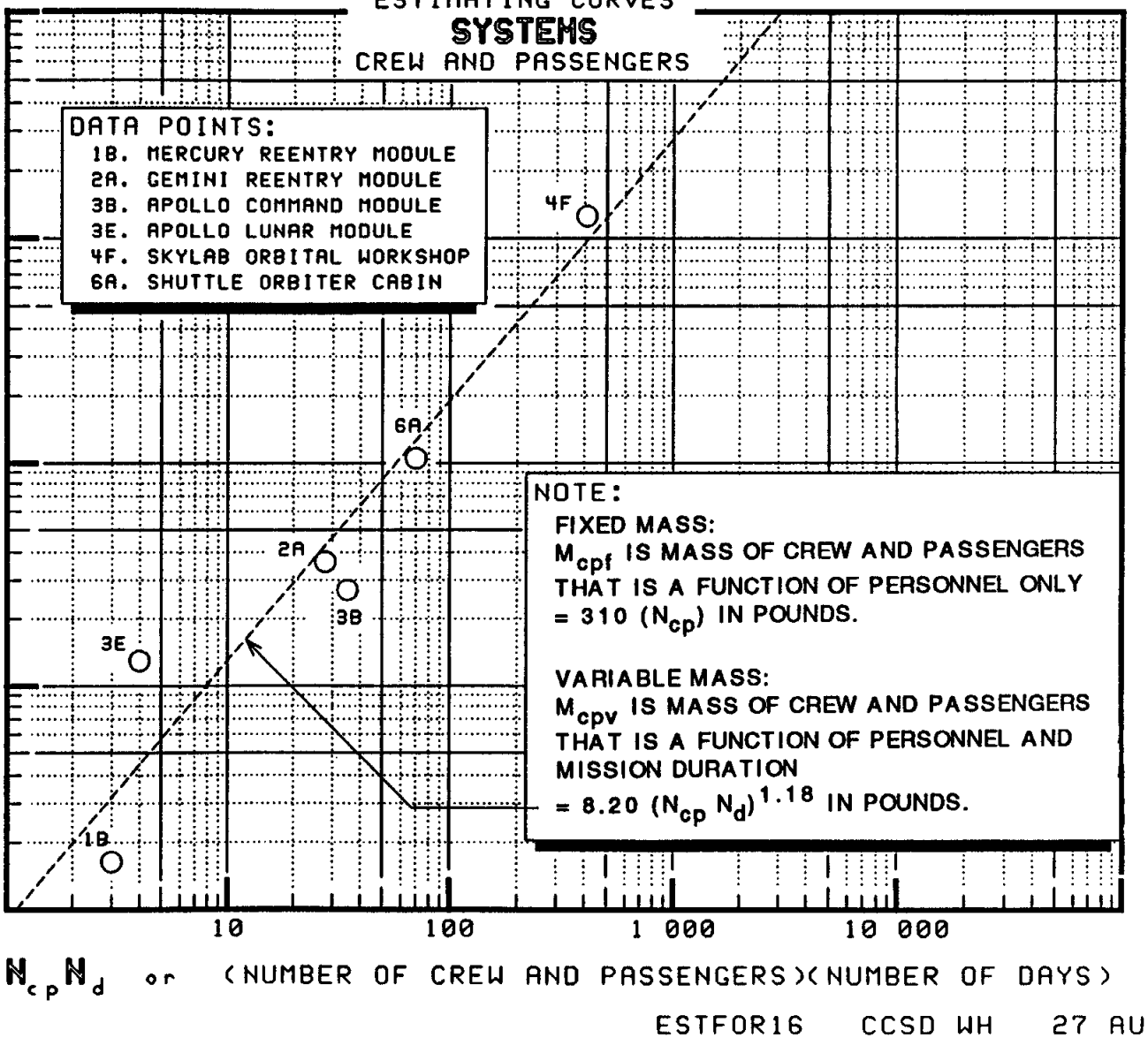
FIGURE 6
ESTIMATING CURVES
SYSTEMS
CREW AND PASSENGERS



M_{cpv} MASS POUNDS

$N_{cp}N_d$ or (NUMBER OF CREW AND PASSENGERS)(NUMBER OF DAYS)

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FIGURE 7

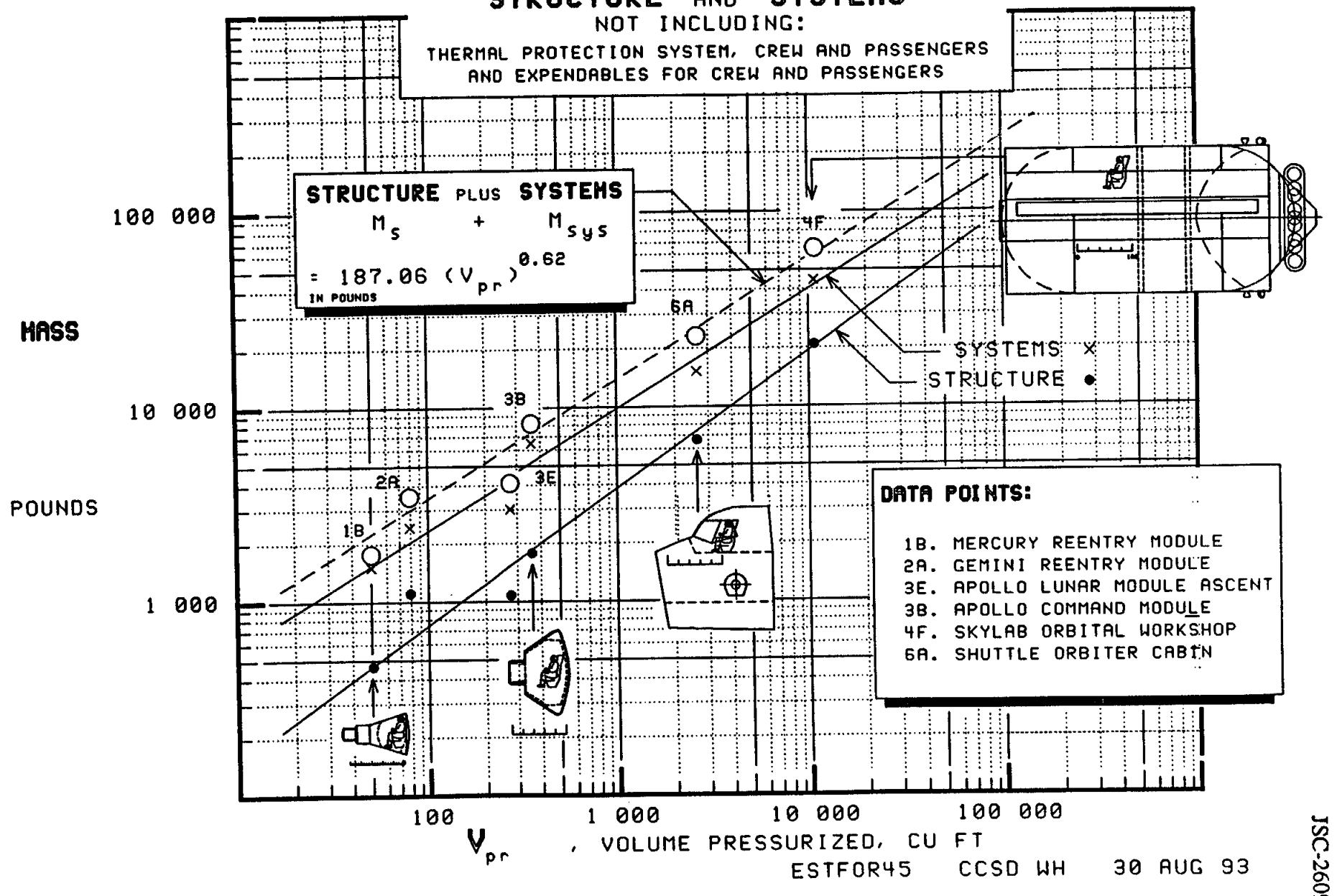

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Figure 8 shows a plot of DRY MASS versus wetted area for a number of vehicles, winged and non-winged, but all are manned. Mercury is the smallest hardware value while the Shuttle Orbiter is the largest hardware value. The Shuttle Orbiter has been normalized to the other data by removing the main engines.

The solid-line curve fits the data well in that Mercury represents the left end point, Hermes represents the mid point, and the Shuttle Orbiter represents the right end point. It should be noted that all except one study data point fall on or above the solid-line curve giving credence to the mass values obtained. The lone exception is the Shuttle II study vehicle of 1988. Therefore, this curve should be used to estimate the minimum DRY MASS of a vehicle under study.

The dashed-line curve is 15 % by mass below the solid-line curve for a given wetted area. This represents a reference curve for the possibility of improving the overall design technology.

A rectangular grid plot is shown as an insert in figure 8 to illustrate the differences in the two different types of plots.

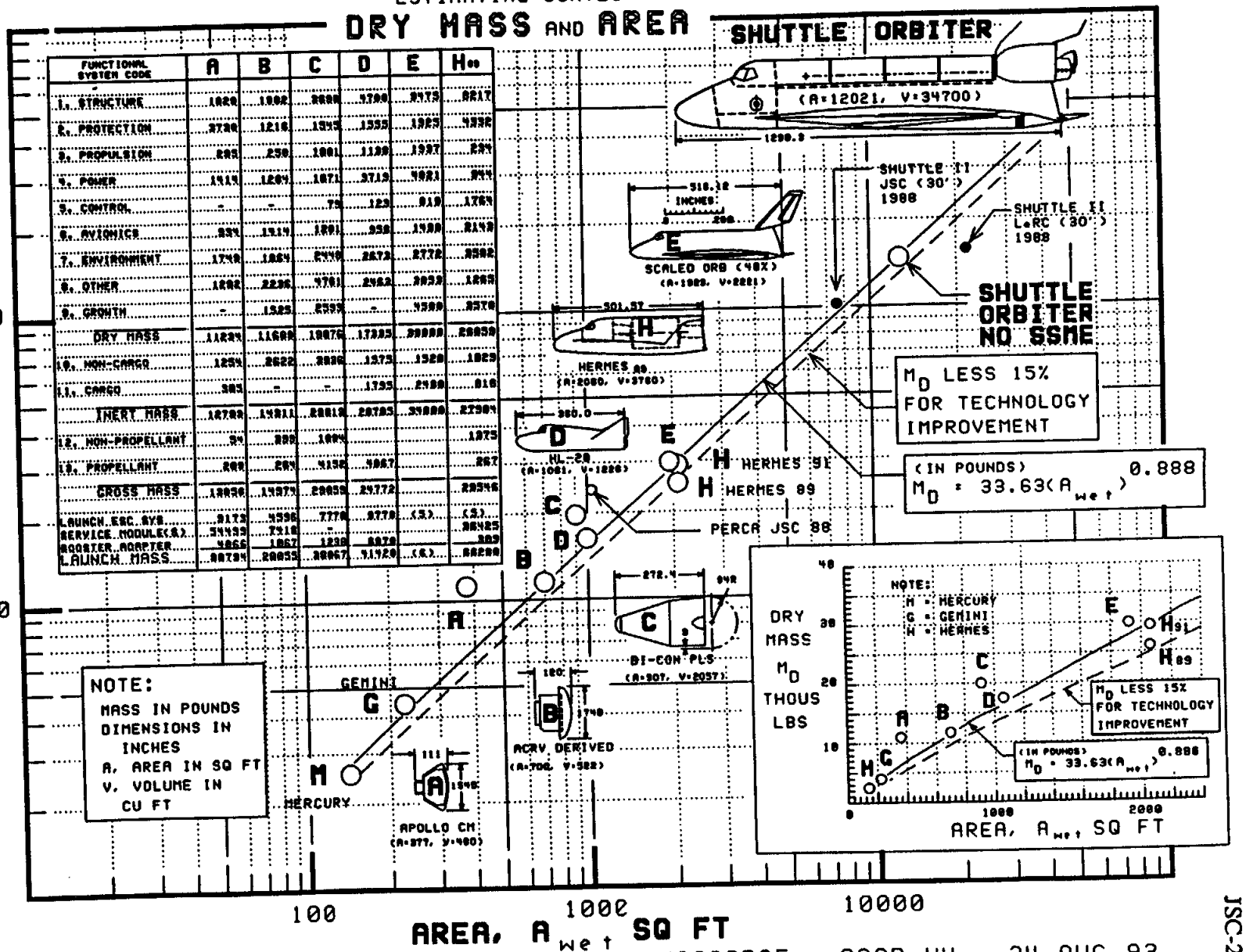
Figure 9 shows a plot of DRY MASS versus wetted volume for the same vehicles of figure 8. Essentially, the same may be said of wetted volume as was said for wetted area except that the scatter of data points is greater. This indicates that the DRY MASS is more area dependent than volume dependent and therefore wetted area should be used as the preferred estimating parameter.

The solid-line curve fits the hardware data well and again, all of the study data points fall on or above this curve with the lone exception being the Shuttle II of 1988.

The techniques presented here are good for developing mass estimates for many different vehicle types during conceptual design. Other techniques exist and should be used when applicable. Comparing results from different estimating methods is always a good practice.

FIGURE 8

ESTIMATING CURVES



FUNCTIONAL SYSTEM CODE	A	B	C	D	E	H89
1. STRUCTURE	1020	1002	2888	5700	9175	8217
2. PROTECTION	2720	1210	1545	1555	1925	4330
3. PROPULSION	295	250	1001	1139	1937	894
4. POWER	1415	1284	1871	3719	7021	944
5. CONTROL	-	-	75	125	819	1765
6. AVIONICS	934	1414	1891	939	1980	2142
7. ENVIRONMENT	1740	1864	2440	2672	2772	3582
8. OTHER	1892	2236	4781	2462	3033	1893
9. GROWTH	-	1525	2395	-	4389	3570
DRY MASS	11824	11688	19076	17385	29888	29859
10. NON-CARGO	1254	2622	2836	1375	1528	1825
11. CARGO	385	-	-	1795	2189	816
INERT MASS	13782	14311	22812	20785	34888	32304
12. NON-PROPELLANT	94	899	1884			1875
13. PROPELLANT	888	884	4138	3987		267
GROSS MASS	14836	14975	28855	24772		28346
LAUNCH ESC SYS	3173	4396	7778	8778	(5.)	(5.)
SERVICE MODULE(S)	34435	7418	-			88425
BOOSTER ADAPTER	4865	1867	1238	8878		389
LAUNCH MASS	88784	28855	38867	91428	(6.)	88288

DRY MASS M_D THOUS LBS

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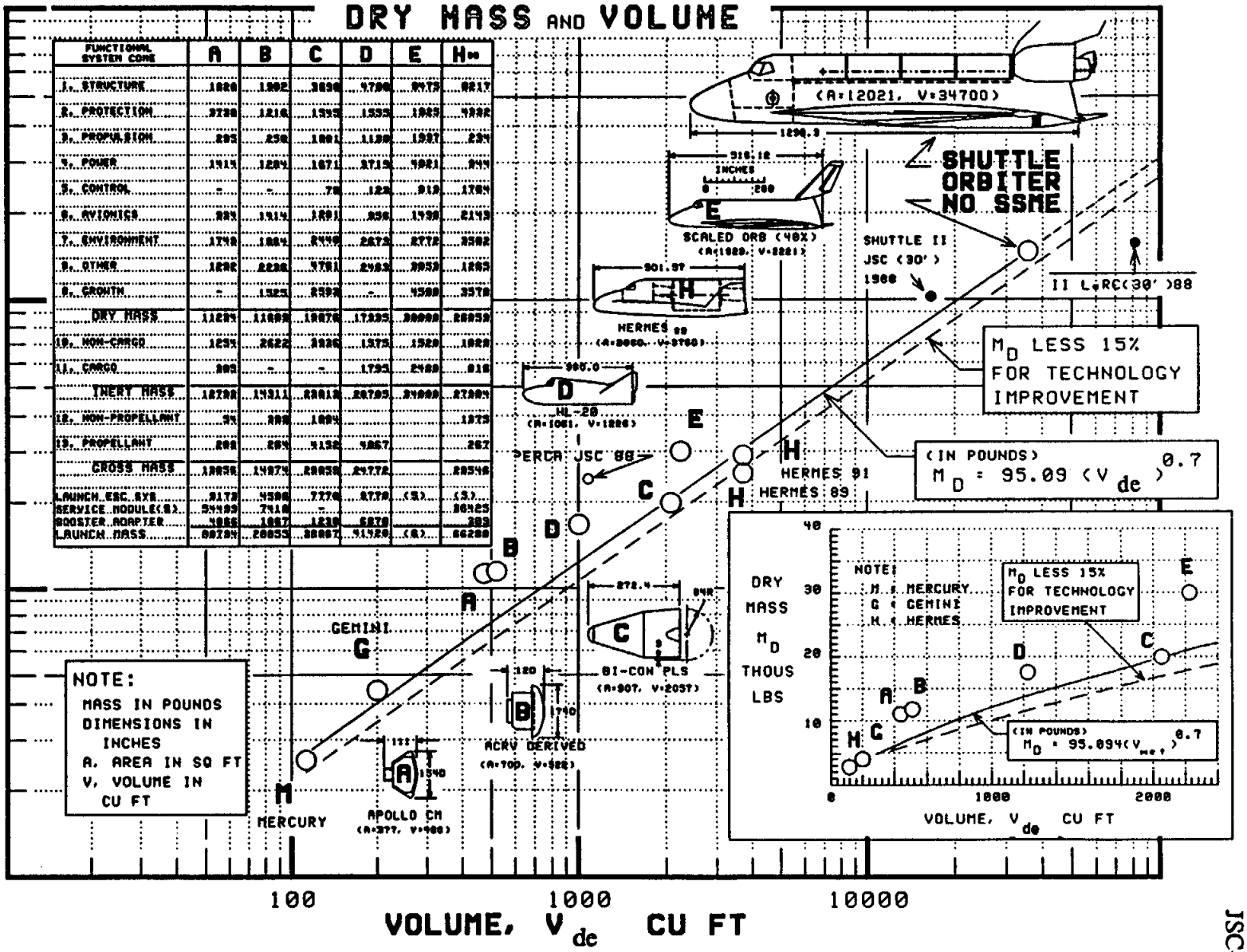
FIGURE 9
ESTIMATING CURVES



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PART 2 - MASS FORECASTING

A vehicle mass-growth forecast is made after an initial mass estimate has been derived. Mass forecasting applies growth factors to mass estimates in order to predict the vehicle mass at final production. Historically, vehicle mass estimates grow as the design become more mature based on many reasons. These reasons include items left out of the original estimate, requirement changes, ballast, and installation items among others. As the vehicle design matures, appropriate reduction of the mass growth allowance should be incorporated.

Forecasting should also predict the effect on mass of emerging technologies. New technologies often reduce mass by increased performance or by reduction in size. New lighter materials, offering greater strength and stiffness, is one example of increased performance. The cost benefit of the new technologies and materials must be estimated and weighed against the possible mass savings.

Parameters such as vehicle density and program duration also contribute to mass growth of aerospace vehicles. Vehicle density in conceptual design is a design parameter that indicates the potential for mass growth of aerospace vehicles. Low density allows volume for mass growth. Vehicle program duration, from concept through operation, is used for forecasting the mass estimate (growth allowance included) made in conceptual design.

Figure 10 shows data that pertain to the mass growth of a vehicle during the development phase. Generalized mass growth curves for various NASA vehicles are shown to illustrate the types of curves as well as the magnitude of the growth. The mass growth ranges from 10 to 60%. The growth curve shown for the Shuttle Orbiter only accounts for growth during the Phase C/D portion of the program. Therefore, for this one curve, concept is meant to describe the vehicle maturity at the beginning of phase C/D. Earlier phases of the Shuttle development are not shown due to changing requirements and configuration.

Figure 11 shows to scale the Apollo Spacecraft as it was conceived in 1961 and as it appeared at the first lunar mission. Note that the mass of the 1961 configuration is 58,220 pounds whereas the final configuration in 1971 is 116,265 pounds which is a factor of approximately two. The masses are for the gross launch condition which includes propellants.

FIGURE 10

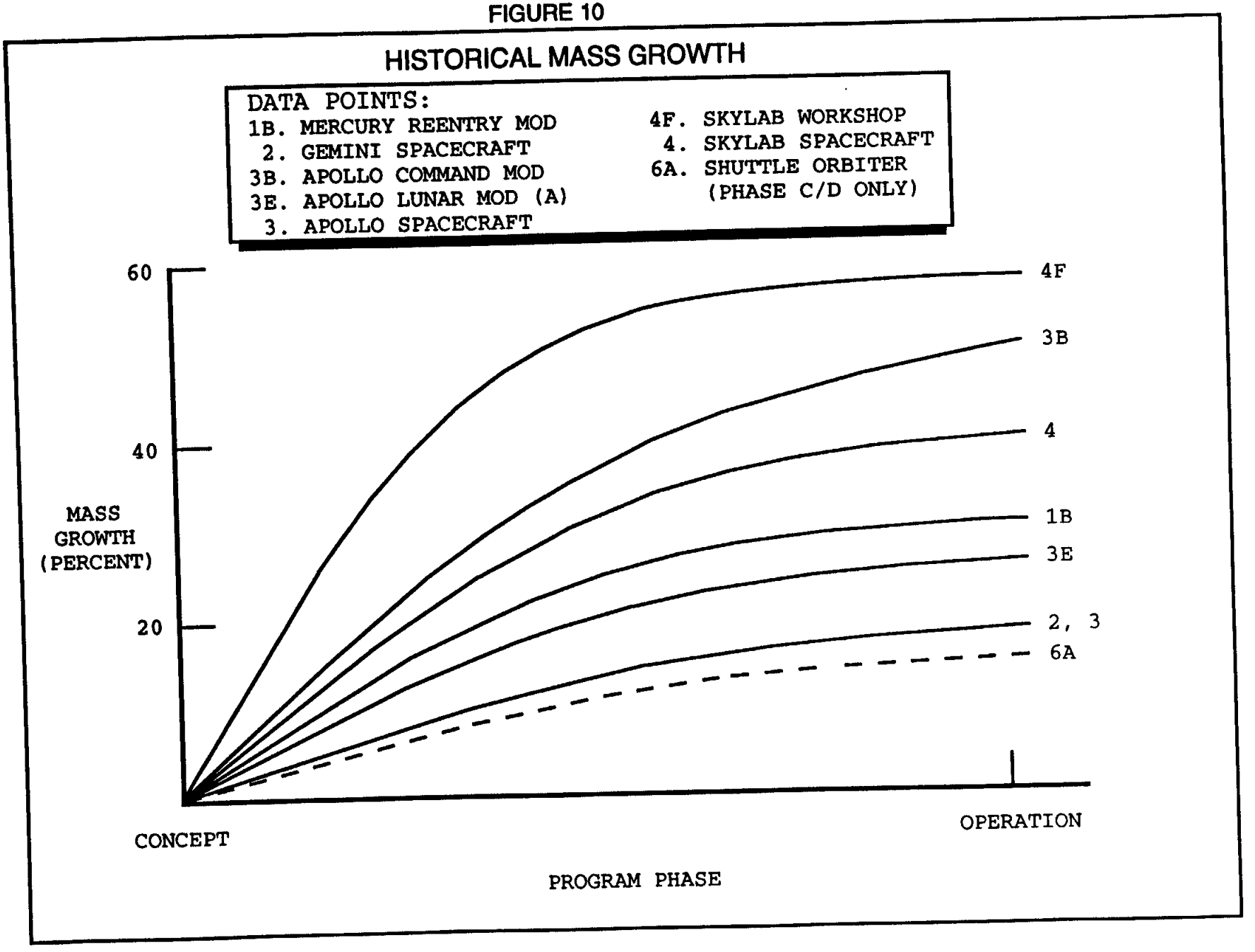
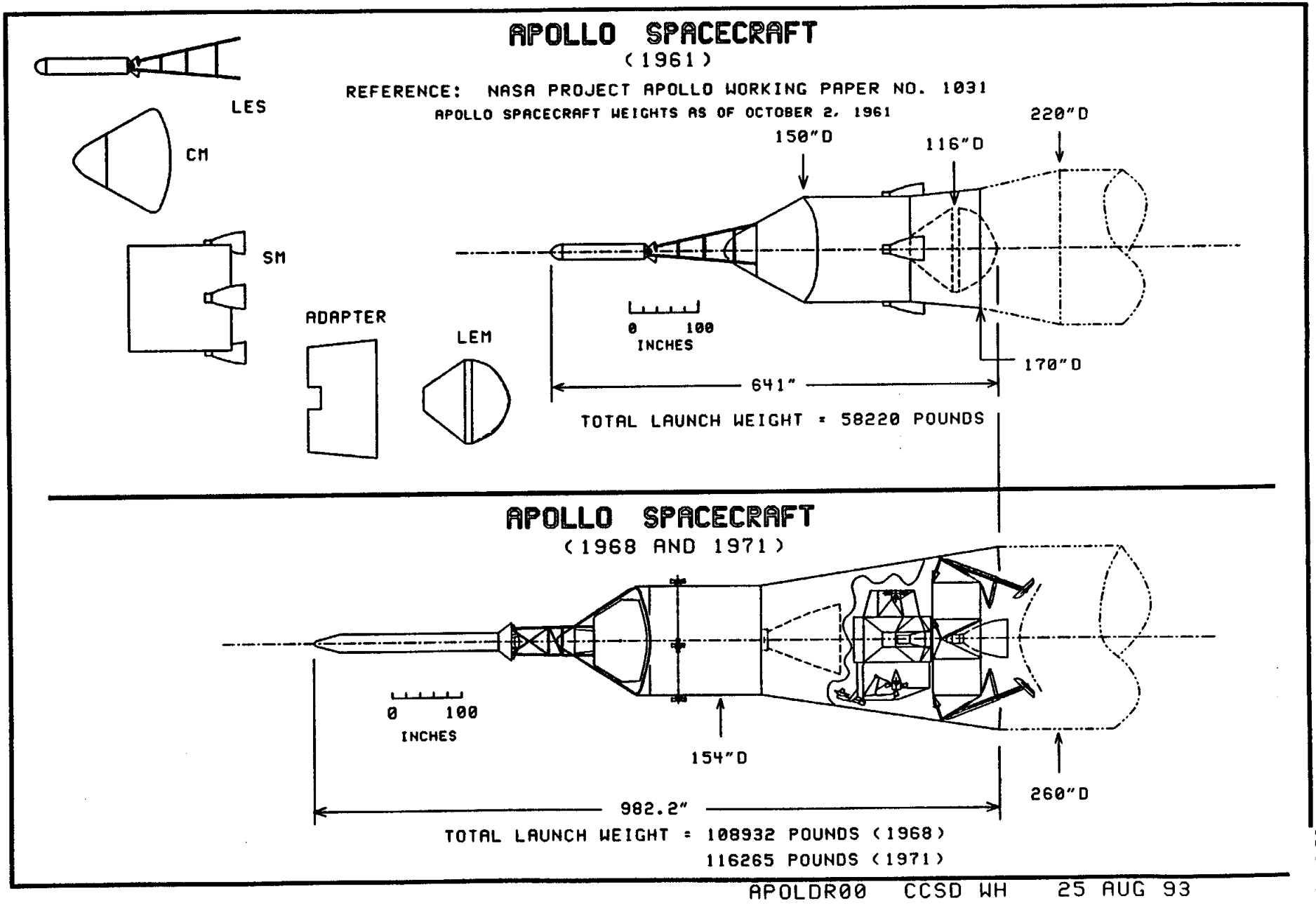

HISTORICAL MASS GROWTH
DATA POINTS:
1B. MERCURY REENTRY MOD
2. GEMINI SPACECRAFT
3B. APOLLO COMMAND MOD
3E. APOLLO LUNAR MOD (A)
3. APOLLO SPACECRAFT
4F. SKYLAB WORKSHOP
4. SKYLAB SPACECRAFT
6A. SHUTTLE ORBITER (PHASE C/D ONLY)
60
40
20
MASS GROWTH (PERCENT)
4F
3B
4
1B
3E
2, 3
6A
CONCEPT
OPERATION
PROGRAM PHASE

FIGURE 11


APOLLO SPACECRAFT
(1961)
REFERENCE: NASA PROJECT APOLLO WORKING PAPER NO. 1031
APOLLO SPACECRAFT WEIGHTS AS OF OCTOBER 2, 1961
LES
CM
SM
ADAPTER
LEM
150"D
116"D
220"D
0 100
INCHES
170"D
641"
TOTAL LAUNCH WEIGHT = 58220 POUNDS
APOLLO SPACECRAFT
(1968 AND 1971)
0 100
INCHES
154"D
260"D
982.2"
TOTAL LAUNCH WEIGHT = 108932 POUNDS (1968)
116265 POUNDS (1971)
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Figures 12 and 12.1 show the Skylab mass growth based on the initial mission requirements of October 1, 1969. The curves extend to the launch date of May 14, 1973.

In figure 12, the curve labeled combination is for all of the modules combined of Skylab which are identified under the legend. The combination curve is divided into the design process curve and the mission requirements curve. The design process curve reflects the mass that the contractor has the responsibility for whereas the mission requirements curve reflects the mass increases that resulted due to changing requirements imposed on the contractor by the customer after the initial mission requirements.

Figure 12.1 is for the Skylab Orbital Workshop only and shows curves that are similar to those shown in figure 12. The Workshop reflects the largest of all the modules. Two large increases in mass are shown in the last half of 1970. The first is crew-related subsystems and the second is crew-related and electrical-related subsystems. These two large increases are chosen for example only.

Table 1 shows the detailed listing of the changes that comprise the two changes above broken down by mission requirements and design process.

Figure 13 shows the Shuttle Orbiter dry mass history from proposal, May 1972 to February 1990. It is pointed out that this plot reflects Phase C, D, and E only. Phases A and B of the Shuttle development are not applicable due to changing requirements and configuration. Phase B extension data which includes expendable designs are not included.

Appendix A offers examples of estimating and forecasting the mass of various types of spacecraft. Each example provides important insights for the specific application. To improve future forecasting techniques, tools are being developed to automate the process of allocating the growth allowance as a function of design maturity.

FIGURE 12

TOTAL SKYLAB MASS GROWTH

RELATIVE TO INITIAL MISSION REQUIREMENTS (10/69)

PLOTS INCLUDE ALL MODULES

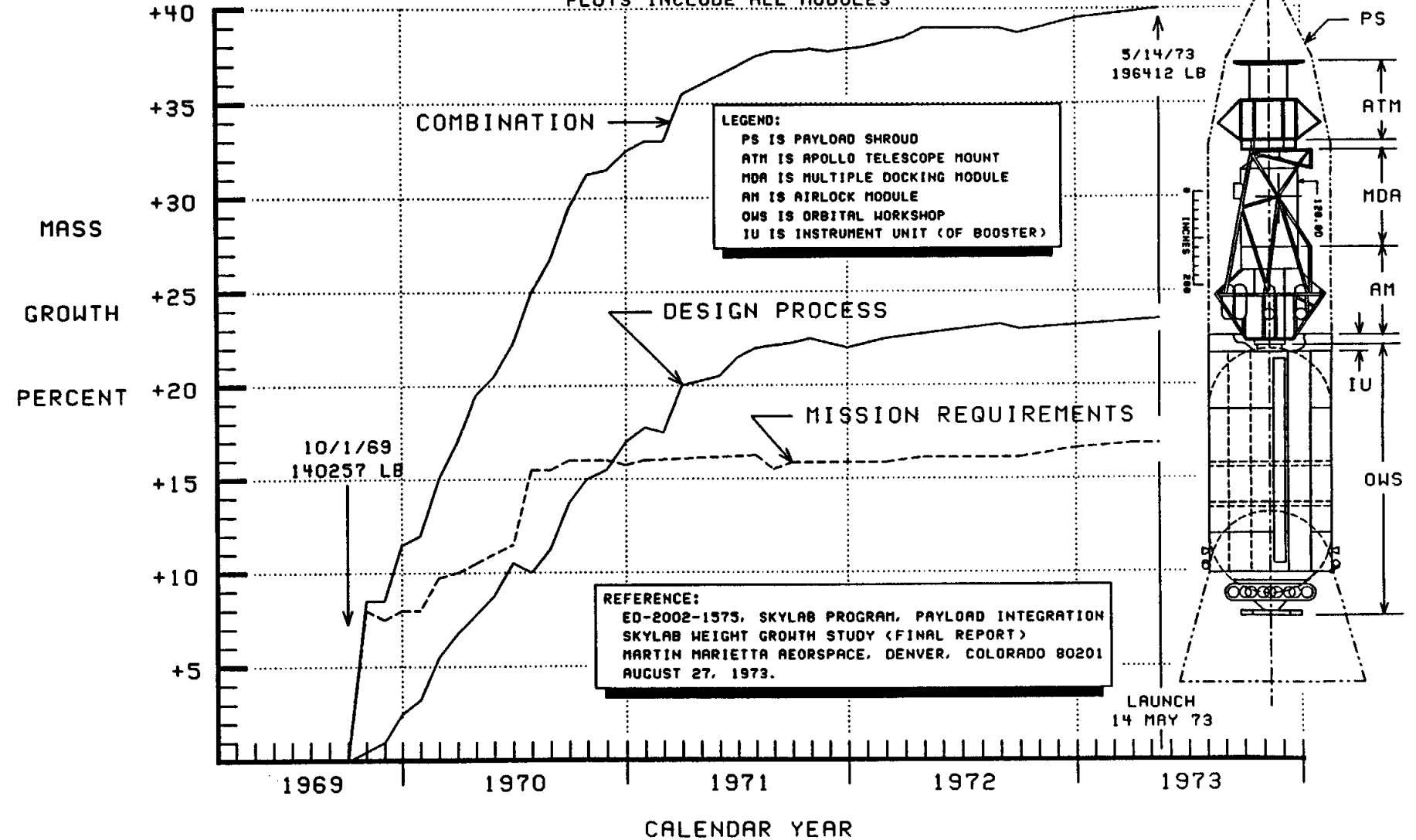

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FIGURE 12.1

SKYLAB ORBITAL WORKSHOP MASS GROWTH

RELATIVE TO INITIAL MISSION REQUIREMENTS (10/69)

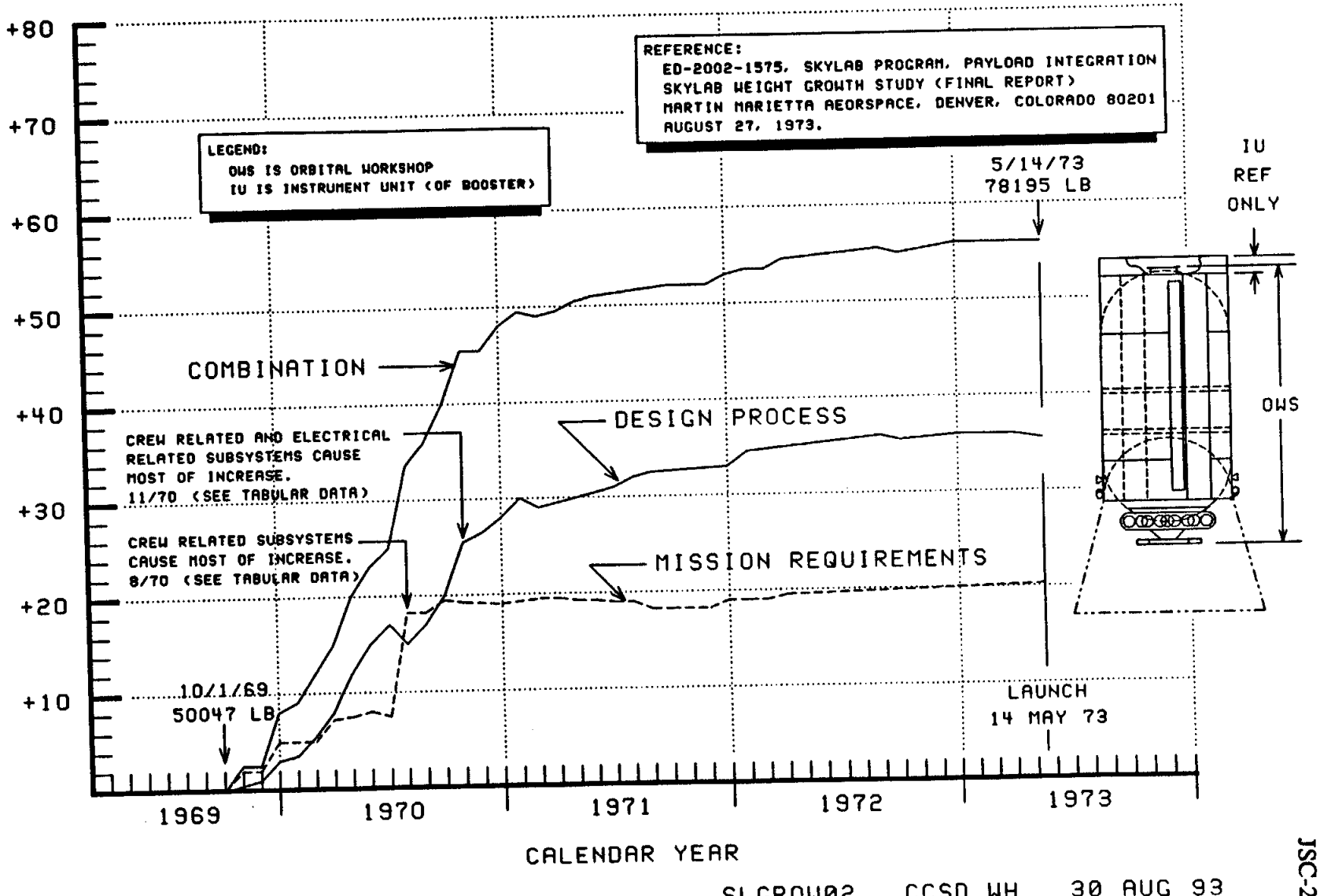

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TABLE 1

SKYLAB ORBITAL WORKSHOP MASS GROWTH

RELATIVE TO INITIAL MISSION REQUIREMENTS (10/69)

SUBSYSTEM	NOTE: MASS SHOWN IS IN POUNDS. OWS ON 10/1/69 IS 50047 LB. OWS ON 5/14/73 IS 78195 LB.	AUGUST 1970		NOVEMBER 1970	
		MISSION REQUIREMENTS	DESIGN PROCESS	MISSION REQUIREMENTS	DESIGN PROCESS
STRUCTURE (PRIMARY)		0	0	0	+31
STRUCTURE (SECONDARY)		0	+59	0	+29
EQUIPMENT SUPPORTS		0	0	+27	-3
METEOROID PROTECTION		0	+95	0	-12
INSULATION AND PAINT		0	0	0	0
ATTITUDE CONTROL AND PNEUMATIC SYSTEM (ACP)		0	0	0	-67
ACP PROPELLANT AND GAS		0	0	0	0
ACP SUPPORTS		0	0	0	+28
ELECTRICAL EQUIPMENT		0	+14	0	-21
ELECTRICAL WIRING		+22	+227	+92	+108
SOLAR ARRAYS (SA)		0	0	0	+192
SA DEPLOYMENT AND MECHANISM		0	0	0	+159
INSTRUMENTATION AND COMMUNICATION		0	-13	+32	+84
CABIN ATMOSPHERE SYSTEM (CAS)		0	+29	0	+36
CAS PRESSURIZATION GAS		0	0	0	0
FOOD		+1294	0	0	0
FOOD ACCESSORIES AND CONTAINERS		+477	0	0	+464
POTABLE WATER SYSTEM		0	+303	0	0
POTABLE WATER		0	0	0	0
WASTE MANAGEMENT		+882	0	0	+821
CREW ACCOMMODATIONS		-16	0	0	0
CREW RESTRAINTS		+98	0	+8	0
CREW SYSTEMS STOWAGE AND SPARES		+417	0	-215	+56
CLOTHING (STOWAGE)		+233	0	0	0
HYGIENE AND MEDICAL (STOWAGE)		0	+4	0	+73
OFF-DUTY EQUIPMENT		0	+75	0	0
TRASH CONTAINERS		0	0	+46	+93
CREW SYSTEMS STOWAGE CONTAINERS		+905	0	+3	0
CREW SYSTEMS SUPPORTS		+593	0	+1	+238
EXPERIMENTS		+167	-287	+31	+75
EXPERIMENTS CONTAINERS		+66	-1503	0	+15
EXPERIMENTS SUPPORTS		0	+29	0	+40
TOTAL		+5138	-968	+25	+2439

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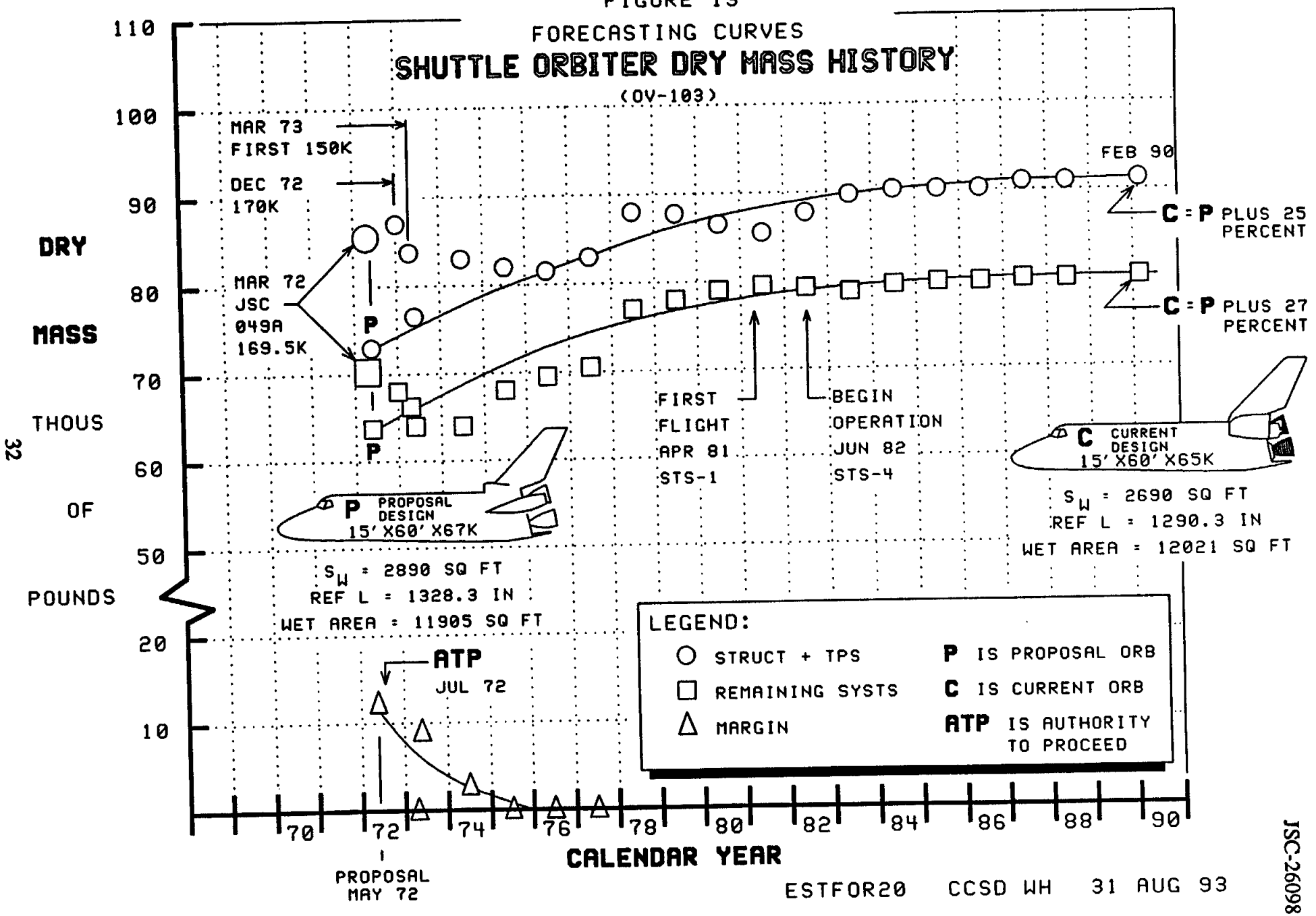
FIGURE 13

FORECASTING CURVES



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REFERENCES

1. DESIGN MASS PROPERTIES, Guidelines and Formats for Aerospace Vehicles, JSC-23303, by Willie Heineman, Jr., NASA, Lyndon B. Johnson Space Center, Advanced Programs Office, Systems Definition Branch, Houston, Texas, March 1989.

2. NASA TECHNICAL NOTE, FUNDAMENTAL TECHNIQUES OF WEIGHT ESTIMATING AND FORECASTING FOR ADVANCED MANNED SPACECRAFT AND SPACE STATIONS, NASA TN D-6349, by Willie Heineman, Jr., NASA, Manned Spacecraft Center, Houston Texas, May 1971.

3. Military Specification, MASS PROPERTIES CONTROL REQUIREMENTS FOR MISSILE AND SPACE VEHICLES, MIL-M-38310B(USAF), Amendment 2, January 15, 1976.

4. GUIDELINES FOR MASS PROPERTIES CONTROL ON INTERNATIONAL SPACE AND MISSILE SYSTEMS, issued by INTERNATIONAL SOCIETY OF ALLIED WEIGHT ENGINEERS, INC., Recommended Practice Number 2, April 1, 1985.

APPENDICES

APPENDIX A
ESTIMATING and FORECASTING EXAMPLES

Data Item **Page**

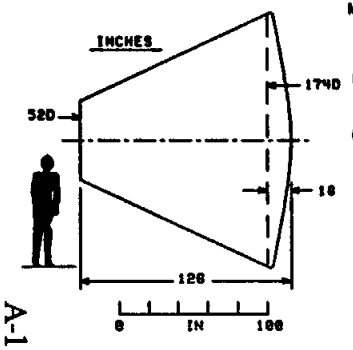
EXAMPLE 1

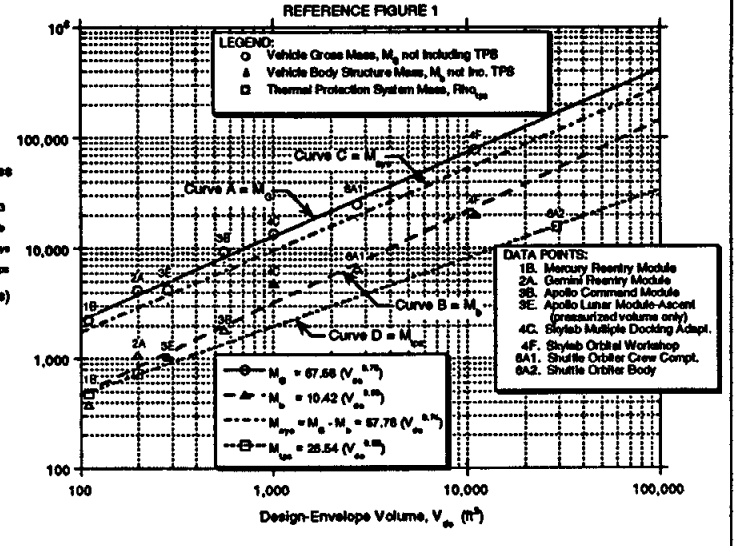
MANNED, NON-WINGED, REENTRY VEHICLE

ESTIMATING

DESIGN-ENVELOPE VOLUME

V_{de} = 800 CU FT





A-1

GIVEN:

DESIGN-ENVELOPE VOLUME, V_{de} = 800 CU FT BASED ON CONCEPT DESIGN DRAWING. THIS VOLUME DOES NOT INCLUDE TPS.

FIND:

FIND THE ESTIMATED GROSS MASS, M_G OF THE REENTRY VEHICLE.

$M_G = 67.58(800)^{0.76} = 10868$ NOT INCL TPS PER CURVE A.

FIND THE ESTIMATED BODY STRUCTURE MASS, M_b NOT INCL TPS.

$M_b = 10.42(800)^{0.83} = 2676$ LB NOT INCL TPS PER CURVE B

FIND THE REMAINING SYSTEMS MASS, M_{sys} NOT INCL TPS.

M_{sys} = CURVE A - CURVE B = 10868 - 2676 = 8192 LB.

FIND THE ESTIMATED BODY TPS MASS, M_{tps}.

$M_{tps} = 26.54(800)^{0.62} = 1674$ LB.

<u>THEREFORE</u>, THE TOTAL ESTIMATED GROSS MASS OF THE VEHICLE IS 2676 + 8192 + 1674 = 12542 LB.

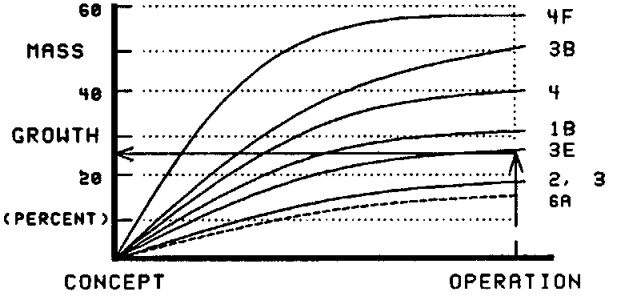
<u>NOW</u>, APPLY THIS ESTIMATE TO A PROGRAMITIC PROJECTION BY USING THE FORECASTING TECHNIQUE ON THE RIGHT.

FORECASTING

REFERENCE FIGURE 10

DATA POINTS:

1B. MERCURY REENTRY MOD	4F. SKYLAB WORKSHOP
2. GEMINI SPACECRAFT	4. SKYLAB SPACECRAFT
3B. APOLLO COMMAND MOD	6A. SHUTTLE ORBITER (PHASE C/D ONLY)
3E. APOLLO LUNAR MOD(A)	
3. APOLLO SPACECRAFT	



GIVEN:

GIVEN THE 12542 LB ESTIMATE IN CONCEPTUAL OR PRELIMINARY DESIGN.

FIND:

FIND THE MASS GROWTH ALLOWANCE VALUE TO APPLY TO THE VEHICLE PROGRAM.

NOTE THAT THE ESTIMATED VALUES ARE AVERAGE AND THEREFORE, AN AVAERAGE MASS GROWTH WOULD BE REASONABLE.

<u>A MASS GROWTH ALLOWANCE VALUE</u> OF 25 PERCENT IS CHOSEN SINCE MERCURY AND GEMINI ARE FAIRLY GOOD EXAMPLES OF THIS TYPE OF VEHICLE.

THEREFORE, AN OPERATIONAL VEHICLE MASS OF 1.25(12542) = 15678 LB WOULD BE PROJECTED.

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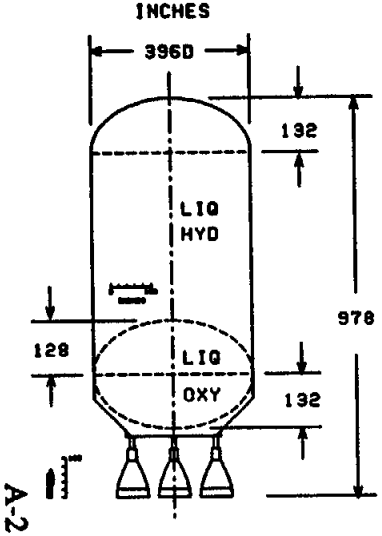
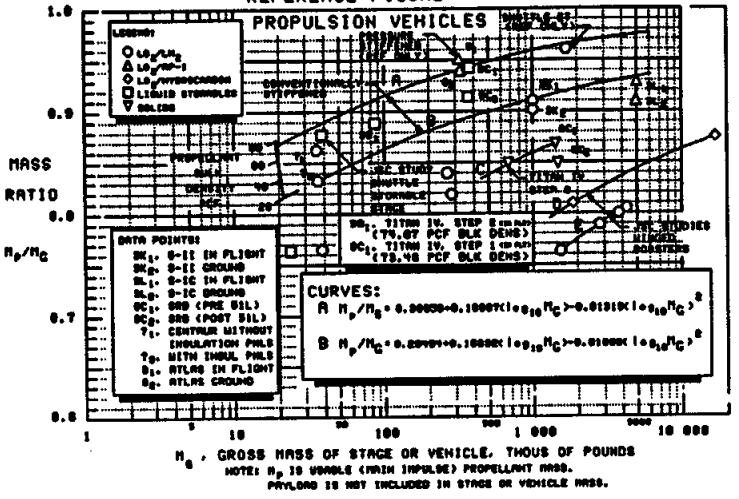
EXAMPLE 2

PROPULSION VEHICLES

ESTIMATING



REFERENCE FIGURE 3



A-2

GIVEN:

A CONCEPTUAL DESIGN OF A PROPULSION STAGE IS SIZED BASED ON AN ASSUMED MASS RATIO OF 0.92 FOR LIQ OXY/LIQ HYD AT A MIXTURE RATIO OF 5 TO 1. THE TOTAL USABLE MAIN IMPULSE PROPELLANT IS CALCULATED TO BE 960000 POUNDS BASED ON THE DIMENSIONS ABOVE. THE GROSS MASS IS CALCULATED TO BE 1021000 POUNDS BASED ON A MASS RATIO OF 0.92.

