CONTRACT NAS8-35564

(NASA-CR-178905) GENERAL PURPOSE AFT CARGO CARRIER STUDY, VOLUME 1 Final Technical Report (Martin Marietta Aerospace) 393 p CSCL 22B G3/18

N87-12587
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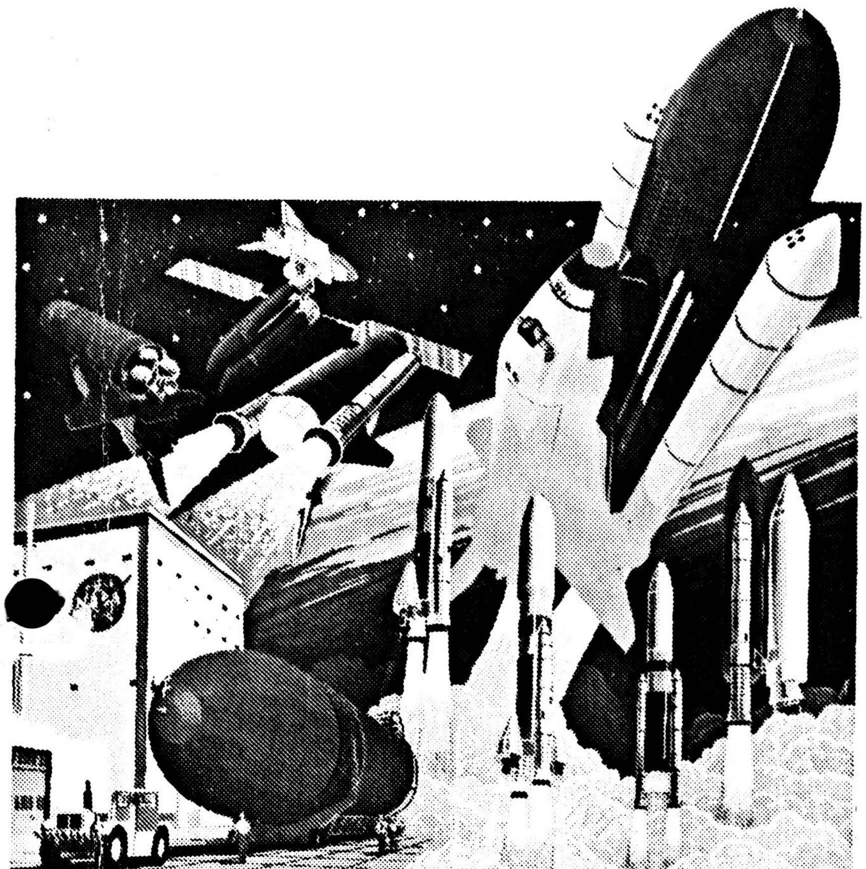
44197

Volume I
Technical

Final Report May 1985

General Purpose Aft Cargo Carrier Study



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MICHOUD DIVISION

Contract NAS8-35564

VOLUME I

Technical

Final
Report

May 1985

GENERAL PURPOSE AFT CARGO CARRIER STUDY

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Michoud Division
New Orleans, Louisiana 70189

FOREWORD

This volume is part of the Final Report of the General Purpose Aft Cargo Carrier study extension performed under National Aeronautics and Space Administration (NASA) Contract NAS8-35564, Modification Number 2. The report was prepared by the Michoud Division of Martin Marietta Denver Aerospace, New Orleans, Louisiana, for the NASA/Marshall Space Flight Center (MSFC).

The Contracting Officer Representative at MSFC was James E. Hughes. The Martin Marietta Study Manager was Thomas B. Mobley.

The Final Report is prepared in three volumes:

- Volume I - Technical
- Volume II - DACC Program Cost and Work Breakdown Structure/Dictionary
- Volume III - GPACC Program Cost and Work Breakdown Structure/Dictionary

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Introduction

Requirements

Payload Integration

Design (General Purpose)

Design (Dedicated OTV)

Mission Analyses

Planning

Costs

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ACC RELATED STUDY CONTRACTORS

Since 1981, the ACC has been studied by the Michoud Division of Martin Marietta Denver Aerospace under NASA and USAF Space Division contracts. Total contract values exceed $2.25M.

ACC Related Study Contracts

TITLE	CONTRACT NO.	VALUE	DURATION
SHUTTLE DERIVED VEHICLES (SDV) TECHNOLOGY REQUIREMENTS STUDY	NAS8-34183	25K	SEPT '81 - MAY '82
AFT CARGO CARRIER (ACC) AND SHUTTLE DERIVED CARGO VEHICLE (SDCV) DEFINITION STUDY	NAS8-34183	195K	AUG '82 - FEB '83
ET PRODUCTION IMPACT ASSESSMENT - TD-213	NAS8-30300	250K	JULY '82 - FEB '83
ADVANCED SPACE TRANSPORTATION SYSTEM GROUND OPERATIONS STUDY	NAS10-10572	151K	NOV '82 - DEC '83
EXTERNAL TANK/AFT CARGO CARRIER ASSESSMENT - TD-629	NAS8-30300	500K	APR '83 - OCT '83
GENERAL PURPOSE AFT CARGO CARRIER STUDY	NAS8-35564	440K	AUG '83 - APR '84
ADVANCED SPACE TRANSPORTATION SYSTEM GROUND OPERATIONS STUDY EXTENSION	NAS10-10572	149K	DEC '83 - MAY '85
GENERAL PURPOSE AFT CARGO CARRIER STUDY EXTENSION	NAS8-35564	500K	APR '84 - APR '85
EXTERNAL TANK/AFT CARGO CARRIER ASSESSMENT EXTENSION (TD-629 RI)	NAS8-30300	58K	AUG '84 - OCT '84

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ACC RELATED STUDY CONTRACTS

Other aerospace companies have studied the ACC under contract to NASA. These studies addressed the integration and interface definition of the ACC with the STS and potential ACC payloads.

ACC Related Study Contracts

TITLE	CONTRACTOR	CONTRACT NO.	VALUE	DURATION
ACC/PAM INTEGRATION STUDY (MDAC)	McDONNELL DOUGLAS	NAS8-32842		AUG '83 - JUN '84
STS/ACC INTEGRATION ASSESSMENT STUDY (RI)	ROCKWELL INTERNATIONAL	NAS9-14000 SCHED D WBS 10.8.1		SEP '84 - MAY '85
ORBITAL TRANSFER VEHICLE CONCEPT DEFINITION AND SYSTEMS ANALYSIS STUDY (MMC, BOEING, GENERAL DYNAMICS)	MARTIN MARIETTA AEROSPACE THE BOEING CO GENERAL DYNAMICS CORP	NAS8-36108		AUG '84 - JUL '85

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