FIND:

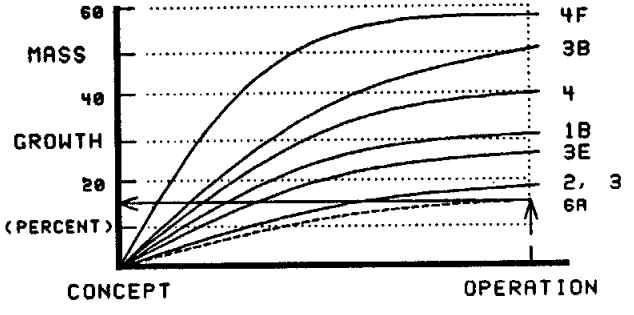
FIND THE ESTIMATED MASS RATIO BASED ON THE GROSS MASS THAT IS OBTAINED FROM THE ASSUMED MASS RATIO ABOVE.
AT A MIXTURE RATIO OF 5 TO 1, A BULK DENSITY OF 19.29 IS OBTAINED FOR LIQ OXY/LIQ HYD PROPELLANT. THIS CORRESPONDS TO CURVE B OF THE PLOT ABOVE WHICH YIELDS A MASS RATIO OF APPROXIMATELY 0.91 AT APPROXIMATELY 1021000 POUNDS.
THEREFORE, THIS SUGGESTS THAT THE ORIGINALLY ASSUMED MASS RATIO OF 0.92 IS TOO LARGE FOR THE SIZE STAGE SHOWN.
AT THIS POINT, IF A MASS RATIO OF 0.92 IS STILL DESIRED, THE STAGE GROSS MASS MUST BE INCREASED BY RESIZING AS SEEN FROM CURVE B OF FIGURE **3** .

FORECASTING

REFERENCE FIGURE 10

DATA POINTS:

1B. MERCURY REENTRY MOD	4F. SKYLAB WORKSHOP
2. GEMINI SPACECRAFT	4. SKYLAB SPACECRAFT
3B. APOLLO COMMAND MOD	6A. SHUTTLE ORBITER (PHASE C/D ONLY)
3E. APOLLO LUNAR MOD(A)	
3. APOLLO SPACECRAFT	



GIVEN:

GIVEN THE DRY MASS OR THE BURN-OUT MASS OF THE PROPULSION STAGE IN PRELIMINARY OR CONCEPTUAL DESIGN.

FIND:

FIND THE MASS GROWTH ALLOWANCE VALUE TO APPLY TO THE PROGRAM.
THE DRY MASS OR BURN-OUT MASS DOES NOT GROW AS MUCH AS MANNED SPACECRAFT AND SPACE STATIONS. NOR DO THEY GROW AS MUCH AS MOST UNMANNED SPACECRAFT. THESE ALL GROW ABOUT 25 PERCENT ON THE AVERAGE.

A MASS GROWTH ALLOWANCE OF 15 PERCENT IS CHOSEN BASED ON TYPICAL VALUES FOR STAGES.

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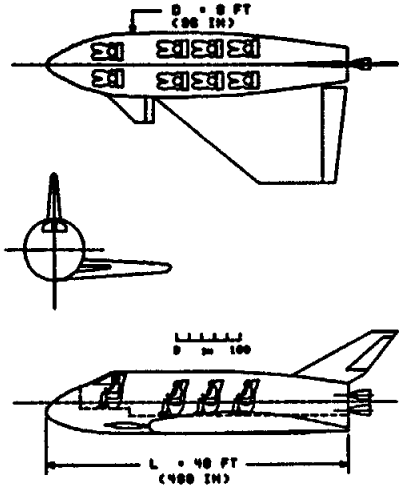
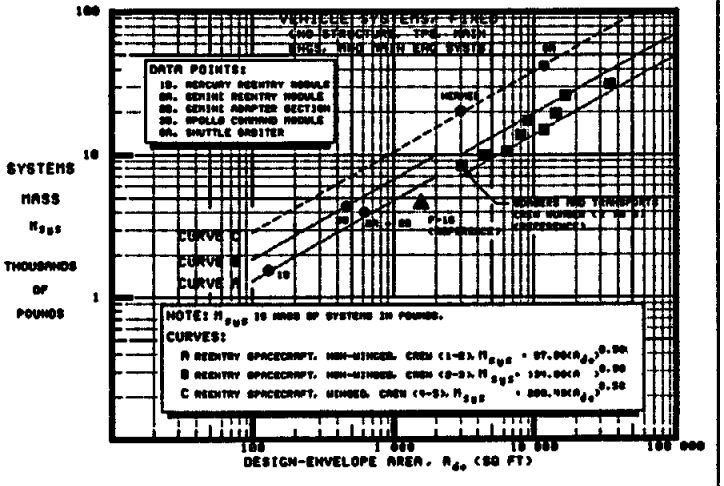
EXAMPLE 3

MANNED, WINGED, CARGO ORBITER

ESTIMATING



REFERENCE FIGURE 5



GIVEN:

BODY DIAMETER, D_b = 8 FT; BODY LENGTH, L_b = 40 FT; NO MAIN ENGINES.
NUMBER OF CREW AND PASSENGERS, N_{cp} = 8.
NUMBER OF DAYS DESIGN MISSION DURATION, N_d = 2.
ASSUME LANDING MASS, M_{ldg} = 50000 LB. ASSUME M_{ldg}/S_w = 80 PSF OR OR APPROX THE VALUE OF SHUTTLE ORBITER. S_w IS THE THEORETICAL PLANFORM AREA OF THE WING.

FIND:

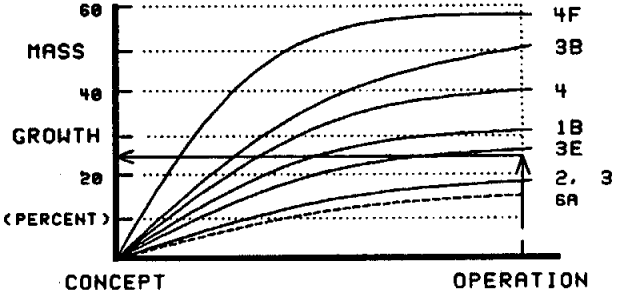
SIZE WING AND TAIL; MASS OF STRUCTURE, THERMAL PROTECTION SYSTEM, AND REMAINING SYSTEMS. (SEE DERIVATION ON THE NEXT PAGE.)
THE REMAINING SYSTEMS, M_{sys} CAN BE DERIVED FROM FIGURE 5 ABOVE WHEN THE WETTED AREA IS KNOWN AS DERIVED ON THE NEXT PAGE.
OR FROM FIGURE 5 , CURVE C = $208.49(2138)^{0.55}$ = 16,040 LB.
NOTE: THE 50 000 lb IS ALSO THE INERT MASS OR FUNCTIONAL CODES 1. THROUGH 11. (OR ASSUMED AS APPROXIMATELY TRUE.).
ALSO IN THIS EXAMPLE, THE 50 000 lb IS THE GROSS MASS SINCE THE 16,040 LB INCLUDES THE SYSTEMS THAT COMPRISE IT.

FORECASTING

REFERENCE FIGURE 10

DATA POINTS:

1B. MERCURY REENTRY MOD	4F. SKYLAB WORKSHOP
2. GEMINI SPACECRAFT	4. SKYLAB SPACECRAFT
3B. APOLLO COMMAND MOD	6A. SHUTTLE ORBITER (PHASE C/D ONLY)
3E. APOLLO LUNAR MOD(A)	
3. APOLLO SPACECRAFT	



GIVEN:

GIVEN THE 35 000 LB ESTIMATE IN CONCEPTUAL OR PRELIMINARY DESIGN.

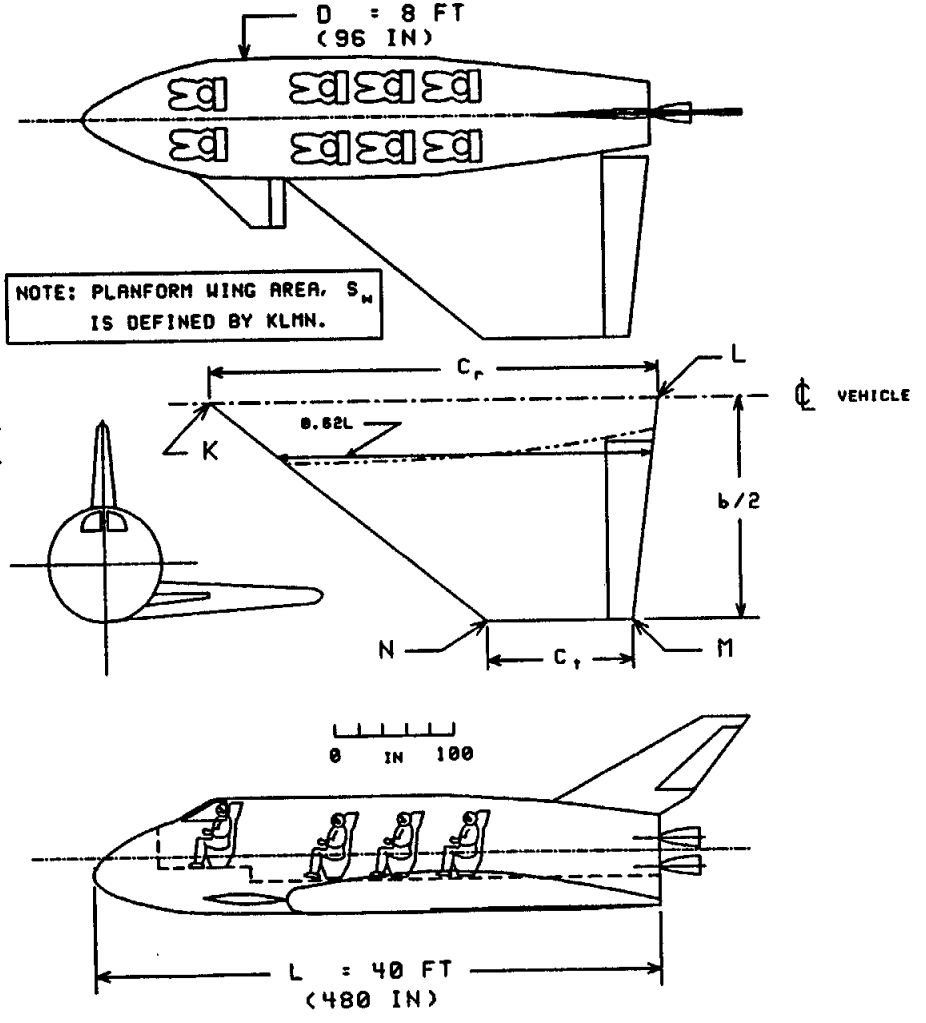
FIND:

FIND THE MASS GROWTH ALLOWANCE VALUE TO APPLY TO THE VEHICLE PROGRAM.
NOTE THAT THE ESTIMATED VALUES ARE AVERAGE AND THEREFORE, AND AVERAGE MASS GROWTH ALLOWANCE WOULD BE REASONABLE.
AS IN EXAMPLE 1, THE ALLOWANCE FOR A MANNED VEHICLE SHOULD BE 25 PERCENT, THEREFORE, AN OPERATIONAL VEHICLE MASS OF 1.25(35,000) = 43,750 LB WOULD BE PROJECTED.
NOTE: THERE MAY BE CASES OF VEHICLE DESIGNS WHERE DESIGN MATURITY HAS DEVELOPED IN CONCEPTUAL AND PRELIMINARY DESIGN TO THE EXTENT THAT A SMALLER ALLOWANCE WOULD REASONABLE (BUT NEVER LESS THAN 15 PERCENT

EXAMPLE 3 (CONTINUED)

MANNED, WINGED, CARGO ORBITER

ESTIMATING



1. BODY WETTED AREA, $A_b = 0.85(\pi DL) + (\pi D^2/4) = 1,028$ SQ FT, WHERE 0.85 ACCOUNTS FOR THE NARROWING OF THE BODY AT BOTH ENDS, AND $\pi D^2/4$ ACCOUNTS FOR AN AFT END CLOSURE BASED ON AN AVERAGE D OF 5.4 FT.
2. ASSUME LANDING MASS, $M_{ldg} = 50,000$ LB.
3. ASSUME $M_{ldg}/S_W = 80$ PSF OR APPROXIMATELY THE VALUE OF SHUTTLE ORBITER. S_W IS THE THEORETICAL PLANFORM AREA OF THE WING. THEREFORE, S_W IS 50,000/80 = 625 SQ FT.
4. WING WETTED AREA, $A_W = 2(1.07S_W - 0.62LD) = 941$ SQ FT. WHERE 1.07 ACCOUNTS FOR THE WING CURVATURE AND 0.62L ACCOUNTS FOR AN AVERAGE CHORD LENGTH AT THE WING-BODY INTERSECTION. THIS AVERAGE VALUE MAY CHANGE .
5. ASSUME TAIL AND CANARD WETTED AREA, $A_t = 0.18\ A_W = 169$ SQ FT.
6. THEREFORE, TOTAL WETTED AREA, $A_{wet} = 1028 + 941 + 169 = 2138$ SQ FT.
7. STRUCTURE MASS, M_s PLUS THERMAL PROTECTION SYSTEM MASS, $M_{tps} = 6.78A_{wet} = 14496$ LB. FOR THE SHUTTLE ORBITER, $M_s + M_{tps} = 7.53$ LB PER SQ FT. THIS VALUE IS REDUCED BY 10 PERCENT TO REFLECT AN IMPROVED TECHNOLOGY.
8. LANDING GEAR MASS, $M_{lg} = 0.04$(LANDING MASS, M_{ldg}) = 2,000 LB.
9. THE REMAINING SYSTEMS, $M_{sys} = 208.49A_{wet}^{0.56} = 16,040$ LB.
10. THEREFORE, TOTAL DRY MASS, $M_D = 14,496 + 2,000 + 16,040 = 32,536$ LB.
11. MASS REMAINING FOR CREW, PASSENGERS, PAYLOAD, UNUSABLE FLUIDS, GASES, AND SO ON, $M_{cpu} = 50,000 - 32,536 = 17,464$ LB.

SEE THE NEXT PAGE TO ESTIMATE CREW AND PASSENGER SYSTEMS.

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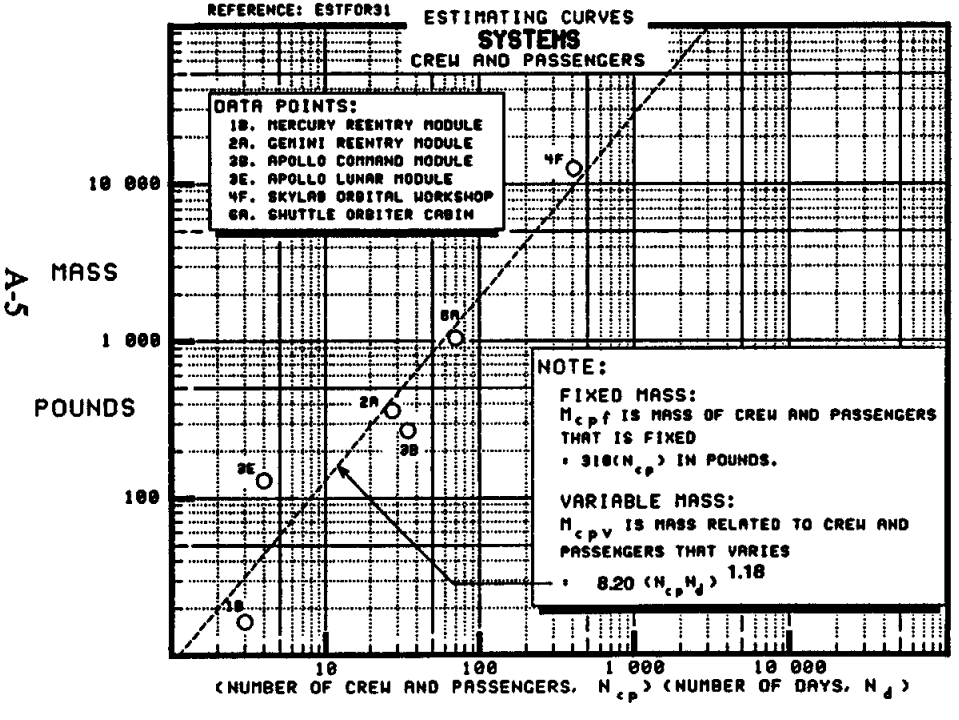
EXAMPLE 3 (CONTINUED)

MANNED, WINGED, CARGO ORBITER

ESTIMATING

REFERENCE FIGURE 6



12. FROM FIGURE 6 , THE FIXED MASS FOR CREW AND PASSENGERS IS 310(N_{cp}) = 310(8) = 2,400 LB. ALSO, FROM FIGURE 1.5, THE VARAIBLE MASS = $8.20\,(N_{cp}N_d)^{1.18}$ = $8.20\,((8)(2))^{1.18}$ = = 214 LB.
13. THEREFORE, REMAINING FOR PAYLOAD, UNUSABLE FLUIDS, GASES, AND SO ON, IS 17,464 - 214 = 17,250 LB.
14. THE INITIALLY ASSUMED 50,000 LB FOR THE LANDING MASS IS ALSO THE INERT MASS, M_I OR APPROXIMATELY. THE 17,250 LB ABOVE INCLUDES THE UNUSABLE FLUIDS AND GASES WHICH IS A RELATIVELY SMALL VALUE. FOR EXAMPLE, IF 17,000 LB OF USABLE PROPELLANT WAS REQUIRED, AND IF A LARGE VALUE OF 5% WAS ALLOWED FOR UNUSABLE PROPELLANT, THIS WOULD BE ONLY 850 LB FOR UNUSABLE PROPELLANT. THEREFORE, NEARLY ALL OF THE 17,250 LB IS ALLOWANCE FOR PAYLOAD OR CARGO.

NOTE:

AT THIS POINT, A DECISION IS NEEDED TO DETERMINE THE TYPE AND DENSITY RANGE OF THE PAYLOAD OR CARGO TO BE CARRIED. PAYLOADS AND PAYLOAD BAY SIZING DATA HAS BEEN PLOTTED IN A GENERALIZED MANNER SHOWN IN FIGURE C-4. THESE DATA SHOULD PROVIDE A REASONABLE ESTIMATE FOR CONCEPTUAL DESIGNS. IN ANY EVENT, RESIZING THE VECHICLE IS A MOST PROBABLE SITIATION. AND MOST LIKELY, THE VEHICLE SHOULD BE RESIZED LARGER FOR THE 50,000 LB LANDING MASS OR THE ASSUMED LANDING MASS REDUCED FOR THE SIZE VEHICLE SHOWN.

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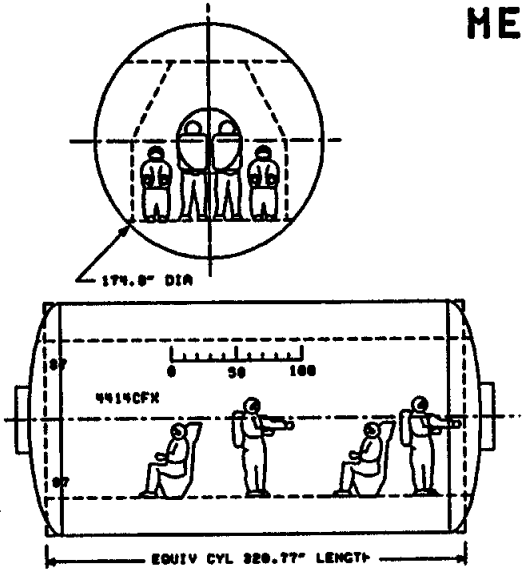
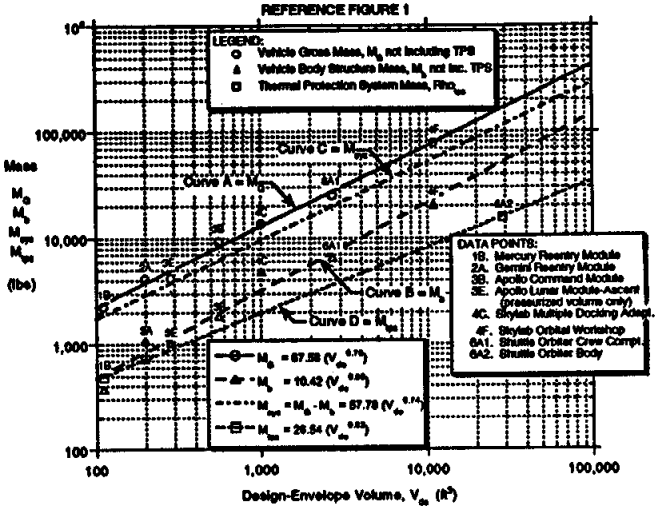
EXAMPLE 4

MANNED, PRESSURIZED, SPACE MODULES

ESTIMATING METHOD 1



REFERENCE FIGURE 1



GIVEN:

HABITATION MODULE WITH A PRESSURIZED VOLUME OF 4414 CU FT, A CREW OF FOUR WITH A STAYTIME OF 45 DAYS.

FIND:

FIND THE ESTIMATED MASS OF THE MODULE WITHOUT PROTECTION SYSTEMS AND PROPELLANT.

REFERENCE FIGURE 1 : THE PRESSURIZED VOLUME MAY BE CONSIDERED APPROXIMATELY THE SAME AS THE DESIGN-ENVELOPE VOLUME WHICH IS ESPECIALLY TRUE FOR LARGE MODULES SUCH AS THE ONE SHOWN.

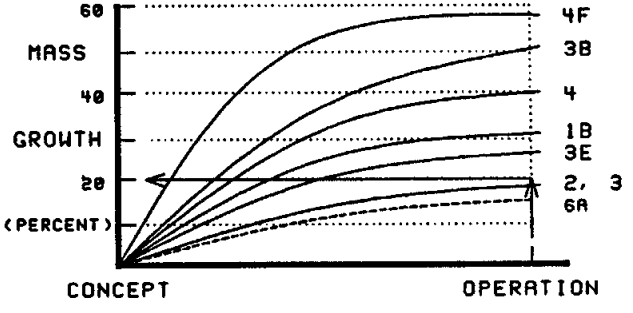
OR $M_{G2} = 67.58(V_{de})^{0.75}$ = 39800 LB. NOTE THAT ONLY VOLUME IS USED TO MAKE THE ESTIMATE.

FORECASTING

REFERENCE FIGURE 10

DATA POINTS:

1B. MERCURY REENTRY MOD	4F. SKYLAB WORKSHOP
2. GEMINI SPACECRAFT	4. SKYLAB SPACECRAFT
3B. APOLLO COMMAND MOD	6A. SHUTTLE ORBITER (PHASE C/D ONLY)
3E. APOLLO LUNAR MOD(A)	
3. APOLLO SPACECRAFT	



GIVEN:

GIVEN THE 39800 LB ESTIMATE IN CONCEPTUAL OR PRELIMINARY DESIGN.

FIND:

FIND THE MASS GROWTH ALLOWANCE VALUE TO APPLY TO THE VEHICLE PROGRAM.

IN THIS CASE, A VALUE OF 20 PERCENT IS CHOSEN. ALTHOUGH MANNED, REFLECTING HIGHER GROWTH RATES, IT IS NOT A RETURN VEHICLE, IN WHICH CASE, A 25 PERCENT VALUE WOULD BE CHOSEN.

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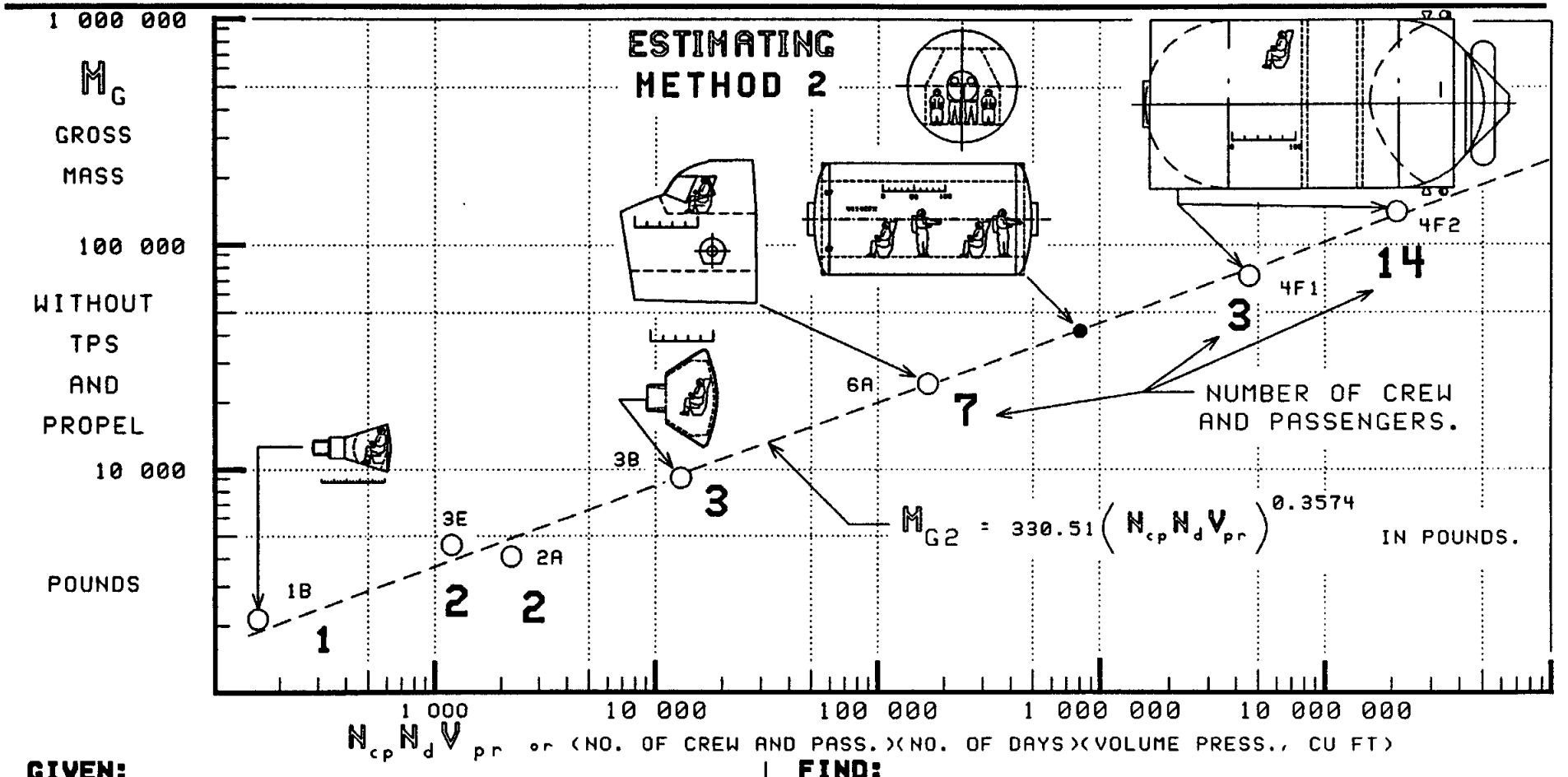
EXAMPLE 4 (CONTINUED)

MANNED, PRESSURIZED, SPACE MODULES



GIVEN:

HABITATION MODULE WITH A PRESSURIZED VOLUME OF 4414 CU FT, A CREW OF FOUR WITH A STAYTIME OF 45 DAYS. THIS IS THE SAME MODULE AND CONDITIONS AS SHOWN IN METHOD 1.

FIND:

FIND THE ESTIMATED MASS OF THE MODULE WITHOUT PROTECTION SYSTEMS AND PROPELLANT.

WHEN THE SUBSTITUTIONS ARE MADE IN THE FORMULA ABOVE, THE MASS IS CALCULATED TO BE 42450 LB. THIS ESTIMATE IS LARGER THAN THE VALUE FROM METHOD 1 BUT NOT UNREASONABLY SO.

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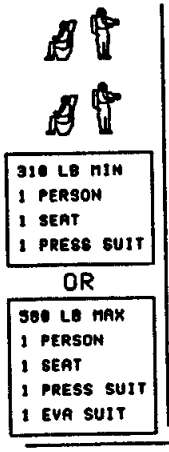
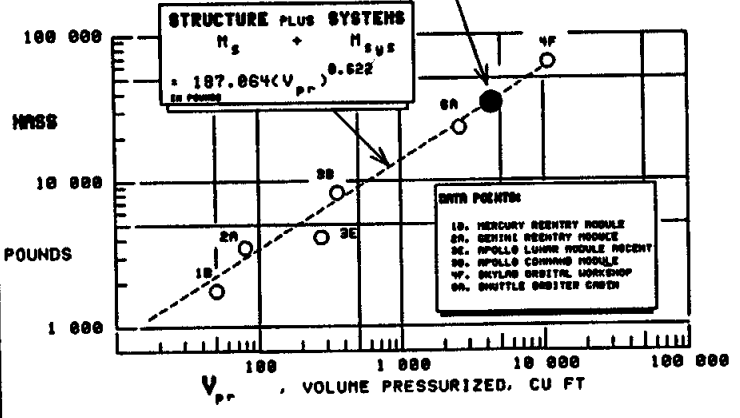
EXAMPLE 4 (CONTINUED)

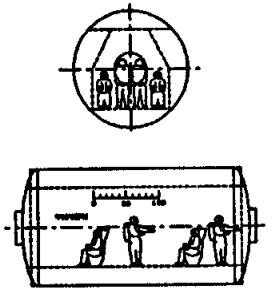
MANNED, PRESSURIZED, SPACE MODULES

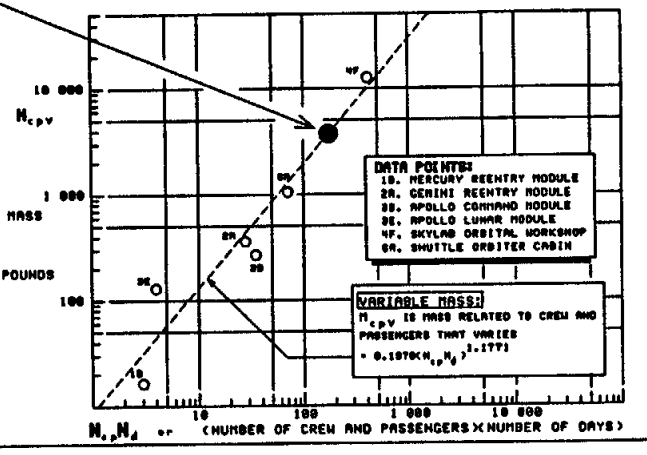
ESTIMATING METHOD 3

$$M_{G2} = \left[\overbrace{(310)(N_{cp})}^{\text{CREW + PASSENGERS}} + \overbrace{(187.064)(V_{pr})^{0.62}}^{\text{INERT MODULE}} \right] + \left[\overbrace{(\ 8.20\ )(N_{cp}N_d)^{1.18}}^{\text{EXPENDABLES FOR CREW AND PASSENGERS}} \right] = \left[1240 + 34600 \right] + \left[3760 \right] = 39600 \text{ LB}$$









GIVEN:

HABITATION MODULE WITH A PRESSURIZED VOLUME OF 4414 CU FT, A CREW OF FOUR WITH A STAYTIME OF 45 DAYS. THIS IS THE SAME MODULE AND CONDITIONS AS SHOWN IN METHODS 1 AND 2.

FIND:

FIND THE ESTIMATED MASS OF THE MODULE WITHOUT PROTECTION SYSTEMS AND PROPELLANT.
WHEN THE SUBSTITUTIONS ARE MADE IN THE FORMULA ABOVE, THE MASS IS CALCULATED TO BE 39600 LB. THIS ESTIMATE IS SOMEWHAT LOWER IN VALUE THAN THOSE OBTAINED BY METHODS 1 AND 2 BUT STILL WELL WITHIN AN EXPECTED RANGE FOR CONCEPTUAL DESIGN WITH FEW EARLY KNOWN DESIGN PARAMETERS.

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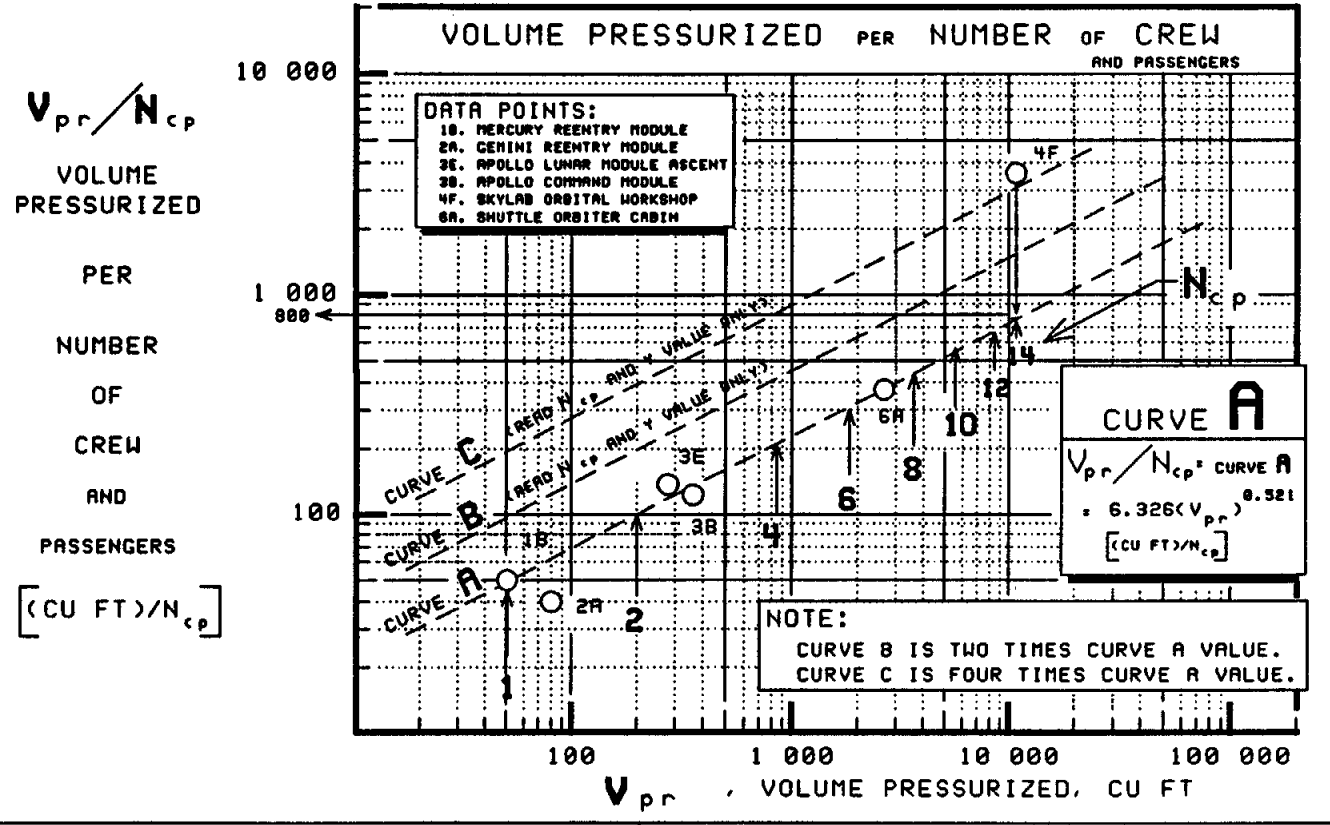
EXAMPLE 4 (CONTINUED)

MANNED, PRESSURIZED, SPACE MODULES

VOLUME CONSIDERATIONS



ONE OF THE MAJOR CONSIDERATIONS IN THE DESIGN OF ANY VEHICLE IS THE VOLUME AND AREA ALLOWANCES FOR ALL OF THE SYSTEMS AND THE CREW AND PASSENGERS. THE FIGURE ABOVE SHOWS A PLOT OF VOLUME PRESSURIZED PER PERSON VERSUS THE TOTAL PRESSURIZED VOLUME OF THE VEHICLE BASED ON A NUMBER OF HARDWARE DATA POINTS. THE RESULT IS CURVE A WHEN CERTAIN ADJUSTMENTS ARE MADE. DATA POINT 2A IS NOT USED BECAUSE THE PRESSURIZED VOLUME PER PERSON IS TOO SMALL WHEN COMPARED TO THE REST. LIKEWISE, DATA POINT 4F IS NOT USED BECAUSE THE VOLUME PRESSURIZED PER PERSON IS TOO LARGE.

THE RESULTING CURVE A FITS THE REMAINING FOUR DATA POINTS WELL. ALSO, THE NUMBER OF PERSONS PROVIDES A GOOD FIT ON THE BASIS OF 1B (1), 3B (3), AND 6A (7), REPRESENTING MERCURY REENTRY MODULE, APOLLO COMMAND MODULE, AND SHUTTLE ORBITER CABIN, RESPECTIVELY. CURVE B IS TWO TIMES CURVE A VALUES FOR REFERENCE AND CURVE C IS FOUR TIMES CURVE A VALUES. NOTE THAT DATA POINT 4F WITH A CREW OF THREE RESULTS IN OVER 3000 CU FT PER PERSON AT SLIGHTLY ABOVE CURVE C. AT CURVE A, THE NUMBER OF CREW IS 14 WITH 800+ CU FT PER PERSON COMPARED TO 377 FOR 6A.

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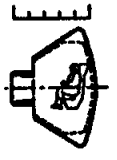
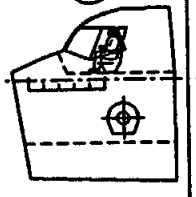
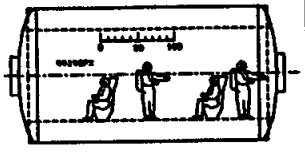
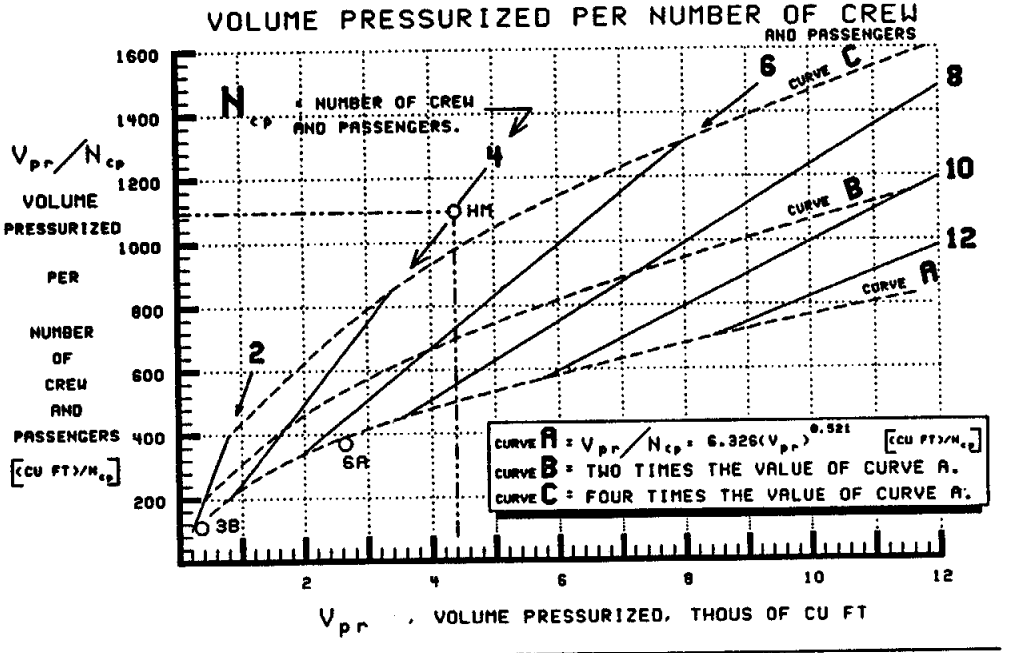
EXAMPLE 4 (CONTINUED)

MANNED, PRESSURIZED, SPACE MODULES

VOLUME CONSIDERATIONS

DATA POINT (SEE PLOT)	3B 	6A 	HM 
VEHICLE	APOLLO COMMAND MODULE	SHUTTLE ORBITER CABIN	HABITATION MODULE
PRESSUR VOLUME V_{pr} (CU FT)	366	2640	4414
NUMBER OF CREW AND PASS, N_{cp}	3	7	4
V_{pr}/N_{cp}	122	377	1104



BASED ON THE PREVIOUS PLOT, A PRESSURIZED VOLUME PER PERSON IS OBTAINED FROM CURVE A REPRESENTING IN A GENERALIZED MANNER THE VOLUME STANDARDS OF SPACE MODULES TO DATE. THIS PRESSURIZED VOLUME ENCLOSES THE CREW AND PASSENGERS AS WELL AS MANY OF THE SYSTEMS OF THE MODULE. THEREFORE IT SHOULD BE KEPT IN MIND THAT THE USE OF THE PLOTS AND CURVES SHOWN HERE HAVE CERTAIN LIMITAIONS AND SOUND JUDGMENT IS ESSENTIAL. OF COURSE, THIS IS TRUE OF ALL PLOTS AND CURVES THAT PERTAIN TO CONCEPTUAL DESIGNS PARTICULARLY.

NOTE THAT AS MODULES BECOME LARGER, THE PRESSURIZED VOLUME PER PERSON BECOMES LARGER AND THEREFORE IT IS REASONABLY ASSUMED THAT THE "FREE" VOLUME OR THE VOLUME THAT ONE CAN MOVE AROUND IN, BECOMES LARGER PROVIDING A BETTER LEVEL OF COMFORT. NO ATTEMPTS WERE MADE TO DETERMINE "FREE" VOLUMES BECAUSE OF THE TIME INVOLVED RESEARCHING DOCUMENTATION AS WELL AS STUDYING THE DATA.

FINALLY, NOTE THAT DATA POINT HM WITH A CREW OF FOUR, ENJOYS A VOLUME PER PERSON OF 1100 CU FT WHICH IS ABOVE CURVE C. PROCEEDING WITH THIS DESIGN IS QUESTIONABLE. IF THE MODULE IS MAINTAINED AT ITS PRESENT SIZE OF 4414 CU FT, THE PLOT INDICATES THAT A CREW OF EIGHT IS REQUIRED AT CURVE A. THIS MAY BE TOO SMALL BASED ON OTHER DESIGN CONSIDERATIONS. A COMPROMISE OF A CREW OF SIX NEAR CURVE B MAY BE THE WAY TO PROCEED.

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APPENDIX B
DEFINITIONS AND GUIDELINES

INTRODUCTION

Consistency is the most important consideration in the recording and reporting of mass properties data. Consistency of definition and placement of the data makes it useful for assessment of stand-alone designs or comparability between competing vehicle designs. Consistency between designers and analysts will limit the confusion and possible misuse of the data. Documentation of study results and presentations should all report the mass properties data to the same format. Reporting the data in various formats allows for data scattering which ultimately can lead to mass growth.

A vehicle mass recording and reporting format has been developed that can be used for practically all types of vehicles. DESIGN MASS PROPERTIES, Guidelines and Formats for Aerospace Vehicles, JSC-23303 defines this format, along with the definitions that govern the placement of the data. The definitions and guidelines from JSC-23303 follow for reference purposes.

FUNCTIONAL SYSTEM CODES 1. THROUGH 13.

1. STRUCTURE

   Wing, tail, body, fins, skirts, primary, secondary, pressurized, unpressurized, fuel and oxidizer tanks if integral with the body structure, and so on.

   Note: Reference 3 defines aerodynamic surfaces structure (wing, tail, and so on) as the basic and secondary load-carrying members for all primary lifting and aerodynamic control surfaces, both fixed and movable, exclusive of the non-structural panels used for induced environmental protection systems. Body structure is the basic and secondary load-carrying members, exclusive of the non-structural panels used for induced environmental protection systems.

2. PROTECTION

   Heat, micro meteoroid, radiation, noise, and so on.

   Note: Reference 3 defines induced environmental protection as the devices which in themselves, or in combination, protect the vehicle structure from the detrimental effects of heat, noise, micro meteorites, and radiation.

3. PROPULSION

Main, maneuver, reaction control, tanks if not integral with the body structure, structural supports, circuitry, and so on.

Note: Reference 3 defines main propulsive items that provide flight path thrust and acceleration and include rocket engines, nuclear engines, propulsive devices, and related equipment, such as fuel systems, oxidizer systems, and pressurizing systems. Secondary propulsion systems, such as maneuver, reaction control, and attitude control, are defined as control units, exclusive of navigation and guidance, which provide relatively small amounts of thrust or force compared to the main propulsion system, usually for purposes such as velocity control, attitude control, rendezvous, and docking.

4. POWER

Electrical source, hydraulic source, pneumatic source, conversion and distribution, structural supports and so on.

Note: Reference 3 defines prime power source as systems used to generate power for purposes other than propulsion, including the source of initial power. However, once the power has been generated, any additional conversion equipment is listed under the Power Conversion and Distribution group (that is, hydraulic, pneumatic, or electrical).

Power conversion and distribution is defined as the systems used to distribute electrical, hydraulic, or pneumatic power. The source of initial power is included in the Prime Power Source group.

5. CONTROL

Surface controls, thrust vector controls, structural supports, circuitry, and so on.

Note: Surface controls are normally associated with winged vehicles and are the systems, generally exclusive of the integrated avionics, that move the control surfaces of aerodynamic surfaces, such as elevons, rudders, speed brakes, body flaps, and so on. This included actuators, plumbing, fluid within the systems, cockpit controls such as rudder pedals, and so on. Thrust vector controls are normally associated with booster vehicles and are the systems, generally exclusive of the integrated avionics, that move the main engines. This includes actuators, plumbing, fluid within the system, structural, and so on.

6. AVIONICS

Guidance, navigation, communications, instrumentation, tracking, data processing, structural supports, circuitry, and so on.

Note: Reference 3 defines guidance and navigation as a group divided into the following major subgroups:

a. Guidance Source; receives a sensor signal.
b. Guidance Evaluation; evaluates signals, determines navigation requirements and informs the output systems.
c. Output; activates the control systems.

Communications is defined as the equipment required for all means of communication within, emanating from, and received by the missile or space vehicle. This includes such items as transmitters, receivers, antennas, power amplifiers, television cameras, and spares. Instrumentation is defined as measuring, signal conditioning, recording, and programming systems for data sampling and recording, including the sensors, circuitry, signal converters, and recording media from the measurement source to a point of telemetry or permanent storage.
(Note; The Shuttle Orbiter also lists tracking and data processing under Avionics.)

7. ENVIRONMENT

Environmental control system, personnel provisions, crew station controls, panels, pressurized volume, unpressurized volume, structural supports, circuitry, and so on.

Note: Reference 3 defines environmental control as the system that controls internal environmental conditions such as temperature, pressure, humidity, atmospheric constituents, and odor for personnel and equipment. Personnel provisions are defined as items within the crew cabin, such as accommodations, fixed life support equipment, cargo handling, furnishings, and built-in emergency equipment. Crew station controls and panels are defined as items consisting of crew station controls, pedestals, stands, and display panels for all systems.

8. OTHER

Landing gear, parachute system, docking system, manipulator, structural supports, circuitry, and so on.

Note: Reference 3 defines launch, recovery, and docking as the items that provide the vehicle with the capability to be launched from or brought to rest with respect to a mass.

9. GROWTH

Percentage of DRY MASS, and so on.

Note: Reference 3 defines mass growth allowance as the mass allowance to account for changes due to development and manufacturing problems, changes in design requirements, and other in-scope causes that are not identifiable at the time. Also, Reference 2 states, "The contractor shall develop and substantiate appropriate weight growth allowances consistent with prior experience."

10. NON-CARGO

Unusable propellant, unusable service items (fluids, gases), reserve propellant, personnel, structural supports, circuitry, and so on.

Note: Reference 3 defines unusable propellant as residual propellant and service items, remaining in a item, which are not usable. Also, reserve propellant and service items are the propellant and service items carried by a propulsion stage or module in excess of that required to perform a mission with a nominal vehicle. Personnel is the crew required to perform a particular mission, including the non fixed items required to support the crew both inside and outside the spacecraft, such as personal gear, life support items, and crew accessories.

11. CARGO

Payload, payload support equipment, structural supports, circuitry, and so on.

Note: Reference 3 defines cargo as items stored aboard the spacecraft that will be required to perform certain functions during the mission. These items include scientific instruments and equipment to perform experiments, passengers, and associated equipment.

12. NON-PROPELLANT

Usable food, usable water, usable fluids, usable gases, structural supports, circuitry, and so on.

13. PROPELLANT

A. Usable propellant (full thrust propellant); main (delta v), maneuver (delta v), and so on.

Note: Reference 3 defines full thrust propellant as propellant consumed during the burning period from the specified value of thrust following ignition, or from lift-off from the launch pad, to the specified value of thrust following the cutoff signal.

B. Unusable propellant and fluid losses

Note: Separate totals should be supplied for A and B, and if data for B are not available, notes of estimates should be supplied for a, b, c, and d, either separately, or as a group. Reference 3 defines unusable propellant and fluid losses as:

a. Inflight losses; propellant losses associated with the use of auxiliary propulsion systems. These include losses for roll and attitude control, venting losses from pressurization gases, and boil-off losses.

b. Thrust-decay propellant; propellant consumed from the specified value of thrust, following the engine cutoff signal, to stage or module separation, or to zero value of thrust.

c. Thrust-buildup propellant; propellant consumed from ignition to the specified value of thrust, or consumed prior to lift-off from the launch pad.

d. Pre-ignition losses; fluid losses associated with starting the primary propulsion system of a stage or module which occur prior to the ignition signal.

FUNCTIONAL SYSTEMS

MIL-M-38310B (REF. 3)	JSC-23303	
1.0 AERODYNAMIC SURFACES	1.0 STRUCTURE	1.0 STRUCTURE
2.0 BODY STRUCTURE	2.0 PROTECTION	1.0 AERODYNAMIC SURF
3.0 INDUCED ENVIR PROT	3.0 PROPULSION	2.0 BODY STRUCTURE
4.0 LNCH RECOV AND DOCK	4.0 POWER	2.0 PROTECTION
5.0 MAIN PROPULSION	5.0 CONTROL	3.0 INDUCED ENVIR PROT
6.0 ORIENT CONTROL SEP ULL	6.0 AVIONICS	3.0 PROPULSION
7.0 PRIME POWER SOURCE	7.0 ENVIRONMENT	5.0 MAIN PROPULSION
8.0 POWER CONV AND DISTR	8.0 OTHER	6.0 ORIENT CONTR SEP ULL
9.0 GUIDANCE AND NAV	9.0 GROWTH	4.0 POWER
10.0 INSTURMENTATION	**DRY MASS**	7.0 PRIME POWER SOURCE
11.0 COMMUNICATION	10.0 NON-CARGO	8.0 POWER CONV AND DISTR
12.0 ENVIRONMENTAL CONTR	11.0 CARGO	5.0 CONTROL
13.0 ARMAMENT	**INERT MASS**	6.0 AVIONICS
14.0 PERSONNEL PROV	12.0 NON-PROPELLANT	9.0 GUIDANCE AND NAV
15.0 CREW STA CONTR PAN	13.0 PROPELLANT	10.0 INSTRUMENTATION
16.0 RANGE SAFETY AND ABORT	**GROSS MASS**	11.0 COMMUNICATION
16A. WEIGHT GROWTH ALLOW		7.0 ENVIRONMENT
DRY WEIGHT		12.0 ENVIRONMENTAL CONTR
17.0 PERSONNEL		14.0 PERSONNEL PROV
18.0 CARGO		15.0 CREW STA CONTR PAN
19.0 ORDNANCE		8.0 OTHER
20.0 BALLAST		4.0 LNCH RECOV AND DOCK
21.0 RESID PROPEL AND SERV		16.0 RANGE SAFETY AND ABORT
22.0 RESERV PROPEL AND SERV		9.0 GROWTH
INERT WEIGHT		16A. WEIGHT GROWTH ALLOW
23.0 INFLIGHT LOSSES		**DRY MASS**
24.0 THRUST DECAY PROPEL		10.0 NON-CARGO
25.0 FULL THRUST PROPEL		17.0 PERSONNEL
26.0 THRUST PROPEL BUILDUP		19.0 ORDNANCE
27.0 PRE-IGNITION LOSSES		20.0 BALLAST
GROSS WEIGHT		21.0 RESID PROPEL AND SERV
		22.0 RESERV PROPEL AND SERV
		11.0 CARGO
		18.0 CARGO
		INERT MASS
		12.0 NON-PROPELLANT
		23.0 INFLIGHT LOSSES
		27.0 PRE-IGNITION LOSSES
		13.0 PROPELLANT
		23.0, 24.0, 26.0, AND 27.0
		25.0 FULL THRUST PROPEL
		GROSS MASS

NOTE:
THE JSC-23303 FUNCTIONAL SYSTEMS ARE A GROUPING OF MIL-M-38310B FUNCTIONAL SYSTEMS.

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APPENDIX C
DATA FACTORS AND PLOTS

TABLE C-1

MISSION MASS PARAMETERS

NORMALIZED DATA POINT VALUES

DATA POINT	1B	2A	3B	3E	6A	4F
VEHICLE	MERCURY REENTRY MODULE	GEMINI REENTRY MODULE	APOLLO COMMAND MODULE	APOLLO LUNAR MODULE	SHUTTLE ORBITER CABIN	SKYLAB ORTITAL WORKSHOP
GROSS MASS, POUNDS, M_{G1}	2724	4948	13056	10571	23474	78195
LESS PROTECTION SYSTEMS	-480	-729	-3730	-364		-1282
LESS PROPELLANT	-55	-72	-209	-5494		-1465
LESS MAIN PROPULSION SYSTEM				-469		
PLUS EXPENDABLES IN SERVICE MOD		316	221			
PLUS CREW				620	2170	930
(NOTE: A CONSTANT 310 LB PER CREW MEMBER, SEAT AND MISCL IS USED TO SIMPLIFY RECORDING.)						
GROSS MASS, POUNDS, M_{G2}	2189	4463	9338	4864	25644	76378
BODY STRUCTURE, M_b	377	1074	1820	1026	6639	20311
SYSTEMS, M_{sys} (WITHOUT CREW)	1486	2407	6313	3082	15791	43145
INERT MASS, M_I (WITHOUT CREW)	1863	3481	8133	4108	22430	63456
CREW	310	620	930	620	2170	930
EXPENDABLES AND CONSUMABLES	16	362	275	136	1044	11992
GROSS MASS, POUNDS, M_{G2}	2189	4463	9338	4864	25644	76378
NUMBER OF CREW, N_c	1	2	3	2	7	3
NUMBER OF DAYS, N_d	3	14	11.3	2	10	(28+56+56)
VOLUME PRESSUR, CU FT, V_{pr}	50	80	366	283	2640	10500
V_{pr} / N_c , CU FT PER CREW	50	40	122	142	377	3500

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TABLE C-2

DESIGN DATA
PROPULSION VEHICLES

DATA POINT VEHICLE	1 CENTAUR	2 S-IVB	3 S-II	4 S-IC	5 ATLAS BOOSTER	ATLAS SUSTAINER	6 SHUTTLE ET (REF)
ENGINES, TYPE	RL10A-3-3	J-2S	J-2S	F-1	MA-5		SSME [3]
ENGINES, NUMBER	1	1	5	5	2	1	3
ENGINES, THRUST EACH, LB	32800 ALTITUDE	241000 ALT, NOM	240052 ALT, NOM	1522000 SL	377000 SL	60000 ALT	470000 ALT(RATED)
SPECIFIC IMPULSE, I_{SP}, SEC	446	433.5	431.5	264.0	258.98	219.48	453.5
OXIDIZER, O	LO2	LO2	LO2	LO2	LO2	LO2	LO2
FUEL, F	LH2	LH2	LH2	RP-1	RP-1	RP-1	LH2
MIXTURE RATIO, O/F	5.00	5.00	5.00	2.27	2.25	2.22	6.00 [4]
DENSITY O, PCF	68.60	68.60 [1]	68.60 [1]	69.40 [2]	69.40	69.40	71.134 [4]
DENSITY F, PCF	4.20	4.20 [1]	4.20 [1]	49.81 [2]	49.81	49.81	4.419 [4]
BULK DENSITY, PCF	19.29	19.29	19.29	61.95	61.90	61.85	22.53
PROPELLANT MASS, M_P, LB (USABLE MAIN-IMPULSE)	29848	224510	960110	4563474	300893		1599789
GROSS STAGE MASS, M_{G1}, LB (FLIGHT CONDITION)	34620	266172	1056856	4936991	317434		
MASS RATIO, M_P/M_{G1}	0.862	0.843	0.908	0.924	0.948		
GROSS STAGE MASS, M_{G2}, LB (GROUND CONDITION)	38735	273898	1066919	5025001	320858		1670746
MASS RATIO, M_P/M_{G2}	0.771	0.820	0.900	0.908	0.938		0.958

1. ASSUMED SAME AS CENTAUR; 2. ASSUMED SAME AS ATLAS; 3. ON SHUTTLE ORBITER; 4. PRESSED

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TABLE C-2 (CONTINUED)

DESIGN DATA
PROPULSION VEHICLES

DATA POINT VEHICLE	7 APOLLO[5] LM(A)	8 APOLLO[5] LM(D)	9 APOLLO[5] SM	10 TITAN IV STEP 2	11 TITAN IV STEP 1	12 TITAN IV STEP 0	13 STS SRB[8]
ENGINES, TYPE				LR87-AJ-11	LR87-AJ-11		
ENGINES, NUMBER	1	1	1	1	2	2 (2 SRB)	2 (2 SRB)
ENGINES, THRUST EACH, LB	3500	10000 MAX	21500	103500 NOM VAC	273800 NOM VAC	1665830 MAX AT 19S	3300000 INITIAL
SPECIFIC IMPULSE, I_{SP}, SEC	309.3	306.6	309.0	316.45	301.45	271.30	266.40
OXIDIZER, O	N2O4	N2O4	N2O4	N2O4	N2O4		
FUEL, F	UDMH/N2H4	UDMH/N2H4	UDMH/N2H4	UDMH/N2H4	UDMH/N2H4		
MIXTURE RATIO, O/F	1.6	1.6	1.6	1.775	1.910		
DENSITY O, PCF	89.21	89.21	89.21	89.21	89.21		
DENSITY F, PCF	55.94	55.94	55.94	55.94	55.94		
BULK DENSITY, PCF	72.60	72.60	72.60	73.46	74.07		
PROPELLANT MASS, M_P, LB (USABLE MAIN-IMPULSE)	5039	17517	35311	76843	340734	590800[9]	1107720[9]
GROSS STAGE MASS, M_{G1}, LB (FLIGHT CONDITION)	10777[6]	22893[7]	49860	86274	369029	695865[9]	1300812[9]
MASS RATIO, M_P/M_{G1}	0.468	0.765	0.708	0.891	0.923	0.849	0.852
GROSS STAGE MASS, M_{G2}, LB (GROUND CONDITION)							
MASS RATIO, M_P/M_{G2}							

5. APOLLO 11 MISSION; 6. LUNAR SURFACE; 7. IGNITION; 8. POST 51L; 9. FOR ONE SRB

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TABLE C-3

DESIGN DATA

SATURN V / APOLLO 11

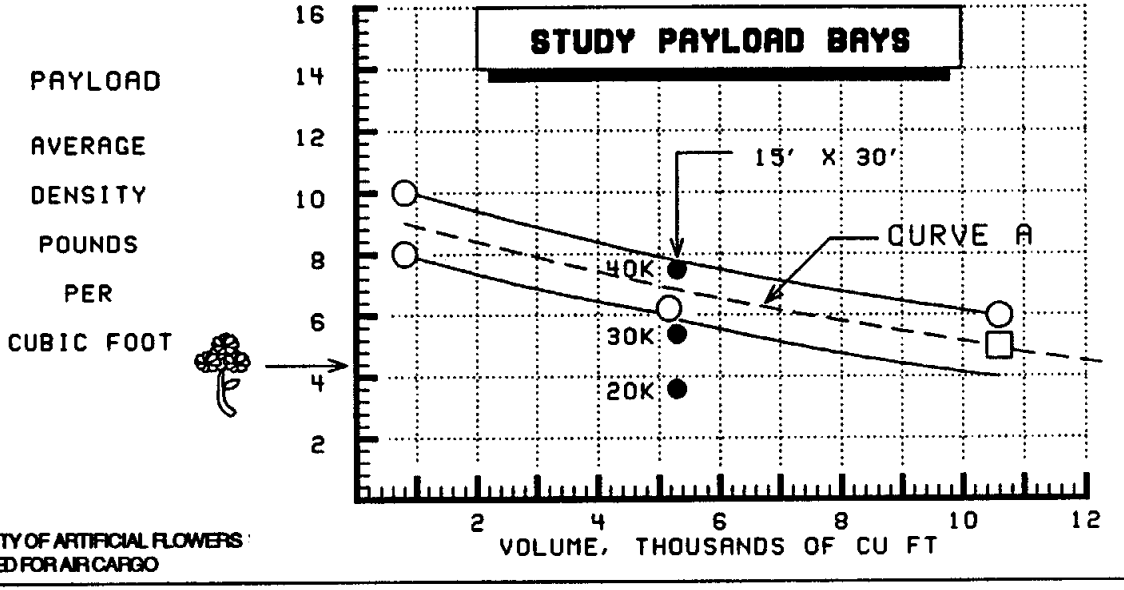
(REF: SATURN V LAUNCH VEHICLE FLIGHT EVALUATION REPORT-AS-506, APOLLO 11 MISSION, MPR-SAT-FE-69-9, MSFC, SEPTEMBER 20, 1969)

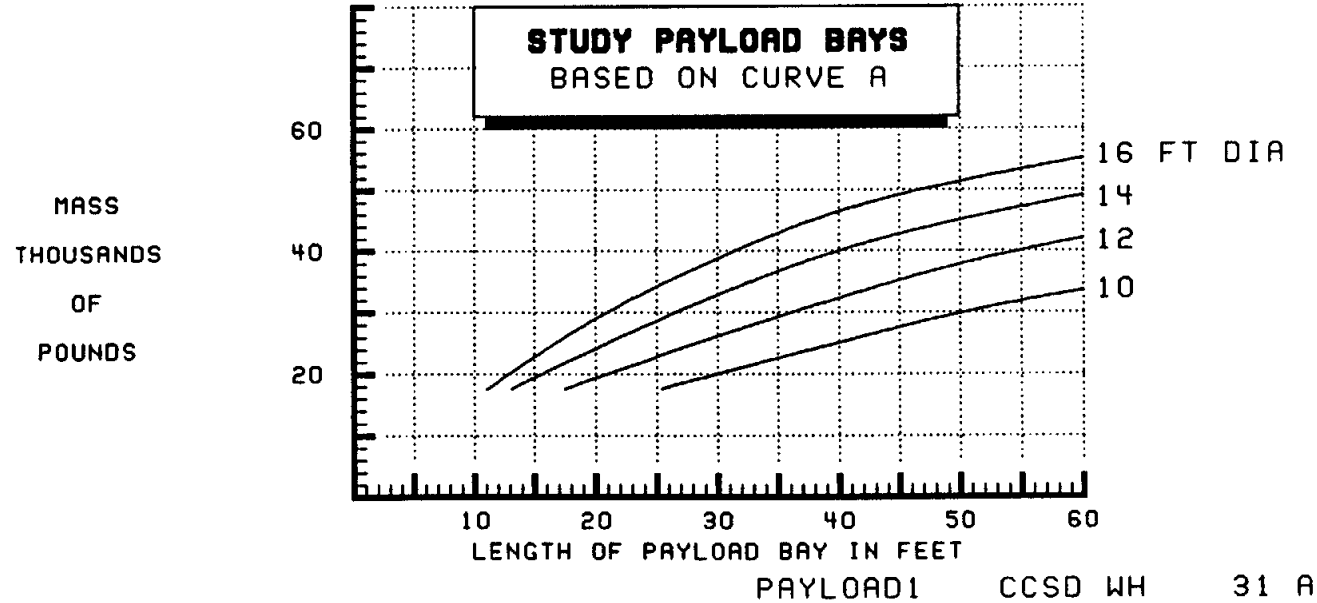
NOTE: ALL MASS IS IN POUNDS.	STAGE		
	S-1C	S-II	S-IVB
FLIGHT CONDITION (NO INTERSTAGES AND NO THRUST BUILD-UP PROPELLANT)			
GROSS MASS OF STAGE (REF DATA)	5023648	1058140	262613
INSTRUMENT UNIT			4275
THRUST BUILD-UP PROPELLANT	-86657	-1284	-716
GROSS MASS OF STAGE, M_{G1}	4936991	1056856	266172
MAINSTAGE PROPELLANT, M_p	4563474	960110	224510
M_p/M_{G1}	0.924	0.908	0.843
GROUND CONDITION (INCLUDING INTERSTAGES AND THRUST BUILD-UP PROPELLANT)			
GROSS MASS OF STAGE (REF DATA)	5023648	1058140	262613
INSTRUMENT UNIT			4275
INTERSTAGE	1353	8779	7010
GROSS MASS OF STAGE, M_{G2}	5025001	1066919	273898
MAINSTAGE PROPELLANT, M_p	4563474	960110	224510
M_p/M_{G2}	0.908	0.900	0.820

SATUDE01 CCSD WH 31 AUG 93

FIGURE C-4

PAYLOAD and PAYLOAD BAY SIZING





PAYLOAD1 CCSD WH 31 AUG 93

REFERENCES

(Propulsion Vehicles)

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2. Shuttle Storable Stage, 1987 JANNAF Propulsion Meeting, (Boyd, Brasher, Mallini, all of JSC), December, 1987.

3. Shuttle External Tank (ET) Mass Properties Status Report, MMC-ET-SE02-97, Martin Marietta Michoud Aerospace, New Orleans, Louisiana, June 15, 1987.

4. Atlas/Centaur Configuration, Performance, and Weight Status Report No. GDC-63-0495-116, Contract NAS3-22914, September 1982.

5. Saturn V Launch Vehicle Flight Evaluation Report-AS-506, Apollo 11 Mission, MPR-SAT-FE-69-9, NASA MSFC, September 20, 1969.

6. Apollo 11 Mission Report, MSC-00171, NASA, Manned Spacecraft Center, Houston, Texas, November 1969.

APPENDIX D
DATA BASE AND DATA POINTS

APPENDIX D
DATA BASE AND DATA POINTS
(continued)

Mass Data and Design Data Key

Definition of Data Points Used Throughout This Document

1. PROJECT MERCURY
1A. Launch Escape System (LES)
1B. Reentry Module (RM)
1C. Retro Pack (RP)
1D. Adapter Section (AS)

2. GEMINI PROGRAM
2A. Reentry Module (RM)
2B. Adapter Section (AS)

3. APOLLO PROGRAM
3A. Launch Escape System (LES)
3B. Command Module (CM)
3C. Service Module (SM)
3D. Spacecraft Lunar Module Adapter (SLA)
3E. Apollo Lunar Module Ascent Stage (AS)
3F. Apollo Lunar Module Descent Stage (DS)
3J. Saturn/Apollo S-IVB Stage
3K. Saturn/Apollo S-II Stage
3L. Saturn/Apollo S-I Stage

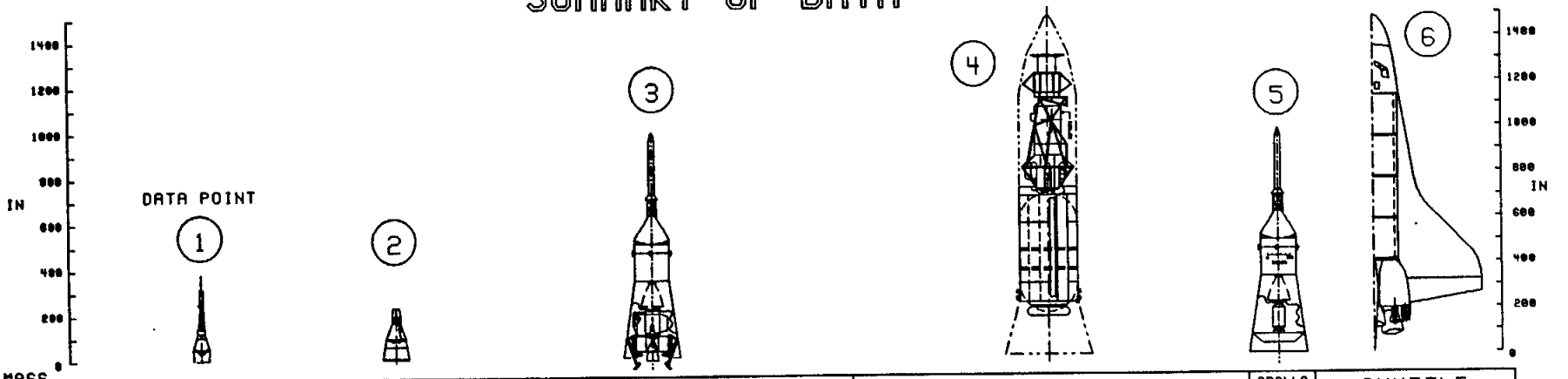
4. SKYLAB PROGRAM
4A. Payload Shroud (PS)
4B. Apollo Telescope Mount (ATM)
4C. Multiple Docking Adapter (MDA)
4D. Airlock Module (AM)
4E. Instrument Unit (IU)
4F. Orbital Workshop (OWS)

5. APOLLO-SOYUZ TEST PROJECT (ASTP)
5A. Apollo Command and Service Module (CSM)
5B. Docking Module (DM)
5C. Soyuz Spacecraft

6. SPACE SHUTTLE VEHICLE (SSV)
6A. Orbiter
6B. External Tank (ET)
6C. Solid Rocket Booster (SRB)

7. CENTAUR
8. ATLAS
9. TITAN

SUMMARY OF DATA



NOTE: ALL MASS IS IN POUNDS.

FUNCTIONAL SYSTEM CODE	MERCURY				GEMINI		APOLLO						SKYLAB						APOLLO SOYUZ	SHUTTLE		
	A	B	C	D	A	B	A	B	C	D	E	F	A	B	C	D	E	F	B	A	B	C
1. STRUCTURE	164	377	28	188	1074	487	1316	1820	3227	2218	1026	1015	24556	6298	4798	14216	698	20311	1809	63287	52589	254960
2. PROTECTION	22	488	-	-	729	11	1886	3738	544	258	364	463	67	1885	137	489	982	1282	233	28838	5959	52416
3. PROPULSION	356	152	64	-	144	487	2278	295	3192	-	711	1891	-	-	-	-	-	5838	-	37684	2951	1888
4. POWER	22	328	13	5	237	472	87	1414	2842	68	795	786	18	18585	1668	4584	1589	18688	142	16628	372	2548
5. CONTROL	-	-	-	-	-	-	84	-	-	-	-	-	-	-	-	-	-	-	-	2785	-	4655
6. AVIONICS	-	315	-	-	559	138	-	934	428	-	388	63	2	2911	238	1491	1218	1386	88	4555	68	269
7. ENVIRONMENT	-	341	-	-	1866	385	-	1748	221	-	681	427	-	227	1621	28697	-	14661	967	9454	-	786
8. OTHER	234	488	28	5	353	368	1225	1298	953	538	651	681	838	973	87	338	-	-	913	9642	6676	69268
9. GROWTH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	428	-	-
DRY MASS	798	2393	125	198	4156	2188	5976	11234	18687	4866	4567	4446	25473	21919	8541	41735	4399	53286	4144	172397	68615	385892
18. NON-CARGO	-	244	-	-	569	-	-	1254	933	-	374	768	-	-	-	-	-	3918	-	18336	8289	-
11. CARGO	-	-	-	-	27	12	-	385	58	-	-	1899	-	2778	5184	558	-	7622	268	28552	-	-
INERT MASS	798	2637	125	198	4752	2128	5976	12793	11588	4866	4941	6388	25473	24697	13645	42294	4399	64738	4412	211285	76824	385892
12. NON-PROPELLANT	-	32	-	-	87	88	-	54	988	-	136	558	-	-	-	7788	-	11992	188	9239	3948	-
13. PROPELLANT	293	55	144	-	72	689	3197	288	41918	-	5488	18788	-	-	-	-	-	1465	-	28978	1573383	2214668
GROSS MASS	1891	2724	269	198	4861	2897	9173	13856	54489	4866	18571	25665	25473	24697	13645	58883	4399	78185	4512	249582	1654875	2688552
GROSS MASS	4274				7758		117838						196412						4512	4584129		

A. LAUNCH ESCAPE SYS
B. REENTRY MODULE
C. RETRO PACK
D. ADAPTER SECTION

A. REENTRY MODULE
B. ADAPTER SECTION

A. LAUNCH ESCAPE SYSTEM
B. COMMAND MODULE
C. SERVICE MODULE
D. LUNAR MODULE ADAPTER
E. LUNAR MODULE ASCENT STAGE
F. LUNAR MODULE DESCENT STAGE

A. PAYLOAD SHROUD
B. APOLLO TELESCOPE MOUNT
C. MULTIPLE DOCKING ADAPTER
D. AIRLOCK MODULE
E. INSTRUMENT UNIT
F. ORBITAL WORKSHOP

B. DOCKING MODULE

A. ORBITER
B. EXT TANK
C. SOLID ROCKET BOOSTERS (2)

SUMDAT01 CCSD WH 2 DEC 92

NOTE: ALL MASS IS IN POUNDS.

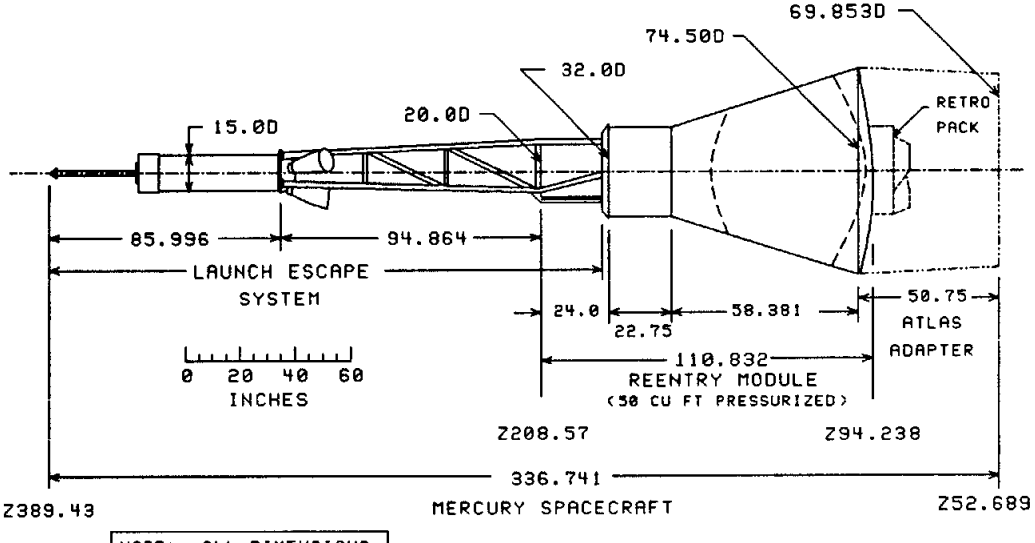
DATA POINT (1)

DESIGN MASS SUMMARY

MERCURY SPACECRAFT (20 FEB 62)

FUNCTIONAL SYSTEM CODE	A	B	C	D
1. STRUCTURE	164	377	28	180
2. PROTECTION	22	480	-	-
3. PROPULSION	356	152	64	-
4. POWER	22	320	13	5
5. CONTROL	-	-	-	-
6. AVIONICS	-	315	-	-
7. ENVIRONMENT	-	341	-	-
8. OTHER	234	408	20	5
9. GROWTH	-	-	-	-
DRY MASS	798	2393	125	190
10. NON-CARGO	-	244	-	-
11. CARGO	-	-	-	-
INERT MASS	798	2637	125	190
12. NON-PROPELLANT	-	32	-	-
13. PROPELLANT	293	55	144	-
GROSS MASS (4274)	1091	2724	269	190

REFERENCE: PROJECT MERCURY ACTUAL WEIGHT REPORT, CAPSULE NO. 16 (MA-8), MCDONNELL AIRCRAFT, REPORT 9141, PAGE 3, 8 OCT 1962.



NOTE: ALL DIMENSIONS ARE IN INCHES.

MERCDR01 CCSD WH 14 AUG 89

NOTE:

A. LAUNCH ESCAPE SYSTEM (LES)
B. REENTRY MODULE (RM)
C. RETRO PACK (RP)
D. ADAPTER SECTION (AS)

	RM	AS
DESIGN-ENVELOPE VOLUME, V_{de} (CU FT)	110	119
PRESSURIZED VOLUME, V_{pr} (CU FT)	50	
DESIGN-ENVELOPE SURF AREA, A_{de} (SQ FT)	139	[a] 80

DESIGN MISSION, 3 DAYS MAX; CREW OF ONE

[a] SIDEWALL ONLY

MERCMP01 CCSD WH 19 AUG 93

NOTE: ALL MASS IS IN POUNDS.

MASS SUMMARY

MERCURY LAUNCH ESCAPE SYSTEM (20 FEB 62)

DATA POINT 1A

1. STRUCTURE	164.17	4. POWER	21.95	8. OTHER	233.60
TRUSS	118.76	CIRCUITRY		AERODYNAMIC SPIKE	25.70
RINGS		LAUNCH ESCAPE SY SEP	1.82	BALLAST	185.17
ATTACH RING	11.32	ESCAPE ROCKET FIRE	1.17	PYLON JETTISON ROCKET	22.73
SEPARATION RING AND COVER	34.09	PYLON JETTISON FIRE	0.76		
		ELECTRICAL TUNNELS	9.14		
		ELECTRICAL INSTALLATION	9.06		
				9. GROWTH	
				DRY MASS	798.41
		5. CONTROL	-	10. NON-CARGO	-
2. PROTECTION	22.39	6. AVIONICS	-	11. CARGO	-
HEAT PROTECTION	22.39			**INERT MASS**	798.41
				12. NON-PROPELLANT	-
3. PROPULSION	356.30				
MOTOR CASE	356.30				
		7. ENVIRONMENT	-	13. PROPELLANT	293.20
				GROSS MASS	1091.61

MERCMP02 CCSD WH 9 NOV 92

MERCURY LAUNCH ESCAPE SYSTEM
DESIGN MASS SUMMARY (JSC FORMAT)

ALL MASS IN POUNDS

1. STRUCTURE			
	TRUSS		118.76
		TOTAL FOR TRUSS	(118.76)
	ATTACH RING		11.32
	SEPARATION RING & COVER		34.09
		TOTAL FOR RINGS	(45.41)
		TOTAL FOR STRUCTURE	(164.17)
2. PROTECTION			
	HEAT PROTECTION		22.39
		TOTAL FOR HEAT PROTECTION	(22.39)
		TOTAL FOR PROTECTION	(22.39)
3. PROPULSION			
	MOTOR CASE		356.3
		TOTAL FOR MOTOR CASE	(356.3)
		TOTAL FOR PROPULSION	(356.3)
4. POWER			
	LAUNCH ESCAPE SYSTEM SEPARATIO		1.82
	ESCAPE ROCKET FIRE		1.17
	PYLON JETTISON FIRE		0.76
		TOTAL FOR CIRCUITRY	(3.75)
	ELECTRICAL TUNNELS		9.14
		TOTAL FOR ELECTRICAL TUNNELS	(9.14)
	ELECTRICAL INSULATION		9.06
		TOTAL FOR ELECTRICAL INSULATIO	(9.06)
		TOTAL FOR POWER	(21.95)
8. OTHER			
	AERODYNAMIC SPIKE		25.7
		TOTAL FOR AERODYNAMIC SPIKE	(25.7)
	BALLAST		185.17
		TOTAL FOR BALLAST	(185.17)
	PYLON JETTISON ROCKET		22.73
		TOTAL FOR PYLON JETTISON ROCKE	(22.73)
		TOTAL FOR OTHER	(233.6)
13. PROPELLANT			
	PROPELLANT		293.2
		TOTAL FOR PROPELLANT	(293.2)
		TOTAL FOR PROPELLANT	(293.2)
		GROSS VEHICLE WEIGHT	1091.61

NOTE: ALL MASS IS IN POUNDS.

MASS SUMMARY

MERCURY REENTRY MODULE (20 FEB 62)

DATA POINT 1B

1. STRUCTURE	377	4. POWER	320	8. OTHER	408
PRESSURIZED BODY	71	PRIMARY BATT (4)	152	CHUTE SYS (2)	157
LARGE BULKHEAD	47	SQUIB BATT (2)	50	IMPACT SYS	136
SMALL BULKHEAD	16	MISCL BATT	10	CHUTE, IMPACT SYS WIR	21
HATCH	16	DC POWER WIRING	14	RECOVERY SYS	35
WINDOWS AND FRAME	30	AC POWER SYSTEM	30	FLOTATION BALLAST	41
SPECIAL RINGS	35			ACTUAL WEIGHT ADJUST	18
SHEAR WEBS, SEAT BEAMS	28	WIRING	46	9. GROWTH	
DOORS	15	MISCL	6	**DRY MASS**	2393
PARACHUTE STRUCT PROV	36	MOUNTING	12		
NOSE ANTENNA STRUCT	37	5. CONTROL	–	10. NON-CARGO	244
ANTENNA	27			RCS PEROXIDE TRAPPED	5
ANTENNA MISCL	8			CREW (1)	180
MISCL	11			SUIT (1)	24
				SURVIVAL KIT	34
				BALLAST	1
2. PROTECTION	480	6. AVIONICS	315	11. CARGO	–
HEAT PROT SHINGLES	114	COMMUNICATIONS	113		
INSULATION	58	INSTRUMENTATION	121	**INERT MASS**	2637
HEAT SHIELD ABLATIVE	308	ATTITUDE CONTR SYS			
		AUTOMATIC CONTR	81	12. NON-PROPELLANT	32
				RCS PRESS (He, 0.5 lb)	1
				WATER (COOLING)	15
3. PROPULSION	152			OXYGEN (CREW)	8
RCS THRUSTERS	21			WATER (CREW)	8
RCS CONTROLLERS	12				
RCS MOUNTING	11				
RCS INSULATION	10	7. ENVIRONMENT	293	13. PROPELLANT	55
RCS PRESSURIZATION SYS	17	ENVIRONMENTAL CONTR SYS	127	RCS PEROXIDE USABLE	55
RCS PROPELLANT SYS	43	PANELS, MISCL	66		
RETRO WIRING	28	SEAT	54		
RCS HEAT SINK	10	SEAT INSTL	16		
		ATTITUDE CONTR SYS			
		MANUAL CONTR	26		
		INTERIOR LIGHTS	4		
		DISPLAYS	48	**GROSS MASS**	2724

MERCMP03 CCSD WH 9 NOV 92

MERCURY REENTRY MODULE
DESIGN MASS SUMMARY (JSC FORMAT)

ALL MASS IN POUNDS

1. STRUCTURE		
	HATCH (ENTRANCE)	16.06
	PERISCOPE	9.48
	SNORKEL AIR INLET	3.6
	MISCELLANEOUS	1.44
	TOTAL FOR ACCESS DOORS	(30.58)
	HOIST SUPPORT STRUCT	3.86
	TOTAL FOR HOIST SUPPORT STRUCT	(3.86)
	LARGE (AFT) BULKHEAD	46.89
	TOTAL FOR LARGE (AFT) BULKHEAD	(46.89)
	STRUCTURE	37.31
	BICONE ANTENNA	26.67
	CIRCUITRY	0.91
	EJECTOR	5.53
	CLAMP RING ATTACH	1.07
	TOTAL FOR NOSE ANTENNA	(71.49001)
	PAINT	5.
	TOTAL FOR PAINT	(5.)
	PARACHUTE STRUC PROV	35.85
	TOTAL FOR PARACHUTE STRUC PROV	(35.85)
	SKIN	30.98
	LONGITUDINAL STIFFENERS	39.77
	TOTAL FOR PRESS BODY (SIDE)	(70.75)
	SHEAR WEBS,SEAT BEAMS&SUPPORTS	27.52
	TOTAL FOR SHEAR WEBS	(27.52)
	SMALL (FWD) BULKHEAD	16.44
	TOTAL FOR SMALL (FWD) BULKHEAD	(16.44)
	CONTOUR BREAK (STA 164)	5.33
	HEAT SHIELD ATTACH (STA 104)	17.74
	SEPARATION (STA 184)	5.57
	SPLICE FITTING (STA 164)	6.22
	TOTAL FOR SPECIAL RINGS	(34.86)
	VIBRAT TEST MISC FIX	1.83
	TOTAL FOR VIBRAT TEST MISC FIX	(1.83)
	WINDOW POLE	0.59
	TOTAL FOR WINDOW POLE	(0.59)
	WINDOWS & FRAMES	29.82
	TOTAL FOR WINDOWS & FRAMES	(29.82)
	TOTAL FOR STRUCTURE	(375.48)
2. PROTECTION		
	HEAT PROTEC SHINGLES	113.78
	TOTAL FOR HEAT PROTEC SHINGLES	(113.78)
	INSERTS	1.3
	ABLATION ASSEMBLY	297.59
	ABLATED MATERIAL	6.5
	RING, BALLAST MOUNTING	2.2
	TOTAL FOR HEAT SHIELD	(307.59)
	INSULATION	57.6
	TOTAL FOR INSULATION	(57.6)
	TOTAL FOR PROTECTION	(478.97)
3. PROPULSION		
	PRESSURE SYSTEM BOTTLE-MANUAL	5.35
	PRESSURE SYSTEM VALVING-MANUAL	3.23

PROPELLANT SYSTEM TANK-MANUAL		8.65
PROPELLANT SYS TANK MOUNT-MAN		1.78
PROPELLANT SYSTEM TUBING-MANUA		7.03
PROPELLANT SYSTEM VALVING-MAN		5.61
THRUST SYSTEM THRUSTERS-MANUAL		5.66
CNTRL SYSTEM PUSH-PULL-MANUAL		1.26
CNTRL SYSTEM CIRCUITRY-MANUAL		1.16
MAN CNTRL SYS RATE STABIL SOLE		6.01
INSTALL MOUNTING & SUPP-MAN		4.62
INSTALLATION INSULATION-MANUAL		2.89
PRESSURE SYSTEM BOTTLE-AUTO		5.35
PRESSURE SYSTEM VALVING-AUTO		3.2
PROPELLANT SYSTEM TANK-AUTO		11.16
PROPELLANT SYS TANK MOUNT-AUTO		2.21
PROPELLANT SYS TUBING&FTGS-AUT		4.07
PROPELLANT SYSTEM VALVING-AUTO		2.29
THRUST SYSTEM THRUSTERS&SOLEN		15.44
CNTRL SYSTEM PUSH-PULL-AUTO		3.06
CNTRL SYSTEM CIRCUITRY-AUTO		0.3
INSTALL MOUNTING & SUPP-AUTO		6.33
INSTALLATION INSULATION-AUTO		6.86
INSTALLATION HEAT SINKS-AUTO		9.74
TOTAL FOR REACTION CONTR SYST	(	123.26)
RETRO CIRCUITRY		28.34
TOTAL FOR RETRO CIRCUITRY	(	28.34)
TOTAL FOR PROPULSION	(	151.6)

4. POWER

PRIMARY BATTERIES		152.2
SQUIB BATTERIES		50.
BATTERY VENT SYSTEM		0.81
EXTERNAL POWER SUPPLY		2.95
DIODE PANEL		1.88
POWER RELAYS		3.99
DC POWER CIRCUITRY		14.12
AC POWER PRIMARY INVERTERS		15.52
AC POWER RESERVE INVERTER		9.38
AC POWER CIRCUITRY		5.47
EXTERNAL POWER CIRCUITRY		0.77
GROUND TEST CIRCUITRY		11.38
TOWER SEPARATION CIRCUITRY		4.74
ESCAPE ROCKET CIRCUITRY		3.64
PYLON JETTISON CIRCUITRY		1.2
ADAPTER SEPARATION CIRCUITRY		8.95
ABORT INITIATION CIRCUITRY		6.89
LAUNCH & ORBIT, MISCL CIRCUITR		6.56
EMERGENCY HOLD CIRCUITRY		2.21
PIGTAILS		0.92
TERMINAL BLOCKS		4.74
MOUNTING & INSTALLATION		11.78
TOTAL FOR ELECTRICAL SYSTEM	(	320.1)
TOTAL FOR POWER	(	320.1)

6. AVIONICS

HORIZON SCANNER		7.87
HORIZON SCANNER MOUNTING		0.51
HORIZON SCANNER CIRCUITRY		0.73
ATTITUDE GYROS (2)		14.78
RATE GYROS (3)		6.03

CALIBRATOR		31.28
ACCELEROMETER		0.61
RATE DAMPER		5.25
MOUNTING		1.28
CIRCUITRY		13.04
	TOTAL FOR ATTITUDE CONTROL SYS (	81.38)
BICONE ANTENNA		1.2
UHF DESCENT ANTENNA		0.81
HF VOICE UNIT		3.22
HF VOICE CIRCUITRY		1.93
UHF VOICE UNIT		3.55
UHF VOICE CIRCUITRY		2.1
MIKE/AUDIO CONTROL UNITS		3.25
MIKE/AUDIO CONTROL CIRCUITRY		3.58
S BAND UNIT		12.2
S BAND CIRCUITRY		0.51
C BAND UNIT		11.8
C BAND CIRCUITRY		0.24
COMMAND RECEIVER / DECODER		9.5
COMMAND CIRCUITRY		3.56
ANTENNA SWITCHING UNITS		10.3
ANTENNA SWITCHING CIRCUITRY		1.68
MISCL CONTROL CIRCUITRY		1.11
EQUIPMENT SHELVING		19.08
C&S BAND ANTENNA		6.15
ANTENNACIRCUITRY/COAXIAL CABLE		4.53
EQUIPMENT MOUNTING		12.6
	TOTAL FOR COMMUNICATIONS (	112.9)
PERSONNEL ENVIRON SENSORS		3.46
BIO MED SENSORS		9.47
PILOT CAMERA		6.87
INSTRUMENT CAMERA		8.19
RECORDER		13.79
INSTALLATION/CIRCUITRY		3.93
TRANSMITTER UNITS		2.78
TRANSMITTER POWER SUPPLY (2)		3.58
TRANSMITTER PROGRAMMER		2.75
TRANSMITTER CIRCUITRY		9.6
COSMIC RAY DETECTOR		1.24
SIGNAL CONDITIONING PACKAGE C		5.92
CIRCUITRY, SENSOR CIRCUITS		14.31
OUTSIDE TEMP SENSORS		2.45
REACTION CONTROL SENSORS		1.9
SIGNAL CONDITIONING PACKAGE E		3.1
SIGNAL CONDITIONING MOUNTING		1.27
SIGNAL CONDITIONING PACKAGE A		14.78
SIGNAL CONDITIONING PACKAGE D		11.3
	TOTAL FOR INSTRUMENTATION (	120.69)
	TOTAL FOR AVIONICS (	314.97)

7. ENVIRONMENT

INDICATORS		30.89
CIRCUITRY, INSTALLATION		16.81
	TOTAL FOR DISPLAYS (	47.7)
SUIT BOTTLE		9.21
SUIT VALVING		2.46
SUIT PRESSURE REGULATOR		1.5
SUIT CONTROLS		1.72
SUIT COMPRESSORS		3.8

SUIT C02 AND ODOR ABSORBER		13.13
SUIT HEAT EXCHANGER		2.87
SEPARATOR,SUIT WATER		3.97
SUIT COOLANT QUANTITY INDICATO		2.36
SUIT COOLING WATER TANK		5.7
SUIT CONDENSATE TANK		1.31
SUIT VALVES AND CONTROLS		5.58
SUIT DUCTS		3.62
SUIT SOLIDS TRAP		1.1
EMERGENCY BREATHING BOTTLE		9.21
EMERGENCY BREATHING VALVING		1.61
EMERGENCY BREATHING CONTROLS		0.93
EQUIPMENT COOLING BLOWER		0.74
EQUIPMENT COOLING HEAT EXCHANG		2.2
EQUIPMENT COOLING VALVING		3.88
CABIN PRESSURE RELIEF		5.05
POST LANDING VALVES		8.38
POST LANDING CONTROLS		0.69
POST LANDING DUCTS		1.76
POST LANDING BELLOWS MOTOR		1.05
INSTALLATION PARTS		17.59
CIRCUITRY		5.62
INVERTER COOLING FIX		10.36
TOTAL FOR ENVIRON CONTROL SYST	(	127.4)
INTERIOR LIGHTS		3.82
TOTAL FOR INTERIOR LIGHTS	(	3.82)
FLY-BY-WIRE CIRCUITRY		2.2
EMERGENCY MANUAL RELEASE		5.21
ABORT HANDLE ASSEMBLY		1.69
HAND CONTROLLER		2.78
RODS AND BELLCRANKS		9.83
SUPPORT BRACKETRY		3.84
TOTAL FOR MANUAL CONTROL SYST	(	25.55)
MAPS, CHARTBOARD		1.78
PANEL, CONSOLES		16.91
PERISCOPE		45.26
PERISCOPE CIRCUITRY		2.29
TOTAL FOR PANELS, MISC	(	66.24)
BULKHEAD WEB, LEG SUPPORT		5.55
COUCH		53.7
RESTRAINT		10.82
TOTAL FOR SEAT	(	70.07)
TOTAL FOR ENVIRONMENT	(	340.78)

8. OTHER

ACTUAL WEIGHT ADJUST		18.
TOTAL FOR ACTUAL WEIGHT ADJUST	(	18.)
FLOTATION BALLAST		41.
TOTAL FOR FLOTATION BALLAST	(	41.)
DROGUE CHUTE		11.51
RESERVE CHUTE		67.11
CHUTE SYSTEM CONTROLS		4.12
CHUTE SYSTEM MOUNTINGS		2.32
IMPACT SKIRT		23.67
PILOT CHUTE		4.32
MAIN CHUTE		67.86
IMPACT STRAPS AND SPRINGS		10.47
IMPACT FIBERGLASS SHIELD		26.6
IMPACT MISCL SKIRT INSTALLATIO		17.29

IMPACT PNEUMATICS & MECHANISM			15.92
CIRCUITRY			21.39
IMPACT CAPSULE RING			14.39
IMPACT HEAT SHIELD RING			27.8
	TOTAL FOR LANDING SYSTEM	(	314.77)
RESCUE BEACON			7.4
WHIP ANTENNA			4.95
CIRCUITRY			3.85
SOFAR BOMBS			4.36
DYE MARKER			3.54
CHAFF			0.6
DISPLAY			1.4
RECOVERY VOICE			4.88
SUPER SARAH			3.81
	TOTAL FOR RECOVERY SYSTEM	(	34.79)
	TOTAL FOR OTHER	(	408.56)
10. NON-CARGO			
BALLAST			1.
	TOTAL FOR BALLAST	(	1.)
CREW (1)			180.
	TOTAL FOR CREW (1)	(	180.)
RCS PEROXIDE TRAPPED			5.
	TOTAL FOR RCS PEROXIDE TRAPPED	(	5.)
SUIT (1)			24.
	TOTAL FOR SUIT (1)	(	24.)
SURVIVAL KIT			34.
	TOTAL FOR SURVIVAL KIT	(	34.)
	TOTAL FOR NON-CARGO	(	244.)
12. NON-PROPELLANT			
OXYGEN (CREW)			8.
	TOTAL FOR OXYGEN (CREW)	(	8.)
RCS PRESS (He,.5 LB)			1.
	TOTAL FOR RCS PRESS (He,.5 LB)	(	1.)
WATER (COOLING)			15.
	TOTAL FOR WATER (COOLING)	(	15.)
WATER (CREW)			8.
	TOTAL FOR WATER (CREW)	(	8.)
	TOTAL FOR NON-PROPELLANT	(	32.)
13. PROPELLANT			
RCS PEROXIDE USABLE			55.
	TOTAL FOR RCS PEROXIDE USABLE	(	55.)
	TOTAL FOR PROPELLANT	(	55.)
	GROSS VEHICLE WEIGHT		2721.46

MERCURY RETROGRADE&POSIGRADE SYST
DESIGN MASS SUMMARY (JSC FORMAT)

ALL MASS IN POUNDS

1. STRUCTURE			
	STRUCTURAL INSTALLATION		27.71
	TOTAL FOR STRUCTURAL INSTALLAT	(	27.71)
	PAINT		0.27
	TOTAL FOR PAINT	(	0.27)
	TOTAL FOR STRUCTURE	(	27.98)
3. PROPULSION			
	CASE AND NOZZLE		57.18
	IGNITERS		2.46
	HEATERS		2.25
	TOTAL FOR RETROGRADE SYSTEM	(	61.89)
	RETENTION STRAPS		2.17
	TOTAL FOR RETENTION STRAPS	(	2.17)
	TOTAL FOR PROPULSION	(	64.06)
4. POWER			
	RETRO PACKAGE CIRCUITRY		10.21
	CIRCUITRY SHIELDING		2.89
	TOTAL FOR CIRCUITRY	(	13.1)
	TOTAL FOR POWER	(	13.1)
8. OTHER			
	POSIGRADE ROCKETS		16.05
	TOTAL FOR POSIGRADE ROCKETS	(	16.05)
	RETRO SYS ACT WT ADJ		0.16
	TOTAL FOR RETRO SYS ACT WT ADJ	(	0.16)
	TOTAL ACTUAL WEIGHT ADJUSTMENT		4.
	TOTAL FOR ACTUAL WEIGHT ADJUST	(	4.)
	TOTAL FOR OTHER	(	20.21)
13. PROPELLANT			
	PROPELLANT		144.74
	TOTAL FOR PROPELLANT	(	144.74)
	TOTAL FOR PROPELLANT	(	144.74)
	GROSS VEHICLE WEIGHT		270.09

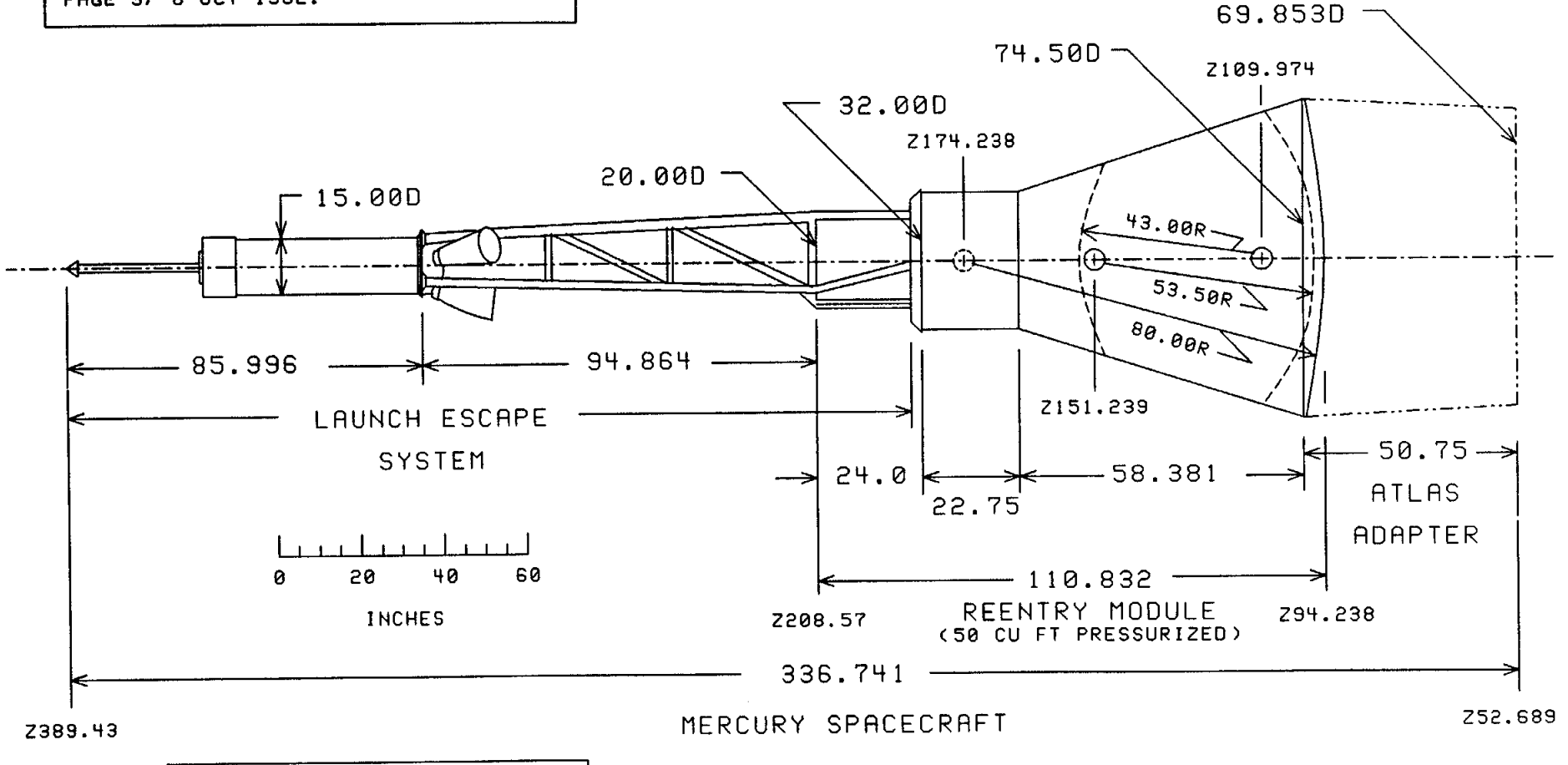
MERCURY ADAPTER
DESIGN MASS SUMMARY (JSC FORMAT)

ALL MASS IN POUNDS

1. STRUCTURE			
	SKINS		68.
		TOTAL FOR SKINS	(68.)
	TOP SEPARATION		8.64
	BOTTOM BOOSTER ATTACH		7.85
	INTERMEDIATE,MA-4 BEEF-UP		24.61
	ATTACHMENTS, BOOSTER/ADAPTER		1.74
		TOTAL FOR RINGS	(42.84)
	ACCESS DOORS		17.51
		TOTAL FOR ACCESS DOORS	(17.51)
	STRETCH FITTINGS		2.84
		TOTAL FOR STRETCH FITTINGS	(2.84)
	SEPARATION RING		48.81
		TOTAL FOR SEPARATION RING	(48.81)
		TOTAL FOR STRUCTURE	(180.)
4. POWER			
	ABORT CIRCUITRY		1.36
	CAPSULE SEPARATION CIRCUITRY		2.42
	EMERGENCY HOLD CIRCUITRY		0.09
	INSTALLATION CIRCUITRY		0.94
		TOTAL FOR CIRCUITRY	(4.81)
		TOTAL FOR POWER	(4.81)
8. OTHER			
	ACTUAL WEIGHT ADJUSTMENT		4.87
		TOTAL FOR ACTUAL WEIGHT ADJUST	(4.87)
		TOTAL FOR OTHER	(4.87)
		GROSS VEHICLE WEIGHT	189.68

MERCURY SPACECRAFT

REFERENCE: PROJECT MERCURY ACTUAL WEIGHT REPORT, CAPSULE NO. 16 (MA-8), MCDONNELL AIRCRAFT, REPORT 9141, PAGE 3, 8 OCT 1962.



NOTE: ALL DIMENSIONS ARE IN INCHES.

MERCDR01 CCSD WH 23 AUG 93

JSC-26098

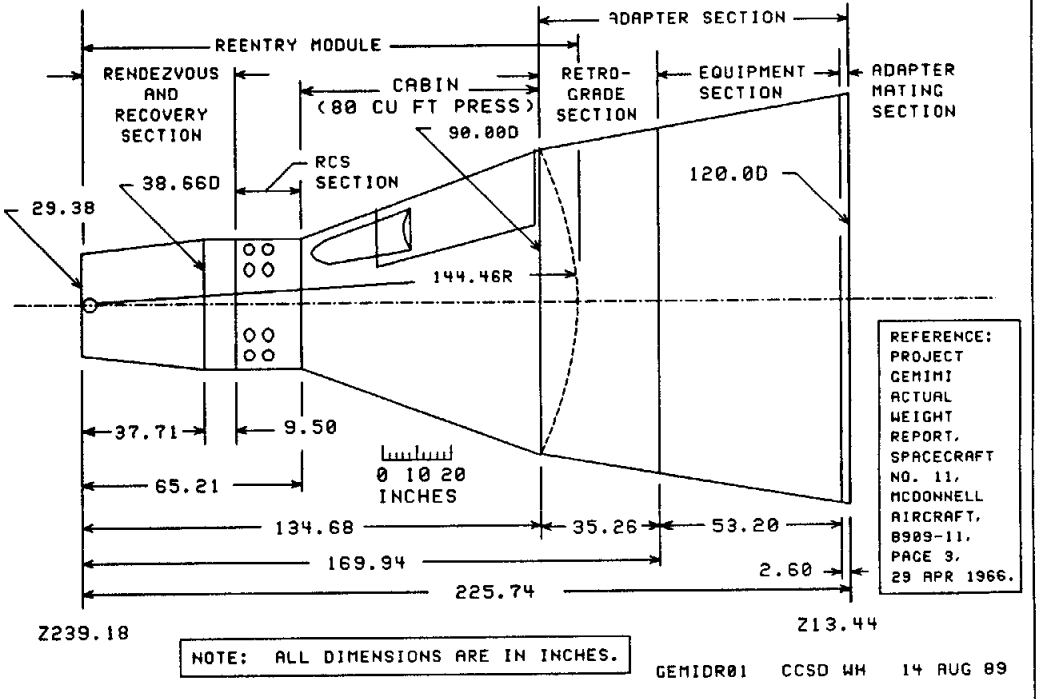
NOTE: ALL MASS IS IN POUNDS.

DATA POINT (2)

DESIGN MASS SUMMARY

GEMINI SPACECRAFT (1 JUN 65)

FUNCTIONAL SYSTEM CODE	A	B	C	D
1. STRUCTURE	1074	407		
2. PROTECTION	729	11		
3. PROPULSION	144	407		
4. POWER	237	472		
5. CONTROL	-	-		
6. AVIONICS	553	138		
7. ENVIRONMENT	1066	305		
8. OTHER	353	368		
9. GROWTH	-	-		
DRY MASS	4156	2108		
10. NON-CARGO	569	-		
11. CARGO	27	12		
INERT MASS	4752	2120		
12. NON-PROPELLANT	37	88		
13. PROPELLANT	72	689		
GROSS MASS (7758)	4861	2897		



NOTE:

A. REENTRY MODULE (RM)

B. ADAPTER SECTION (AS)

	RM	AS
DESIGN-ENVELOPE VOLUME, V_{de} (CU FT)	198	448
PRESSURIZED VOLUME, V_{pr} (CU FT)	80	
DESIGN-ENVELOPE SURF AREA, A_{de} (SQ FT)	217	[a] 208

DESIGN MISSION, 14 DAYS MAX; RENDEZVOUS MISSION, 2 DAYS

CREW OF TWO

[a] SIDEWALL ONLY

GEMIMP01 CCSD WH 19 AUG 93

NOTE: ALL MASS IS IN POUNDS.

MASS SUMMARY

GEMINI REENTRY MODULE (1 JUN 65)

DATA POINT 2A

1. STRUCTURE	1074	4. POWER	237	8. OTHER	353
PRESSURIZED BODY	131	BATT (4 MAIN, 3 SQUIB)	102	RETROGRADE CIRCUITRY	7
LARGE BULKHEAD	79	CONTROL PANELS	82	LANDING SYS (CHUTE)	209
SMALL BULKHEAD	16			RECOVERY SYS	29
CREW HATCH	339	SEPARATION CIRCUITRY	31	RENDEZVOUS SYS	115
NON-PRESSURIZED STRUCT	86	BATT MOUNTING	13	ACTUAL WEIGHT ADJUST	-7
MAIN LDG GEAR FTGS	32	MISCL	9		
SHEAR PANELS	68			9. GROWTH	-
DOORS	79			**DRY MASS**	4156
MISCL	71				
RCS SECTION	78	5. CONTROL	-	10. NON-CARGO	569
RENDEZ AND RECOV SECT	95			CREW (2 IN SUITS)	416
				CREW EQUIP STOWAGE	5
				BALLAST (CG OFFSET)	148
2. PROTECTION	729	6. AVIONICS	553	11. CARGO	27
HATCH SHING AND INSUL	50	INSTRUMENTATION	188	**INERT MASS**	4752
CABIN SHING AND INSUL	149	COMMUNICATION	60		
RCS SEC SHING AND INSUL	62			12. NON-PROPELLANT	37
RR SEC SHING AND INSUL	123	ATT CONTR ELECTRONICS	33	FOOD	5
ABLATOR MATL	187	INERTIAL GUIDANCE	195	WATER (CREW)	15
ABLATOR INSUL	158	HORIZON SENSORS	22	OXYGEN (CREW SECONDARY)	14
3. PROPULSION	144	MTG 11, CIRCUITRY 44	55	NITROGEN GAS (RCS)	3
RCS ENGINES (16)	38				
RCS ENG MOUNTING	4				
RCS PRESS SYS	28				
RCS FUEL SYS	14	7. ENVIRONMENT	1066	13. PROPELLANT	72
RCS OXIDIZER SYS	14	CREW SYSTEMS	605	RCS FUEL	32
RCS SYS INSTL	24	BREATHING SYS	46	RCS OXIDIZER	40
RCS SYS HEATERS	4	AIR RENOV SYS	92		
RCS SYS CIRCUITRY	18	COOLING SYS	103		
		SECONDARY OXYGEN SYS	46		
		CIRCUITRY	14		
		PANEL AND CONSOLES	61		
		MAN CONTR 7, LIGHTS 2	9	**GROSS MASS**	4861
		DISPLAYS	90		

GEMIMP02 CCSD WH 9 NOV 92

GEMINI REENTRY MODULE
DESIGN MASS SUMMARY (JSC FORMAT)

ALL MASS IN POUNDS

1. STRUCTURE		
	SIDE PANELS	44.47
	ECS BAY	37.67
	MISCELLANEOUS PANELS	8.67
	ECS DOOR	26.77
	EQUIPMENT SUPPORTS,SIDE PANELS	8.54
	SEALANT	5.
	TOTAL FOR PRESS BODY STRUCTURE	(131.12)
	PANELS	18.14
	STIFFENERS	44.41
	INSTALLATION	16.17
	TOTAL FOR LARGE BULKHEAD	(78.72)
	PANELS	12.56
	STIFFENERS	3.14
	TOTAL FOR SMALL BULKHEAD	(15.7)
	FIXED STRUCTURE, SILLS	57.84
	ACTUATOR	44.3
	HINGE FITTING, DRIVE BEAM	37.
	BASIC SKIN	29.3
	STRUCTURE DETAILS	81.46
	WINDOW	25.74
	HATCH MECHANISM	44.69
	FLIPPER DOORS	10.86
	FLOTATION CURTAINS	2.9
	HATCH ATTACH BOLTS	4.63
	TOTAL FOR CREW HATCH	(338.72)
	SKIN PANELS, FORWARD SMALL BHD	14.96
	PANELS, SMALL BULKHEAD	7.59
	PANELS, OUTBOARD OF HATCHES	4.19
	STRINGERS	27.5
	STIFFENERS	2.25
	RINGS	9.82
	RING, HEAT SHIELD ATTACH	9.02
	TENSION TIES	11.14
	TOTAL FOR NON-PRESS STRUCTURE	(86.47)
	MAIN LANDING GEAR FITTINGS	31.9
	TOTAL FOR MAIN LNDG GEAR FTGS	(31.9)
	LARGE BULKHEAD	25.15
	TOP CENTER BEAM	10.01
	FLOOR EXTENSION	8.24
	EQUIPMENT SUPPORT BEAMS	24.65
	TOTAL FOR SHEAR PANELS	(68.05)
	DOOR, EQUIPMENT ACCESS	43.46
	DOOR, MAIN LANDING GEAR	29.02
	DOOR, UMBILICAL	2.33
	DOOR, MISCELLANEOUS ACCESS	4.6
	TOTAL FOR DOOR	(79.41)
	MISCELLANEOUS STRUCTURE DETAIL	11.8
	HORIZON SENSOR COVER	9.21
	HOIST FITTINGS	8.12
	FLOTATION MATERIAL	6.98
	PAINT	6.7
	REPAIRS	7.5
	ATTACHING HARDWARE	20.88
	TOTAL FOR MISCELLANEOUS	(71.19)

SKIN, STRINGERS		17.7
RINGS		30.26
MISCELLANEOUS STRUCTURE DETAIL		2.26
FLOTATION MATERIAL		19.19
SEALANT		0.78
ATTACHING HARDWARE		7.91
	TOTAL FOR RCS SECTION (FIXED)	(78.09999)
SKIN, STRINGERS		25.79
RINGS		18.54
SEPARATION RING		3.11
MISCELLANEOUS STRUCTURE DETAIL		7.74
EQUIPMENT MOUNTING		1.72
NOSE FAIRING		26.4
ATTACHING HARDWARE		11.61
	TOTAL FOR RENDEZ&RECOVERY SECT	(94.91)
	TOTAL FOR STRUCTURE	(1074.29)
2. PROTECTION		
SHINGLES		31.58
INSULATION		18.51
	TOTAL FOR CREW HATCH	(50.09)
SHINGLES		65.36
INSULATION		84.18
	TOTAL FOR CABIN WALL	(149.54)
SHINGLES		38.19
INSULATION		24.23
	TOTAL FOR RCS SECTION	(62.42)
SHINGLES		73.67
INSULATION		48.68
	TOTAL FOR RENDEZ&RECOVERY SECT	(122.35)
ABLATIVE MATERIAL		187.06
EDGE RING		27.4
HONEYCOMB BACK-UP		103.93
RING, HEAT SHIELD ATTACH		12.05
SPACERS, SHIELD BACK-UP		10.24
MOUNTING DETAILS		3.66
ACTUAL WEIGHT		0.86
	TOTAL FOR HEAT SHIELD	(345.2)
	TOTAL FOR PROTECTION	(729.6)
3. PROPULSION		
ENGINES		37.44
ENGINE MOUNTING		4.2
PRESSURIZATION SYSTEM TANKS		4.32
PRESSURIZATION TANK MOUNTING		1.68
PRESSURIZATION SYSTEM VALVING		21.88
OXIDIZER TANK		7.67
OXIZIZER TANK MOUNTING		1.68
OXIDIZER VALVING		4.52
FUEL TANK		8.54
FUEL TANK MOUNTING		1.34
FUEL VALVING		4.48
LINES, MISC.		8.41
SHUT-OFF VALVES		8.88
VALVING, MISC.		6.07
MOUNTING DETAILS, MISC.		0.72
HEATERS		3.76
CIRCUITRY		18.03
	TOTAL FOR REACTION CONTROL SYS	(143.62)

	TOTAL FOR PROPULSION	(143.62)
4. POWER		
BATTERIES		102.26
BATTERY MOUNTING		12.38
RELAY PANELS		13.62
DIODE PANEL		0.8
POWER/CONTROL CIRCUITRY		67.8
NOSE FAIRING SEP CIRCUITRY		2.36
RENDEZVOUS & RECOVERY SEP CIRC		8.84
ADAPTER SEPARATION CIRCUITRY		17.32
BOOSTER SEPARATION CIRCUITRY		2.8
MOUNTING & INSTALLATION, MISC		9.12
	TOTAL FOR ELECTRICAL POWER SYS	(237.3)
	TOTAL FOR POWER	(237.3)
6. AVIONICS		
PACKAGE		17.42
INVERTER		6.58
RATE GYROS		8.54
	TOTAL FOR ATTITUDE CNTRL ELECT	(32.54)
COMPUTER		58.89
PLATFORM		33.2
PLATFORM ELECTRONICS		39.75
POWER SUPPLY		47.9
AUXILIARY POWER SUPPLY		3.9
COMPUTER COLDPLATE		7.21
DISPLAY I/O		4.1
	TOTAL FOR INERTIAL GUIDANCE	(194.95)
HORIZON SENSORS		22.02
	TOTAL FOR HORIZON SENSORS	(22.02)
MOUNTING & INSTALLATION		10.83
	TOTAL FOR MOUNTING & INSTALLAT	(10.83)
CIRCUITRY		44.2
	TOTAL FOR CIRCUITRY	(44.2)
TAPE RECORDER		13.83
CAMERAS		11.27
TAPE CARTRIDGES		4.74
TRANSMITTERS (2)		5.04
MULTIPLEXERS		5.79
PCM PROGRAMMER		20.06
POWER CONVERTER/REGULATOR		13.92
DATA COND INSTR PKGS		12.04
SENSORS		12.86
BIO-MEDICAL		10.06
MOUNTINGS		2.86
CIRCUITRY		75.44
	TOTAL FOR INSTRUMENTATION	(187.91)
MULTIPLEXING/SWITCHING		4.72
UHF VOICE		6.26
C-BAND BEACON		10.67
VOICE CONTROL CENTER		6.29
MOUNTING		0.63
ANTENNAS		2.61
CIRCUITRY		28.89
	TOTAL FOR COMMUNICATION	(60.07)
	TOTAL FOR AVIONICS	(552.52)
7. ENVIRONMENT		

ENVIRONMENT INDICATOS	5.39
CIRCUITRY	26.15
ELECTRICAL INDICATORS	1.98
PROPULSION INDICATORS	6.33
RENDEZVOUS INDICATORS	5.21
TIME REFERENCE INDICATORS	11.73
FLIGHT DIRECTOR(ATTITUDE CNTR)	24.17
WARNING LIGHTS	6.12
PITOT STATIC SYSTEM	3.01
TOTAL FOR DISPLAYS	(90.09)
EJECTION SEATS (2)	141.73
EJECTION SEAT NON-PERSONAL KIT	103.58
EJECTION SEAT BACKBOARD	33.04
EJECTION SEAT BALLAST	34.43
EJECTION SEAT PYROTECHNICS	7.22
EJECTION SEAT CATAPULT	56.76
EGRESS KIT	50.3
SEAT BACKUP STRUCTURE	46.46
CIRCUITRY	3.26
CABIN INSULATION	13.63
FOOD STORAGE	14.7
WATER MANAGEMENT	15.
WASTE FACILITIES	10.6
CABIN LIGHTING	1.79
SUIT HOSE EXTENSION KIT	3.45
NAVIGATION AIDS	7.72
EXTRA VEHICULAR ACTIVITY	61.67
TOTAL FOR CREW SYSTEMS	(605.3399)
PRESSURE BREATHING VALVING	7.47
COMPRESSORS	9.14
POWER SUPPLIES, COMPRESSOR	8.62
CONTROLS	13.29
PRESS BREATHING MOUNTING/INSTA	7.12
SOLIDS TRAP	1.08
CARBON DIOXIDE ABSORBER	54.71
RENOVATING SYSTEM VALVING	10.67
DUCTS	18.37
MOUNTING, CO2 ABSORBER	6.98
CABIN HEAT EXCHANGER	12.85
SUIT HEAT EXCHANGER	18.82
CABIN FAN	1.35
HEAT EXCHANGER INSTL	0.73
COOLING FLUIDS	19.19
COLD PLATES	27.68
FLUID LINES	13.36
COOLING SYSTEM VALVING	4.32
COOLING SYSTEM MOUNTING/INSTAL	1.5
POWER SUPPLIES, FAN	2.92
SECONDARY OXYGEN SYSTEM TANKS	40.24
SECONDARY OXYGEN SYSTEM LINES	3.24
SECONDARY OXYGEN SYSTEM MOUNT	2.48
CIRCUITRY	13.85
TOTAL FOR ENVIRON CONTROL SYST	(299.98)
SWITCHES	2.03
FUSES	10.51
CIRCUIT BREAKERS	11.58
PANELS & CONSOLES	36.86
TOTAL FOR PANELS & CONSOLES	(60.98)
ABORT CONTROLS	1.67

	TOTAL FOR ABORT CONTROLS	(	1.67)
MANUAL CONTROLS			5.29
	TOTAL FOR MANUAL CONTROLS	(	5.29)
LIGHTS			2.11
	TOTAL FOR LIGHTS	(	2.11)
	TOTAL FOR ENVIRONMENT	(	1065.46)

8. OTHER

RETROGRADE CIRCUITRY			6.86
	TOTAL FOR RETROGRADE CIRCUITRY	(	6.86)
MAIN CHUTE			111.94
MAIN BRIDLE			7.6
MAIN CONTAINER			10.7
MAIN STRUCTURAL RING/HUB			19.79
MAIN CIRCUITRY			6.86
PILOT CHUTE			13.19
PILOT CHUTE INSTALLATION			6.61
DROGUE CHUTE			13.54
DROGUE CHUTE INSTALLATION			7.67
PILOT/DROGUE CIRCUITRY			11.17
	TOTAL FOR LANDING SYSTEM	(	209.07)
RECOVERY LIGHT			3.05
HF VOICE			12.74
RESCUE BEACON			4.49
DYE MARKER			1.25
STRUCTURAL MOUNTING			1.25
CIRCUITRY			6.55
	TOTAL FOR RECOVERY SYSTEM	(	29.33)
PROPULSION CIRCUITRY			6.15
DOCKING STRUCTURE/MECHANISM			14.32
DOCKING CONTROL			6.15
DOCKING CIRCUITRY			10.22
RADAR ELECTRONICS			74.31
ELECTRONIC CIRCUITRY			3.65
	TOTAL FOR RENDEZVOUS	(	114.8)
ACTUAL WT ADJUSTMENT			-7.
	TOTAL FOR ACTUAL WT ADJUSTMENT	(	-7.)
	TOTAL FOR OTHER	(	353.06)

10. NON-CARGO

CREW EQUIP STORAGE			5.
	TOTAL FOR CREW EQUIP STORAGE	(	5.)
CREW (2 IN SUITS)			416.
	TOTAL FOR CREW (2 IN SUITS)	(	416.)
BALLAST (CG OFFSET)			148.
	TOTAL FOR BALLAST (CG OFFSET)	(	148.)
	TOTAL FOR NON-CARGO	(	569.)

11. CARGO

EXPERIMENTS			27.
	TOTAL FOR EXPERIMENTS	(	27.)
	TOTAL FOR CARGO	(	27.)

12. NON-PROPELLANT

FOOD			5.
	TOTAL FOR FOOD	(	5.)
WATER (CREW)			15.
	TOTAL FOR WATER (CREW)	(	15.)
OXYGEN (CREW-SECONDARY)			14.

	TOTAL FOR OXYGEN (CREW-SEC)	(14.)
N2 GAS (RCS)		3.
	TOTAL FOR N2 GAS (RCS)	(3.)
	TOTAL FOR NON-PROPELLANT	(37.)
13. PROPELLANT		
FUEL		32.
OXIDIZER		40.
	TOTAL FOR RCS	(72.)
	TOTAL FOR PROPELLANT	(72.)
	GROSS VEHICLE WEIGHT	4860.851

NOTE: ALL MASS IS IN POUNDS.

MASS SUMMARY

GEMINI ADAPTER SECTION (1 JUN 65)

DATA POINT 2B

1. STRUCTURE	407	4. POWER	472	8. OTHER	368
SKIN RETRO SECTION	19	BATTERY	352	RETROGRADE SYSTEM	365
SKIN EQUIPMENT SEC	35	FUEL CELL	1	ACTUAL WEIGHT ADJUST	3
STIFFENERS, RETRO	29	POWER CIRCUITRY	31		
STIFFENERS, EQUIP	46	ADAPTER SEPARATION CIR	16		
RINGS, STIFFENING	63	BOOSTER SEPARATION CIR	4		
SPLICE RINGS	43	EXTERIOR LIGHTS	2		
SEPARATION PROV	61	BLAST SHIELD MOUNT	25	9. GROWTH	-
DOORS, EQUIP ACCESS	27	CROSS BEAM ASSY MOUNT	20	**DRY MASS**	2108
MISCL STRUCT	5	DETAILS MOUNT	21		
EQUIPMENT SUPPTS	20	5. CONTROL	-	10. NON-CARGO	-
FAIRINGS	17				
PAINT	37				
ATTACH HARDWARE	5				
2. PROTECTION	11	6. AVIONICS	138	11. CARGO	12
THERMAL CURTAIN	11	COMMUNICATIONS	30	EXPERIMENTS	12
		INSTRUMENTATION	108	**INERT MASS**	2120
				12. NON-PROPELLANT	88
				WATER (CREW PRIMARY)	30
				OXYGEN (CREW PRIMARY)	54
3. PROPULSION	407			HELIUM GAS (OAMS)	4
THRUSTERS 99, MTG 49	148			(OAMS IS ORBIT AND	
PRESS SYS TANK	37			MANEUVERING SYS.)	
PRESS SYS VALVING	15				
OXIDIZER SYS TANKS	19	7. ENVIRONMENT	305	13. PROPELLANT	689
OXIDIZER SYS VALVING	2	PRESSURE BREATHING	51	OAMS FUEL	310
FUEL SYS TANKS	21	COOLING SYSTEM	192	OAMS OXIDIZER	379
FUEL SYS VALVING	2	BLAST SHIELD	16		
SHUTOFF VALVES	7	CIRCUITRY	14		
PROPEL QUANTITY SYS	21	MOUNTING STRUCT	17		
CIRCUITRY	23	WATER TANK (CREW)	7		
ESLECTRONICS	7	WATER SYSTEM	6		
BLAST SHLD 29, BEAM 15	44	STRUCT PROV, EVA	2	**GROSS MASS**	2897
MOUNTING AND INSTL	61				

GEMIMP03 CCSD WH 9 NOV 92

GEMINI ADAPTER MODULE
DESIGN MASS SUMMARY (JSC FORMAT)

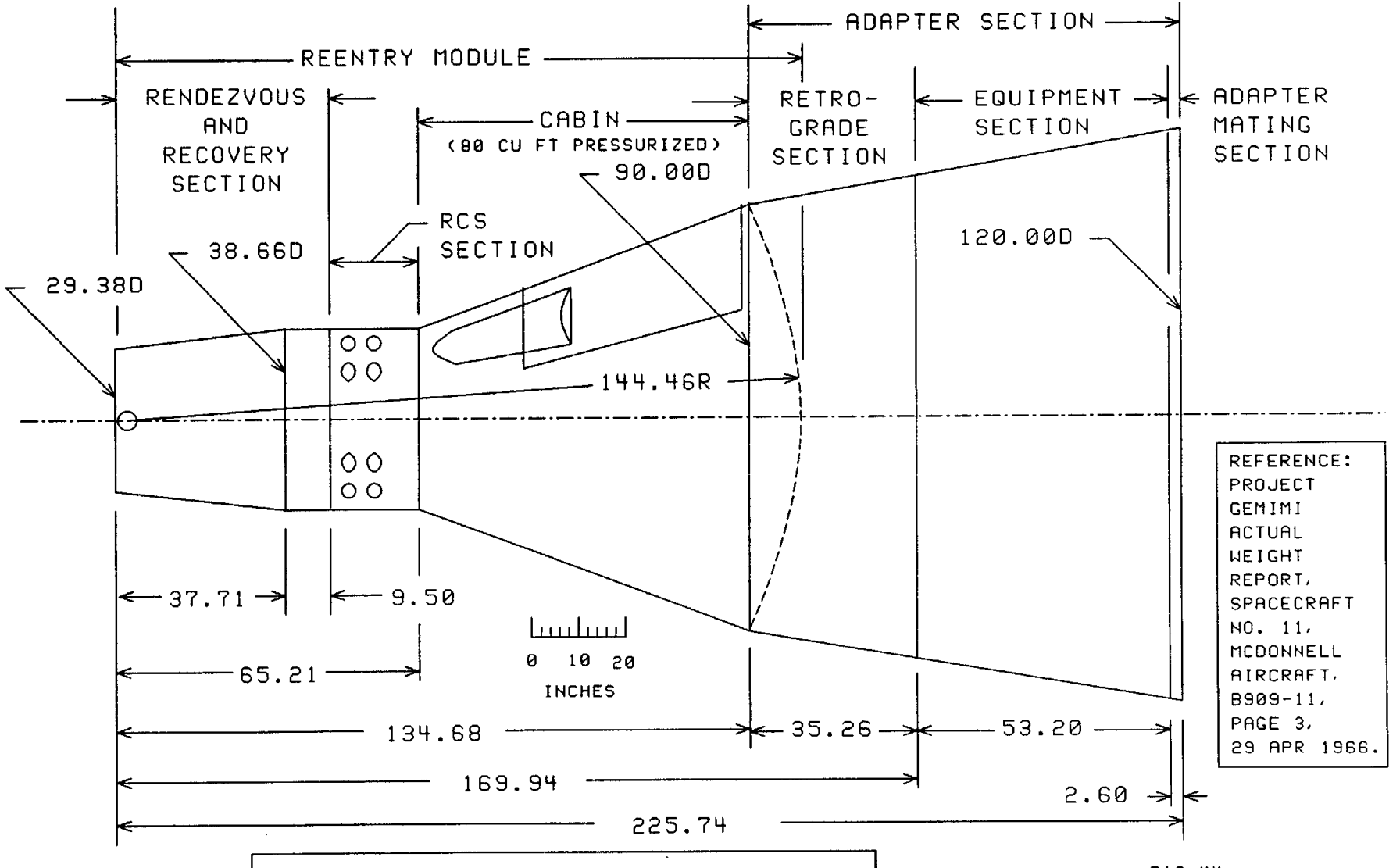
ALL MASS IN POUNDS

1. STRUCTURE			
	RETRO SECTION		18.68
	EQUIPMENT SECTION		35.01
		TOTAL FOR SKIN	(53.69)
	PANELS/RADIATORS, RETRO		29.13
	PANELS/RADIATORS, EQUIPMENT		46.32
		TOTAL FOR STIFFENERS	(75.45)
	RINGS, STIFFENING		62.92
		TOTAL FOR RINGS, STIFFENING	(62.92)
	RETRO TO EQUIPMENT SECTION		14.17
	ADAPTER TO BOOSTER		21.7
	REENTRY MODULE TO ADAPTER		6.96
		TOTAL FOR RINGS, SPLICE	(42.83)
	BOOSTER TO ADAPTER		18.26
	RETRO TO EQUIP SECTION		19.6
	REENTRY MODULE TO ADAPTER		21.05
	SPRING CARTRIDGE		2.01
		TOTAL FOR SEPARATION PROVISION	(60.92)
	DOORS, EQUIP ACCESS		27.42
		TOTAL FOR DOORS, EQUIP ACCESS	(27.42)
	MISCL STRUCT DETAILS		4.58
		TOTAL FOR MISCL STRUCT DETAILS	(4.58)
	EQUIPMENT SUPPORTS		20.
		TOTAL FOR EQUIPMENT SUPPORTS	(20.)
	FAIRINGS		17.05
		TOTAL FOR FAIRINGS	(17.05)
	PAINT		36.56
		TOTAL FOR PAINT	(36.56)
	ATTACHING HARDWARE		5.24
		TOTAL FOR ATTACHING HARDWARE	(5.24)
		TOTAL FOR STRUCTURE	(406.66)
2. PROTECTION			
	THERMAL CURTAIN		10.8
		TOTAL FOR THERMAL CURTAIN	(10.8)
		TOTAL FOR PROTECTION	(10.8)
3. PROPULSION			
	THRUSTERS		98.56
	THRUSTER MOUNTING		49.33
	PRESSURE TANK		37.12
	PRESSURE VALVING		15.04
	OXIDIZER TANKS		18.48
	OXIDIZER VALVES		2.25
	FUEL TANKS		21.26
	FUEL VALVES		2.23
	SHUTOFF VALVES		7.24
	PROPEL QUANTITY SYSTEM		21.06
	CICUITRY		23.08
	OAMS ELECTRONICS		7.4
	BLAST SHIELD		28.99
	CROSS BEAM		14.73
	MOUNTING & INSTALLATION		60.85
		TOTAL FOR ORBIT ATT & MANEUVER	(407.62)
		TOTAL FOR PROPULSION	(407.62)

4. POWER		
	BATTERY	351.93
	FUEL CELL	0.74
	POWER CIRCUITRY	31.02
	ADAPTER SEPARATION CIRCUITRY	16.06
	BOOSTER SEPARATION CIRCUITRY	4.2
	EXTERIOR LIGHTS	1.82
	BLAST SHIELD	25.11
	CROSS BEAM ASSEMBLY	20.08
	DETAILS	20.55
	TOTAL FOR ELECTRICAL POWER SYS	(471.51)
	TOTAL FOR POWER	(471.51)
6. AVIONICS		
	HF VOICE	7.3
	C BAND BEACON	10.66
	ACQUISITION AID TRANSMITTER	1.02
	MULTIPLEXING/SWITCHING	0.49
	UHF EXTENDABLE ANTENNA	0.8
	MOUNTING	2.62
	CIRCUITRY	7.12
	TOTAL FOR COMMUNICATIONS	(30.01)
	TRANSMITTER	2.52
	MULTIPLEXING/SWITCHING	6.97
	COMMAND SYSTEM	21.97
	INSTRUMENTATION PACKAGES	4.38
	SENSORS	4.04
	BLAST SHIELD	14.88
	STRUCTURAL MOUNTING	13.55
	CIRCUITRY	39.7
	TOTAL FOR INSTRUMENTATION	(108.01)
	TOTAL FOR AVIONICS	(138.02)
7. ENVIRONMENT		
	PRESSURE BREATHING BOTTLE	42.19
	PRESSURE BREATHING VALVING	2.79
	PRESS BREATHING LINES/DUCTING	5.85
	HEAT EXCHANGERS	34.6
	COOLING FLUID	38.36
	LAUNCH COOLANT WATER	7.
	PUMPS	49.22
	COLD PLATES	14.6
	LINES AND CLAMPS	22.47
	VALVING	10.26
	COOLANT RESERVOIR	12.34
	INSTALLATION DETAILS	2.91
	BLAST SHIELD	16.39
	CICUITRY	13.63
	STRUCTURAL MOUNTING	17.34
	TOTAL FOR ENVIRON CONTROL SYS	(289.95)
	WATER TANK (CREW)	7.29
	WATER MANAGEMENT SYSTEM	6.07
	EVA STRUCTURAL PROVISIONS	2.01
	TOTAL FOR CREW SYSTEMS	(15.37)
	TOTAL FOR ENVIRONMENT	(305.32)
8. OTHER		
	CASE	43.84

PROPELLANT			222.48
IGNITORS			3.28
TRUSS			27.89
ATTACH FITTINGS			9.93
CIRCUITRY			11.67
BLAST SHIELD			28.81
MISCL ATTACHMENTS			3.85
SHRAPNEL PROTECTION			13.25
	TOTAL FOR RETROGRADE SYSTEM	(	365.)
ACTUAL WT ADJUSTMENT			3.39
	TOTAL FOR ACTUAL WT ADJUSTMENT	(	3.39)
	TOTAL FOR OTHER	(	368.39)
11. CARGO			
EXPERIMENTS			12.
	TOTAL FOR EXPERIMENTS	(	12.)
	TOTAL FOR CARGO	(	12.)
12. NON-PROPELLANT			
WATER (CREW PRIMARY)			30.
	TOTAL FOR WATER (CREW PRIMARY)	(	30.)
OXYGEN(CREW PRIMARY)			54.
	TOTAL FOR OXYGEN(CREW PRIMARY)	(	54.)
HELIUM GAS (OAMS)			4.
	TOTAL FOR HELIUM GAS (OAMS)	(	4.)
	TOTAL FOR NON-PROPELLANT	(	88.)
13. PROPELLANT			
OAMS FUEL			310.
	TOTAL FOR OAMS FUEL	(	310.)
OAMS OXIDIZER			379.
	TOTAL FOR OAMS OXIDIZER	(	379.)
	TOTAL FOR PROPELLANT	(	689.)
	GROSS VEHICLE WEIGHT		2897.32

GEMINI SPACECRAFT



REFERENCE: PROJECT GEMIMI ACTUAL WEIGHT REPORT, SPACECRAFT NO. 11, MCDONNELL AIRCRAFT, B909-11, PAGE 3, 29 APR 1966.

NOTE: ALL DIMENSIONS ARE IN INCHES.

GEMIDR01 CCSD WH 24 AUG 93

JSC-26098

NOTE: ALL MASS IS IN POUNDS.

DATA POINT (3)

DESIGN MASS SUMMARY

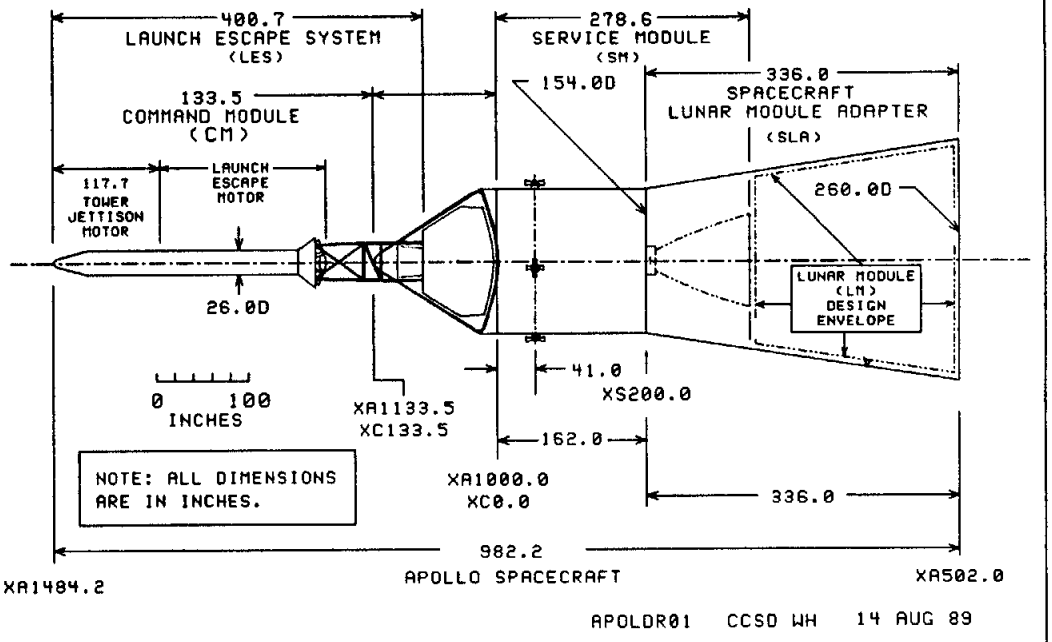
APOLLO SPACECRAFT (1 MAR 71)

SPACECRAFT 112, MISSION J1

FUNCTIONAL SYSTEM CODE	A	B	C	D
1. STRUCTURE	1316	1820	3227	3218
2. PROTECTION	1006	3730	544	250
3. PROPULSION	2278	295	3192	-
4. POWER	67	1414	2042	60
5. CONTROL	84	-	-	-
6. AVIONICS	-	934	428	-
7. ENVIRONMENT	-	1749	221	-
8. OTHER	1225	1292	953	538
9. GROWTH	-	-	-	-
DRY MASS	5976	11234	10607	4066
10. NON-CARGO	-	1254	933	-
11. CARGO	-	305	50	-
INERT MASS	5976	12793	11590	4066
12. NON-PROPELLANT	-	54	999	-
13. PROPELLANT	3197	209	41910	-
GROSS MASS (80794) LM 36236 117030	9173	13056	54499	4066

PRIMARY REFERENCE: APOLLO SPACECRAFT OPERATIONAL DATA BOOK, SNA-8-D-027(I), REVISION 3, AMENDMENT 64, 16 APRIL 1971.

FIGURE 2-3, APOLLO SPACECRAFT REFERENCE DIMENSIONS, 16 APRIL 1971.



APOLDR01 CCSD WH 14 AUG 89

NOTE:

A. LAUNCH ESCAPE SYSTEM (LES)
B. COMMAND MODULE (CM)
C. SERVICE MODULE (SM)
D. SPACECRAFT LUNAR MODULE ADAPTER (SLA) (DESIGNED TO CONTAIN LUNAR MODULE (LM).)

	CM	SM	SLA
DESIGN-ENVELOPE VOLUME, V_{de} (CU FT)	559	1970	6540
PRESSURIZED VOLUME, V_{pr} (CU FT)	[a] 366		
DESIGN-ENVELOPE SURF AREA, A_{de} (SQ FT)	[a] 377	613	[a] 1515

DESIGN MISSION, 11 DAYS MAX; CREW OF THREE. [a] SIDEWALL ONLY.

APOLMP01 CCSD WH 20 AUG 93

NOTE: ALL MASS IS IN POUNDS.

MASS SUMMARY

APOLLO LAUNCH ESCAPE SYSTEM (LES), 1 MAR 71

DATA POINT 3A

SPACECRAFT 112
MISSION J1

1. STRUCTURE	1316	4. POWER	67	8. OTHER	1225
CANARD SURFACES	239	ELECTRICAL TRANSM	43	LES ORD AND SEP PROV	44
CANARD SECT FIXED STR	525	ELECTRICAL HARDWARE	24	Q BALL	25
CANARD FITTINGS	4			PYRO INITIATORS	1
SKIRT	196			BALLAST	1155
SKIRT FITTINGS	26				
TOWER STRUCTURE	206			9. GROWTH	-
TOWER FITTINGS	70			**DRY MASS**	5976
MISCL ATTACH	21				
SECONDARY STRUCTURE	29	5. CONTROL	84	10. NON-CARGO	-
		CANARD ACTUATOR MECHN	84		
2. PROTECTION	1006	6. AVIONICS	-	11. CARGO	-
INSULATION				**INERT MASS**	5976
SKIRT	10				
TOWER	107			12. NON-PROPELLANT	-
COMMAND MODULE	889				
BOOST PROT COVER					
3. PROPULSION	2278				
PITCH MOTOR EXPENDED	41				
JETTISON MOTOR	558				
ESCAPE MOTOR EXPENDED	1679				
		7. ENVIRONMENT	-	13. PROPELLANT	3197
				PITCH MOTOR	9
				ESCAPE MOTOR	3188
				GROSS MASS	9173

APOLMP02 CCSD WH 9 NOV 92

APOLLO LAUNCH ESCAPE SYSTEM JSC-26098
DESIGN MASS SUMMARY (JSC FORMAT)

ALL MASS IN POUNDS

1. STRUCTURE			
	FITTINGS AND ATTACH PARTS		4.2
	CANARD SURFACES		239.6
	CANARD SECTION-FIXED STRUCTURE		525.6
	TOTAL FOR BASIC BODY STRUC-FWD	(	769.4)
	FITTINGS AND ATTACH PARTS		0.5
	TOTAL FOR BASIC BODY STRUC-CTR	(	0.5)
	FITTINGS AND ATTACH PARTS		13.
	ESCAPE MOTOR SKIRT-SKINS		49.5
	ESCAPE MOTOR SKIRT-FRAMES		146.8
	ESCAPE MOTOR SKIRT-FITTINGS		12.
	TOWER STRUCTURE		206.
	TOWER FITTINGS		69.8
	MISC AND ATTACH		21.1
	TOTAL FOR BASIC BODY STRUC-AFT	(	518.2)
	BALLAST INSTALLATION PROVISION		29.2
	TOTAL FOR SECONDARY STRUCTURE	(	29.2)
	TOTAL FOR STRUCTURE	(	1317.3)
2. PROTECTION			
	ESCAPE MOTOR SKIRT INSULATION		9.5
	TOWER INSULATION		106.6
	C/M BOOST PROTECTION COVER INS		889.6
	TOTAL FOR INSULATION	(	1005.7)
	TOTAL FOR PROTECTION	(	1005.7)
3. PROPULSION			
	PITCH MOTOR EXPENDED		40.6
	JETTISON MOTOR		557.8
	ESCAPE MOTOR EXPENDED		1678.5
	TOTAL FOR ENGINE SYSTEM	(	2276.9)
	TOTAL FOR PROPULSION	(	2276.9)
4. POWER			
	ELECTRICAL TRANSMISSION		43.4
	INSTALLATION HARDWARE		23.6
	TOTAL FOR ELECTRICAL POWER SYS	(	67.)
	TOTAL FOR POWER	(	67.)
5. CONTROL			
	CANARD ACTUATING MECHANISM		83.7
	TOTAL FOR SYSTEM ACTUATION	(	83.7)
	TOTAL FOR CONTROL	(	83.7)
8. OTHER			
	TOWER-COMMAND MODULE SEPARATIO		4.
	PYROTECHNICS		40.
	TOTAL FOR ORDNANCE & SEPAR SYS	(	44.)
	Q-BALL		25.
	PYROTECHNIC INITIATORS		1.
	TOTAL FOR GOV FURNISHED EQUIP	(	26.)
	BALLAST		1155.
	TOTAL FOR BALLAST	(	1155.)
	TOTAL FOR OTHER	(	1225.)

13. PROPELLANT		
PITCH MOTOR		9.
ESCAPE MOTOR		3188.
	TOTAL FOR PROPELLANT - SOLID	(3197.)
	TOTAL FOR PROPELLANT	(3197.)
	GROSS VEHICLE WEIGHT	9172.601

NOTE: ALL MASS IS IN POUNDS.

MASS SUMMARY

APOLLO COMMAND MODULE (CM), 1 MAR 71

DATA POINT 3B

SPACECRAFT 112
MISSION J1

1. STRUCTURE	1820	4. POWER	1414	8. OTHER	1292
PRIMARY BODY STRU		ELECTR PWR SYST (EPS)	1414	MISCL 27; MANU VAR -130	-103
FORWARD SECTION	245			BALLAST	163
CENTER SECTION	735			ORDINANCE AND SEPARA	35
AFT SECTION	207			DOCKING PROV	248
SECONDARY BODY STRU	626			EARTH IMPACT AND RECOV	270
ALEM STRUCT DELTA	7			EARTH LANDING SYST	679
				9. GROWTH	-
				DRY MASS	11234
		5. CONTROL	-	10. NON-CARGO	1254
				CREW	504
				CREW EQUIP	464
				MISCL EQ 11; ALEM 69	80
				ECS RESIDUALS	169
				RCS RESIDUALS	37
2. PROTECTION	3730	6. AVIONICS	934	11. CARGO (RETURN)	305
HEAT SHIELD SUBSTRUC		STABILIZATION AND CONTR	202		
FORWARD SECTION	177	INSTRUMENTATION	37	**INERT MASS**	12793
CENTER SECTION	1131	COMMUNICATIONS	302		
AFT SECTION	787			12. NON-PROPELLANT	54
ABLATOR MATERIAL	1472	GUID, NAV, AND CONTR	393	WATER (USABLE)	54
INSULATION	163				
3. PROPULSION	295				
REACT CONTR SYST (RCS)	295				
		7. ENVIRONMENT	1749		
		CREW SYSTEMS	448	13. PROPELLANT	209
		ENVIRON CONTR SYS (ECS)	573	RCS	
		CREW COUCH	289	USABLE	209
		(UNITIZED; ATTENUA-		UNUSABLE	0
		TION 111 LB IS IN			
		CODE 8.0 (EARTH			
		IMPACT SYSTEM.)			
		LIGHTING	21		
		CONTROLS AND PANELS	363	**GROSS MASS**	13056
		DISPLAYS	55		

APOLMP03 CCSD WH 9 NOV 92

APOLLO COMMAND MODULE
DESIGN MASS SUMMARY (JSC FORMAT)

ALL MASS IN POUNDS

1. STRUCTURE		
	HONEYCOMB PANELS	60.4
	LONGERONS	2.4
	FRAMES AND RINGS	64.7
	WINDOWS,HATCHES,ACC DOORS&FRAM	0.9
	MECHANISMS	33.3
	BODY TO HEAT SHIELD ATTACH	0.5
	FITTINGS AND ATTACH PARTS	82.6
	TOTAL FOR BASIC BODY STRUC-FWD (	244.8)
	HONEYCOMB PANELS	259.1
	LONGERONS	112.4
	FRAMES AND RINGS	150.2
	WINDOWS,HATCHES,ACC DOORS&FRAM	96.3
	BODY TO HEAT SHIELD ATTACH	54.2
	FITTINGS AND ATTACH PARTS	63.
	TOTAL FOR BASIC BODY STRUC-CTR (	735.2)
	HONEYCOMB PANELS	126.
	FRAMES AND RINGS	77.9
	BODY TO HEAT SHIELD ATTACH	2.6
	FITTINGS AND ATTACH PARTS	0.1
	TOTAL FOR BASIC BODY STRUC-AFT (	206.6)
	RH EQUIPMENT BAY	130.9
	LH EQUIPMENT BAY	131.6
	FORWARD LH EQUIPMENT BAY	25.1
	FORWARD RH EQUIPMENT BAY	41.9
	MAIN DISPLAY PANEL	37.4
	LOWER EQUIPMENT BAY	184.7
	FORWARD COMPARTMENT AREA	5.
	AFT EQUIPMENT BAY	22.5
	AFT COMPT AREA WIRE SUPPORTS	7.9
	AFT COMPT AREA EQUIP SUPPORTS	39.
	TOTAL FOR SECONDARY STRUCTURE (	626.)
	ALEM STRUCTURE PROVISIONS DELT	6.8
	TOTAL FOR ALEM STRUCTURES DELT (	6.8)
	TOTAL FOR STRUCTURE (	1819.4)
2. PROTECTION		
	HONEYCOMB PANELS	67.7
	FRAMES AND RINGS	27.9
	ACCESS DOORS	0.1
	FITTINGS AND ATTACH PARTS	42.6
	WINDOWS AND HATCH COVERS	37.9
	CLOSEOUTS	0.8
	TOTAL FOR HEAT SHIELD SUB-FWD (	177.)
	HONEYCOMB PANELS	243.8
	FRAMES AND RINGS	124.1
	ACCESS DOORS	340.6
	BODY STRUCTURE TO HS ATTACH	120.7
	FITTINGS AND ATTACH PARTS	97.8
	WINDOWS AND HATCH COVERS	64.8
	MECHANISMS	91.
	CLOSEOUTS	20.9
	AIR VENT	27.7
	TOTAL FOR HEAT SHIELD SUB-CTR (	1131.4)
	HONEYCOMB PANELS	556.6

FRAMES AND RINGS		55.8
BODY STRUCTURE TO HS ATTACH		50.4
FITTINGS AND ATTACH PARTS		66.
WINDOWS AND HATCH COVERS		0.3
CLOSEOUTS		7.1
TOROIDAL ASSEMBLY		50.6
	TOTAL FOR HEAT SHIELD SUB-AFT	(786.7999)
FORWARD SECTION ABLATOR		135.3
CENTER SECTION ABLATOR		407.5
AFT SECTION ABLATOR		929.6
	TOTAL FOR ABLATOR MATERIAL	(1472.4)
FORWARD SECTION INSULATION		17.6
CENTER SECTION INSULATION		83.
AFT SECTION INSULATION		62.8
	TOTAL FOR INSULATION	(163.4)
	TOTAL FOR PROTECTION	(3731.)
3. PROPULSION		
TANKS AND EXPULSION FUEL		13.4
PLUMBING AND FITTINGS FUEL		19.6
VALVES AND REGULATORS FUEL		10.5
SUPPORTS FUEL		5.6
TANKS AND EXPULSION OXID		14.8
PLUMBING AND FITTINGS OXID		20.
VALVES AND REGULATORS OXID		10.5
SUPPORTS OXID		7.7
TANKS PRESS		10.2
PLUMBING AND FITTINGS PRESS		7.5
VALVES AND REGULATORS PRESS		22.4
SUPPORTS PRESS		7.1
ENGINES		97.2
ENGINE SUPPORTS		1.3
ENGINE NOZZLE INSERTS		47.
	TOTAL FOR REACTION CONTROL SYS	(294.8)
	TOTAL FOR PROPULSION	(294.8)
4. POWER		
BATTERY-ENTRY ENERGY SOURCE		56.6
BATTERY-POST LAND ENERGY SOURC		28.3
BATTERY-PYROTECH ENERGY SOURCE		5.2
PLUMBING-ENERGY SOURCE		1.6
EQUIPMENT SUPPORTS		1.
INVERTERS-POWER CONVERSION		157.5
BATTERY CHARGER-POWER CONVERS		4.6
DC POWER PANEL		8.6
AC POWER BOX		10.
BATTERY CIRCUIT BREAKER PANEL		4.7
ELECTRICAL POWER CIRC BKR PNL		3.2
UPRIGHTING SYSTEM		9.5
TERMINAL DISTRIBUTION PANELS		18.6
SUPPORTS AND INSTALLATION PROV		1.5
ELECTRICAL HARNESS INST		729.7
LOWER EQUIP BAY MOTOR SWITCHES		6.8
CIRCUIT INTERRUPTORS		30.5
RCS CONTROLLER		26.4
SUPPORTS AND INSTALLATION PROV		131.1
JUNCTION BOX ASSEMBLY		7.8
MASTER EVENT SEQUENCE CONTROL		113.4
PYRO CONTINUITY BOX		10.8

SUPPORTS AND HARDWARE		3.5
CONTROLLER-POST LANDING VENT		3.5
ALEM EPS DELTA		39.3
TOTAL FOR ELECTRICAL POWER SYS	(	1413.7)
TOTAL FOR POWER	(	1413.7)

6. AVIONICS

GYRO PACKAGE		45.
CONTROL ELECTRONICS		16.5
SERVO AMPLIFIER		12.4
DISPLAY ELECTRONICS		24.8
SOLENOID DRIVER AMPLIFIER		20.6
GYRO DISPLAY COUPLER		24.7
GYRO PACKAGE MOUNTING PLATE		4.6
DISPLAY AND CONTROLS		53.2
TOTAL FOR STABILIZATION&CONTRO	(	201.8)
SIGNAL CONDITIONERS		7.7
ACCELEROMETERS		1.2
MISCELLANEOUS INSTRUMENTATION		14.8
TV CAMERA & LENS		0.3
IFTS & GSE ELECTRICAL PROVISIO		4.5
DATA DISTRIBUTION PANEL		3.4
INSTRUMENTATION SUPPORTS		4.9
TOTAL FOR INSTRUMENTATION	(	36.8)
UNIFIED S-BAND		31.7
S-BAND POWER AMPLIFIER		31.7
MULTIPLEXER		6.1
SIGNAL CONDITIONER		34.2
RECORDER		39.6
AUDIO CENTER		7.6
PREMODULATOR PROCESSOR		11.5
CENTRAL TIMER		6.6
UP DATA LINK		21.
VHF-AM TRANSMITTER-RECEIVER		13.5
RECOVERY BEACON		2.5
TRIPLEXER		1.6
PCM		42.1
HF/VHF RECOVERY ANT TRNSM LINE		11.4
2KMC HIGH GAIN ANT TRANS LINE		0.4
VHF OMNI ANT TRANS LINES&SW		2.8
2KMC OMNI ANT & TRANS LINES		28.1
VIDEO COAX & CONNECTORS		1.6
COMMUNICATIONS SUPPORTS		1.
ALEM COMMUNICATIONS DELTA		7.3
TOTAL FOR COMMUNICATIONS	(	302.3)
PIPA ELECTRONICS ASSY		8.5
SIGNAL CONDITIONER ASSY		5.8
COMPUTER KEYBOARD		36.
INDICATOR CONTROL PANEL		14.4
BELLOWS ASSY		10.7
OPTICAL SUSBSYSTEM		60.7
OPTICAL SHROUD		3.4
OPTICAL EYEPIECE STORAGE ASSY		9.
ELECTRICAL PROVISIONS		25.4
NAVIGATION BASE		17.4
POWER SERVO ASSY		49.2
INERTIAL MEASUREMENT UNIT		45.2
APOLLO GUIDANCE COMPUTER		70.7
COUPLING DATA UNIT		36.5

TOTAL FOR GN&C	(392.9)
TOTAL FOR AVIONICS	(933.8001)

7. ENVIRONMENT

MASTER CAUTION LIGHTS	13.9
CAUTION AND WARNING SYSTEM	6.5
ENTRY MONITOR DISPLAY	21.3
G-METER	0.9
LAUNCH VEHICLE EDS	0.9
CAUTION & ABORT LT	0.5
BAROMETRIC INDICATOR	1.5
EVENT TIMER	1.5
SPS CHAMBER PRESS&ANGLE OF ATT	0.7
REACTION CONTROL DISPLAY	6.1
GMT READOUT	1.1
TOTAL FOR DISPLAYS	(54.9)
RESTRAINTASSY-REST STATION,CRE	10.3
DELIVERY ASSY-WATER,PERSONAL	5.
LINES AND FITTINGS	5.5
WASTE BAGS	7.2
WIRING-COMMON UTILITY	0.8
SUPPORTS	3.4
UMBILICAL-CREWMAN	28.2
ELECTRICAL UMBILICAL-PGA	16.6
MISCELLANEOUS	29.3
BODY MOUNTED MIRRORS	3.8
OPTICAL DOCKING AID	3.3
REMOVABLE ITEMS	200.8
PERMANENT ITEMS	29.6
ALEM CREW SYSTEMS DELTA	104.2
TOTAL FOR CREW SYSTEMS	(448.)
PRESSURE SUIT CIRCUIT CONTROLS	1.9
PRESSURE SUIT CIRC CO2 SENSOR	2.7
PRESSURE SUIT DUCTING,FITTINGS	9.4
WATER GLYCOL CIRCUIT CONTROLS	1.7
WATER GLYCOL CIRCUIT PLUMBING	35.5
WATER GLYCOL	48.9
WATER GLYCOL CIRCUIT COLDPLATE	46.9
WATER GLYCOL SUPPORTS&HARDWARE	2.8
PRESS AND TEMP VALVES	4.3
PRESS AND TEMP DUCTING	1.8
PRESS AND TEMP PLUMBING	0.6
PRESS AND TEMP SUPPORTS&HARDWA	7.
OXYGEN SUPPLY VALVES&REGULATOR	3.
OXYGEN SUPPLY CONTROLS	1.4
OXYGEN SURGE TANK	8.9
OXYGEN SUPPLY EMERGENCY TANKS	12.6
OXYGEN SUPPLY PLUMBING	10.6
OXYGEN SUPPLY SUPPORTS&HARDWAR	16.1
WATER SUPPLY SYSTEM VALVES	0.3
WATER SUPPLY POTABLE WATER TNK	7.8
WATER SUPPLY WASTE WATER TANK	10.9
WATER SUPPLY SYSTEM PLUMBING	6.8
WATER SUPPLY SUPPORTS&ATTCH	1.7
COMMON ITEMS LEM PRESS SYSTEM	6.5
COMMON ITEMS SUPPORTS	0.2
WASTE MANAGEMENT WASTE DISPOSA	6.2
WASTE MANAGEMENT VALVES	3.4
WASTE MANAGEMENT LINES&FITTING	2.8

WASTE MANAGEMENT LINES&FITTING		18.4
WASTE MGMT PLUMB INST HDWR		5.8
POST LAND VENTILATION SYSTEM		8.1
ENVIRONMENTAL CONTROL UNIT		170.6
OXYGEN CONTROL PANEL		14.3
WATER CONTROL PANEL		2.6
END ITEMS		81.2
ALEM ECS DELTA		9.4
TOTAL FOR ENVIRON CONTROL SYS	(	573.1)
CREW COUCH UNITIZED		286.8
MANUAL CONTROLS AIR PRESS REG		2.9
TOTAL FOR MECHANICAL SUBSYSTEM	(	289.7)
MODE SELECT FUNCTION-SWITCHES		3.1
CREW SAFETY CONTROLS		3.9
CONTROL STATION MOUNTING PANEL		26.8
CONTROL STATION MISC SWITCHES		2.7
ECS GASES 7 CONTROL		8.4
HIGH GAIN ANTENNA CONTROL		1.8
CRYOGENIC CONTROLS		6.6
CENTER STATION MOUNTING PANEL		45.3
CENTER STATION MISC SWITCHES		5.
COMMUNICATIONS CONTROLS		6.6
POWER DISTRIBUTION CONTROLS		2.2
FUEL CELL CONTROLS		6.7
SERVICE PROPULSION CONTROLS		9.8
SYS MGMT STA MOUNTING PANEL		28.6
SYS MGMT STA MISC SWITCHES		0.1
RH CONSOLE BUS SWITCHES		2.4
RH CONSOLE AUDIO PANEL		2.5
RH CONSOLE LIGHTING CONTROL		2.6
RH CONSOLE CIRCUIT BREAKERS		9.4
RH CONSOLE MOUNTING PANELS		14.5
MISSION SEQUENCE CONTROLS		2.
LH CONSOLE LIGHTING CONTROLS		4.3
LH CONSOLE AUDIO PANEL		3.2
SCS POWER CONTROL		3.4
LH CONSOLE CIRCUIT BREAKERS		7.2
LH CONSOLE MOUNTING PANEL		14.7
LH CONSOLE MISC SWITCHES		0.3
LOWER EQUIP BAY LIGHTING CONTR		5.8
TIMERS		2.4
NAV AUDIO CONTROL		1.8
RCS		3.4
LOWER EQUIP BAY PANELS		11.3
LH FWD EQUIP BAY PANEL		0.3
CIRCUIT BREAKERS-PANEL 11		3.7
CIRCUIT BREAKERS-PANEL 13		4.5
RH FWD EQUIP BAY PANELS		14.5
INSTR DATA DISTR PANEL		2.4
PANEL WIRING & CONNECTORS		68.5
ALEM CONTROLS & DISPLAYS DELTA		20.3
TOTAL FOR CONTROLS	(	363.)
WINDOW SHADES		6.6
INTERNAL LIGHTING		14.6
TOTAL FOR LIGHTING	(	21.2)
TOTAL FOR ENVIRONMENT	(	1749.9)

8. OTHER

AFT H/S - C/M BALLAST	162.6

	TOTAL FOR BALLAST	(162.6)
MANUFACTURING VARIATIONS		-130.
	TOTAL FOR MANUFACTURING VARIA	(-130.)
EVA HAND HOLDS		27.1
	TOTAL FOR EVA HAND HOLDS	(27.1)
PYROTECHNICS		11.
CM-LES ATTACH		3.7
CM-SM ATTACH		17.1
PYROTECHNIC INITIATORS		3.3
	TOTAL FOR ORDNANCE&SEP PROVIS	(35.1)
DOCKING PROVISIONS - LM		247.5
	TOTAL FOR DOCKING PROVISIONS	(247.5)
CRUSHABLE RIBS		45.8
CREW COUCH ATTENUATION		110.9
SINGLE POINT FLOTATION SYSTEM		62.9
SEA PICK-UP HOOK		15.
PARACHUTE ATTACH FITTINGS		31.6
RECOVERY AIDS		4.3
	TOTAL FOR EARTH IMPACT AND REC	(270.5)
DROGUE CHUTE SYSTEM		97.8
PILOT CHUTE SYSTEM		28.9
MAIN CHUTE CLUSTER		432.
DISCONNECT MAIN CLUSTER		30.
PARACHUTE SEQUENCE CONTROL		0.7
PARACHUTE ATTACH PROVISIONS		5.2
DYE MARKER		1.9
FLASHING LIGHT AND COMPONENT		4.2
HS EJECTOR		36.8
HS PLUMBING		5.1
HS BREECH		18.6
HS ATTACH PROVISIONS		18.3
	TOTAL FOR EARTH LANDING SYSTEM	(679.5)
	TOTAL FOR OTHER	(1292.3)
10. NON-CARGO		
COMMANDER - LH COUCH		183.
CM PILOT - CTR COUCH		159.
LM PILOT - RH COUCH		162.
	TOTAL FOR CREW	(504.)
FLIGHT CREW SUPPORT		76.2
CREW SYSTEMS		289.8
MED RESEARCH OPERATIONS		73.9
SPACE PHYSICS		2.8
TELECOMMUNICATIONS SYSTEM		18.9
GUIDANCE AND CONTROL		2.3
	TOTAL FOR CREW EQUIPMENT	(463.9)
ORDEAL		6.9
VAN ALLEN BELT DOSIMETER		3.3
MISCELLANEOUS		0.7
	TOTAL FOR MISCELLANEOUS EQUIP	(10.9)
CREW SYSTEMS ALEM		16.
MED RESEARCH OPERATIONS ALEM		50.
ADVANCED SYSTEM		2.9
	TOTAL FOR ALEM CREW EQUIP	(68.9)
FUEL RESIDUALS		13.3
OXIDIZER RESIDUALS		23.1
HELIUM-PRESSURIZATION		1.
	TOTAL FOR RCS RESIDUALS	(37.4)
SURGE TANK		3.7

REPRESSURIZATION TANKS		3.
LIOH CARTRIGE		100.
POTABLE WATER		1.
WASTE WATER		1.
ALEM ECS NON EXPENDABLE DELTA		60.
	TOTAL FOR ECS RESIDUALS	(168.7)
	TOTAL FOR NON-CARGO	(1253.8)
11. CARGO		
RETURNED CARGO		305.
	TOTAL FOR RETURNED CARGO	(305.)
	TOTAL FOR CARGO	(305.)
12. NON-PROPELLANT		
POTABLE WATER		36.
WASTE WATER		18.
	TOTAL FOR WATER (USABLE)	(54.)
	TOTAL FOR NON-PROPELLANT	(54.)
13. PROPELLANT		
RCS FUEL		75.1
RCS OXIDIZER		133.5
	TOTAL FOR RCS PROPELLANT	(208.6)
	TOTAL FOR PROPELLANT	(208.6)
	GROSS VEHICLE WEIGHT	13056.3

NOTE: ALL MASS IS IN POUNDS.

MASS SUMMARY

APOLLO SERVICE MODULE (SM), 1 MAR 71

DATA POINT 3C

SPACECRAFT 112
MISSION J1

1. STRUCTURE	3227	4. POWER	2042	8. OTHER	953
BODY		ELECTRICAL		ORDINANCE AND SEPARA	20
PRIMARY	1544	ELEC PWR EQUIP	1294	MANUFACTURING VAR	-100
(CENTER SECTION)		ELEC INSTL	557	GOV FURN EQUIP	1033
SECONDARY	519	SEQUENTIAL CONTR	14		
FAIRING CM/SM	122	ALEM DELTA	177		
MISCL	44				
APOLLO LUNAR EXTENDED	998			9. GROWTH	-
MISSION (ALEM) PROV				**DRY MASS**	10607
		5. CONTROL	-	10. NON-CARGO	933
				RCS RESIDUALS	32
				ELEC PWR RESID	17
				ECS RESIDUALS	6
				MAIN PROPUL RESID	878
2. PROTECTION	544	6. AVIONICS	428	11. CARGO	50
AFT HEAT SHIELD	84	INSTRUMENTATION	294	ALEM SCIENTIFIC EQUIP	50
INSULATION	460	COMMUNICATIONS	134	**INERT MASS**	11590
				12. NON-PROPELLANT	999
				ELEC PWR EXPENDABLES	778
				ECS EXPENDABLES	221
3. PROPULSION	3192				
MAIN					
ENGINE	829				
FUEL SYS	592				
OXIDIZER SYS	609	7. ENVIRONMENT	221	13. PROPELLANT	41910
PRESS SYS	729	ENVIRON CONTR SYS	221	RCS	
RCS				USABLE	1316
ENGINES	85			UNUSABLE	0
FUEL SYS	102			MAIN	
OXIDIZER SYS	103			USABLE (MAX)	40594
PRESS SYS	112			UNUSABLE	0
ELEC PROV	31			**GROSS MASS**	54499

APOLMP04 CCSD WH 9 NOV 92

ALL MASS IN POUNDS

1. STRUCTURE		
	HONEYCOMB PANELS	391.7
	WINDOWS,HATCHES,ACC DOORS,FRAM	6.8
	FITTINGS AND ATTACH PARTS	64.2
	RADIAL BEAMS	364.
	INTERNAL PARTITIONS	7.6
	FORWARD BULKHEAD	127.2
	AFT BULKHEAD	309.8
	RCS PANELS	272.5
	TOTAL FOR BASIC BODY STRUC-CTR	(1543.8)
	SPS ENGINE SUPPORT STRUCTURE	60.2
	HYDROGEN TANK SUPPORTS & SHELF	16.8
	OXYGEN TANK SUPPORTS & SHELF	32.9
	FUEL CELL SUPPORTS & SHELF	36.9
	EPS MOUNTING PROVISIONS	103.3
	ECS MOUNTING PROVISIONS	14.8
	INSTRUMENTATION MOUNTING PROVI	6.2
	COMMUNICATIONS MOUNTING PROVIS	2.5
	R/R ANTENNA & EQUIPMENT SUPPOR	1.4
	HI GAIN ANTENNA SUPPORTS	29.1
	SPS FUEL SYSTEM SUPPORTS	11.2
	SPS OXIDIZER SYSTEM SUPPORTS	14.7
	SPS PRESSURE SYSTEM SUPPORTS	10.
	RCS FUEL SYSTEM SUPPORTS	49.6
	RCS OXIDIZER SYSTEM SUPPORTS	51.4
	RCS PRESSURE SYSTEM SUPPORTS	10.6
	RCS ENGINE SUPPORTS	43.6
	C/M-S/M UMBILICAL PROVISIONS	16.7
	FLYAWAY&CARRY ON UMBIL. PROVIS	6.7
	TOTAL FOR SECONDARY STRUCTURE	(518.6)
	HONEYCOMB PANELS - SHELL	71.7
	UMBILICAL FAIRING	0.7
	SPLICES	8.1
	FIBERGLAS SANDWICH & C/M CLOSE	33.4
	FITTINGS & ATTACH PARTS	7.6
	TOTAL FOR FAIRING-C/M TO S/M	(121.5)
	PAINT & FINISHES	40.
	NITROGEN PURGE	4.2
	TOTAL FOR MISCELLANEOUS	(44.2)
	ALEM STRUCTURE PROVISION DELTA	998.4
	TOTAL FOR ALEM STRUCTURE DELTA	(998.4)
	TOTAL FOR STRUCTURE	(3226.5)
2. PROTECTION		
	AFT HEAT SHIELD	84.1
	TOTAL FOR AFT HEAT SHIELD	(84.1)
	FORWARD SECTION	4.
	CENTER SECTION	107.9
	FAIRING	14.4
	AFT HEAT SHIELD	108.1
	MOUNTING PROVISIONS	57.2
	SPS TANKS	36.3
	BULKHEADS	16.7
	BOOST PROTECT&RCS PLUME SHIELD	77.8
	SPS ENGINE CLOSEOUT	37.7

TOTAL FOR INSULATION	(460.1)
TOTAL FOR PROTECTION	(544.2)

3. PROPULSION

ENGINES	821.1
DRAINS	2.7
TEMPERATURE CONTROLS	5.
FLIGHT COMBUSTION STABILITY MO	0.3
TANKS	385.2
LOWER SKIRTS & RINGS	33.4
UPPER SKIRTS, RINGS & SUPPORTS	6.5
INTERNAL SUPPORTS	7.5
TANKS & DOORS	16.8
PLUMBING & FITTINGS	27.3
VALVES & REGULATORS	2.2
QUANTITY INDICATION	37.2
TEMPERATURE CONTROL	1.5
SUPPORTS	2.6
ZERO G CONTROLS & BAFFLES	71.6
TANKS	385.2
LOWER SKIRTS & RINGS	33.4
UPPER SKIRTS, RINGS & SUPPORTS	6.5
INTERNAL SUPPORTS	7.5
TANKS & DOORS	20.4
PLUMBING & FITTINGS	23.4
VALVES & REGULATORS	2.1
QUANTITY INDICATION	37.
MIXTURE RATIO CONTROLS	18.3
TEMPERATURE CONTROL	1.9
SUPPORTS	2.2
ZERO G CONTROLS & BAFFLES	71.5
TANKS	636.
TANK SUPPORTS	2.4
PLUMBING & FITTINGS	31.2
VALVES & REGULATORS	36.4
HEAT EXCHANGER	16.7
SUPPORTS	6.7
TOTAL FOR MAIN PROPULSION	(2759.7)
ENGINES	82.4
TEMPERATURE CONTROL	1.2
SUPPORTS	1.
TANKS & EXPULSION	56.4
PLUMBING & FITTINGS	8.2
VALVES & REGULATORS	27.6
TEMPERATURE CONTROL	0.4
SUPPORTS	9.8
TANKS & EXPULSION	62.4
PLUMBING & FITTINGS	11.8
VALVES & REGULATORS	19.6
TEMPERATURE CONTROL	0.4
SUPPORTS	9.2
TANKS	46.
PLUMBING & FITTINGS	13.2
VALVES & REGULATORS	50.4
SUPPORTS	2.
SUPPORTS, CONDUITS, ETC	2.9
WIRING-COMMON UTILITY	28.
TOTAL FOR RCS PROPULSION	(432.9)
TOTAL FOR PROPULSION	(3192.599)

4. POWER

LIGHTING		21.7
H2 SYSTEM SUBCONTRACTOR ITEMS		151.6
H2 SYSTEM PLUMBING		5.6
H2 SYSTEM VALVES		11.5
H2 SYSTEM SUPPORTS		2.7
O2 SYSTEM SUBCONTRACTOR ITEMS		175.1
O2 SYSTEM PLUMBING		6.1
O2 SYSTEM VALVES		23.1
O2 SYSTEM SUPPORTS		2.5
FUEL CELL SYS CONTRACTOR ITEMS		711.
FUEL CELL SYS PLUMBING		16.8
FUEL CELL SYS SUPPORTS		17.4
FUEL CELL SYS WATER GLYCOL		24.4
FUEL CELL SYS SPACE RADIATORS		29.6
FUEL CELL SYS KOH		10.
POWER DISTRIBUTION BOX		42.6
CRYO ELEC CONTROL BOX		11.5
TERMINAL DISTRIBUTION PANELS		7.5
SUPPORTS & INSTALLATION PROV		7.1
SPS CONTROL BOX		16.5
TOTAL FOR ELECTRICAL PWR EQUIP	(	1294.3)
ELECTRICAL HARNESS INSTALLATIO		486.3
CIRCUIT INTERRUPTERS		8.6
SUPPORTS & INSTALLATION PROVIS		62.5
TOTAL FOR ELECTRICAL INSTALL	(	557.4)
SM JETTISON CONTROLLER		13.6
SUPPORTS & HARDWARE		0.1
TOTAL FOR SEQUENTL EVENTS CONT	(	13.7)
ALEM EPS DELTA		177.3
TOTAL FOR ALEM EPS DELTA	(	177.3)
TOTAL FOR POWER	(	2042.7)

6. AVIONICS

SIGNAL CONDITIONERS		16.7
TRANSDUCERS		33.1
MISCELLANEOUS		13.8
RADIATION DETECTION		8.
SENSOR ELECTRICAL PROVISION		0.2
WIRING-COMMON UTILITY		1.8
SPS FUEL GAUGING PROVISION		1.8
SUPPORTS		13.
ALEM INSTRUMENTATION DELTA		205.3
TOTAL FOR INSTRUMENTATION	(	293.7)
2KMC HIGH GAIN ANT TRANS LINES		4.2
HIGH GAIN ANTENNA		93.9
VHF OMNI ANT TRANS LINES		34.7
SUPPORTS		0.8
TOTAL FOR COMMUNICATIONS	(	133.6)
TOTAL FOR AVIONICS	(	427.3)

7. ENVIRONMENT

WGC VALVES	9.8
WGC CONTROLS	21.9
WGC PLUMBING%SID	15.8
WGC SPACE RADIATOR%SID	102.4
WGC SUPPORTS & HARDWARE	15.7
WSS PLUMBING%SID	0.6

WSS SUPPORT & ATTACH PARTS		0.3
HTS PLUMBING & FITTINGS		9.1
HTS SUPPORTS		6.9
HTS HEAT TRANSFER FLUID		30.7
HTS MISCELLANEOUS COMPONENTS		2.9
HTS INSTALLATION HARDWARE		4.9
TOTAL FOR ENVIRON CONTROL SYS	(	221.)
TOTAL FOR ENVIRONMENT	(	221.)
8. OTHER		
PYROTECHNICS		1.
C/M-S/M TENSION TIE		18.5
TOTAL FOR ORDNANCE & SEP PROV	(	19.5)
MANUFACTURING VARIATIONS		-100.
TOTAL FOR MANUFACTURING VARIA	(	-100.)
TRANSPONDER		14.8
WAVEGUIDE		1.5
ANTENNA KIT		0.6
MISCELLANEOUS		0.6
PYROTECHNIC INITIATORS		0.4
MISCELLANEOUS		135.
ALEM GFE DELTA		879.9
TOTAL FOR GOV FURNISHED EQUIP	(	1032.8)
TOTAL FOR OTHER	(	952.3)
10. NON-CARGO		
FUEL		8.4
OXIDIZER		18.
HELIUM-PRESSURIZATION		6.
TOTAL FOR RCS RESIDUALS	(	32.4)
HYDROGEN - EPS		2.4
OXYGEN - EPS		9.2
ALEM EPS NON EXPENDABLE DELTA		5.8
TOTAL FOR ELECTRCL PWR NON-EXP	(	17.4)
OXYGEN - ECS		4.
ALEM ECS NON EXPENDABLE DELTA		2.
TOTAL FOR ECS NON-EXPENDABLE	(	6.)
STORAGE BOTTLES		87.6
PROPELLANT TANKS		5.4
NITROGEN		1.3
ENGINE-OUTSIDE TANK OXID		47.4
FEED LINE-OUTSIDE TANK OXID		44.7
TRANSFER LINE-OUTSIDE TNK OXID		31.6
RESIDUAL OXIDIZER		382.1
ENGINE-OUTSIDE TANK FUEL		29.6
FEED LINE-OUTSIDE TANK FUEL		29.5
TRANSFER LINE-OUTSIDE TNK FUEL		19.5
RESIDUAL FUEL		199.
TOTAL FOR MAIN PROPUL RESIDUAL	(	877.7)
TOTAL FOR NON-CARGO	(	933.5)
11. CARGO		
ALEM SCIENTIFIC EQUIPMENT		50.
TOTAL FOR ALEM SCIENTIFIC EQUI	(	50.)
TOTAL FOR CARGO	(	50.)
12. NON-PROPELLANT		
HYDROGEN EPS		53.
OXYGEN EPS		472.8

ALEM EPS EXPENDABLE DELTA			252.1
	TOTAL FOR EPS EXPENDABLES	(	777.9)
OXYGEN ECS			147.
ALEM ECS EXPENDABLE DELTA			73.5
	TOTAL FOR ECS EXPENDABLES	(	220.5)
	TOTAL FOR NON-PROPELLANT	(	998.4)
13. PROPELLANT			
RCS FUEL USABLE			432.4
	TOTAL FOR RCS FUEL USABLE	(	432.4)
RCS OXIDIZER USABLE			883.6
	TOTAL FOR RCS OXIDIZER USABLE	(	883.6)
RCS UNUSABLE			0.
	TOTAL FOR RCS UNUSABLE	(	0.)
MAIN USABLE			40594.
	TOTAL FOR MAIN USABLE	(	40594.)
MAIN UNUSABLE			0.
	TOTAL FOR MAIN UNUSABLE	(	0.)
	TOTAL FOR PROPELLANT	(	41910.)
	GROSS VEHICLE WEIGHT		54498.5

NOTE: ALL MASS IS IN POUNDS.

MASS SUMMARY

APOLLO SPACECRAFT/LUNAR MODULE ADAPTER (SLA), 1 MAR 71

DATA POINT 3D

SPACECRAFT 112
MISSION J1

1. STRUCTURE	3218	4. POWER	60	8. OTHER	538
PRIMARY BODY STRUCT	3076	WIRING	60	PYROTECHNICS	66
				SEPARATION PROV	472
SECONDARY BODY STRUCT					
LM SUPPORT	92				
EPS MTG PROV	14				
UMBIL PROV	9				
MISCL	27			9. GROWTH	-
				DRY MASS	4066
		5. CONTROL	-	10. NON-CARGO	-
2. PROTECTION	250	6. AVIONICS	-	11. CARGO (LM, ALEM 36000 LB, REF MISSION J1)	-
INSULATION	250			**INERT MASS**	4066
				12. NON-PROPELLANT	-
3. PROPULSION	-				
		7. ENVIRONMENT	-	13. PROPELLANT	-
				GROSS MASS	4066

APOLMP05 CCSD WH 9 NOV 92

APOLLO ADAPTER
DESIGN MASS SUMMARY (JSC FORMAT)

ALL MASS IN POUNDS

1. STRUCTURE			
	HONEYCOMB PANELS		1736.3
	LONGERONS		48.2
	FRAMES & RINGS		56.
	WNDOWS,HATCHES,ACC DOORS&FRAME		84.2
	FITTINGS & ATTACH PARTS		105.1
	TOTAL FOR BASIC BODY STRUC-FWD	(	2029.8)
	HONEYCOMB PANELS		760.6
	LONGERONS		5.2
	FRAMES & RINGS		222.6
	WNDOWS,HATCHES,ACC DOORS&FRAME		16.8
	FITTINGS & ATTACH PARTS		40.4
	TOTAL FOR BASIC BODY STRUC-AFT	(	1045.6)
	LEM SUPPORT		92.4
	EPS MOUNTING PROVISIONS		14.1
	FLYAWAY&CARRY ON UMBIL.PROV		8.5
	TOTAL FOR SECONDARY STRUCTURE	(	115.)
	SERVICING PLATFORM PROVISIONS		27.2
	TOTAL FOR MISCELLANEOUS	(	27.2)
	TOTAL FOR STRUCTURE	(	3217.6)
2. PROTECTION			
	INSULATION		250.1
	TOTAL FOR INSULATION	(	250.1)
	TOTAL FOR PROTECTION	(	250.1)
4. POWER			
	WIRING-COMMON UTILITY		59.9
	TOTAL FOR ELECTRICAL POWER SYS	(	59.9)
	TOTAL FOR POWER	(	59.9)
8. OTHER			
	PYROTECHNICS & INITIATORS		65.5
	PANEL EJECTION SYSTEM		182.7
	DEBRIS CATCHER		178.6
	FITTINGS & ATTACH PARTS		34.5
	LEM PROVISIONS		23.3
	S/M-SLA UMBILICAL		11.7
	SLA-LEM UMBILICAL		41.5
	TOTAL FOR ORDNANCE & SEP PROV	(	537.8)
	TOTAL FOR OTHER	(	537.8)
	GROSS VEHICLE WEIGHT		4065.4

NOTE: ALL MASS IS IN POUNDS.

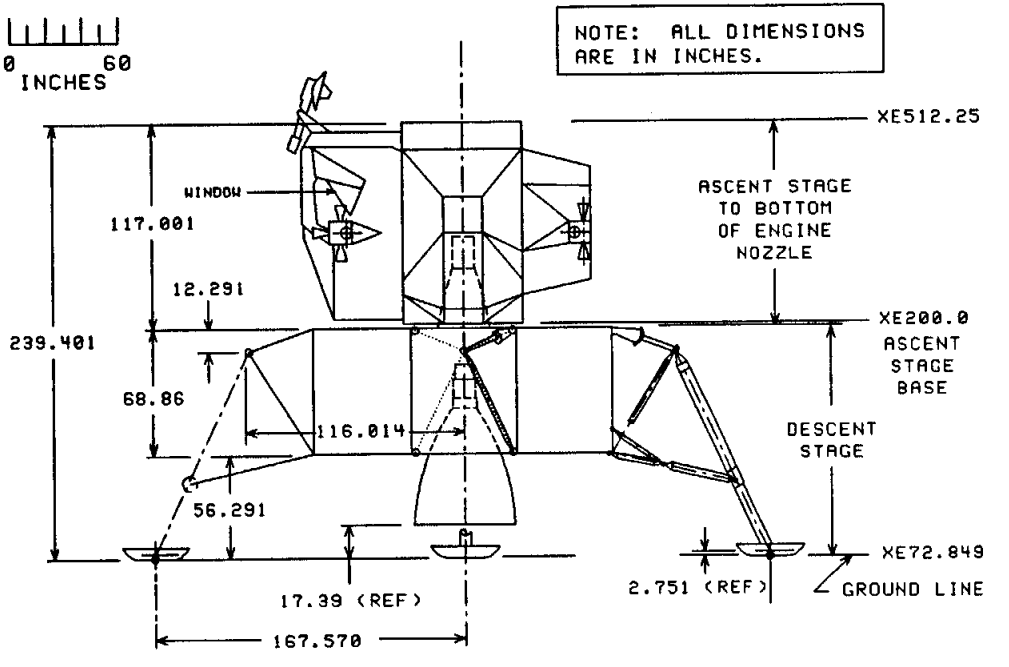
DATA POINT ③

DESIGN MASS SUMMARY

APOLLO LUNAR MODULE (LM), 26 JUL 71

LM 10, MISSION J1

FUNCTIONAL SYSTEM CODE	E	F	G	H
1. STRUCTURE	1026	1015		
2. PROTECTION	364	463		
3. PROPULSION	711	1091		
4. POWER	735	786		
5. CONTROL	-	-		
6. AVIONICS	399	63		
7. ENVIRONMENT	681	427		
8. OTHER	651	601		
9. GROWTH	-	-		
DRY MASS	4567	4446		
10. NON-CARGO	374	763		
11. CARGO	-	1099		
INERT MASS	4941	6308		
12. NON-PROPELLANT	136	558		
13. PROPELLANT	5494	18799		
GROSS MASS (36236)	10571	25665		



APOLDR06 CCSD WH 28 AUG 89

NOTE:

E. ASCENT STAGE (AS)

F. DESCENT STAGE (DS)

	AS	DS
DESIGN-ENVELOPE VOLUME, V_{de} (CU FT)	750	
PRESSURIZED VOLUME, V_{pr} (CU FT)	283	
DESIGN-ENVELOPE SURFACE AREA, A_{de} (SQ FT)		

DESIGN MISSION.

APOLMP06 CCSD WH 20 AUG 93

NOTE: ALL MASS IS IN POUNDS.

MASS SUMMARY

APOLLO LUNAR MODULE (LM), ASCENT STAGE (AS), 26 JUL 71

DATA POINT 3E

LM 10
MISSION J1

1. STRUCTURE	1026	4. POWER	735	8. OTHER	651
CABIN FRONT FACE	181	BATTERIES	247	ELEC EXPLOSIVE DEVICES	29
CABIN BARREL	203	INVERTER, CONTROL, ETC	151	EARTH LAUNCH GFE	682
MIDSECTION	572	HARNESS ASSYS	287	MANUFACTURING VARIATION	-60
AFT END BODY	70	INSTALLATION HDWR	50		
				9. GROWTH	-
				DRY MASS	4567
		5. CONTROL	-	10. NON-CARGO	374
				UNUSABLE MAIN PROPEL	252
				UNUSABLE RCS PROPEL	122
2. PROTECTION	364	6. AVIONICS	399	11. CARGO	-
WINDOW SHIELDING	2	STABILITY AND CONTROL	79		
CABIN FRONT FACE	83	NAVIGATION , GUID	78	**INERT MASS**	4941
CABIN BARREL AND MIDSECTION	227	INSTRUMENTATION	129		
AFT END BODY	52	COMMUNICATIONS	113	12. NON-PROPELLANT	136
				LIQUIDS AND GASES	136
3. PROPULSION	711				
ASCENT PROPUL SYS (ENGINE 173)	469				
REACTION CONTR SYS	242				
		7. ENVIRONMENT	681	13. PROPELLANT	5494
		CONTROLS	185	MAIN PROPEL (DELTA V)	4985
		CREW PROVISIONS	152	RCS PROPEL (DELTA V)	509
		ENVIRON CONTR SYS	296		
		DISPLAYS	48		
				GROSS MASS	10571

APOLMP07 CCSD WH 9 NOV 92

APOLLO LUNAR MODULE-ASCENT STAGE
DESIGN MASS SUMMARY (JSC FORMAT)

ALL MASS IN POUNDS

1. STRUCTURE		
	FRONT FACE SKINS	46.2
	BEAMS VERTICAL	22.8
	CAPS FF BEAMS	2.2
	STIFFENERS SKIN	19.4
	FRONT FACE WINDOW FRAMES	14.2
	INTERSTAGE MTS EXT	13.3
	EVA HANDRAIL INSTL	6.5
	CABIN 340 SUPPORTS	2.1
	CABIN SUPPORTS	0.2
	CABIN EPS SUPPORTS	2.7
	CABIN COMM SUPPORTS	0.7
	FRONT FACE WINDOWS	24.1
	FRONT FACE HATCH	13.
	FRONT FACE JSF	13.6
	TOTAL FOR FRONT FACE TOTAL	(181.)
	CABIN SKINS	29.9
	CABIN IMU BEAMS	18.7
	CABIN LONGERONS	21.2
	FRAMES CABIN SKINS	16.8
	FRAMES UPR DOCKING WINDOW	5.9
	CABIN 340 SUPPORTS	38.
	ECS SUPPORTS	3.5
	EPS SUPPORTS	3.3
	RCS SUPPORTS	7.4
	CONSOLE SUPPORTS	2.
	CABIN DECK	24.3
	CABIN WINDOW	4.
	CABIN JSF	27.5
	TOTAL FOR CABIN TOTAL	(202.5)
	TUNNEL SKINS	15.5
	MIDSECTION SKINS	22.9
	MIDSECTION BULKHEADS	97.4
	BEAMS Y22	16.6
	BEAMS Y17	12.
	BEAMS Y37	4.1
	BEAMS ENGINE	15.
	BEAMS BULKHEADS	21.5
	MIDSECTION LONGERONS	9.4
	MIDSECTION STIFFENERS	32.
	MIDSECTION FRAMES	23.2
	MIDSECTION INTERSTAGE MTS	21.8
	MIDSECTION S&C SUPPORTS	0.8
	MIDSECTION N&G SUPPORTS	0.8
	MIDSECTION 340 SUPPORTS	54.7
	MIDSECTION ECS SUPPORTS	17.1
	MIDSECTION INST SUPPORTS	1.
	MIDSECTION EPS SUPPORTS	12.2
	MIDSECTION PROP SUPPORTS	30.2
	MIDSECTION RCS SUPPORTS	49.9
	MIDSECTION COMM SUPPORTS	13.9
	MIDSECTION GFE SUPPORTS	3.2
	MS DECK X2335	14.2
	MS DECK X2535	18.4
	MS DECK X277	7.7

MS DECK X294		22.1
MS DECK X310		1.9
MIDSECTION HATCH		10.9
MIDSECTION JSF		21.5
	TOTAL FOR MIDSECTION TOTAL	(571.9)
AEB RACKS-WO-CP		16.3
AEB HORIZONTAL BEAMS		9.8
AEB COLD-PLATE ASY		18.7
AEB FTG&TRUSSES		6.2
AEB ECS SUPPTS		1.
AEB INST SUPPTS		0.2
AEB EPS SUPPTS		5.3
AEB PROP SUPPTS		1.2
AEB RCS SUPPTS		9.7
AEB ANTENNA SUPPTS		0.5
AEB JSF		1.4
	TOTAL FOR AEB TOTAL	(70.3)
ASCENT LCD TOTAL		0.1
ASCENT MISCL/LCD		0.2
	TOTAL FOR ASCENT MISCL/LCD	(0.3)
	TOTAL FOR STRUCTURE	(1026.)

2. PROTECTION

WINDOW SHIELDING		1.6
	TOTAL FOR FRONT FACE THER PROT	(1.6)
WINDOW SHIELDING		0.7
	TOTAL FOR CABIN THERM PROTECT	(0.7)
FRONT FACE CABIN SHIELDING		39.1
FRONT FACE CABIN INSULATION		27.5
FRONT FACE CABIN JSF		12.6
FRONT FACE CABIN SUPPTS		4.2
MIDSECTION SHIELD		58.5
MIDSECTION INSUL		55.2
MIDSECTION JSF		5.2
MIDSECTION SHIELD SUPPORTS		107.6
AEB SHIELDING		19.5
AEB INSULATION		16.2
AEB JSF		2.9
AEB SUPPTS		13.1
	TOTAL FOR A/S THERMO PROTECT	(361.6)
	TOTAL FOR PROTECTION	(363.9)

3. PROPULSION

PROPELLANT TANK INST		130.7
PROPELLANT QUANTITY SENSORS		1.8
PROPELLANT PLUMBING		23.
HELIUM TANKS		107.8
PRESSURIZATION PLUMBING		26.6
PRESSURIZATION SYS		4.5
ASCENT ENGINE		172.7
ENGINE & MISC		2.4
	TOTAL FOR ASCENT PROPULSION SY	(469.5)
FUEL TANKS		17.6
OXIDIZER TANKS		21.
ASCENT PROP TIE-IN		13.4
FUEL SYSTEM		22.1
OXIDIZER SYSTEM		22.
PROP FILTER & ISO VALVE		3.9
HELIUM TANKS		16.6

PLUMBING-PRESS SYS A		11.9
PLUMBING-PRESS SYS B		11.7
THRUST CHAMBER ASSY		82.5
HARDWARE CLUSTER 1		4.9
HARDWARE CLUSTER 2		4.8
HARDWARE CLUSTER 3		4.8
HARDWARE CLUSTER 4		4.7
TOTAL FOR REACTION CONTROL SYS	(	241.9)
TOTAL FOR PROPULSION	(	711.4)

4. POWER

BATTERY ASCENT		247.3
ELECT CONT ASSY		21.
INVERTER ASCENT		30.8
ELECTRONIC UNIT		20.1
PANEL 11 ASCENT		42.5
PANEL 16 ASCENT		36.4
GN&C HARNESS ASSY		5.1
S&C HARNESS ASSY		0.1
ECS HARNESS ASSY		12.1
INSTR HARNESS ASSY		1.8
EPS HARNESS ASSY		13.3
PROP HARNESS ASSY		3.1
RCS HARNESS ASSY		1.2
COMM HARNESS ASSY		4.4
EDS HARNESS ASSY		6.
MULTI-SUBSYS HARNESS		229.3
MISC HARNESS ASSY		3.
INSTALLATION HARDWARE		49.2
DELTA WEIGHT CHANGES		0.9
WIRE ADJUSTMENT		7.2
TOTAL FOR ELECTRICAL POWER SYS	(	734.8)
TOTAL FOR POWER	(	734.8)

6. AVIONICS

ATCA		23.7
RATE GYRO ASSY		2.
ABORT GUIDANCE SYSTEM		53.3
TOTAL FOR STABILITY & CONTROL	(	79.)
REN RADAR SECT		78.1
TOTAL FOR NAVIGATION&GUIDANCE	(	78.1)
SIGNAL CONDITIONER		70.9
PCMTEA		22.6
DATA STORAGE UNIT		2.5
CAUTION & WARNING		18.3
AEB JSF		0.2
ECS SENSORS		5.9
PROP SENSORS		3.6
RCS SENSORS		4.9
TOTAL FOR INSTRUMENTATION	(	128.9)
VHF XCEIVER & DIPLEXER		13.1
SIG PROCESSOR ASSY		10.4
VHF IN-FLIGHT ANTENNA		4.8
UHF RANGING SYS		2.6
EVA ANTENNA ASSY		2.
S-BAND TRANSCEIVER		20.
POWER AMPL & DIPLEX		18.7
IN-FLIGHT ANTENNAS		0.8
STEERABLE ANTENNA		27.5

MISCELLANEOUS		13.3
	TOTAL FOR COMMUNICATIONS	(113.2)
	TOTAL FOR AVIONICS	(399.2)

7. ENVIRONMENT

PANEL 1 DISPLAYS & INDICATORS		16.7
PANEL 2 DISPLAYS & INDICATORS		18.1
PANEL 3 DISPLAYS & INDICATORS		1.4
PANEL 6 DISPLAYS & INDICATORS		7.4
PANEL 8 DISPLAYS & INDICATORS		0.4
PANEL 12 DISPLAYS & INDICATORS		1.9
PANEL 14 DISPLAYS & INDICATORS		2.1
	TOTAL FOR DISPLAYS	(48.00001)
SUPPORT STRUCTURE		32.5
PANEL 1		32.8
PANEL 2		24.4
PANEL 3		18.3
PANEL 4A		0.9
PANEL 4B		0.9
PANEL 5		5.3
PANEL 6		1.9
PANEL 8		10.
PANEL 12		16.
PANEL 14		7.
NON-PANEL ITEMS		35.
MISCELLANEOUS		0.2
	TOTAL FOR CONTROLS	(185.2)
FURNISHINGS		71.5
OUTER LIGHTING		26.4
INNER LIGHTING		4.4
MISCELLANEOUS		8.6
WASTE MANAGEMENT		3.9
PAINT		6.
CREW PROVISIONS		31.3
	TOTAL FOR CREW PROVISIONS	(152.1)
HAM STD 190 PKG		101.8
190 PKG HDW		10.
O2+H2O COOLANT ASSY		36.1
ATMOS REVIT SECTION		2.8
-290 SUBTOTAL		7.9
HTS PRI LOOP		24.9
HTS SECONDARY LOOP		8.
TOTAL GOX TANKS		10.1
390 OX MODULE		8.9
390 PKG-HDW		7.7
PLSS O2 RECHARGE		3.5
TOTAL H20 TANKS		10.7
490 H2O MODULE		5.7
490 PKG-HDW		4.9
PLUMBING GAEC		28.7
COLD PLATES R&D		2.9
TOTAL PRIMARY CP		2.6
LIOH CARTRIDGE		18.2
	TOTAL FOR ECS	(295.4)
	TOTAL FOR ENVIRONMENT	(680.7001)

8. OTHER

EXPLOSIVE DEVICES	19.
EXPLOSIVE STRUCTURE	9.7

	TOTAL FOR ELEC EXPLOSIVE DEVIC	(	28.7)
DROGUE			21.4
BPA INSTALLED HARDWARE			1.3
PRIMARY GN&C SYS			258.4
ORDEAL			6.9
CREW PROVISIONS			376.9
INSTRUMENT SCIENCE EQUIPMENT			15.7
ELECTRICAL ASCENT			1.7
	TOTAL FOR EARTH LAUNCH GFE	(	682.3)
MFG VAR AT WHG			-70.4
VARIOUS UPDATES			10.6
	TOTAL FOR MANUFACTURING VARIA	(	-59.8)
	TOTAL FOR OTHER	(	651.2)
10. NON-CARGO			
TRAPPED APS			14.2
UNUSED APS PROP			47.7
DISP & MALFUNCTION			140.3
UNUSABLE PROPELLANT			49.9
	TOTAL FOR UNUSABLE PROP-MAIN	(	252.1)
UNUSABLE PROP-RCS			121.7
	TOTAL FOR UNUSABLE PROP-RCS	(	121.7)
	TOTAL FOR NON-CARGO	(	373.8)
12. NON-PROPELLANT			
TOTAL COOLANT			24.6
TANKED GOX			4.8
WATER-RESIDUAL			1.1
WATER TANKED			90.
NITROGEN ASC H2O TNK			0.1
HELIUM-ASCENT-APS			13.
HELIUM-ASCENT-RCS			2.1
	TOTAL FOR LIQUIDS & GASSES	(	135.7)
	TOTAL FOR NON-PROPELLANT	(	135.7)
13. PROPELLANT			
DELTA-V PROPELLANT			4984.9
	TOTAL FOR MAIN PROPELLANT	(	4984.9)
RCS PROPELLANT DELTA-V			509.5
	TOTAL FOR RCS PROPELLANT	(	509.5)
	TOTAL FOR PROPELLANT	(	5494.4)
	GROSS VEHICLE WEIGHT		10571.1

NOTE: ALL MASS IS IN POUNDS.

MASS SUMMARY

APOLLO LUNAR MODULE (LM), DESCENT STG (DS), 26 JUL 71

DATA POINT 3F

LM 10 MISSION J1

1. STRUCTURE	1015	4. POWER	786	8. OTHER	681
FORWARD SECTION	220	BATTERIES	670	LANDING GEAR INSTL	486
CENTER SECTION LEFT	154	ELEC CONTR ASSY, MISCL	43	ELEC EXPLOSIVE DEVICES	24
MID-CENTER SECTION	112	HARNESS ASSY	48	EARTH LAUNCH GFE	115
CENTER SECTION RIGHT	167	INSTALLATION HDWR	12	MANUFACTURING VARIATION AND MISCL	-24
AFT SECTION	298	MISCL	13		
MISCL	10			9. GROWTH	
MESS STOR, REL STRU	23			**DRY MASS**	4446
ALSEP REMOTE DEPLOY	31				
		5. CONTROL	-	10. NON-CARGO	763
				TRAPPED PROPEL	76
				UNUSED PROPEL	349
				DISPERSION AND MALFUNCTION PROPEL	338
2. PROTECTION	463	6. AVIONICS	63	11. CARGO	1099
THERMAL PROT AFT	1	STABILITY AND CONTROL	13	SCIENCE EQUIPMENT	1099
BASE HEAT SHIELD	1	NAVIG AND GUID	43	**INERT MASS**	6308
REMAINDER	461	INSTRUMENTATION	7		
				12. NON-PROPELLANT	558
				COOLANT	3
				GOX	94
3. PROPULSION	1091			WATER	408
PROPEL TANK INSTL	489			NITROGEN	1
PROPEL FD DISCN INSTL	6			HELIUM	52
PROPEL PLUMBING	46				
HELIUM TANK	114	7. ENVIRONMENT	427	13. PROPELLANT	18799
PRESSURIZ PLUMBING	68	DISPLAYS AND CONTROLS	3	MAIN PROPEL (DELTA V)	18799
ENGINE AND MISCL	368	CREW PROVISIONS	228		
		ENVIRON CONTR SYS	196		
				GROSS MASS	25665

APOLMP08 CCSD WH 9 NOV 92

ALL MASS IN POUNDS

1. STRUCTURE		
WEB FWD END CLOSURE		6.
UPPER CAP FWD CLOSURE		1.2
LOWER CAP FWD CLOSURE		1.7
POST-LEFT FWD CLOSURE		6.5
POST-RIGHT FWD CLOSURE		6.5
STIFFENERS FWD CLOSURE		5.1
LG FITTINGS FWD CLOSURE		2.
JSF FWD CLOSURE		3.1
FORWARD LEFT-PANEL		20.4
FORWARD RIGHT-PANEL		23.2
FORWARD UPPER DECK		16.
FORWARD LOWER DECK		11.8
FWD EQUIPMENT BAY LEFT		11.8
FWD EQUIPMENT BAY RIGHT		10.1
FWD INTERSTAGE MOUNT		4.5
FWD INTERSTAGE MT COL		2.9
FWD LG SUPPT TRUSS		15.3
FWD OXID TANK SUPPORT		33.
FWD TRUSS & SUPPORTS		20.8
S-IV-B ATTACH FTG		7.7
FWD EGRESS PLATFORM		8.6
EQUIPMENT SUPPT FWD SECTION		1.3
TOTAL FOR FORWARD SECTION	(	219.5)
WEB CENTER LFT CLO		5.4
UPR CAP CEN-LEFT CLOSURE		1.1
LWR CAP CEN-LEFT CLOSURE		1.7
POST AFT LEFT CLOSURE		6.5
POST FWD LEFT CLOSURE		6.7
STIF CENTER-LEFT CLOSURE		4.2
LG FTG CENTER-LEFT CLOSURE		2.2
JSF CENTER-LEFT CLOSURE		2.4
FWD PAN CENTER-LEFT		18.5
AFT PAN CENTER-LEFT		22.5
UPR DECK CENTER-LEFT		16.5
LWR DECK CENTER-LEFT		11.3
TRUSS & SUPPT CENTER-LEFT		46.7
S-IV-B ATTACH FTG		7.7
TOTAL FOR CENTER SECTION LEFT	(	153.4)
LF PAN MID-CENTER		14.1
RT PAN MID-CENTER		14.
FWD PAN MID-CENTER		14.8
AFT PAN MID-CENTER		13.9
ENG ACT SUPPT M-C-S		6.2
ENG TRUS SUPPT COL		7.9
ENG SUPPT TRUSSES		10.6
BLAST DEFLECTOR		8.5
JSF CRUCIFORMS ETC		4.9
EQUIPMENT SUPPORT CENTER-MID		17.1
TOTAL FOR MID-CENTER SECTION	(	112.)
WEB CENTER-RT CLOSURE		5.8
UPPER CAP CENTER-RT CLOSURE		1.1
LWR CAP CENTER-RT CLOSURE		1.7
POST FWD RT CLOSURE		6.6
POST AFT RT CLOSURE		6.5

STIF CENTER-RT CLOSURE		5.
LG FTG CENTER-RT CLOSURE		2.
END CLOSURE CENTER-RT		4.4
FWD PAN CENTER-RT		21.5
AFT PAN CENTER-RT		20.1
UPPER DECK CENTER-RT		16.1
LOWER DECK CENTER-RT		12.1
TRUSS & SUPPORT CENTER-RT		51.5
S-IV-B ATTACH FTG		7.6
COLD PLATE & RAILS		0.5
EQUIPMENT SUPPRT CENTER-RT		4.8
TOTAL FOR CENTER SECTION RIGHT	(	167.3)
WEB AFT END CLOSURE		6.6
UPPER CAP AFT CLOSURE		1.2
LOWER CAP AFT CLOSURE		1.7
POST LEFT AFT CLOSURE		7.
POST RIGHT AFT CLOSURE		7.1
STIFFENERS AFT CLOSURE		2.7
LG FTG AFT CLOSURE		2.
JSF AFT END CLOSURE		4.6
AFT LEFT PANEL		21.2
AFT RIGHT PANEL		19.9
AFT UPPER DECK		15.1
AFT LOWER DECK		11.8
SCIENCE EQUIP BAY LOWER DECK		19.7
SCIENCE EQUIP BAY UPPER DECK		7.9
SCIENCE EQUIP BAY DIAG CAP		11.5
SCIENCE EQUIP BAY RT CLOSURE		1.8
SCIENCE EQUIP BAY CEN-PAN		2.1
SCIENCE EQUIP BAY LT CLOSURE		1.8
SCIENCE EQUIP BAY INB-PAN		3.3
EQUIP BAY RIGHT		38.8
AFT LG SUPPORT TRUSS		15.2
AFT OXID TANK SUPPORT		33.
MISC TANK SUPPORTS		19.5
AFT TRUSS & SUPPTS		1.
S-IV-B ATTACH FTG		7.6
EQUIPMENT SUPPT AFT SECTION		34.
TOTAL FOR AFT SECTION	(	298.1)
LAND GEAR CHOCKS		3.2
MISCELLANEOUS		5.4
TOTAL FOR MISCELLANEOUS	(	8.6)
MESS STOW & REL STRU		23.2
TOTAL FOR MESS STOW & REL STRU	(	23.2)
ALSEP REMOTE DEPLOY		31.4
TOTAL FOR ALSEP REMOTE DEPLOY	(	31.4)
DESCENT STUCTURE		1.3
TOTAL FOR DESCENT STUCTURE	(	1.3)
TOTAL FOR STRUCTURE	(	1014.8)

2. PROTECTION

THERMAL PROTECT AFT		1.3
TOTAL FOR THERMAL PROTECT AFT	(	1.3)
BASE HEAT SHIELD		0.6
TOTAL FOR BASE HEAT SHIELD	(	0.6)
UPPER SHIELDING		56.4
UPPER INSULATION		27.6
UPPER JSF		0.4
UPPER SUPPORTS		4.4

SIDE SHIELDING		25.9
SIDE INSULATION		88.1
SIDE JSF		3.6
SIDE SUPPORTS		4.9
LOWER SHIELDING		17.3
LOWER INSULATION		30.4
LOWER JSF		1.
LOWER SUPPORTS		4.7
RBHS SHIELDING		30.9
RBHS INSULATION		66.3
RBHS JSF		6.8
RBHS SUPPORTS		60.1
OUTRIG SHIELDING		11.6
OUTRIG INSULATION		9.8
THERMAL PROTECTION		10.6
TOTAL FOR THERMAL PROTECTION		(460.8)
TOTAL FOR PROTECTION		(462.7)

3. PROPULSION

PROP TANK INSTAL		488.8
PROP FD DISCONNECT INSTAL		5.7
PROPELLANT PLUMBING		45.8
HELIUM TANK		113.9
PRESSURIZATION PLUMBING		68.1
ENGINE & MISC		368.7
TOTAL FOR DESCENT PROP SYST		(1091.)
TOTAL FOR PROPULSION		(1091.)

4. POWER

BATTERY DESCENT		670.3
ELECT CONTROL ASSY		39.5
ELECTRONIC UNIT		3.2
GN&C HARNESS ASSY		2.3
ECS HARNESS ASSY		0.1
INSTR HARNESS ASSY		0.7
EPS HARNESS ASSY		1.6
PROP HARNESS ASSY		4.6
EDS HARNESS ASSY		6.9
MULTI-SUBSYS HARNESS		31.3
EPS INSTAL HARDWARE		12.3
DELTA WEIGHT CHANGES		5.
EPS DESCENT STAGE		8.6
TOTAL FOR ELECT POWER SYST		(786.3999)
TOTAL FOR POWER		(786.3999)

6. AVIONICS

DECA		13.1
TOTAL FOR STABILITY & CONTROL		(13.1)
LAND RADAR SECT		43.2
TOTAL FOR NAVIGATION&GUIDANCE		(43.2)
ECS SENSORS		1.8
PROP SENSORS		2.7
MECH DES SENSOR		1.9
INSTRUMENTATION SENSORS		0.3
TOTAL FOR INSTRUMENTATION		(6.7)
TOTAL FOR AVIONICS		(63.)

7. ENVIRONMENT

DISPLAYS & CONTROLS		3.3

	TOTAL FOR DISPLAYS & CONTROLS	(3.3)
DESCENT		61.1
MESA MODULE		166.9
	TOTAL FOR CREW PROVISIONS	(228.)
INERT DESCENT STAGE LM		92.7
O2 SYSTEM		60.
H2O SYSTEM		22.6
GLYCOL SYSTEM		3.
PLSS O2 RECHARGE		8.2
LIOH CARTRIDGES		9.1
	TOTAL FOR ECS	(195.6)
	TOTAL FOR ENVIRONMENT	(426.9)

8. OTHER

INNER CYL ASSYS		97.4
OUTER CYL ASSYS		88.7
CARTRIDGE ASSYS		24.5
JSF PRIMARY STRUT		4.8
INNER CYL ASSYS		15.2
OUTER CYL ASSYS		14.5
CARTRIDGE ASSYS		37.6
HONEYCOMB PANEL AS		40.
BUMPER ASSEMBLY		1.2
HUB ASSEMBLY		5.
JSF LANDING PAD ASSY		0.7
CROSS MEMBER TUBE ASSY		27.1
SIDE BRACE TUBE ASSY		41.
MISC DEPLOY COMPS		8.4
JSF DEPLOY TRUSS ASSY		5.9
DEPLOYMENT SPRING		3.2
LOCK SPRING ASSY		1.4
DOWN LOCK LATCH ASSY		2.8
CRANK CAM IDLER		2.1
SURFACE PROBE MECH		7.2
JSF MECHANISMS		0.2
THERMAL INSUL LAND GEAR		46.3
EGRESS LADDER		6.7
JSF EGRESS LADDER		0.4
JSF INSTAL PRIMARY STRUT		1.5
JSF INSTAL SECONDARY STRUT		0.3
JSF INSTAL LANDING PAD		1.8
JSF DEPLOY TRUSS		0.3
JSF LG INSTAL		0.2
	TOTAL FOR LANDING GEAR INSTALL	(486.4)
DESCENT EXPLOSIVE DEVICE		14.2
DESCENT STRUCTURE		10.4
	TOTAL FOR ELECT EXPLOSI DEVICE	(24.6)
PLSS BATTERIES		33.6
BPS INSTALLED HARDWARE		2.3
CREW PROVISIONS		78.9
	TOTAL FOR EARTH LAUNCH GFE	(114.8)
VARIOUS UPDATES		-14.8
MFG VARIATION AT WHG		-9.6
	TOTAL FOR MFG VARIATION BY VEH	(-24.4)
	TOTAL FOR OTHER	(601.4001)

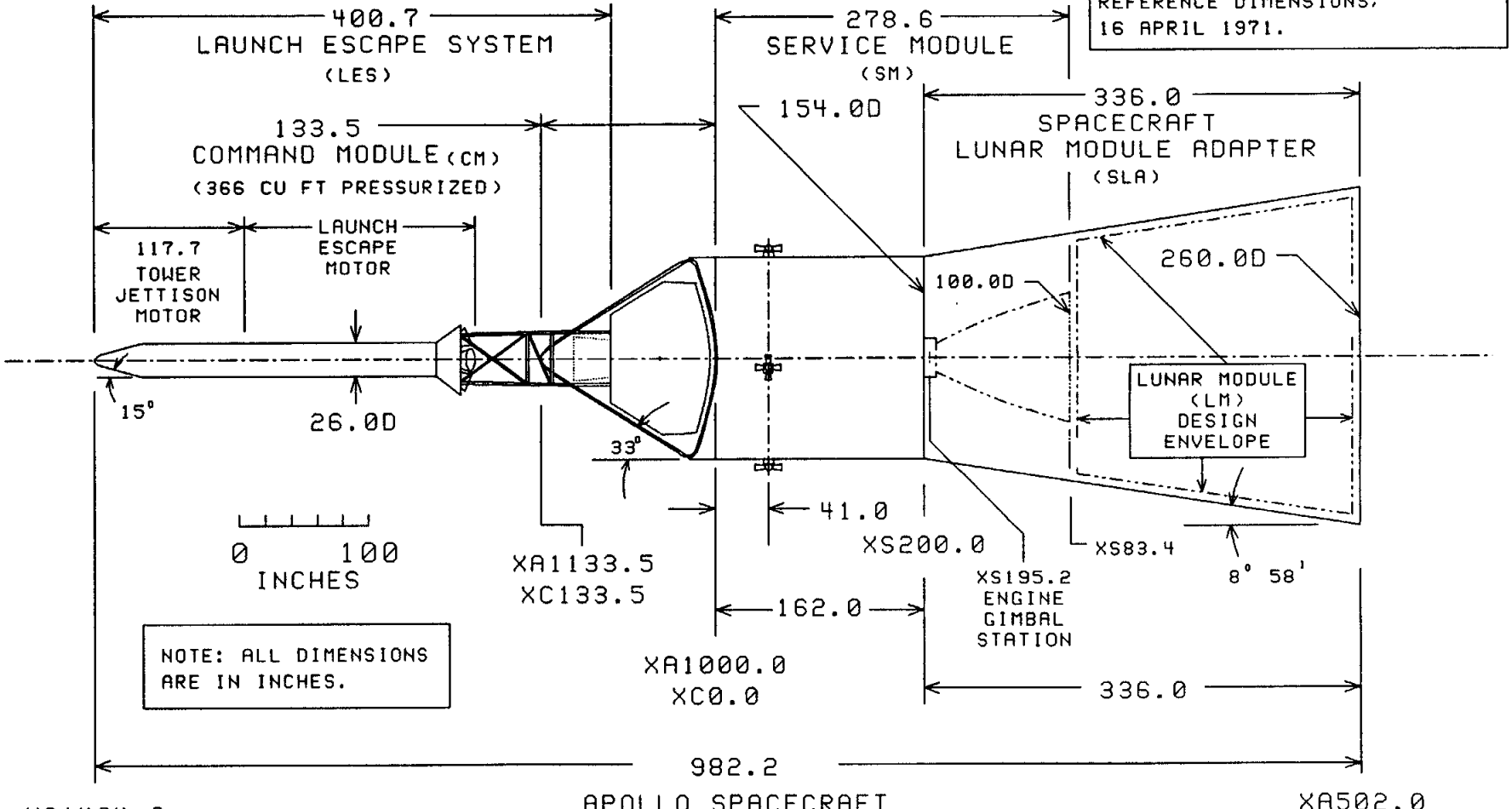
10. NON-CARGO

UNUSED DPS PROP	348.9
TRAPPED DPS	76.3

DISP & MALFUNCTION		337.7
	TOTAL FOR UNUSABLE PROPEL MAIN	(762.9)
	TOTAL FOR NON-CARGO	(762.9)
11. CARGO		
SCIENCE EQUIP		1099.1
	TOTAL FOR EARTH LAUNCH GFE	(1099.1)
	TOTAL FOR CARGO	(1099.1)
12. NON-PROPELLANT		
COOLANT		2.6
GOX		93.8
RESIDUAL WATER		0.4
TANKED WATER		408.
NITROGEN DSC H2O TANK		1.
HELIUM DPS		52.2
	TOTAL FOR LIQUIDS & GASSES	(558.)
	TOTAL FOR NON-PROPELLANT	(558.)
13. PROPELLANT		
MAIN DELTA-V PROP		18798.6
	TOTAL FOR MAIN DELTA-V PROP	(18798.6)
	TOTAL FOR PROPELLANT	(18798.6)
	GROSS VEHICLE WEIGHT	25664.8

APOLLO SPACECRAFT

PRIMARY REFERENCE: APOLLO SPACECRAFT OPERATIONAL DATA BOOK, SNA-8-D-027(I), REVISION 3, AMENDMENT 64, FIGURE 2-3, APOLLO SPACECRAFT REFERENCE DIMENSIONS, 16 APRIL 1971.

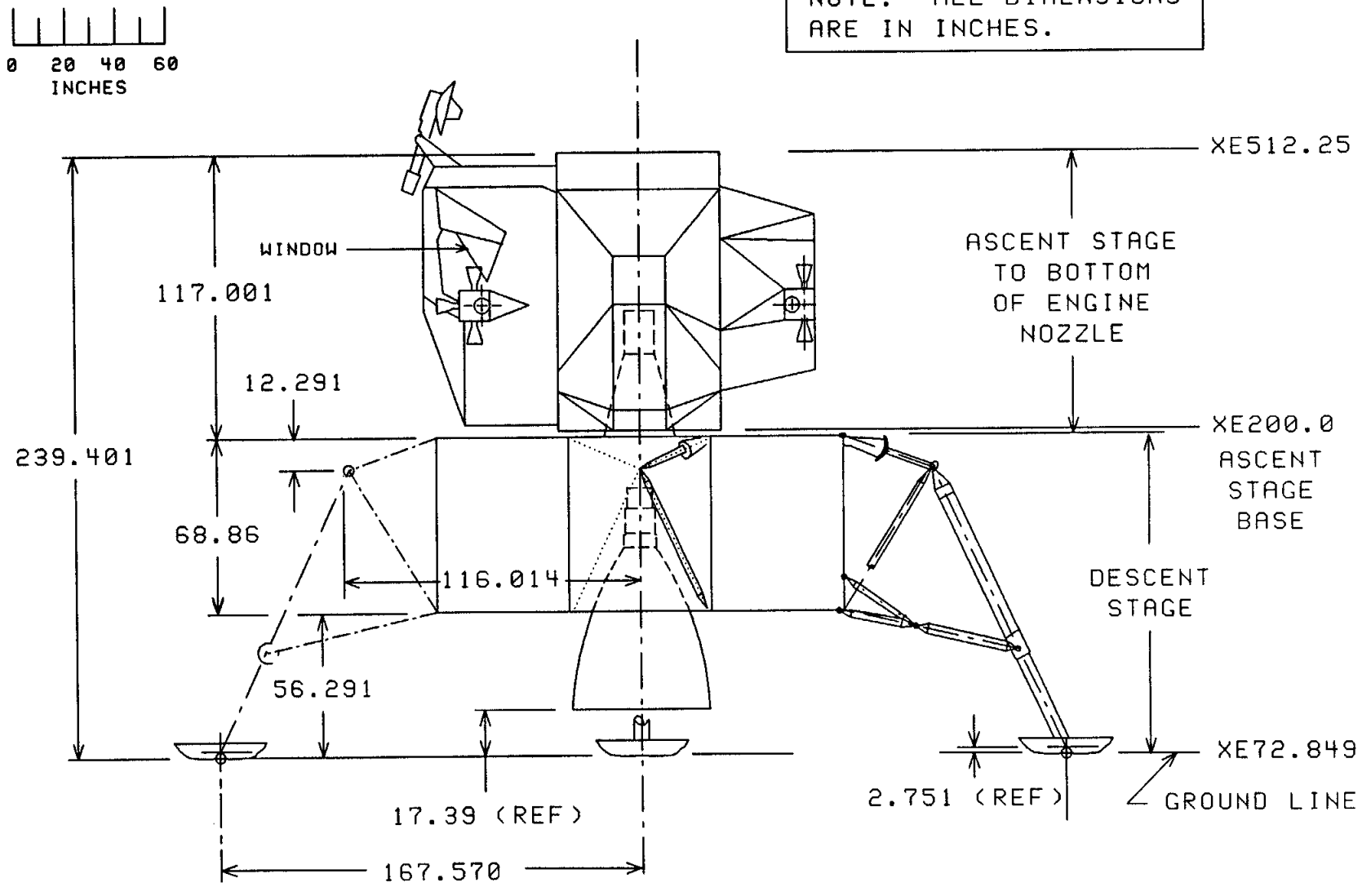


APOLDR01 CCSD WH 24 AUG 93

D-61

JSC-26098

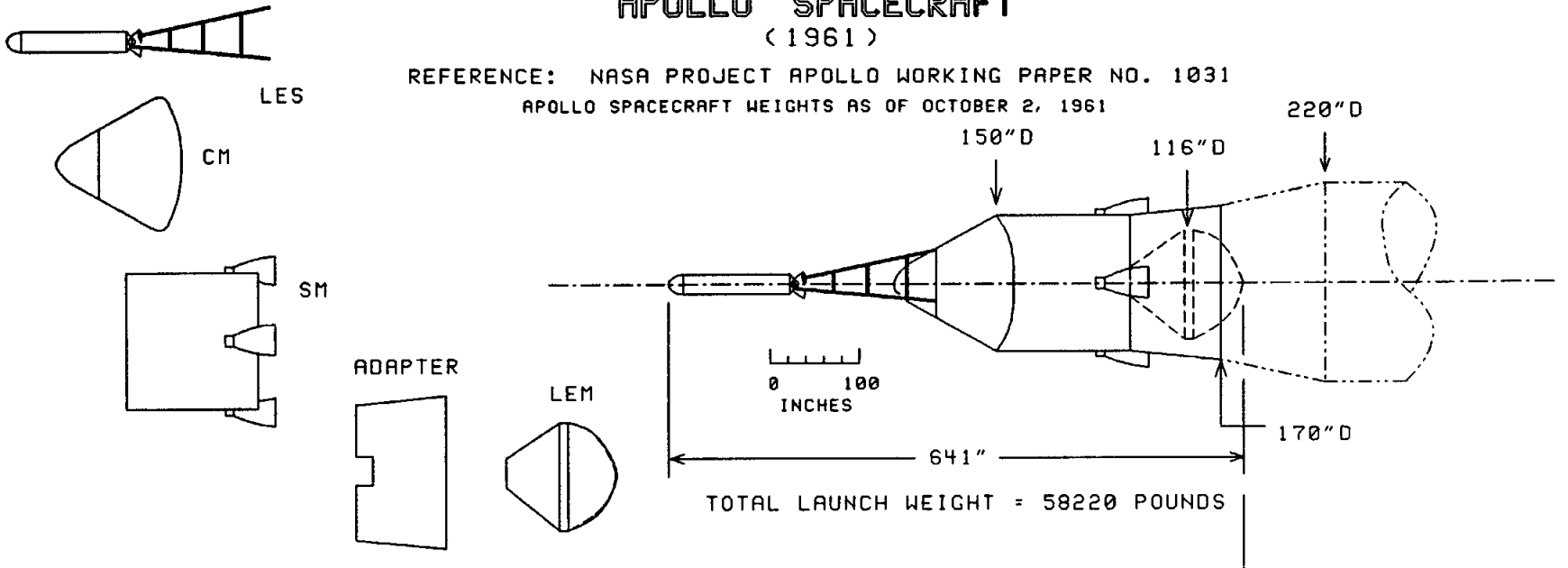
APOLLO LUNAR MODULE



APOLDR06 CCSD WH 23 AUG 93

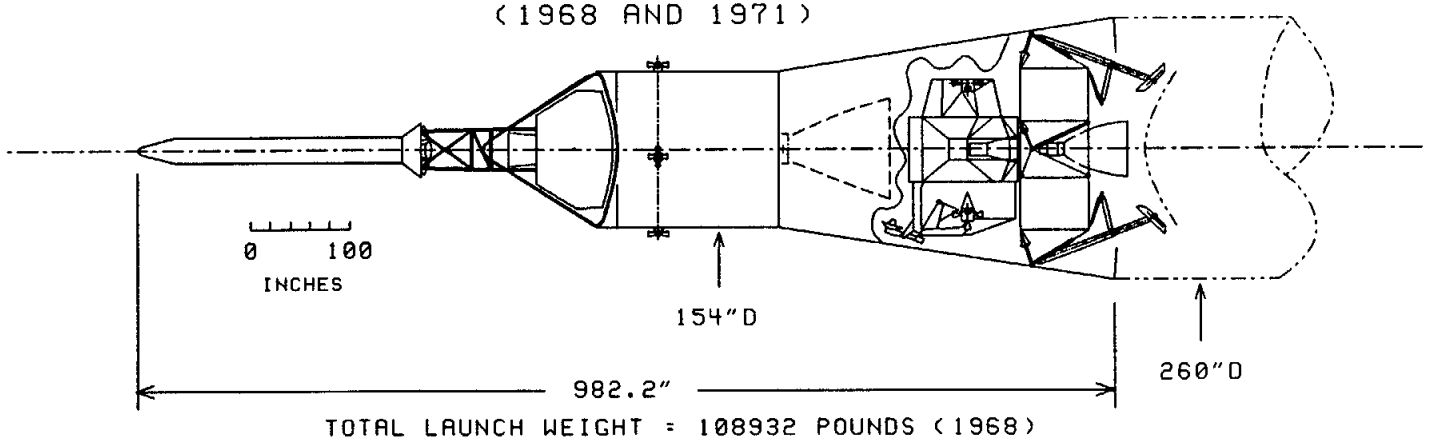
APOLLO SPACECRAFT
(1961)

REFERENCE: NASA PROJECT APOLLO WORKING PAPER NO. 1031
APOLLO SPACECRAFT WEIGHTS AS OF OCTOBER 2, 1961



TOTAL LAUNCH WEIGHT = 58220 POUNDS

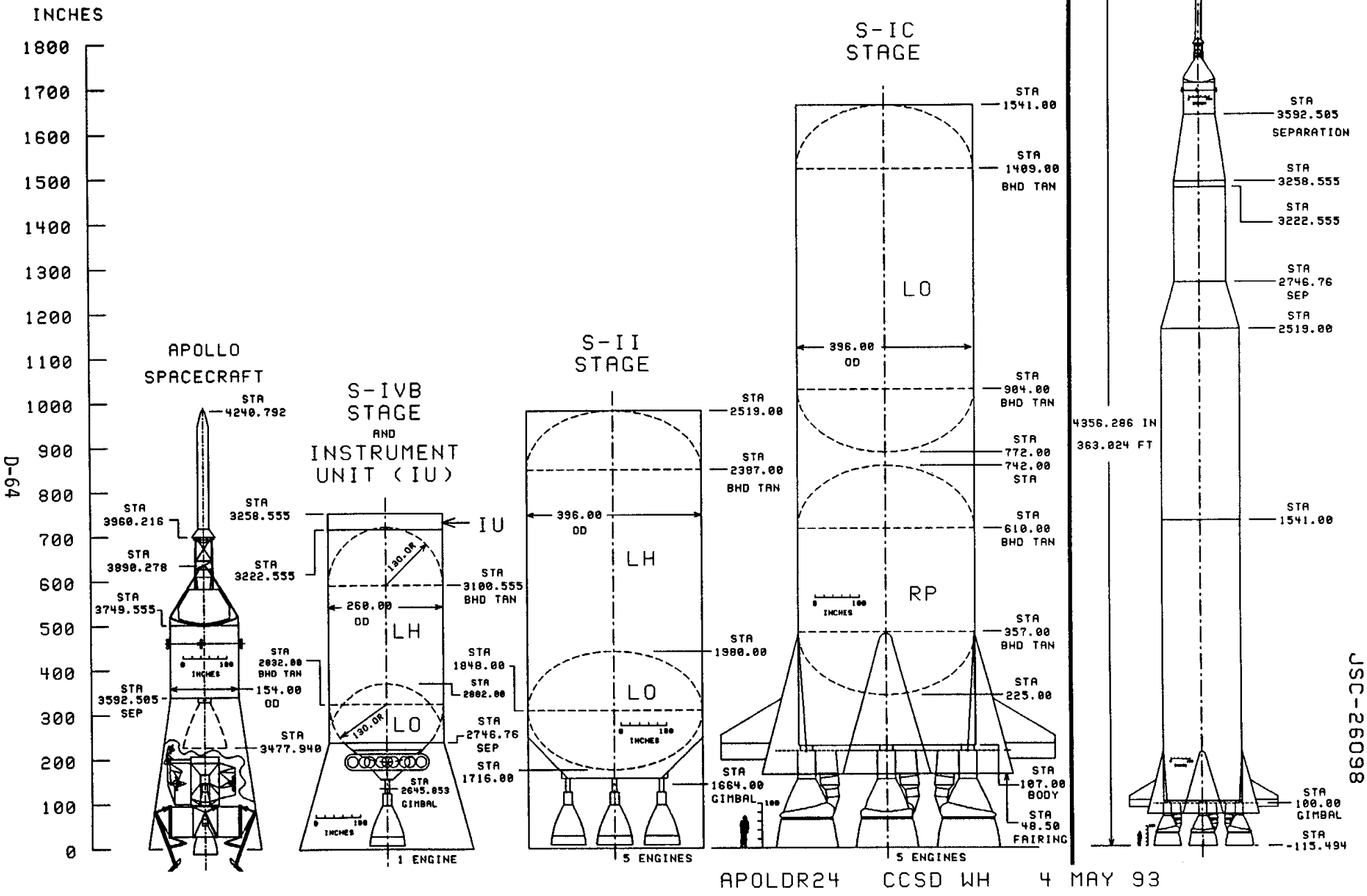
APOLLO SPACECRAFT
(1968 AND 1971)



TOTAL LAUNCH WEIGHT = 108932 POUNDS (1968)
116265 POUNDS (1971)

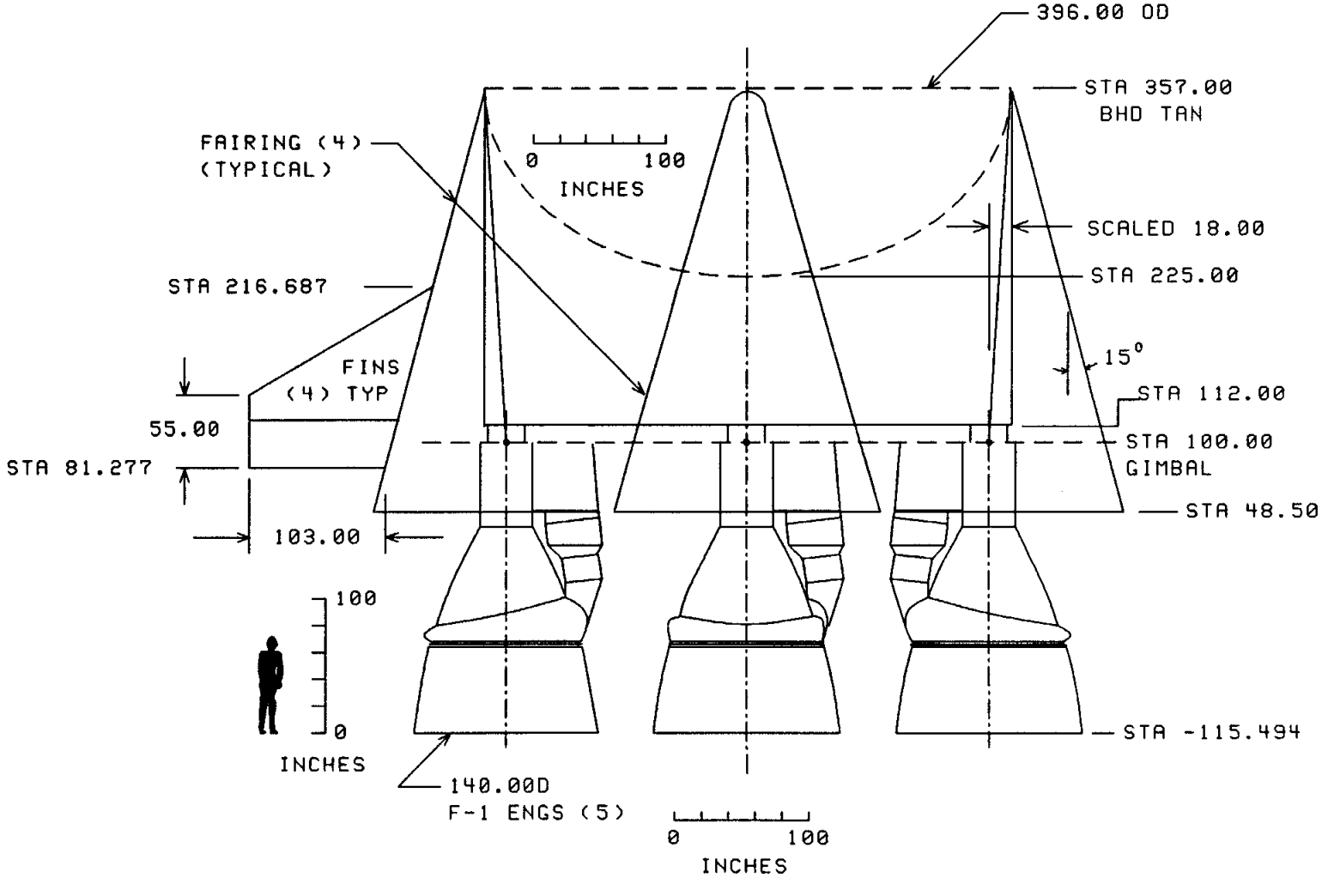
APOLDR00 CCSD WH 25 AUG 93

APOLLO SATURN V



APOLLO SATURN V

S-IC ENGINE INSTALLATION



D-65

JSC-26098

APOLDR25 CCSD WH 25 AUG 93

NOTE: ALL MASS IS IN POUNDS.

DATA POINT (4)

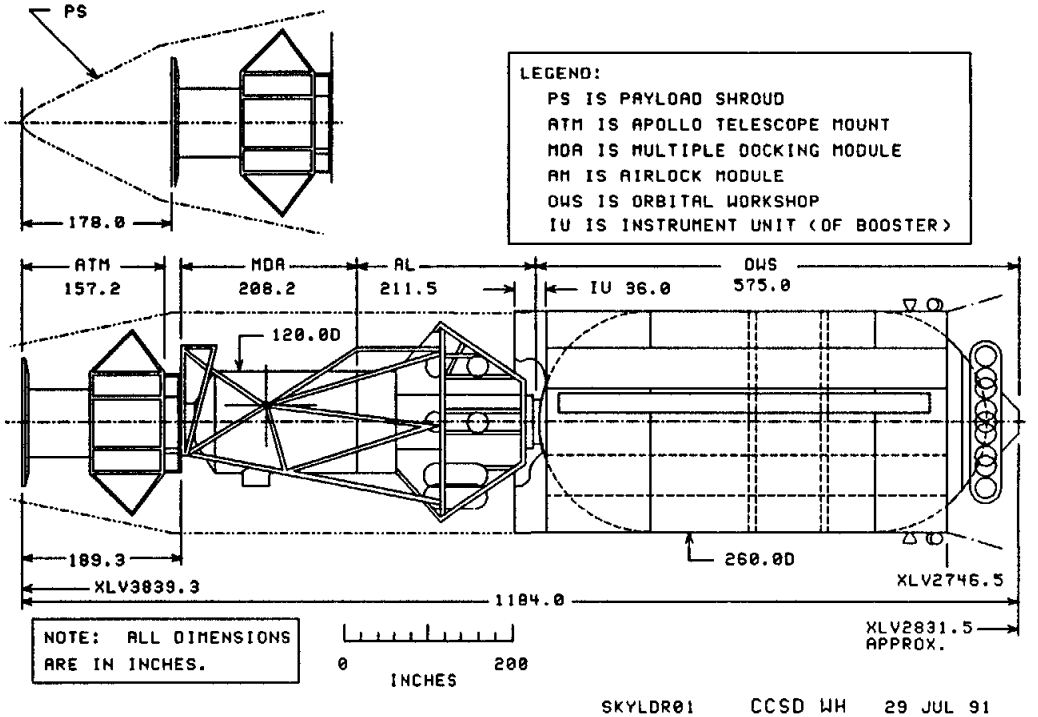
DESIGN MASS SUMMARY

SKYLAB SPACECAFT

REF: ED-2002-1575, AUG 27, 1973,
SKYLAB PROGRAM PAYLOAD INTEG
SKYLAB WEIGHT GROWTH STUDY

FUNCTIONAL SYSTEM CODE	A	B	C	D
1. STRUCTURE	24556	6298	4798	14216
2. PROTECTION	67	1005	137	489
3. PROPULSION	-	-	-	-
4. POWER	10	10505	1668	4504
5. CONTROL	-	-	-	-
6. AVIONICS	2	2911	230	1491
7. ENVIRONMENT	-	227	1621	20697
8. OTHER	838	973	87	338
9. GROWTH	-	-	-	-
DRY MASS	25473	21919	8541	41735
10. NON-CARGO	-	-	-	-
11. CARGO	-	2778	5104	559
INERT MASS	25473	24697	13645	42294
12. NON-PROPELLANT	-	-	-	7709
13. PROPELLANT	-	-	-	-
GROSS MASS	25473	24697	13645	50003

SKYLAB SPACECRAFT
(LAUNCH CONFIGURATION)



SKYLDR01 CCSD WH 29 JUL 91

NOTE:

A. PAYLOAD SHROUD (PS)
B. APOLLO TELESCOPE MOUNT (ATM)
C. MULTIPLE DOCKING ADAPTER (MDA)
D. AIRLOCK MODULE (AM)

SKYLMP01 CCSD WH 20 AUG 93

NOTE: ALL MASS IS IN POUNDS.

DATA POINT (4)

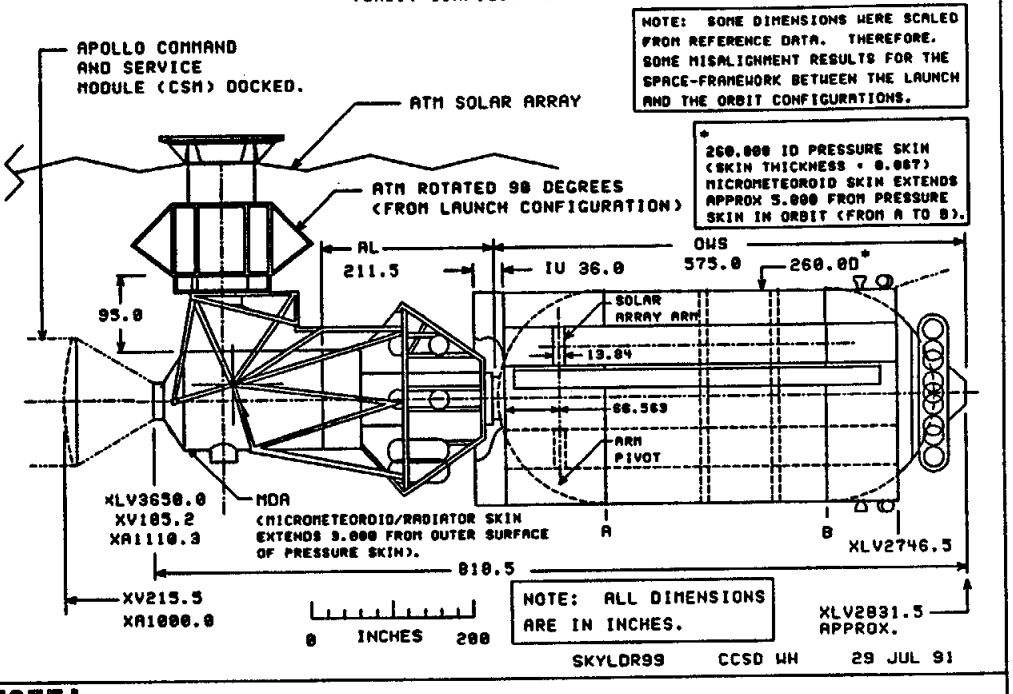
DESIGN MASS SUMMARY

SKYLAB SPACECAFT

REF: ED-2002-1575, AUG 27, 1973,
SKYLAB PROGRAM PAYLOAD INTEG
SKYLAB WEIGHT GROWTH STUDY

FUNCTIONAL SYSTEM CODE	E	F		
1. STRUCTURE	690	20311		
2. PROTECTION	982	1282		
3. PROPULSION	-	5038		
4. POWER	1509	10608		
5. CONTROL	-	-		
6. AVIONICS	1218	1306		
7. ENVIRONMENT	-	14661		
8. OTHER	-	-		
9. GROWTH	-	-		
DRY MASS	4399	53206		
10. NON-CARGO	-	3910		
11. CARGO	-	7622		
INERT MASS	4399	64738		
12. NON-PROPELLANT	-	11992		
13. PROPELLANT	-	1465		
GROSS MASS (A+B+C+D+E+F = 196412)	4399	78195		

SKYLAB SPACECRAFT
(ORBIT CONFIGURATION)



NOTE: SOME DIMENSIONS WERE SCALED FROM REFERENCE DATA. THEREFORE, SOME MISALIGNMENT RESULTS FOR THE SPACE-FRAMEWORK BETWEEN THE LAUNCH AND THE ORBIT CONFIGURATIONS.

* 260.000 ID PRESSURE SKIN (SKIN THICKNESS = 0.087) MICROMETEOROID SKIN EXTENDS APPROX 5.000 FROM PRESSURE SKIN IN ORBIT (FROM A TO B).

(MICROMETEOROID/RADIATOR SKIN EXTENDS 9.000 FROM OUTER SURFACE OF PRESSURE SKIN).

NOTE: ALL DIMENSIONS ARE IN INCHES.

SKYLDR99 CCSD WH 29 JUL 91

NOTE:

E. INSTRUMENT UNIT (IU)
F. ORBITAL WORKSHOP (OWS)

1. THE MASSES FOR A THROUGH F ARE FINAL, 14 MAY 1973. THE TOTAL OF 196412 POUNDS COMPARES TO 140257 ON 1 OCTOBER 1969.

SKYLMP02 CCSD WH 20 AUG 93

NOTE: ALL MASS IS IN POUNDS.

MASS SUMMARY

SKYLAB PAYLOAD SHROUD (PS)

DATA POINT 4A

1. STRUCTURE	24556	4. POWER	10	8. OTHER	838
PRIMARY STRUCTURE	23853	ELECTRICAL WIRING	10	SEPARATION SYSTEM	838
SECONDARY STRUCTURE	522				
EQUIPMENT SUPPORTS	31				
INSULATION AND PAINT	150				
				9. GROWTH	-
				DRY MASS	25473
		5. CONTROL	-	10. NON-CARGO	-
2. PROTECTION	67	6. AVIONICS	2	11. CARGO	-
THERMAL CONTROL	67	INSTRUMENTATION	2		
				INERT MASS	25473
				12. NON-PROPELLANT	-
3. PROPULSION	-				
		7. ENVIRONMENT	-	13. PROPELLANT	-
				GROSS MASS	25473

SKYLMP03 CCSD WH 10 NOV 92

NOTE: ALL MASS IS IN POUNDS.

MASS SUMMARY

SKYLAB APOLLO TELESCOPE MOUNT (ATM)

DATA POINT 4B

1. STRUCTURE	6298	4. POWER	10505	8. OTHER	973
PRIMARY STRUCTURE	4169	ELECTRICAL EQUIPMENT	3239	ATM POINTING MECH	973
SECONDARY STRUCTURE	235	ELECTRICAL WIRING	3295		
EQUIPMENT MOUNTS	629	SOLAR ARRAYS	2765		
INSULATION AND PAINT	1265	SOLAR ARRAY DEPLOY	1206		
				9. GROWTH	-
				DRY MASS	21919
		5. CONTROL	-	10. NON-CARGO	-
2. PROTECTION	1005	6. AVIONICS	2911	11. CARGO	2778
ENVIRONMENTAL PROT	1005	INSTRUMENTATION, COMM	788	EXPERIMENTS AND INSTL	2778
		GUIDANCE	2123	**INERT MASS**	24697
				12. NON-PROPELLANT	-
3. PROPULSION	-				
		7. ENVIRONMENT	227	13. PROPELLANT	-
		CREW RESTRAINTS	227		
				GROSS MASS	24697

SKYLMP04 CCSD WH 10 NOV 92

NOTE: ALL MASS IS IN POUNDS.

MASS SUMMARY

SKYLAB MULTIPLE DOCKING ADAPTER (MDA)

DATA POINT 4C

1. STRUCTURE	4798	4. POWER	1668	8. OTHER	87
PRIMARY STRUCTURE	3655	ELECTRICAL EQUIPMENT	1081	DOCKING EQUIPMENT	87
SECONDARY STRUCTURE	98	ELECTRICAL WIRING	587		
EQUIPMENT SUPPORTS	655				
INSULATION AND PAINT	390				
				9. GROWTH	-
				DRY MASS	8541
		5. CONTROL	-	10. NON-CARGO	-
2. PROTECTION	137	6. AVIONICS	230	11. CARGO	5104
METEOROID PROTECTION	137	INSTURMENTATION, COMM	230	EXPERIMENTS AND INSTL	5104
				INERT MASS	13645
				12. NON-PROPELLANT	-
3. PROPULSION	-				
		7. ENVIRONMENT	1621	13. PROPELLANT	-
		ENVIRON CONTR SYS	844		
		CREW RESTRAINTS	70		
		STOWAGE AND SPARES	377		
		CREW SYS CONTAINERS	204		
		CREW SYS SUPPORTS	126		
				GROSS MASS	13645

SKYLMP05 CCSD WH 10 NOV 92

NOTE: ALL MASS IS IN POUNDS.

MASS SUMMARY

SKYLAB AIRLOCK MODULE (AM)

DATA POINT 4D

1. STRUCTURE	14216	4. POWER	4504	8. OTHER	338
PRIMARY STRUCTURE	10101	ELECTRICAL EQUIPMENT	1904	ATM DEPLOYMENT MECH	338
SECONDARY STRUCTURE	83	ELECTRICAL WIRING	2600		
EQUIPMENT SUPPORTS	3632				
INSULATION AND PAINT	400				
				9. GROWTH	-
				DRY MASS	41735
		5. CONTROL	-	10. NON-CARGO	-
2. PROTECTION	489	6. AVIONICS	1491	11. CARGO	559
METEOROID PROTECTION	489	INSTRUMENTATION, COMM	1491	EXPERIMENTS AND INSTL	559
				INERT MASS	42294
				12. NON-PROPELLANT	7709
				ENVIRON CONTR GAS	7709
3. PROPULSION	-				
		7. ENVIRONMENT	20697	13. PROPELLANT	-
		ENVIRONMENTAL CONTROL	19850		
		CREW RESTRAINTS	170		
		STOWAGE AND SPARES	504		
		CREW SYS CONTAINERS	141		
		CREW SYS SUPPORTS	32		
				GROSS MASS	50003

SKYLMP06 CCSD WH 10 NOV 92

NOTE: ALL MASS IS IN POUNDS.

MASS SUMMARY

SKYLAB INSTRUMENT UNIT (IU)

DATA POINT 4E

1. STRUCTURE	690	4. POWER	1509	8. OTHER	-
PRIMARY STRUCTURE	560	ELECTRICAL EQUIPMENT	1026		
EQUIPMENT SUPPORTS	100	ELECTRICAL WIRING	483		
INSULATION AND PAINT	30				
				9. GROWTH	-
				DRY MASS	4399
		5. CONTROL	-	10. NON-CARGO	-
2. PROTECTION	982	6. AVIONICS	1218	11. CARGO	-
THERMAL CONTROL	982	INSTRUMENTATION, COMM	375		
		GUIDANCE	843	**INERT MASS**	4399
				12. NON-PROPELLANT	-
3. PROPULSION	-				
		7. ENVIRONMENT	-	13. PROPELLANT	-
				GROSS MASS	4399

SLYLMP07 CCSD WH 10 NOV 92

NOTE: ALL MASS IS IN POUNDS.

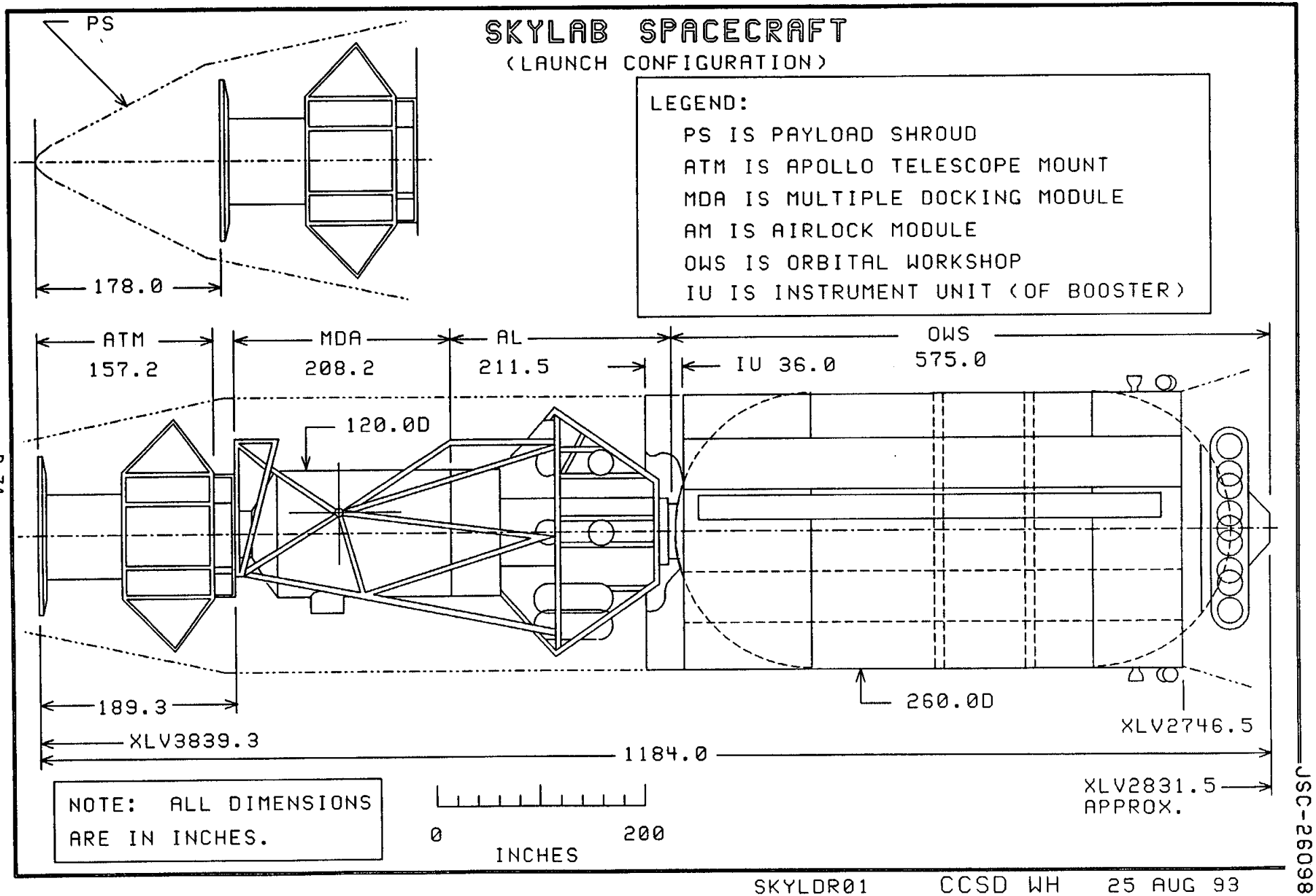
MASS SUMMARY

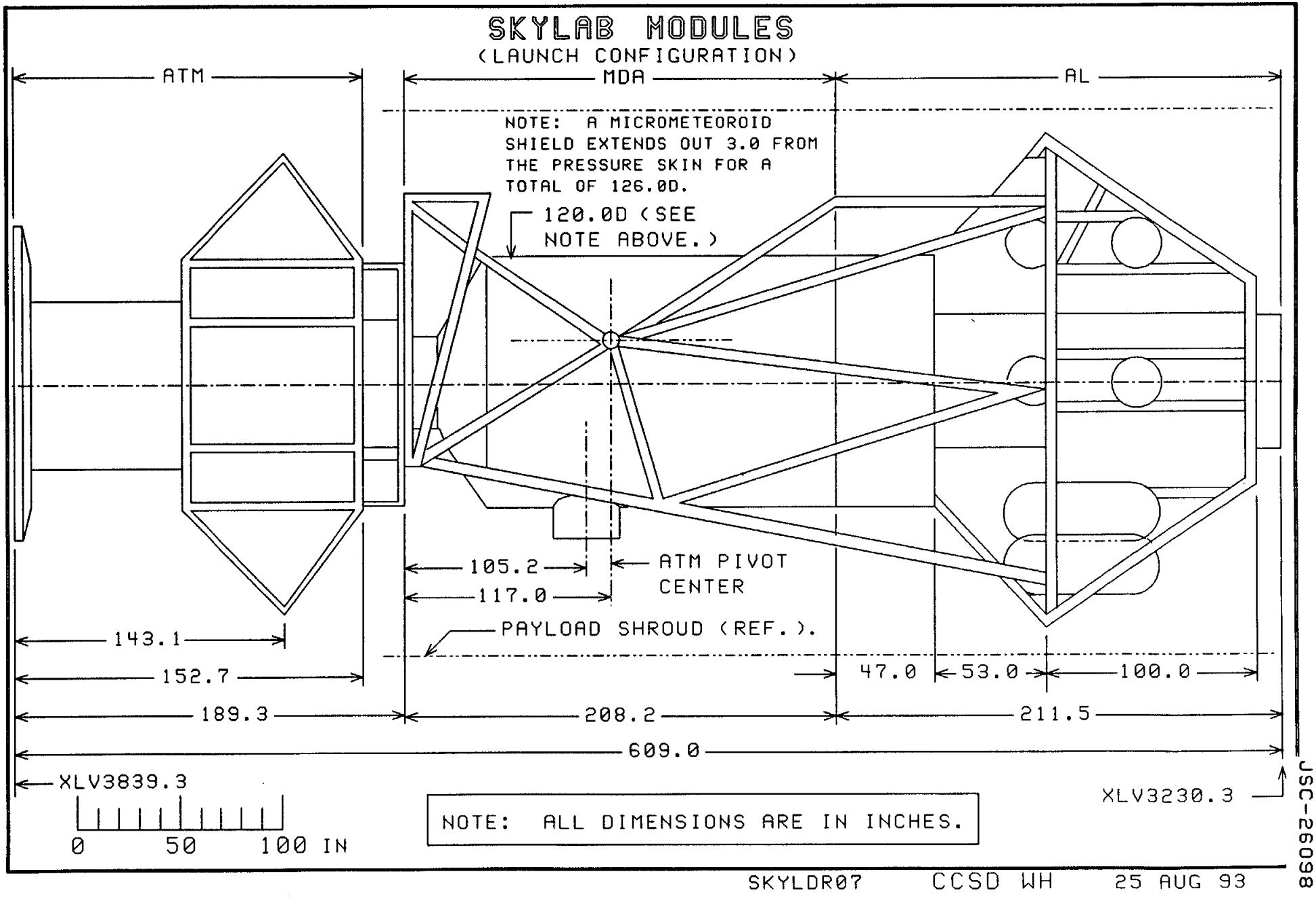
SKYLAB ORBITAL WORKSHOP (OWS)

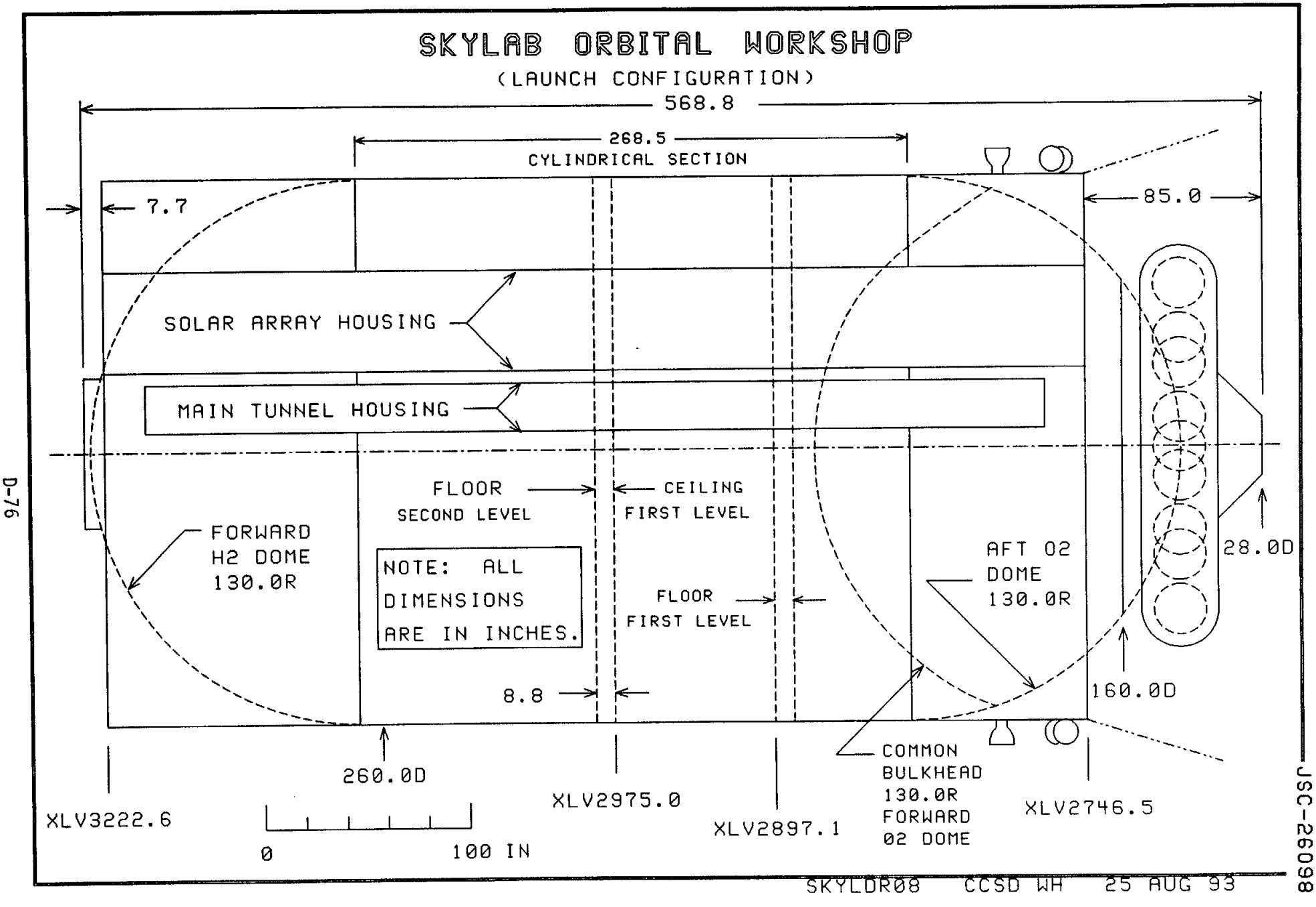
DATA POINT (4F)

1. STRUCTURE	20311	4. POWER	10608	8. OTHER	-
PRIMARY STRUCTURE	10940	ELECTRICAL EQUIPMENT	2036		
SECONDARY STRUCTURE	4622	ELECTRICAL WIRING	3094		
EQUIPMENT SUPPORTS	1260	SOLAR ARRAYS	3374		
INSULATION AND PAINT	3489	SOLAR ARRAY DEPLOY	2104		
				9. GROWTH	-
				DRY MASS	53206
		5. CONTROL	-	10. NON-CARGO	3910
				FOOD ACCESSORIES AND CONTAINERS	3910
2. PROTECTION	1282	6. AVIONICS	1306	11. CARGO	7622
METEOROID PROTECTION	1282	INSTRUMENTATION, COMM	1306	EXPERIMENTS AND INSTL	7622
				INERT MASS	64738
				12. NON-PROPELLANT	11992
				CABIN ATMOS SYS GAS	1499
				FOOD	2402
3. PROPULSION	5038			POTABLE WATER	8091
ATTITUDE CONTROL SYS	3795				
ATT CONTR SYS SUPPTS	1243				
		7. ENVIRONMENT	14661	13. PROPELLANT	1465
		CABIN ATMOSPHERE SYS	2151	ATTITUDE CONTROL SYS PROPELLANT AND GAS	1465
		POTABLE WATER SYSTEM	1199		
		WASTE MANAGEMENT	2254		
		CREW ACCOMMODATIONS AND CONSTRAINTS	855		
		STOWAGE AND SPARES	2997		
		CREW SYS CONTAINERS	3135		
		CREW SYS SUPPORTS	2070	**GROSS MASS**	78195

SKYLMP08 CCSD WH 10 NOV 92


SKYLAB SPACECRAFT
(LAUNCH CONFIGURATION)
PS
178.0
LEGEND:
PS IS PAYLOAD SHROUD
ATM IS APOLLO TELESCOPE MOUNT
MDA IS MULTIPLE DOCKING MODULE
AM IS AIRLOCK MODULE
OWS IS ORBITAL WORKSHOP
IU IS INSTRUMENT UNIT (OF BOOSTER)
ATM
157.2
MDA
208.2
AL
211.5
IU 36.0
OWS
575.0
120.0D
189.3
XLV3839.3
260.0D
XLV2746.5
1184.0
XLV2831.5
APPROX.
NOTE: ALL DIMENSIONS ARE IN INCHES.
0
200
INCHES
SKYLDR01 CCSD WH 25 AUG 93
D-74
JSC-26098

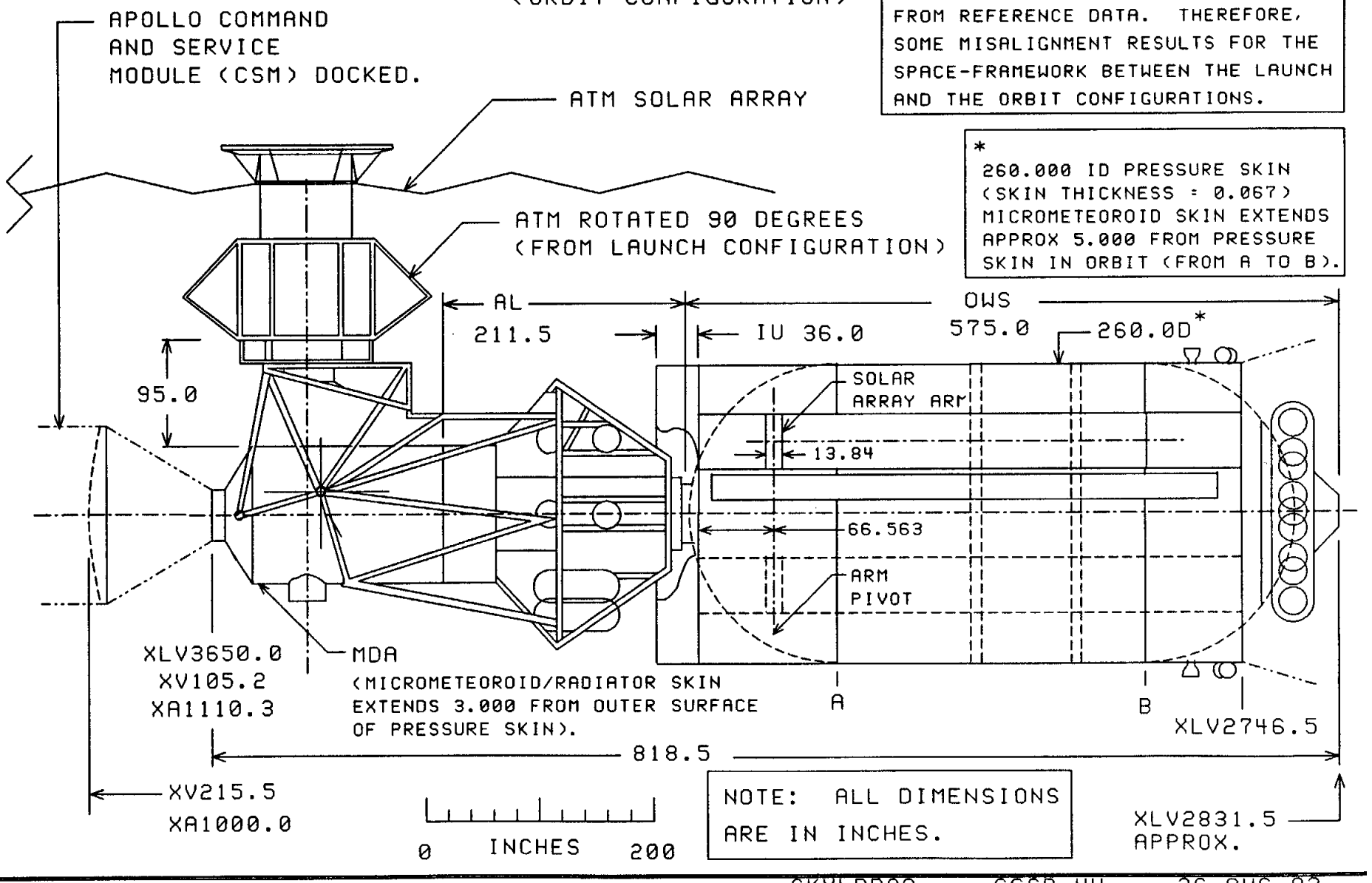

SKYLAB MODULES
(LAUNCH CONFIGURATION)
ATM
MDA
AL
NOTE: A MICROMETEOROID SHIELD EXTENDS OUT 3.0 FROM THE PRESSURE SKIN FOR A TOTAL OF 126.0D.
120.0D (SEE NOTE ABOVE.)
105.2
117.0
ATM PIVOT CENTER
PAYLOAD SHROUD (REF.).
143.1
152.7
189.3
208.2
47.0
53.0
100.0
211.5
609.0
XLV3839.3
XLV3230.3
0
50
100 IN
NOTE: ALL DIMENSIONS ARE IN INCHES.
SKYLDR07 CCSD WH 25 AUG 93
JSC-26098


SKYLAB ORBITAL WORKSHOP
(LAUNCH CONFIGURATION)
568.8
268.5
CYLINDRICAL SECTION
7.7
85.0
SOLAR ARRAY HOUSING
MAIN TUNNEL HOUSING
FLOOR
SECOND LEVEL
CEILING
FIRST LEVEL
FORWARD
H2 DOME
130.0R
NOTE: ALL
DIMENSIONS
ARE IN INCHES.
FLOOR
FIRST LEVEL
AFT 02
DOME
130.0R
28.0D
160.0D
8.8
260.0D
XLV3222.6
XLV2975.0
XLV2897.1
COMMON
BULKHEAD
130.0R
FORWARD
02 DOME
XLV2746.5
0
100 IN
SKYLDR08 CCSD WH 25 AUG 93

JSC-26098

SKYLAB SPACECRAFT

(ORBIT CONFIGURATION)



NOTE: SOME DIMENSIONS WERE SCALED FROM REFERENCE DATA. THEREFORE, SOME MISALIGNMENT RESULTS FOR THE SPACE-FRAMEWORK BETWEEN THE LAUNCH AND THE ORBIT CONFIGURATIONS.

*
260.000 ID PRESSURE SKIN (SKIN THICKNESS = 0.067) MICROMETEOROID SKIN EXTENDS APPROX 5.000 FROM PRESSURE SKIN IN ORBIT (FROM A TO B).

NOTE: ALL DIMENSIONS ARE IN INCHES.

SKYLDR99 CCSD WH 26 AUG 93

JSC-26098

NOTE: ALL MASS IS IN POUNDS.

DATA POINT (5)

DESIGN MASS SUMMARY

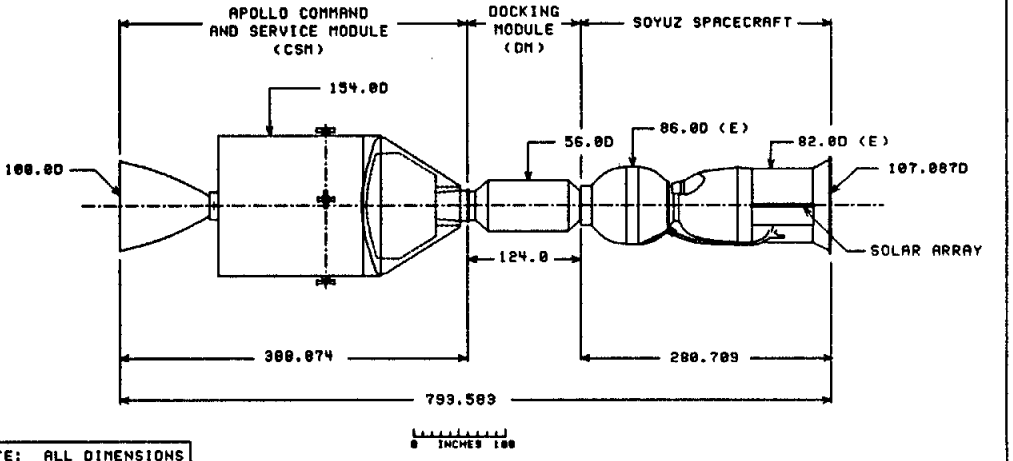
APOLLO-SOYUZ TEST PROJECT

FUNCTIONAL SYSTEM CODE	A	B	C	D
1. STRUCTURE		1809		
2. PROTECTION		233		
3. PROPULSION		-		
4. POWER		142		
5. CONTROL		-		
6. AVIONICS		80		
7. ENVIRONMENT		967		
8. OTHER		913		
9. GROWTH		-		
DRY MASS		4144		
10. NON-CARGO		-		
11. CARGO		268		
INERT MASS		4412		
12. NON-PROPELLANT		100		
13. PROPELLANT		-		
GROSS MASS		4512		

APOLLO-SOYUZ TEST PROJECT
(DOCKED CONFIGURATION)

REFERENCE: APOLLO-SOYUZ TEST PROGRAM, SYSTEM DESCRIPTION MANUAL, CSM 111/ DOCKING MODULE, SECTION 1, JSC, JAN 1974. APOLLO-SOYUZ TEST PROJECT, FACT SHEET, RELEASE NO. 75-9, 1975. APOLLO-SOYUZ TEST PROJECT, INFORMATION FOR PRESS, 1975.

NOTE: SOME DIMENSIONS HAVE BEEN SCALED AND ARE ESTIMATES. THESE DIMENSIONS ARE FOLLOWED BY (E).



NOTE: ALL DIMENSIONS ARE IN INCHES.

APSODR01 CCSD WH 21 AUG 91

NOTE:

A. APOLLO COMMAND AND SERVICE MODULE (CSM)

B. DOCKING MODULE (DM) (REF: ROCKWELL PRINTOUT, DOCKING MODULE, S/C 111, 15 MAY 1974.)

C. SOYUZ SPACECRAFT

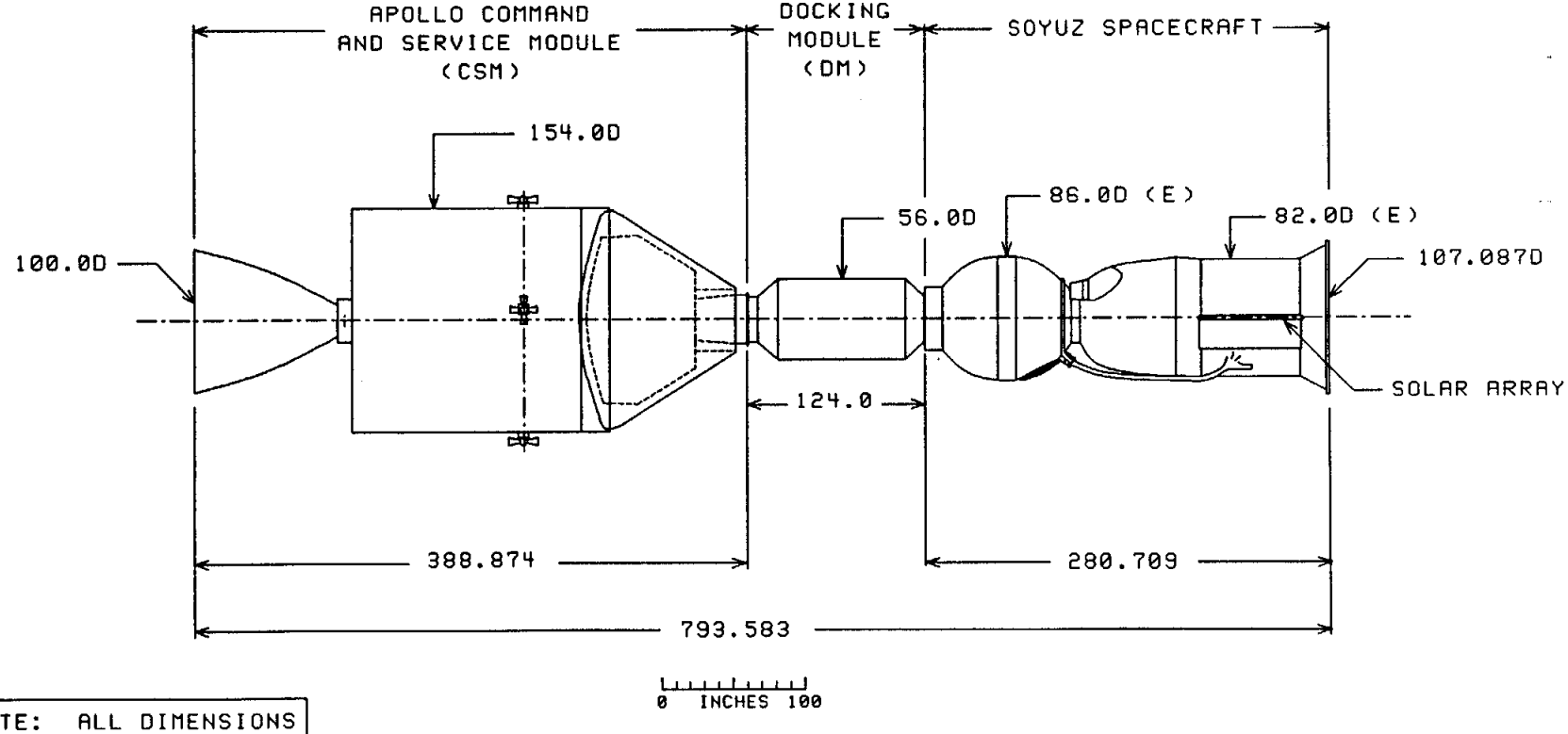
APSOMP01 CCSD WH 20 AUG 93

APOLLO-SOYUZ TEST PROJECT

(DOCKED CONFIGURATION)

REFERENCE: APOLLO-SOYUZ TEST PROGRAM, SYSTEM DESCRIPTION MANUAL, CSM 111/ DOCKING MODULE, SECTION 1, JSC, JAN 1974.
APOLLO-SOYUZ TEST PROJECT, FACT SHEET, RELEASE NO. 75-9, 1975.
APOLLO-SOYUZ TEST PROJECT, INFORMATION FOR PRESS, 1975.

NOTE: SOME DIMENSIONS HAVE BEEN SCALED AND ARE ESTIMATES. THESE DIMENSIONS ARE FOLLOWED BY (E).



NOTE: ALL DIMENSIONS ARE IN INCHES.

APSODR01 CCSD WH 17 AUG 93

NOTE: ALL MASS IS IN POUNDS.

DATA POINT (6)

DESIGN MASS SUMMARY

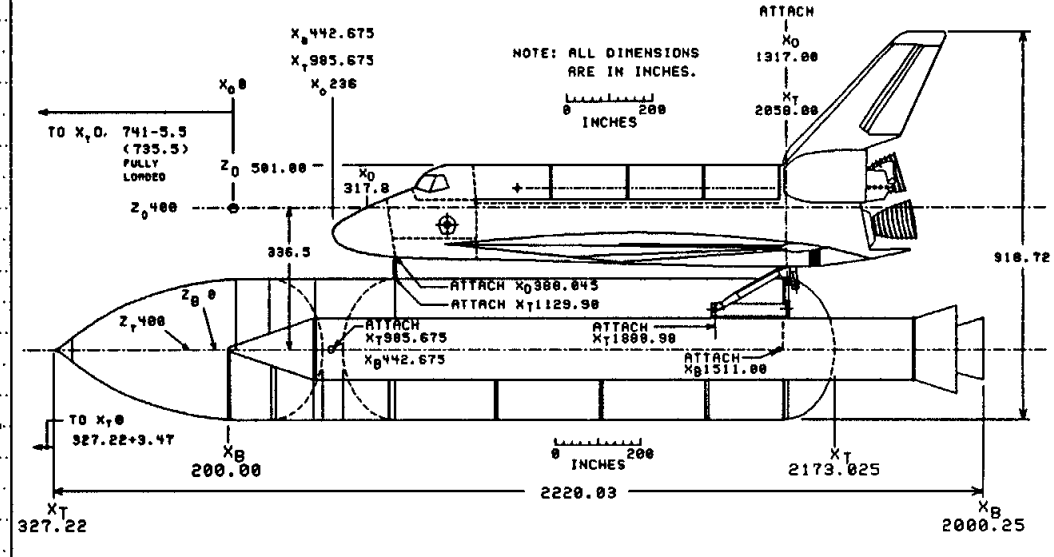
SPACE SHUTTLE VEHICLE (SSV)

REFERENCE: OV-103, FLT 10
21 FEB 90

FUNCTIONAL SYSTEM CODE	A	B	C	D
1. STRUCTURE	63287	52589	254960	
2. PROTECTION	28030	5959	52416	
3. PROPULSION	37604	2951	1000	
4. POWER	16620	372	2546	
5. CONTROL	2785	-	4655	
6. AVIONICS	4555	68	269	
7. ENVIRONMENT	9454	-	786	
8. OTHER	9642	6676	69260	
9. GROWTH	420	-	-	
DRY MASS	172397	68615	385892	
10. NON-CARGO	10336	8209	-	
11. CARGO	28552	-	-	
INERT MASS	211285	76824	385892	
12. NON-PROPELLANT	9239	3948	-	
13. PROPELLANT	28978	1573303	2214660	
GROSS MASS (A+B+C = 4504129)	249502	1654075	2600552	

SPACE SHUTTLE VEHICLE (SSV)

REFERENCE: DRAWING SHUTDR01



NOTE:

A. ORBITER (OV-103, FLT 10), STS-31
B. EXTERNAL TANK (ET), LWT-001
C. SOLID ROCKET BOOSTER (SRB), (2), STS-31

NOTE: ALL MASS IS IN POUNDS.

DATA POINT 6A

MASS SUMMARY

SPACE SHUTTLE DISCOVERY OV-103, FLT 10 — 21 FEB 90

1. STRUCTURE	63287	4. POWER	16620	8. OTHER	9642
BODY GROUP	44628	PRIME POWER	3942	LANDING AND AUX SYS	8868
TAIL GROUP	2609	ELEC CONVR AND DISTR	10828	PAYLOAD PROVISIONS	774
WING GROUP	16050	HYDR CONVR AND DISTR	1850		
				9. GROWTH	420
				DRY MASS	172397
		5. CONTROL	2785	10. NON-CARGO	10336
		SURFACE CONTROLS	2785	PAYLOAD ACCOMODATION	0
				PERSONNEL	5571
				RESERVE AND RESIDUAL	1491
				NON-PROPELLANT	
				RESERV AND RESIS PROPEL	3274
2. PROTECTION	28030	6. AVIONICS	4555	11. CARGO (PAYLOAD 25503,	28552
INDUCED ENVIRONMENTAL	28030	COMMUNICATION AND TRACK	1531	STS OPERATOR 3049	
PROTECTION		DATA PROC AND SOFTWR	1332	**INERT MASS**	211285
		GUIDANCE NAV AND CONTR	967		
		INSTRUMENTATION	725	12. NON-PROPELLANT	9239
				ASCENT PROPEL, DUMP	5166
				IN-FLIGHT LOSSES	4073
3. PROPULSION	37604				
ASCENT PROPULSION	31305				
ORBIT MANEUV SYS (OMS)	3087				
REACT CONTR SYS (RCS)	3212				
		7. ENVIRONMENT	9454	13. PROPELLANT	28978
		CONTROLS SYSTEM	1411	USABLE, OMS	23416
		DISPLAYS SYSTEM	669	USABLE, RCS	5562
		ENVIRONMENTAL CONTROL	5300		
		LIGHTING SYSTEM	203		
		PERSONNEL PROVISIONS	1871		
				GROSS MASS	249502

SHUTMP04 CCSD WH 10 NOV 92

ALL MASS IN POUNDS

1. STRUCTURE	
SECONDARY FORWARD RCS MODULE	9.
FORWARD FUSELAGE-DOORS,MISC	436.3
FORWARD RCS MODULE-DOORS,MISC	33.
CREW MODULE-DOORS,MISC	728.3
OMS/RCS POD-DOORS,MISC	2968.4
MID FUSELAGE-DOORS,MISC	117.5
AFT FUSELAGE-DOORS,MISC	505.7
STRUCTURE - TULSA -PAYLOAD BAY	3008.6
DOOR ACTUATION - PAYLOAD BAY	186.
DOOR LATCH - PAYLOAD BAY	676.
RADIATOR HINGE&LATCH-PAYLD BAY	203.
MISCELLANEOUS - PAYLOAD BAY	580.
SECONDARY CREW MODULE	1912.1
SECONDARY MID FUSELAGE	482.2
SECONDARY AFT FUSELAGE-BODY	1386.4
SECONDARY AFT FUSE-BODY FLAP	464.4
BASIC STRUCT AFT FUSE - BODY	7298.4
AFT FUSELAGE THRUST STRUCTURE	3182.4
BASIC STRUCT FWRD RCS MODULE	343.5
SECONDARY FORWARD FUSELAGE	493.7
BASIC STRUCT CREW MODULE	4213.6
BASIC STRUCT FORWARD FUSELAGE	4299.5
BASIC STRUCT MID FUSELAGE	11100.
TOTAL FOR BODY GROUP	(44628.)
RUDDER/SPEED BRAKE LWR SUP MEC	13.3
OPERATING MECHANISM SUPPORTS	93.
RUDDER/SPEED BRAKE UPPER SURF.	324.5
RUDDER/SPEED BRAKE UP SUP MECH	15.1
RUDDER/SPEED BRAKE LOWER SURF.	319.
OUTER PANEL TORQUE BOX	1406.7
OUTER PANEL LEADING EDGE	88.5
OUTER PANEL TRAILING EDGE	287.7
STRUCTURE	61.2
TOTAL FOR TAIL GROUP	(2609.)
OUTER PANEL INTERIM SECTION	2291.4
OUTER PANEL TORQUE BOX	6357.4
OUTER PANEL LEADING EDGE	188.2
OUTER PANEL TRAILING EDGE	1306.7
SECONDARY STRUCTURE	2413.5
OPERATING MECHANISMS & CONTROL	382.
OPERATING MECH-ACTUATOR LOCKS	167.6
MISC. PROVISIONS AND SUPPORT	112.8
ELEVON INBOARD SURFACE	1291.
ELEVON INBOARD SUPPORT MECH.	278.2
ELEVON OUTBOARD SURFACE	921.6
ELEVON OUTBOARD SUPPORT MECH.	339.6
TOTAL FOR WING GROUP	(16050.)
TOTAL FOR STRUCTURE	(63287.)
2. PROTECTION	
TPS FIXED WING L.E. RCC	3663.4
TPS FIXED WING M.L.G. DOORS	313.8
TPS FIXED WING SURFACE	5566.8
TPS ELEVONS - INBOARD (WING)	1036.6

TPS ELEVONS - OUTBOARD (WING)		802.2
TPS FIN		969.6
TPS RUDDER/SPEED BRAKE LOWER		90.
TPS RUDDER/SPEED BRAKE UPPER		102.
TPS FORWARD N.L.G. DOORS		135.7
TPS FORWARD R.C.S. MODULE		417.4
TPS FORWARD BODY		2208.3
TPS MIDBODY - PAYLOAD BAY DOOR		1075.2
TPS MIDBODY		2688.7
TPS AFT E.T. UMBIL. DOORS		73.2
TPS AFT BODY		1053.
TPS OMS/RCS PODS		1436.
TPS BODY FLAP		943.4
TPS BASE HEAT SHIELD		407.
WING - INTERNAL		102.6
TAIL - INTERNAL		11.5
FORWARD RCS MODULE - INTERNAL		194.3
BODY - FORWARD - INTERNAL		561.9
BODY-PAYLOAD BAY DOORS-INTERNA		366.3
BODY - MID - INTERNAL		1476.5
BODY - AFT - INTERNAL		212.2
OMS/RCS PODS - INTERNAL		449.6
BODY - FLAP - INTERNAL		0.5
WING PURGE AND VENT		70.6
TAIL PURGE AND VENT		10.
BODY - FORWARD PURGE AND VENT		339.2
BODY - MID PURGE AND VENT		699.2
BODY - AFT PURGE AND VENT		343.7
OMS/RCS PODS PURGE AND VENT		21.4
BODY-FORWARD DRN,WINDO,COND		125.4
BODY-MID DRN,WINDO,COND		36.1
BODY-AFT DRN,WINDO,COND		26.7
TOTAL FOR INDUCED ENVIRON PROT	(	28030.)
TOTAL FOR PROTECTION	(	28030.)

3. PROPULSION

SSME GIMBAL SYSTEM		1761.6
SSME HYDRAULIC SUPPLY		221.1
SSME-INSTL,HEAT SHIELD,GN2 PRG		1213.5
PNEUMATIC SYSTEM - HELIUM		2100.4
ET PRESSURIZATION SYSTEM		164.4
PROPELLANT MANAGEMENT SYSTEM		38.
LH2 MAIN FEED SYSTEM		2014.7
LH2 FILL AND DRAIN SYSTEM		261.1
LH2-PRESTART COND, RELIEF,DUMP		376.1
LO2 MAIN FEED SYSTEM		2017.5
LO2 FILL AND DRAIN SYSTEM		242.3
LO2-OVBRD BLEED,RELF,POGO SUPP		123.3
SSME		20771.
TOTAL FOR PROPULSION - ASCENT	(	31305.)
OMS ENGINE INSTALLATION		638.6
OMS PRESSURIZATION SYSTEM		759.
OMS FUEL SYSTEM		839.5
OMS OXIDIZER SYSTEM		849.9
TOTAL FOR PROPULSION - OMS	(	3087.)
RCS AFT POD ENG. INSTALLATION		601.2
RCS AFT PRESSURIZATION SYSTEM		329.
RCS AFT PROPELLANT SYSTEM FUEL		379.2
RCS AFT PROPELLANT SYSTEM OXID		371.6

RCS FWD MODULE ENGINE INST		869.
RCS FWD PRESSURIZATION SYSTEM		148.
RCS FWD PROPELLANT SYSTEM FUEL		265.3
RCS FWD PROPELLANT SYSTEM OXID		248.7
TOTAL FOR PROPULSION - RCS	(	3212.)
TOTAL FOR PROPULSION	(	37604.)

4. POWER

CONVERSION EQUIPMENT		242.7
CONTROL UNITS		1154.5
DISTRIBUTION EQUIPMENT		532.6
ELECTRICAL SUPPORTS		956.
ELECTRICAL INSTALLATION		654.6
ELECTRICAL CABLING		5327.7
ELECTRICAL CONNECTORS		106.5
CABLING INSTALLATION & SUPPORT		1853.4
TOTAL FOR ELEC. CONVR.& DISTR.	(	10828.)
HYDR POWER SUPPLY EQUIPMENT		201.
HYDR DISTRIBUTION & CONTROL		1049.2
HYDR TEMPERATURE CONTROL SYSTE		599.8
TOTAL FOR HYDR. CONVR.& DISTR.	(	1850.)
APU EXHAUST SYSTEM		82.2
APU WATER SYSTEM		92.3
POWER GEN SYSTEM FUEL CELL		1088.
PRSD OXYGEN		987.9
PRSD HYDROGEN		954.
APU POWER SYSTEM		366.3
APU FUEL SYSTEM		325.2
APU LUBE OIL COOLANT LOOP		46.1
TOTAL FOR PRIME POWER	(	3942.)
TOTAL FOR POWER	(	16620.)

5. CONTROL

COCKPIT CONTROLS		70.4
SYSTEM ACTUATION-BODY FLAP		360.7
SYSTEM ACTUATION-ELEVON		1097.3
SYSTEM ACTUAU-RUDDER SPD.BRAKE		1256.6
TOTAL FOR SURFACE CONTROLS	(	2785.)
TOTAL FOR CONTROL	(	2785.)

6. AVIONICS

C&T ANTENNAS		362.6
C&T INSTALLATION		144.7
C&T UNITS		846.8
C&T CIRCUITRY		176.9
TOTAL FOR COMMUNICATION & TRAC	(	1531.)
DATA PROCESSING&SOFTWARE INST.		15.
DATA PROCESSING&SOFTWARE UNITS		1317.2
TOTAL FOR DATA PROCESSING & SO	(	1332.2)
GN&C UNITS		816.9
GN&C INSTALLATION		150.
TOTAL FOR GUIDANCE NAVIG. & CO	(	966.9)
OPERATIONAL FLIGHT INSTR INST.		58.6
INSTRUMENTATION UNITS		666.6
TOTAL FOR INSTRUMENTATION SYST	(	725.2)
TOTAL FOR AVIONICS	(	4555.3)

7. ENVIRONMENT

ROTATION HAND CONTROL		29.7

TRANSLATION HAND CONTROL	10.2
SPEED BRAKE/THRUST CONTROL	9.6
INSTALLATION	50.
MISSION SPECIALIST STA PANELS	54.8
ON ORBIT STATION PANELS	166.1
PAYLOAD MONITOR STATION PANELS	7.7
FLIGHT STATION PANELS	560.5
ANNUNCIATOR CONTROL ASSEMBLY	48.
MISSION SPEC STA PANEL INSTAL	12.
SUPPORTS	346.5
MIDSECTION PANELS	99.3
KEYBOARD	16.8
TOTAL FOR CONTROLS SYSTEM	(1411.2)
C&W INHIBIT/STATUS	3.2
CLOSED CIRCUIT TV MONITOR	42.8
TWO AXIS G METER	1.3
C&P DISPLAY UNIT, HUD	41.8
ELECTRONIC HUD	79.
ALTITUDE DIRECTOR INDICATOR	26.4
CROSS POINTER	5.
ANNUN-COMPUTER EVENT SEQUENCER	5.6
SURFACE POSITION INDICATOR	7.
DISPLAY ELECTRONIC UNIT	137.2
DISPLAY DRIVER UNIT	100.5
DISPLAY UNIT	104.8
EVENT TIMER	3.2
MISSION TIMER	4.8
C&W ELECTRONIC UNIT	30.6
AIRSPEED/MACH INDICATORS	26.2
ALT/VERTICAL VELOCITY INDICAT	25.6
C&W ANNUNCIATORDR	8.1
HORIZON SITUATION INDICATOR	15.4
TOTAL FOR DISPLAYS SYSTEM	(668.4999)
CABIN ATMOSPHERE REVITALIZATN	583.2
HEAT TRANSPORT WATER LOOP	331.
EQUIPMENT ENVIR CONTROL LOOP	746.6
CABIN PRESSURE CONTROL	464.9
AMMONIA SYSTEM	67.2
AIRLOCK SUPPORT SYSTEM	14.1
AIRLOCK SUPPORT SYSTEM-ORBITAL	15.
HEAT TRANSPORT FREON LOOP	3078.
TOTAL FOR ENVIRONMENTAL CONTRL	(5300.)
LIGHT SYSTEM	203.
TOTAL FOR LIGHTING SYSTEM	(203.)
AIRLOCK	13.
PAYLOAD BAY	131.4
FOOD MANAGEMENT SYSTEMS	168.2
WASTE MANAGEMENT SYSTEM	261.
WATER MANAGEMENT SYSTEM	243.
FIRE DETECTION SYSTEM	46.3
COMMANDER STATION	169.
PILOT STATION	169.
PAYLOAD MONITOR STATION	92.
MISSION MONITOR STATION	113.
FURNISHINGS	396.
ORBITER-AIRLOCK PROVISIONS	69.1
TOTAL FOR PERSONNEL PROVISIONS	(1871.)
TOTAL FOR ENVIRONMENT	(9453.7)

8. OTHER		
	MAIN ROLLING GEAR	2300.2
	MAIN GEAR STRUCTURE	2714.4
	NOSE ROLLING GEAR	183.6
	NOSE GEAR STRUCTURE	600.6
	MAIN RETARCT	348.1
	BRAKE OPERATION	345.4
	NOSE RETRACT	107.2
	NOSE STEERING	40.
	AUX SYSTEMS - SEPARATION	908.3
	AUX SYSTEMS-MANIPULATOR-SPAR	941.
	AUX SYSTEMS-MANIPULATOR INSTAL	378.9
	AUX SYSTEMS-MANIPULATOR-GFE	0.3
	TOTAL FOR LANDING & AUX. SYST	(8868.)
	MID FUSELAGE FIXED SCAR ITEMS	96.8
	WING FIXED SCAR ITEMS	2.2
	MID FUSELAGE REMOVABLE PROVIS	675.
	TOTAL FOR PAYLOAD PROVISIONS	(774.)
	TOTAL FOR OTHER	(9642.)
9. GROWTH		
	MARGIN	420.
	TOTAL FOR MARGIN	(420.)
	TOTAL FOR GROWTH	(420.)
10. NON-CARGO		
	AUXILIARY SYSTEMS	0.
	EPS CRYO KIT NO.2	0.
	TOTAL FOR PAYLOAD ACCOMODATION	(0.)
	MARGIN	101.1
	CREW MEMBER PILOT	173.
	CREW MEMBER PAYLOAD MONITOR	251.
	CREW MEMBER MISSION MONITOR	511.
	CREW ACCESSORIES - GFE	2954.
	CREW ACCESSORIES - CFE	1390.9
	CREW MEMBER COMMANDER	190.
	TOTAL FOR PERSONNEL	(5571.)
	ECS RESERVES	197.
	HYDRAULIC COOLING RESIDUALS	126.
	ASCENT PROPULSION RESIDUALS	50.
	MANEUVER RESIDUALS	96.
	REACTION CONTROL RESIDUALS	32.
	ECS RESIDUALS	51.
	PRIME POWER (EPS & APS) RESID	340.
	PRIME POWER (EPS & APS) RESERV	450.
	HYDRAULIC COOLING RESERVES	149.
	TOTAL FOR RESRV&RESID-NON PROP	(1491.)
	MANEUVER RESIDUALS	890.
	REACTION CONTROL RESIDUALS	587.
	MANEUVER RESERVES	758.
	REACTION CONTROL RESERVES	1039.
	TOTAL FOR RESRV&RESID-PROP	(3274.)
	TOTAL FOR NON-CARGO	(10336.)
11. CARGO		
	PAYLOAD/MODULE	25503.
	TOTAL FOR PAYLOAD	(25503.)
	MISSION KITS	3049.

TOTAL FOR STS-OPERATOR	(	3049.)
TOTAL FOR CARGO	(	28552.)

12. NON-PROPELLANT			
UNUSABLE - SSME			1613.
UNUSABLE - ORBITER			3379.
RESERVE - ORBITER			174.
TOTAL FOR ASCENT PROP - DUMP	(		5166.)
ASCENT PROPULSION			171.9
HYDRAULIC COOLING			157.1
CABIN ATMOSPHERE			185.
ECS			662.
PRIME POWER (EPS & APS)			2897.
TOTAL FOR IN-FLIGHT LOSSES	(		4073.)
TOTAL FOR NON-PROPELLANT	(		9239.)
13. PROPELLANT			
MANEUVER			23416.
TOTAL FOR USABLE-OMS	(		23416.)
REACTION CONTROL			5562.
TOTAL FOR USABLE-RCS	(		5562.)
TOTAL FOR PROPELLANT	(		28978.)
GROSS VEHICLE WEIGHT			249502.

NOTE: ALL MASS IS IN POUNDS.

DATA POINT 6B

MASS SUMMARY

SPACE SHUTTLE EXTERNAL TANK (ET), LWT-001

15 JUN 82

1. STRUCTURE	52589	4. POWER	372	8. OTHER	6676
LIQ OXY TANK	12485	ELECTRICAL SYSTEM	372	ORB/SRB ATTACHMENT	4234
INTERTANK	12113			RANGE SAAFETY SYSTEM	326
LIQ HYD TANK	27991			MECHANICAL SYSTEM	1233
				SEPARATION HARDWARE	883
				9. GROWTH	-
				DRY MASS	68615
		5. CONTROL	-	10. NON-CARGO	8209
				UNUSABLE FLUIDS	391
				FLIGHT PERFORMANCE RESERVE	3197
				RESIDUAL LIQ HYD	1609
				RESIDUAL LIQ OXY	3012
2. PROTECTION	5959	6. AVIONICS	68	11. CARGO	-
THERMAL PROTECTION	5959	INSTRUMENTATION	68	**INERT MASS**	76824
				12. NON-PROPELLANT	3948
				LIQUIDS AND GASES	3948
3. PROPULSION	2951				
LIQ OXY SYSTEM	1807				
LIQ HYD SYSTEM	1144				
		7. ENVIRONMENT	-	13. PROPELLANT	1573303
				USABLE PROPELLANT	1568428
				FUEL BIAS	1100
				LESS PRE-PRESS GASES	-423
				TRANSFERRED TO ORB	183
				SSME BUILDUP PROPEL	4015
				GROSS MASS	1654075

SHUTMP03 CCSD WH 10 NOV 92

SPACE SHUTTLE EXTERNAL TANK
DESIGN MASS SUMMARY (JSC FORMAT)

ALL MASS IN POUNDS

1. STRUCTURE		
BHD		89.
FRAME, FWD		110.
OGIVE, FWD		1283.
OGIVE, AFT		3168.
FRAME, XT 745		245.
BARREL		2399.
FRAME, INTERTANK		790.
DOME, AFT		2560.
BAFFLES, SLOSH		1841.
PRIMER, AFT DOME		0.
	TOTAL FOR LO2 TANK	(12485.)
BARREL PANELS, MACHINED		3699.
BARREL PANELS, SKIN/STRINGER		4114.
FRAMES, STABILIZING (4)		1102.
FRAME, SRB THRUST XT 985		752.
BEAM, SRB THRUST		1114.
FITTING, SRB THRUST (2)		821.
ACCESS DOOR		42.
SPLICES, BARREL PANELS (8)		127.
STABILIZERS, FRAME		103.
FASTENERS, ET ASSY		104.
FAIRINGS		85.
INTERNAL PRIMER		50.
	TOTAL FOR INTERTANK	(12113.)
DOME, FWD		1380.
FRAME XT 1109.9		1130.
BARREL, NO. 4		4537.
FRAME XT 1377		414.
BARREL, NO. 3		4555.
FRAME XT 1624		413.
BARREL, NO. 2		4885.
FRAME XT 1871		1162.
BARREL, NO. 1		4988.
FRAME XT 2058		2482.
DOME, AFT		2045.
	TOTAL FOR LH2 TANK	(27991.)
	TOTAL FOR STRUCTURE	(52589.)
2. PROTECTION		
NOSE CONE		23.
LO2 TANK		1216.
INTERTANK		1045.
LH2 TANK		2762.
INTERFACE HARDWARE		151.
PROP/MECH		218.
ELECTRICAL		300.
RANGE SAFETY SYSTEM		6.
CLOSEOUT		238.
	TOTAL FOR THERMAL PROTECT SYS	(5959.)
	TOTAL FOR PROTECTION	(5959.)
3. PROPULSION		
LO2 FEED SYSTEM		1515.
LO2 ANTIGEYSER SYSTEM		0.

LO2 VENT SYSTEM		95.
LO2 PRESSURIZATION SYSTEM		197.
	TOTAL FOR LO2 SYSTEM	(1807.)
LH2 FEED SYSTEM		691.
LH2 RECIR. SYSTEM		31.
LH2 VENT SYSTEM		97.
LH2 PRESSURIZATION SYSTEM		325.
	TOTAL FOR LH2 SYSTEM	(1144.)
	TOTAL FOR PROPULSION	(2951.)
4. POWER		
ET/SRB CABLING		306.
ET/SRB CABLING SUPPORTS		66.
	TOTAL FOR ELECTRICAL SYSTEMS	(372.)
	TOTAL FOR POWER	(372.)
6. AVIONICS		
INSTRUMENTATION		22.
INSTRUMENTATION SUPPORTS		46.
	TOTAL FOR INSTRUMENTATION	(68.)
	TOTAL FOR AVIONICS	(68.)
8. OTHER		
FWD BI-POD ASSY		203.
AFT ET/ORB TRUSS		3407.
TANK FITTINGS - ORB/ET		317.
TANK FITTINGS - SRB/ET		307.
	TOTAL FOR ORB/SRB ATTACHMENTS	(4234.)
HARDWARE, CFE SOURCE		247.
HARDWARE, GFE SOURCE		79.
	TOTAL FOR RANGE SAFETY SYSTEM	(326.)
MECHANICAL SUPPORT SYSTEMS		112.
NOSE CONE		74.
FAIRINGS & CONDUIT		640.
LINE & CONDUIT SUPPORTS		362.
TUMBLE SYSTEM		45.
	TOTAL FOR MECHANICAL SYSTEMS	(1233.)
SRB (GFE)		824.
ORB (GFE) EO-1, EO-2, EO-3		59.
	TOTAL FOR SEPARATION HARDWARE	(883.)
	TOTAL FOR OTHER	(6676.)
10. NON-CARGO		
PROPELLANT, LH2 TANK		223.
PROPELLANT, LH2 LINE		68.
PROPELLANT, LO2 LINE		100.
	TOTAL FOR UNUSABLE FLUIDS	(391.)
FPR LH2		718.
FPR LO2		2479.
	TOTAL FOR FLIGHT PERFO RESERVE	(3197.)
RESIDUAL LH2		1609.
	TOTAL FOR RESIDUAL LH2	(1609.)
RESIDUAL LO2		3012.
	TOTAL FOR RESIDUAL LO2	(3012.)
	TOTAL FOR NON-CARGO	(8209.)
12. NON-PROPELLANT		
GH2, INFLIGHT		958.
GO2, INFLIGHT		2567.

GH2, TRAPPED ULLAGE VAPOR		164.
GO2, TRAPPED ULLAGE VAPOR		197.
HELIUM, LH2 TANK PRE-PRESS		41.
HELIUM, LO2 TANK PRE-PRESS		21.
TOTAL FOR LIQUIDS & GASSES	(	3948.)
TOTAL FOR NON-PROPELLANT	(	3948.)

13. PROPELLANT

USABLE LH2		223617.
USABLE LO2		1344811.
TOTAL FOR USABLE PROPELLANT	(1568428.)	
FUEL BIAS		1100.
TOTAL FOR FUEL BIAS	(	1100.)
LESS PRE-PRES GASSES - LH2		-205.
LESS PRE-PRES GASSES - LO2		-218.
TOTAL FOR LESS PRE-PRES GASSES	(	-423.)
TRANSFERRED TO ORBITER - LH2		51.
TRANSFERRED TO ORBITER - LO2		132.
TOTAL FOR TRANSFERRED TO ORB	(	183.)
SSME BUILDUP PROP - LH2		647.
SSME BUILDUP PROP - LO2		3368.
TOTAL FOR SSME BUILDUP PROP	(	4015.)
TOTAL FOR PROPELLANT	(1573303.)	

GROSS VEHICLE WEIGHT	1654075.

NOTE: ALL MASS IS IN POUNDS FOR TWO SRB'S.

DATA POINT 6C

MASS SUMMARY

SPACE SHUTTLE SOLID ROCKET BOOSTER (SRB)

APPROX APR 1990

NOTE: SRB'S ARE BASED ON STS-31 LEFT, BUT MASSES ARE FOR TWO.

1. STRUCTURE	254960	4. POWER	2546	8. OTHER	69260
BODY STRUCTURE		BATTERY	180	RECOVERY SYSTEM	18054
NOSE CAP	553	DISTRIBUTORS	95	SEPARATION SYSTEM	1438
FRUSTRUM	7762	RECOVERY AIDS	6	RANGE SAFETY AND ABORT	289
FORWARD SKIRT	13260	BARO SWITCH	65	ATTACHMENT PROVISIONS	810
AFT SKIRT	29084	TRANSDUCERS	326	NOZZLE ASSEMBLY	47562
ATTACH STRUCTURE	4870	WIRE	1050	TUNNEL	1107
SYSTEMS TUNNEL	879	CANISTERS	748	9. GROWTH	-
SEPARATION RING	312	BRACKETS AND SUPPTS	21	**DRY MASS** (FOR TWO)	385892
SRM STRUCTURE		RATE GYROS	55		
FORWARD CASE ASSY	52669	5. CONTROL	4655	10. NON-CARGO	-
CENTER CASE ASSY FWD	43123	TVC ACTUATORS	1397		
CENTER CASE ASSY AFT	42677	TVC HYD FLUID RESERVOIR	273		
AFT CASE ASSY	58311	TVC HYD FLUID	146		
CASE STIFFENER RING	1460	TVC FUEL	127		
		TVC INSTALLATION	2712		
2. PROTECTION	52416	6. AVIONICS	269	11. CARGO	-
THERMAL PROTECTION	2936	INSTRUMENTATION	269		
PAINT 297, SEALANT 121	418			**INERT MASS** (FOR TWO)	385892
INSULATION	40727				
LINER	2690			12. NON-PROPELLANT	-
INHIBITOR	3730				
INSULATION EXTERNAL	1915				
3. PROPULSION	1000				
IGNITION SYSTEM	1000				
		7. ENVIRONMENT	786	13. PROPELLANT	2214660
		JOINT HEATER SYSTEM	786	SEPARATION	1247
			-	MAIN	2213145
				IGNITOR	268
				GROSS MASS (FOR TWO)	2600552

SHUTMP02 CCSD WH 10 NOV 92

SPACE SHUTTLE SOLID ROCKET BOOSTER
DESIGN MASS SUMMARY (JSC FORMAT)

ALL MASS IN POUNDS

1. STRUCTURE		
SKIN (INC WELDS)		229.1
RNG FRAMES,STRNGERS,TIE RODS		36.1
FITTINGS		10.4
ASSEMBLY HARDWARE		1.1
	TOTAL FOR NOSE CAP	(276.7)
SKIN (INC WELDS)		1231.4
RNG FRAMES,STRNGERS,LONGERONS		985.4
BEAMS & SHEAR PANELS		478.9
BULKHEADS		38.4
FITTINGS		90.4
BRACKETS,DOUBLERS,GUSSETS		464.4
FLOTATION		229.3
ATTACH HARDWARE		279.3
ASSEMBLY HARDWARE		83.6
	TOTAL FOR FRUSTRUM	(3881.1)
SKIN (INC WELDS)		2144.1
RNG FRAMES,STRNGERS,LONGERONS		1948.8
BEAMS & SHEAR PANELS		36.2
BULKHEADS		330.7
BRACKETS,DOUBLERS,GUSSETS		849.3
CUTOUTS & ASSOCIATED STRUCT		62.4
THRUST POST		292.6
THRUST POST FITTING		799.1
PINS		25.1
VENT PORTS		1.1
MISC		120.9
ASSEMBLY HARDWARE		19.6
	TOTAL FOR FORWARD SKIRT	(6629.9)
SKIN (INC WELDS)		4691.7
RNG FRAMES,STRNGERS,STRUTS,TIE		5308.2
INTERCOASTALS		205.6
HOLDDOWN STRUCTURE		2705.4
BRACKETS,DOUBLERS,GUSSETS		640.8
CUTOUTS & ASSOCIATED STRUCT		30.4
FITTINGS		142.0
ATTACH HARDWARE		603.8
SEPARATION MOTOR MOUNTS		197.1
ASSEMBLY HARDWARE		17.2
	TOTAL FOR AFT SKIRT	(14542.2)
STRUTS		545.0
SRM RING		1890.2
	TOTAL FOR ATTACH STRUCTURE	(2435.2)
FWD SKIRT TUNNEL		42.5
FWD MOTOR CASE TUNNEL		179.0
AFT MOTOR CASE TUNNEL		126.3
AFT SKIRT TUNNEL		24.9
TUNNEL SPLICES		11.9
ASSEMBLY HARDWARE		55.0
	TOTAL FOR SYSTEMS TUNNEL	(439.6)

ASSEMBLY HARDWARE		156.0
	TOTAL FOR SEPARATION RING	(156.0)
FORWARD DOME SEGMENT		3686.0
CYLINDER SEG FWD		11230.0
CYLINDER SEG AFT		11266.0
JOINT - HARDWARE		166.6
COATINGS		85.0
UNACCOUNTABLE		-98.9
	TOTAL FOR SRM FORWARD CASE ASSY	(26334.7)
CYLINDER SEG FWD		10707.0
CYLINDER SEG AFT		10725.0
JOINT - HARDWARE		83.3
COATINGS		74.0
UNACCOUNTABLE		-27.9
CYLINDER SEG FWD		10653.0
CYLINDER SEG AFT		10556.0
JOINT - HARDWARE		83.3
COATINGS		74.0
UNACCOUNTABLE		-27.9
	TOTAL FOR SRM CTR CASE ASSY FWD	(42899.7)
ATTACH SEG		7003.0
STIFFENER SEG FWD		8402.0
STIFFENER SEG AFT		8498.0
AFT CASE SEGMENT		4920.0
JOINT - HARDWARE		253.0
COATINGS		93.4
UNACCOUNTABLE		-14.0
	TOTAL FOR SRM AFT CASE ASSEMBLY	(29155.4)
STIFFENER RING		729.8
	TOTAL FOR SRM STIFFENER RING	(729.8)
	TOTAL FOR STRUCTURE	(127480.3)
2. PROTECTION		
NOSE CAP		26.9
FRUSTRUM		80.5
FORWARD SKIRT		87.9
SYSTEMS TUNNEL		46.9
ET ATTACH RING		77.3
AFT SKIRT		507.1
HEAT SHIELD		633.2
ORDINANCE RING		8.0
	TOTAL FOR THERMAL PROTECTION	(1467.8)
PAINT		148.4
	TOTAL FOR PAINT	(148.4)
SEALANT		60.5
	TOTAL FOR SEALANT	(60.5)
FWD DOME		683.2
CYLINDER		2533.8
JOINT		1270.7
	TOTAL FOR SRM FWD SEGMENT INSULATION	(4487.7)
FWD JOINT		168.6
CYLINDER		1279.4
AFT JOINT		1298.8
	TOTAL FOR SRM CENTER SEG FWD INSULATION	(2746.9)
FWD JOINT		168.6
CYLINDER		1241.4

AFT JOINT		1298.8
	TOTAL FOR SRM CENTER SEG AFT INSULATION	(2708.9)
JOINT		83.6
CYLINDER		6430.7
AFT DOME		3906.1
	TOTAL FOR SRM AFT SEGMENT INSULATION	(10420.4)
FWD DOME		86.3
CYLINDER		258.9
	TOTAL FOR SRM FWD SEGMENT LINER	(345.3)
INHIBITOR FACE		37.4
CYLINDER		280.9
	TOTAL FOR SRM CENTER SEG FWD LINER	(318.3)
INHIBITOR FACE		37.4
CYLINDER		281.8
	TOTAL FOR SRM CENTER SEG AFT LINER	(319.3)
INHIBITOR FACE		14.5
CYLINDER		267.5
AFT DOME		80.5
	TOTAL FOR SRM AFT SEGMENT LINER	(362.5)
SLEEVE		5.1
AFT FACE		272.9
	TOTAL FOR SRM FWD SEGMENT INHIBITOR	(278.0)
FWD FACE		545.7
AFT FACE		20.7
	TOTAL FOR SRM CENTER SEG FWD INHIBITOR	(566.4)
FWD FACE		537.5
AFT FACE		19.2
	TOTAL FOR SRM CENTER SEG AFT INHIBITOR	(556.7)
FWD FACE		464.0
	TOTAL FOR SRM AFT SEGMENT INHIBITOR	(464.0)
FWD SEG (2 EA)		100.2
FWD CTR SEG		50.6
AFT CTR SEG		50.6
AFT SEG (3 EA)		150.2
FWD SKIRT		16.3
AFT SKIRT		18.2
FIELD JOINTS		69.4
	TOTAL FOR JOINTS	(455.5)
RING INSUL (3)		178.3
STUB INSUL (1)		31.0
	TOTAL FOR STIFFENER RING	(209.3)
FWD SEGMENT		54.2
FWD CTR SEGMENT		59.4
AFT CTR SEGMENT		59.1
AFT SEGMENT		45.0
	TOTAL FOR SYSTEMS TUNNEL	(217.8)
GEI-AFT SEGMENT		65.2
	TOTAL FOR GEI-AFT SEGMENT	(65.2)
CLOSEOUT INSUL		9.2
IGNITER INSUL		0.4
	TOTAL FOR HEATER	(9.6)
	TOTAL FOR PROTECTION	(26208.4)

3. PROPULSION		
LINER		3.3
CHAMBER INSULATED		340.3

INSULATION		6.5
ADAPTER		99.5
INITIATOR		4.2
CHAMBER ATT HDW		14.6
INGNITER ATT HDW		19.6
UNACCOUNTABLE		-2.9
	TOTAL FOR SRM IGNITION SYSTEM	(485.1)
S/A DEVICE		13.0
	TOTAL FOR SRM S/A DEVICE	(13.0)
S/A ATTACH HDW		2.0
	TOTAL FOR SRM S/A ATTACH HDW	(2.0)
	TOTAL FOR PROPULSION	(500.1)
4. POWER		
SRB BATTERY		90.0
	TOTAL FOR PRIME POWER	(90.0)
DISTRIBUTORS		47.5
RECOVERY AIDS		2.8
BARO SWITCH		32.3
TRANSDUCERS		163.2
WIRE		524.9
CANISTERS		374.0
BRACKETS & SUPPORTS		10.3
RATE GYROS		27.6
	TOTAL FOR ELECTRICAL&INSTRUMEN	(1182.6)
	TOTAL FOR POWER	(1272.6)
5. CONTROL		
ACTUATORS		698.6
RESERVOIR		136.6
FUEL BOTTLES		64.0
PLUMBING,VALVES,REGULATORS		159.8
FITTINGS & BRACKETRY		918.2
HPU SYSTEM		214.2
TVC HYDRAULIC FLUID		73.0
TVC FUEL		63.6
	TOTAL FOR THRUST VECTOR CONTRL	(2328.0)
	TOTAL FOR CONTRL	(2328.0)
6. AVIONICS		
FWD OFI		5.9
FWD GEI		6.2
CNTR FWD OFI		0.8
CNTR FWD GEI		12.1
CNTR AFT OFI		0.8
CNTR AFTGEI		15.2
AFT OFI		54.6
AFT GEI		34.1
EXIT CONE SEVERANCE CABLE		3.7
EXIT CONE GEI		1.3
	TOTAL FOR SRM INSTRUMENTATION	(134.6)
	TOTAL FOR AVIONICS	(134.6)
7. ENVIRONMENT		
JOINT HEATER		2.8
JOINT HEATER CABLE		15.6

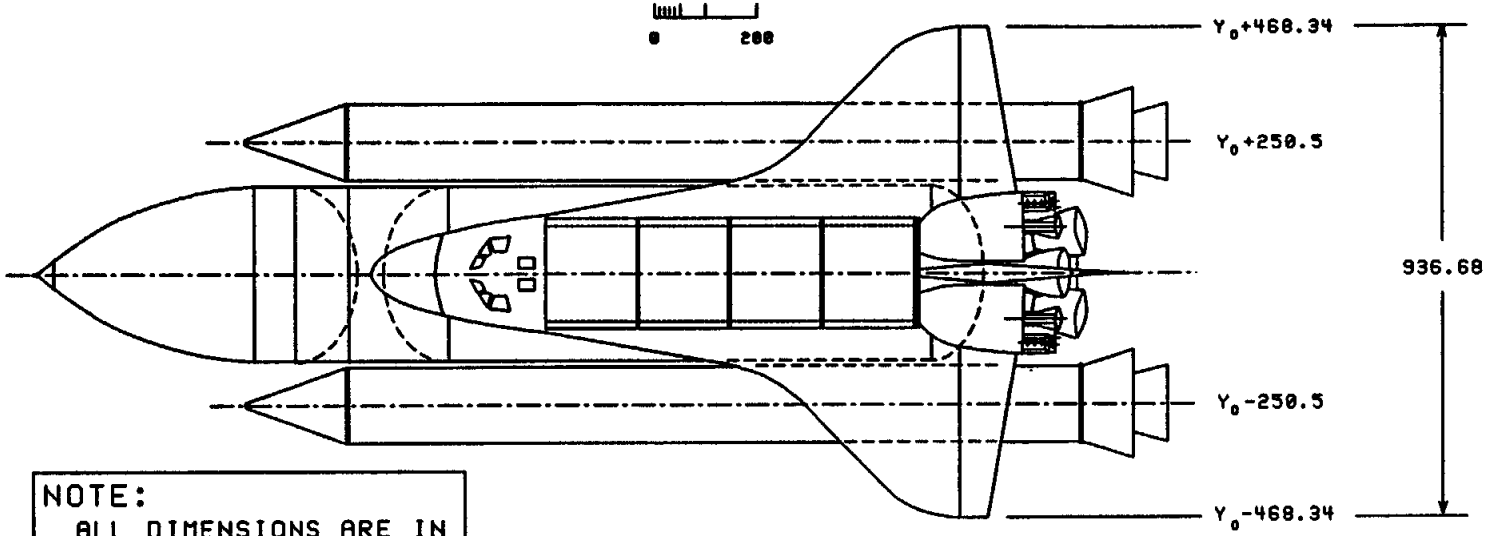
JOINT HEATER CABLE		12.8
JOINT HEATER		58.8
JOINT HEATER CABLE		12.0
JOINT HEATER INSUL		39.9
JOINT HEATER		58.8
JOINT HEATER CABLE		11.7
JOINT HEATER INSUL		39.9
JOINT HEATER		58.8
JOINT HEATER CABLE		42.2
JOINT HEATER INSUL		39.9
	TOTAL FOR SRM JOINT HEATER SYS	(393.2)
	TOTAL FOR ENVIRONMENT	(393.2)

8. OTHER

RECOVERY AIDS		84.5
DECELERATION SUBSYSTEM		8942.3
	TOTAL FOR RECOVERY SYSTEM	(9026.8)
FWD MOTOR CASE		171.6
FWD MOTOR NOZZLE/AFT CLOSURE		138.8
FWD MOTOR LINER		9.8
FWD MOTOR IGNITER		18.8
FWD MOTOR PAINT		2.0
AFT MOTOR CASE		182.0
AFT MOTOR NOZZLE/AFT CLOSURE		129.2
AFT MOTOR LINER		9.8
AFT MOTOR IGNITER		18.8
AFT MOTOR PAINT		2.0
CDF/MANIFOLD ASSY		30.0
INSTALLATION HARDWARE		6.4
	TOTAL FOR SEPARATION SYSTEM	(719.2)
RANGE SAFETY & ABORT		144.4
	TOTAL FOR RANGE SAFETY & ABORT	(144.4)
PINS (531)		194.3
RETAINERS (531)		11.4
RETAINER BANDS		28.5
ADHESIVE		7.4
PACKING		17.4
LUBRICANT		0.9
JOINT FILLER		4.1
FWD SKIRT ATTACH		78.6
AFT SKIRT ATTACH		62.3
	TOTAL FOR SRM ATTACHMENT PROV	(404.8)
FIXED HOUSING ASSY		2523.4
FLEX BEARING ASSY		1593.9
BOOT RINGS & ATTACH		81.2
NOZZLE ATTACH HDW		308.4
FLEXSEAL ASSY		6671.7
NOSE ASSY		2430.2
THROAT ASSY		1551.8
FWD EXIT CONE ASSY		2350.6
UNACCOUNT WT		-115.3
NOZZLE PLUG		87.2

AFT EXIT CONE ASSY		6297.8
	TOTAL FOR SRM NOZZLE ASSEMBLY	(23780.9)
FWD SEGMENT		47.5
FWD CENTER SEGMENT		47.1
AFT CENTER SEGMENT		47.1
AFT SEGMENT		54.5
SPLICE JOINTS		9.0
	TOTAL FOR MOUNT PROV-RUBBER	(205.3)
FWD SEGMENT		82.7
FWD CENTER SEGMENT		82.3
AFT CENTER SEGMENT		82.3
AFT SEGMENT		88.7
SPLICE JOINTS		12.2
	TOTAL FOR FLOOR SUB-ASY(GFE)	(348.2)
	TOTAL FOR OTHER	(34629.6)
13. PROPELLANT		
SEPARATION SYST PROP		623.6
	TOTAL FOR SEPARATION SYST PROP	(623.6)
FWD SEGMENT		301148.9
FWD CENTER SEGMENT		271939.2
AFT CENTER SEGMENT		271762.9
AFT SEGMENT		261721.2
	TOTAL FOR MOTOR PROPELLANT	(1106572.2)
MAIN IGNITER PROP		132.4
INITIATOR PROPELLANT		1.4
	TOTAL FOR IGNITER PROPELLANT	(133.9)
	TOTAL FOR PROPELLANT	(1107329.7)
	GROSS VEHICLE WEIGHT	1,300,276.4

SPACE SHUTTLE VEHICLE



NOTE:
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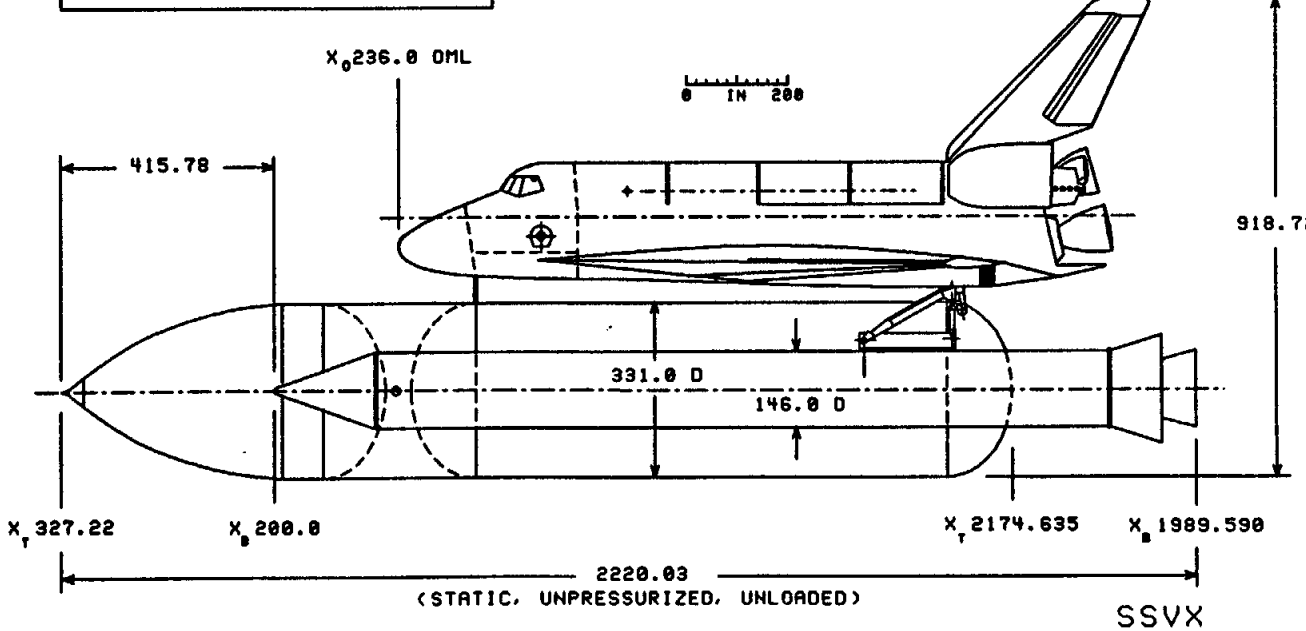

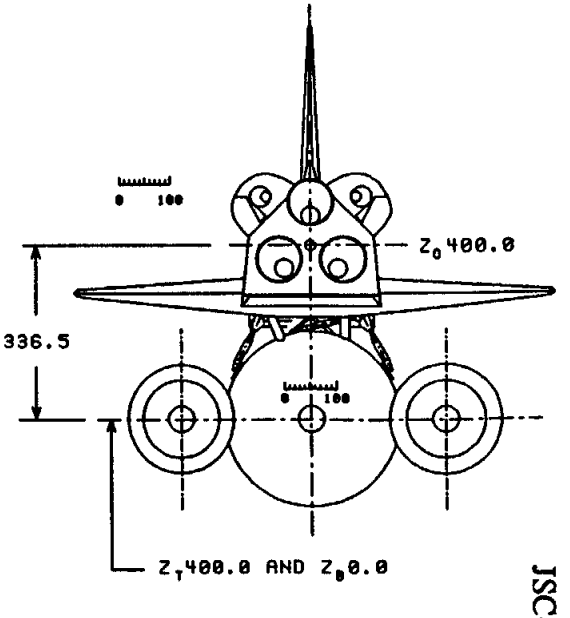

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CCSD WH 21 DEC 93

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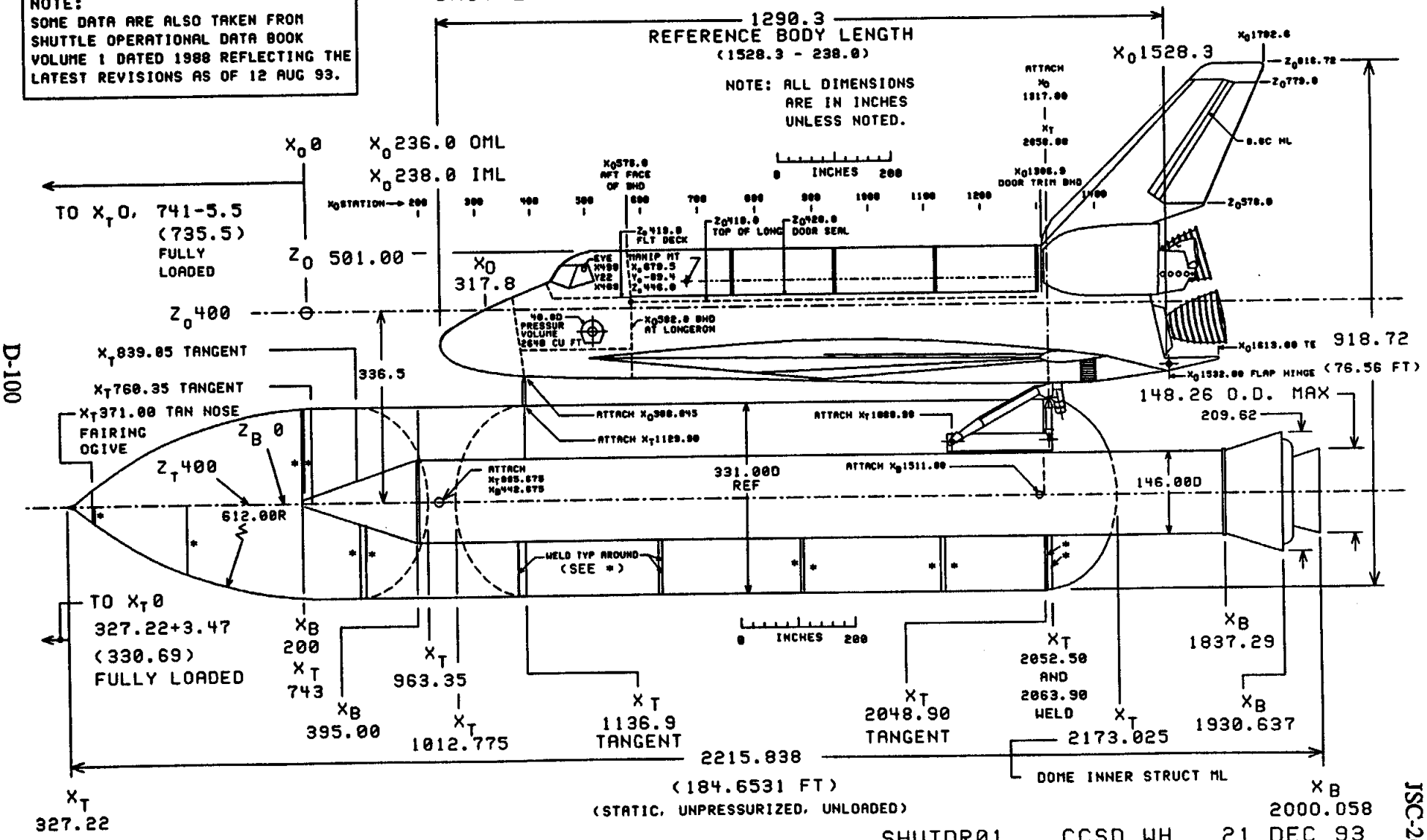
SPACE SHUTTLE VEHICLE

REFERENCE: DWG NO. VC70-000002, DESIGN GEOM ORBITER, REV 9 SEP 80
SHUTTLE OPERATIONAL DATA BOOK, VOL 1

NOTE:
SOME DATA ARE ALSO TAKEN FROM SHUTTLE OPERATIONAL DATA BOOK VOLUME I DATED 1988 REFLECTING THE LATEST REVISIONS AS OF 12 AUG 93.



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SPACE SHUTTLE ORBITER

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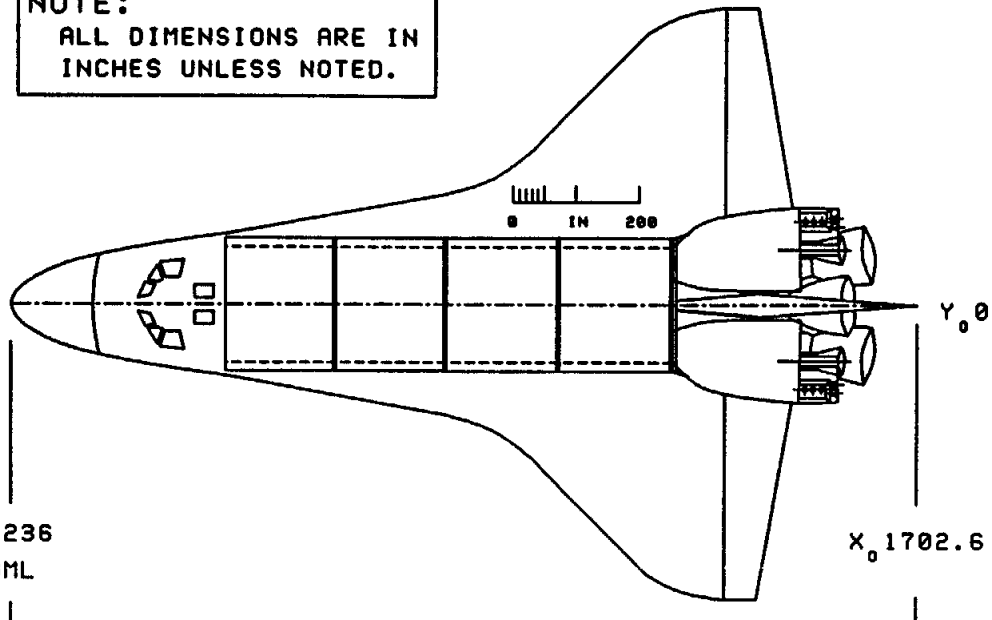

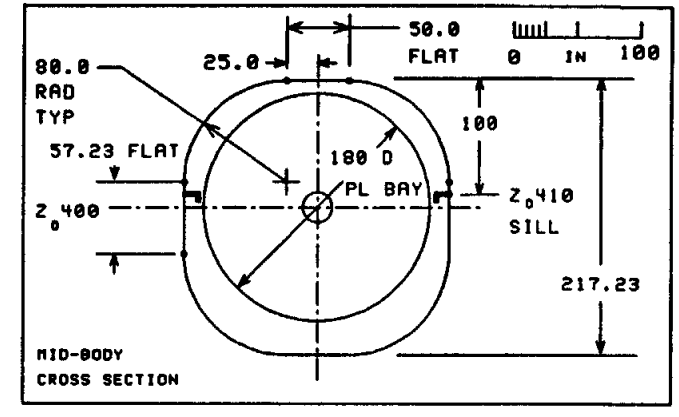

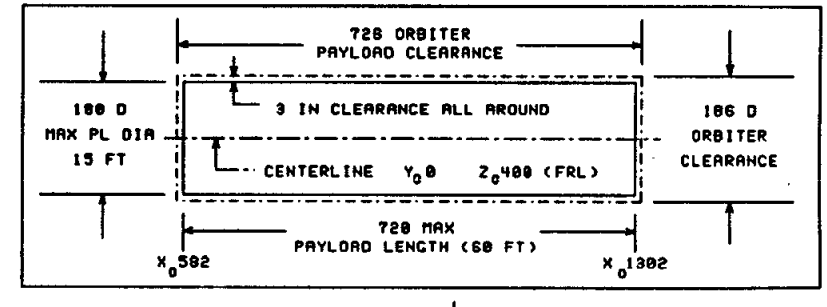

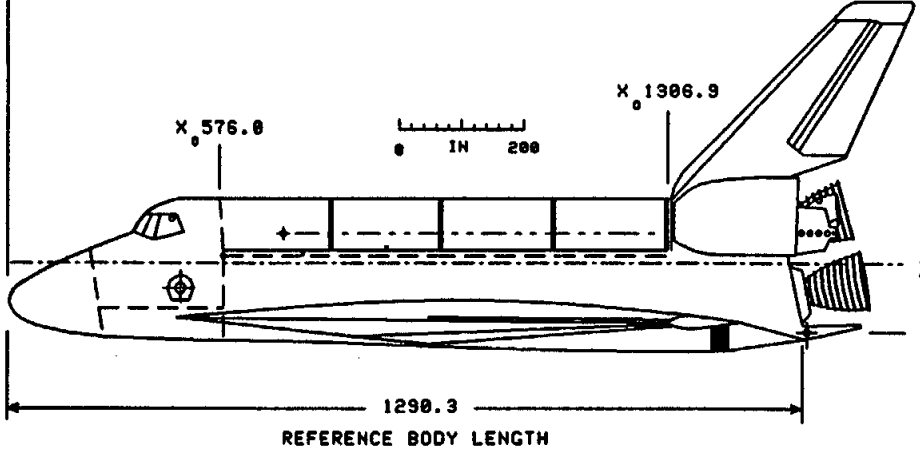

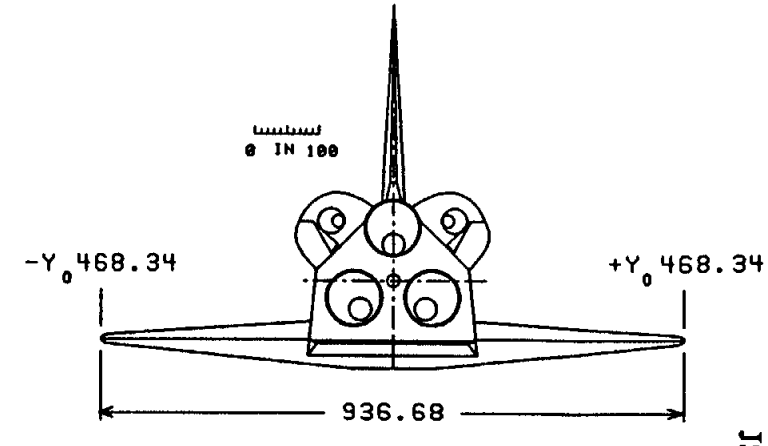

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SPACE SHUTTLE ORBITER

NOTE:
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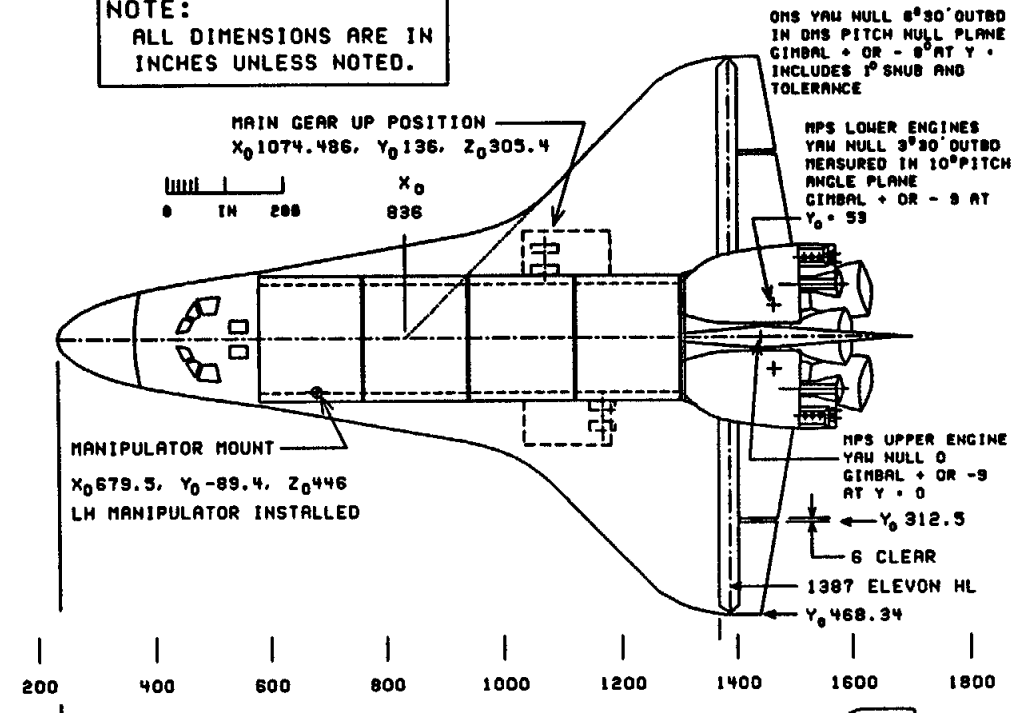
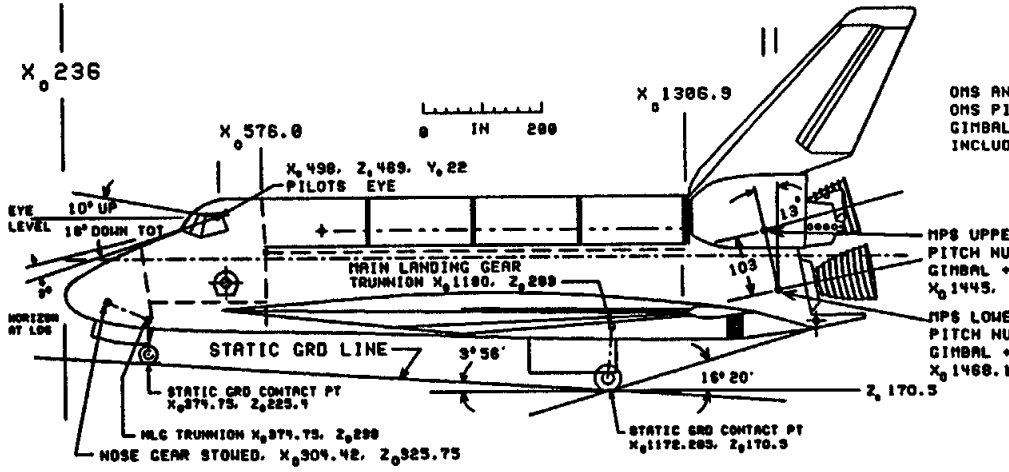
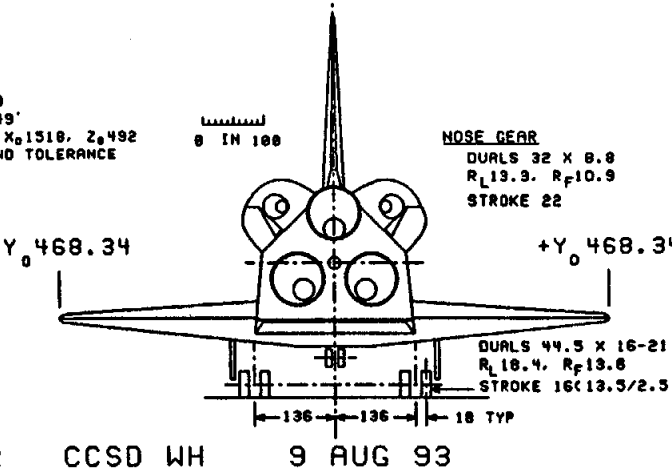


GEOMETRY			
	WING	VERTICAL	FLAP
S_W FT^2	2690	413.25	135.75
A	2.265	1.675	
λ	0.20	0.404	
Λ_{LE}	45°	45°	
DIHEDRAL (℄ CHORD PLANE AND TE)	3° 30', + 0°30'		
α BASIC WING			
t/c Y_0 = 0 (℄ BODY)	0.1137		
t/c Y_0 = 199	0.113		
t/c Y_0 = 468.34	0.12		
b in	936.68	315.72	
C_R in	689.24	268.50	
C_T in	137.86	108.47	
c in	474.81	199.81	
MAC	Y_0 = 182.13	Z = 635.52	
AIRFOIL	TIP.0012-64 MOD Y_0 = 199.0010 MOD	10° SYM 60-40 WEDGE	
V_V (TAIL VOLUME)		0.0537	
S_W EXPOSED, FT^2 (TOTAL)	2012.4 (INCL GLV)	969.1	
S_{GLOVE} EXPOSED, FT^2 (TOTAL)	290.8		
S_W TOTAL WETTED, FT^2	4001.2	738.82	
S_{ELEVON} FT^2 (ONE SIDE)	206.57		
S_{RUDDER} FT^2		97.148	





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SPACE SHUTTLE VEHICLE
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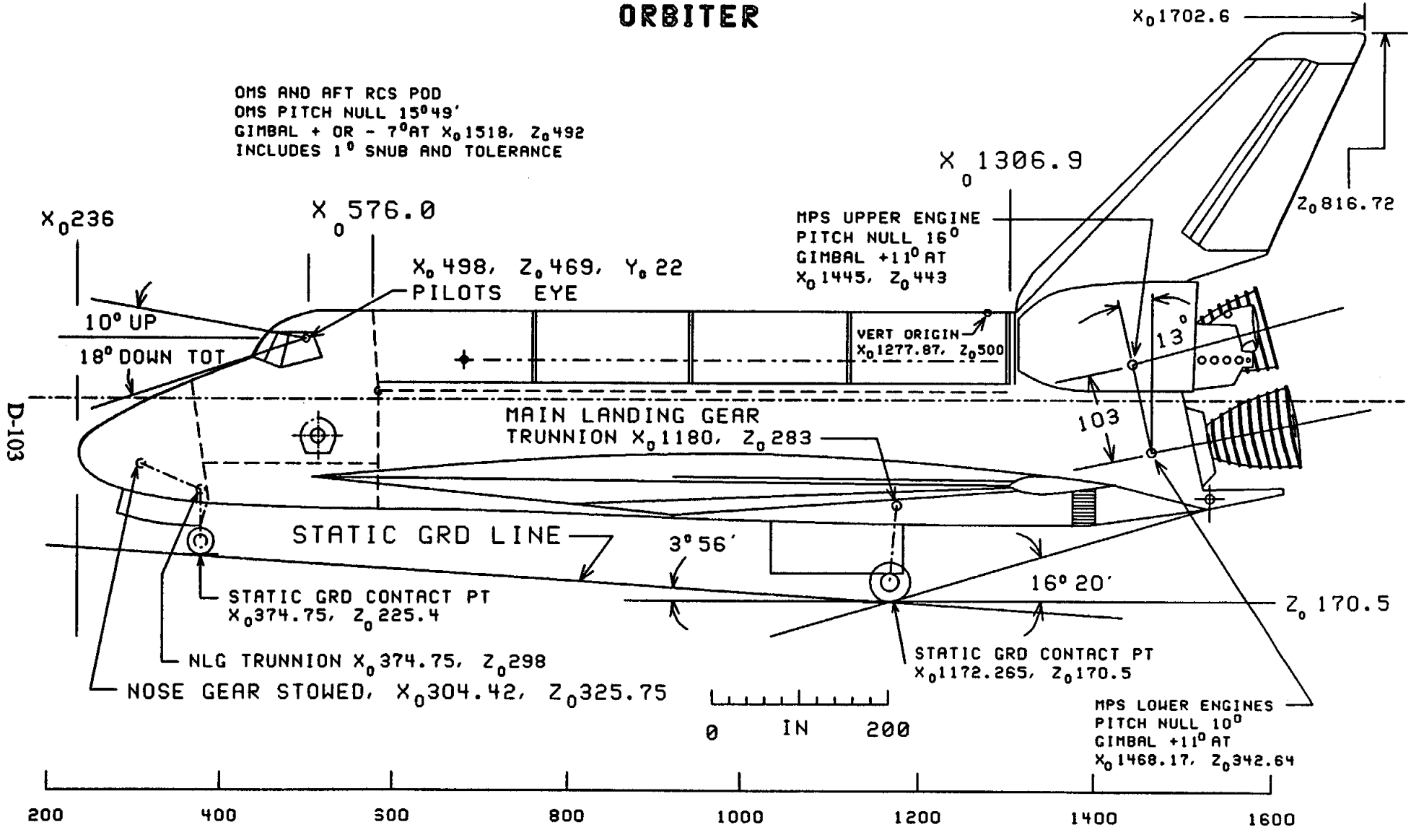

SHUTDR13 CCSD WH 16 AUG 93

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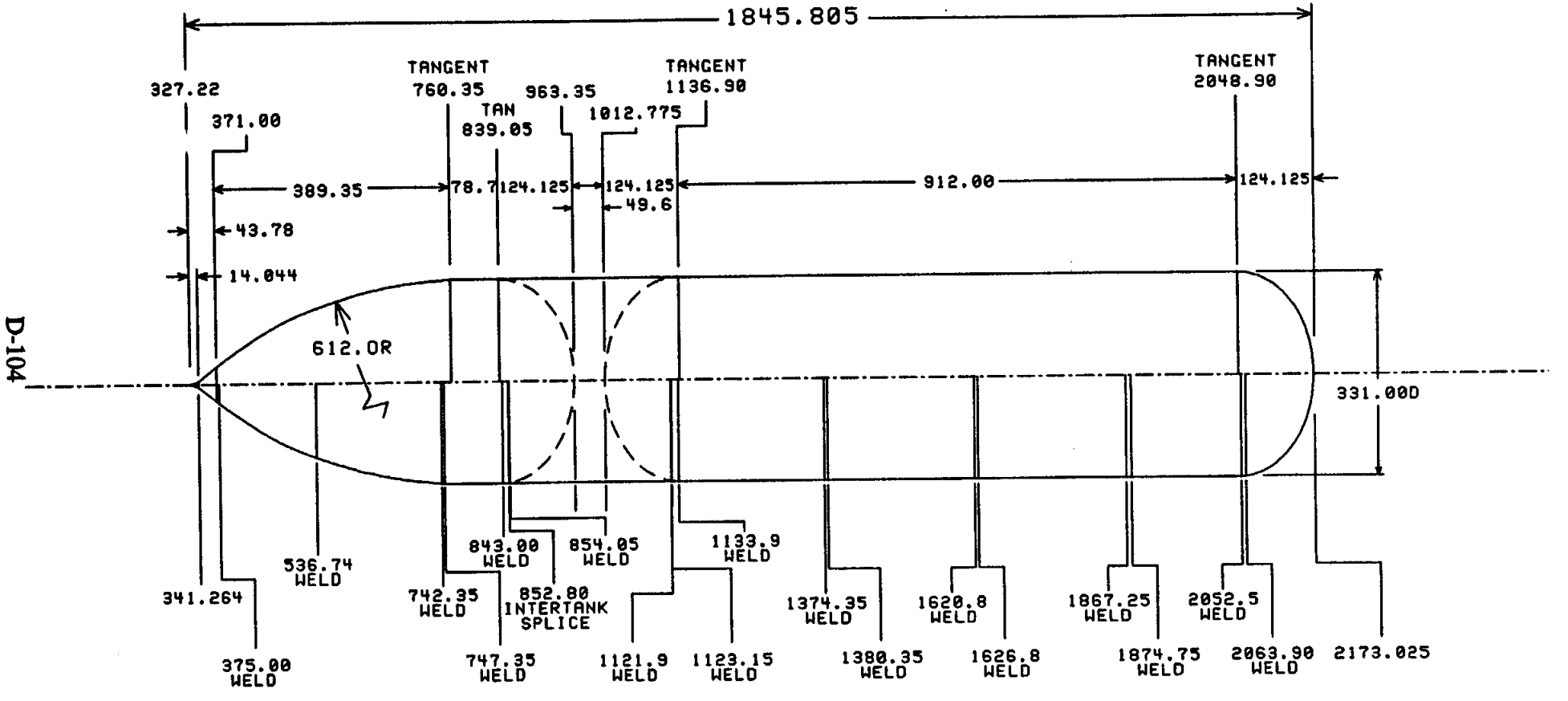
SPACE SHUTTLE VEHICLE

EXTERNAL TANK (ET)

NOTE: STATIONS ARE TANK STATIONS, X_T AND ALL DIMENSIONS ARE IN INCHES. THE DIMENSIONS SHOWN ARE PRIMARY STRUCTURE OUTER MOLDLINE. THERMAL PROTECTION THICKNESS VARIES BETWEEN 0.5 TO 2.0.



SHUTDR03 CCSD WH 9 AUG 93

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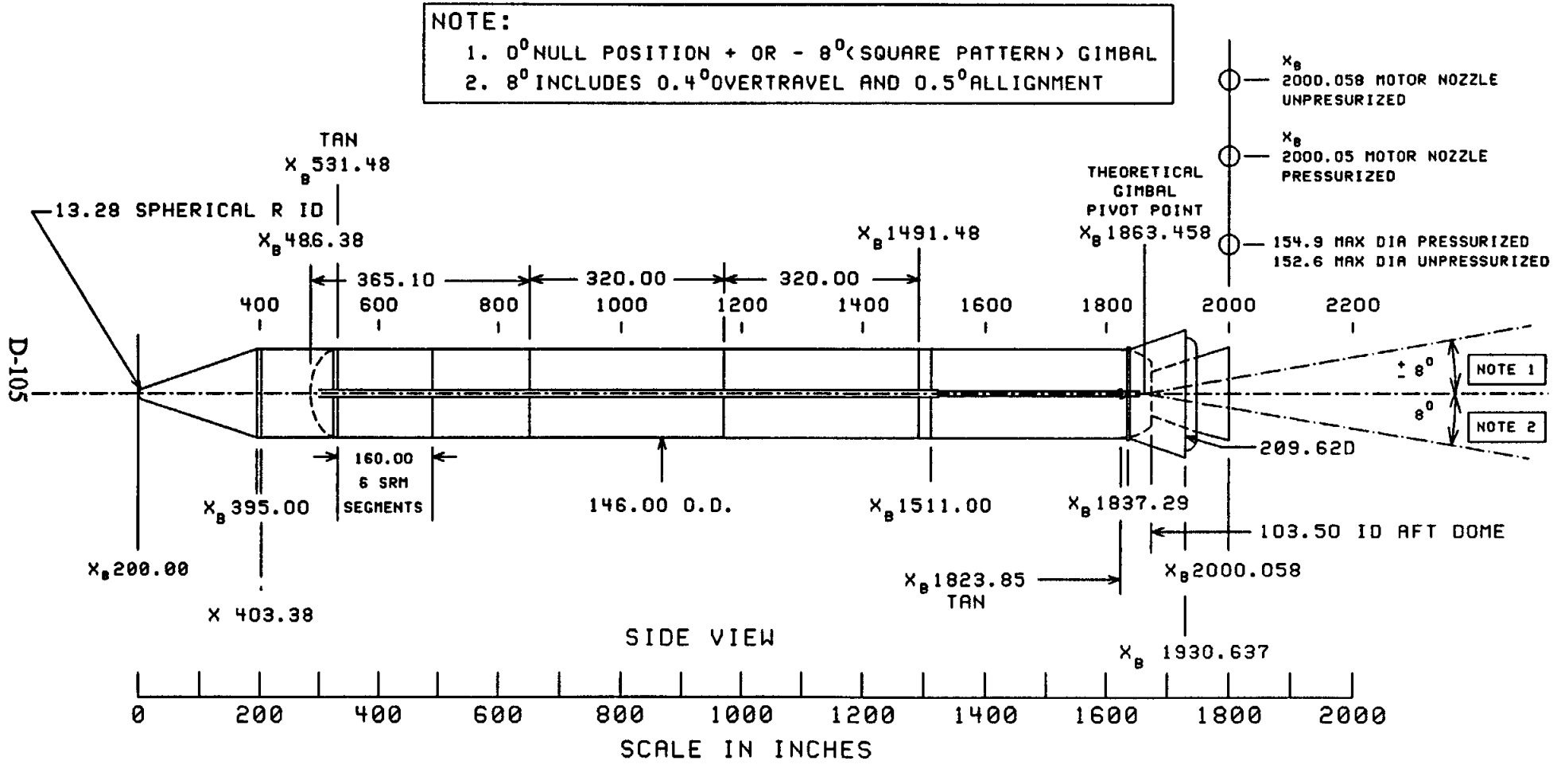
SPACE SHUTTLE VEHICLE

SOLID ROCKET BOOSTER (SRB)



SHUTDR04 CCSD WH 13 AUG 93

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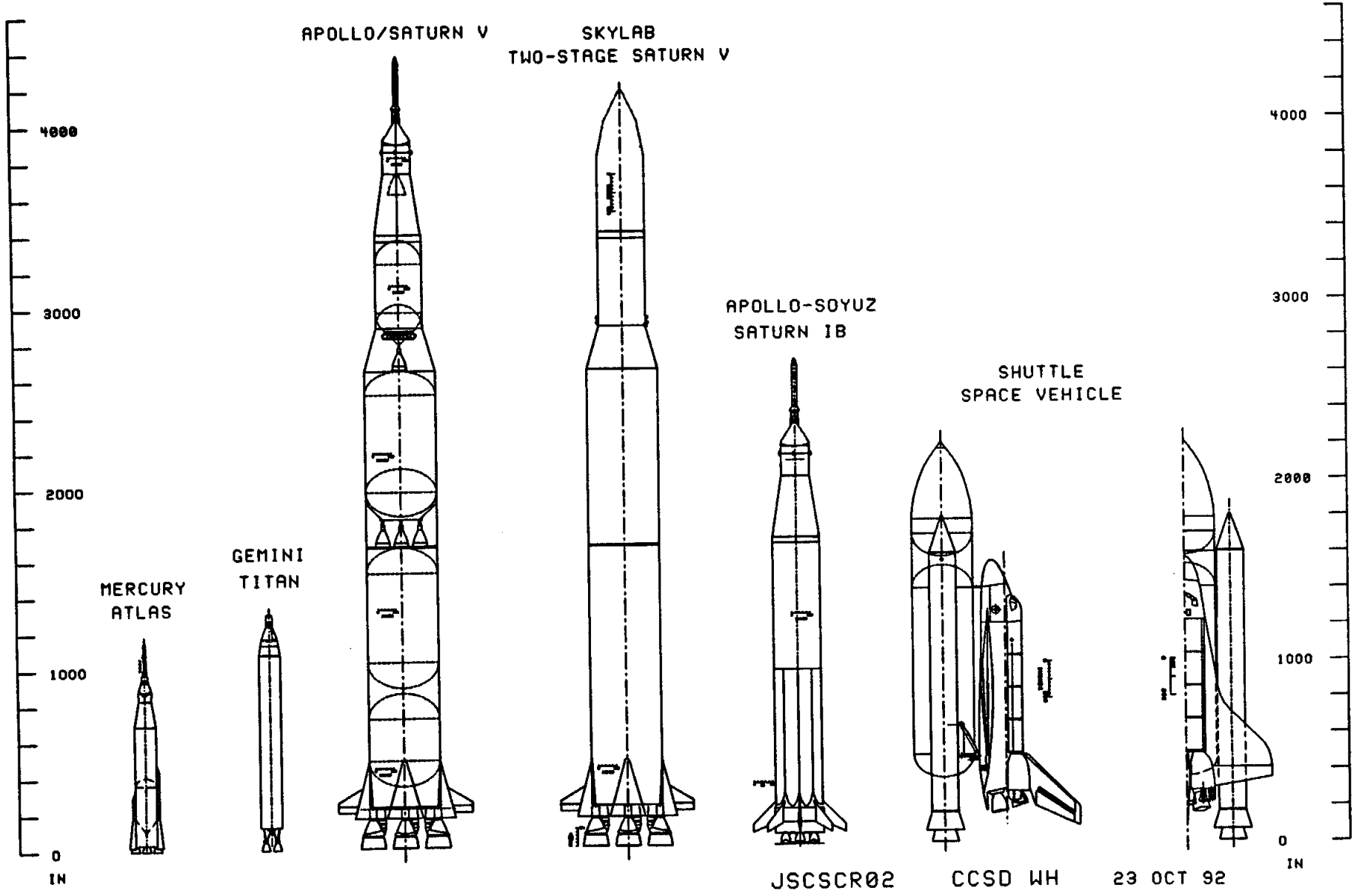
JSC SPACECRAFT

(ALL TO SAME SCALE IN LAUNCH VEHICLE CONFIGURATION)



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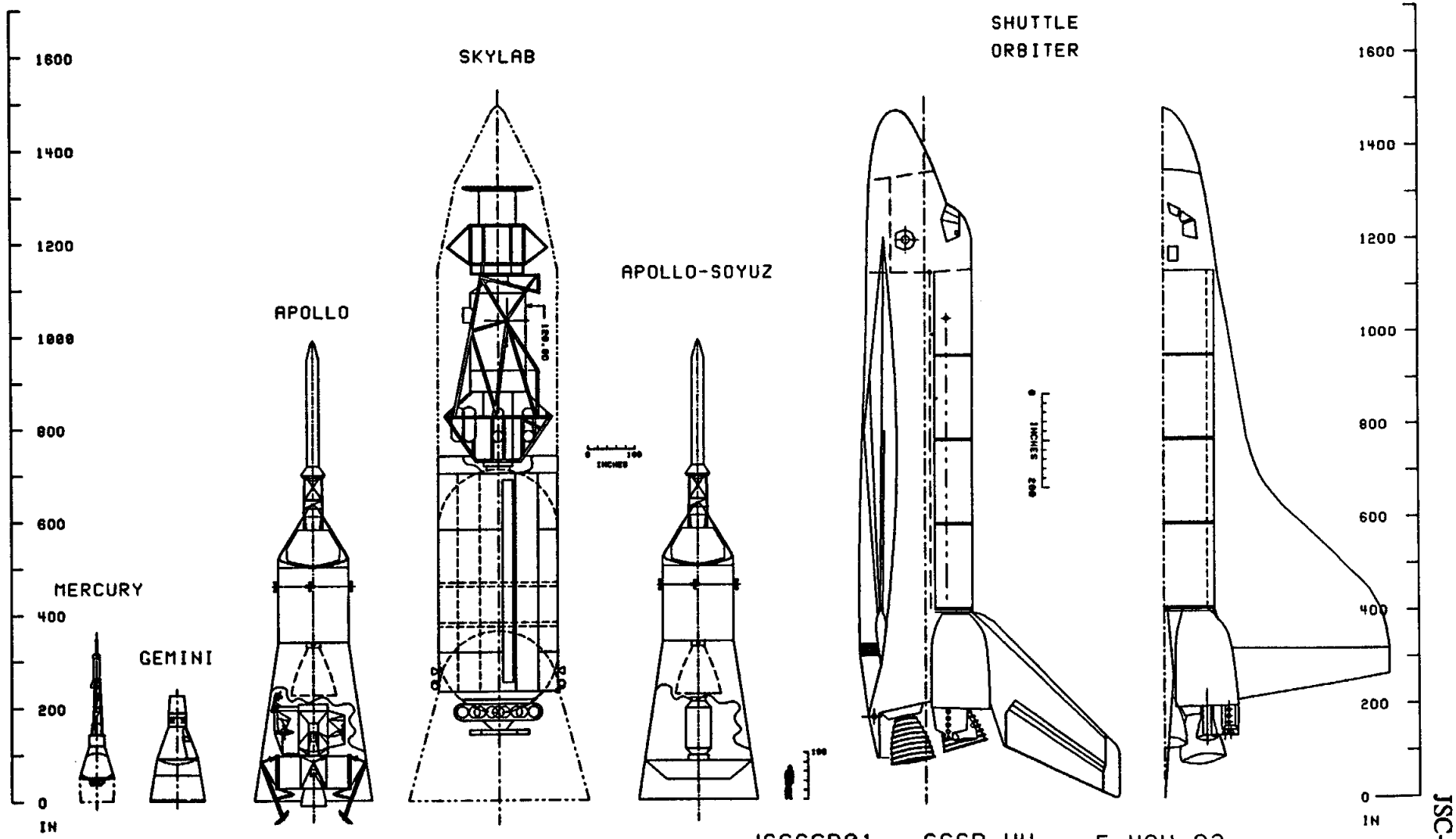
JSC SPACECRAFT

(ALL TO SAME SCALE IN LAUNCH CONFIGURATION)



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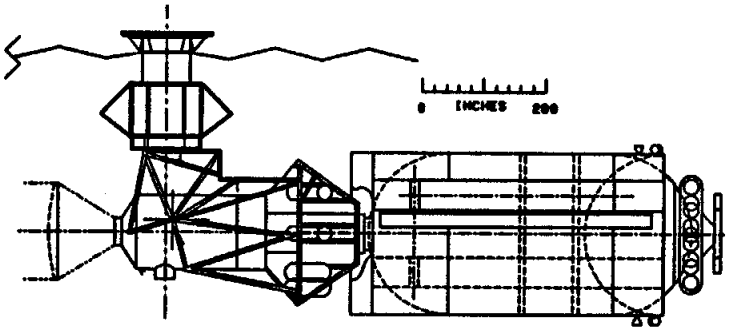
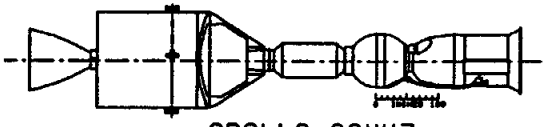
JSC SPACECRAFT

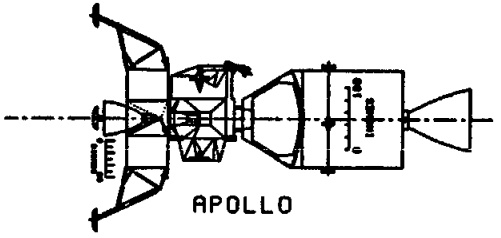
(ALL TO SAME SCALE IN ORBIT CONFIGURATION)



SKYLAB



APOLLO-SOYUZ



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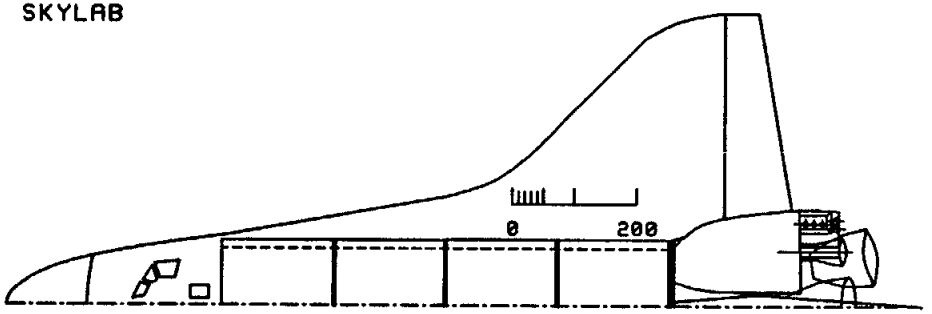

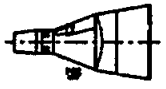

GEMINI

SHUTTLE ORBITER

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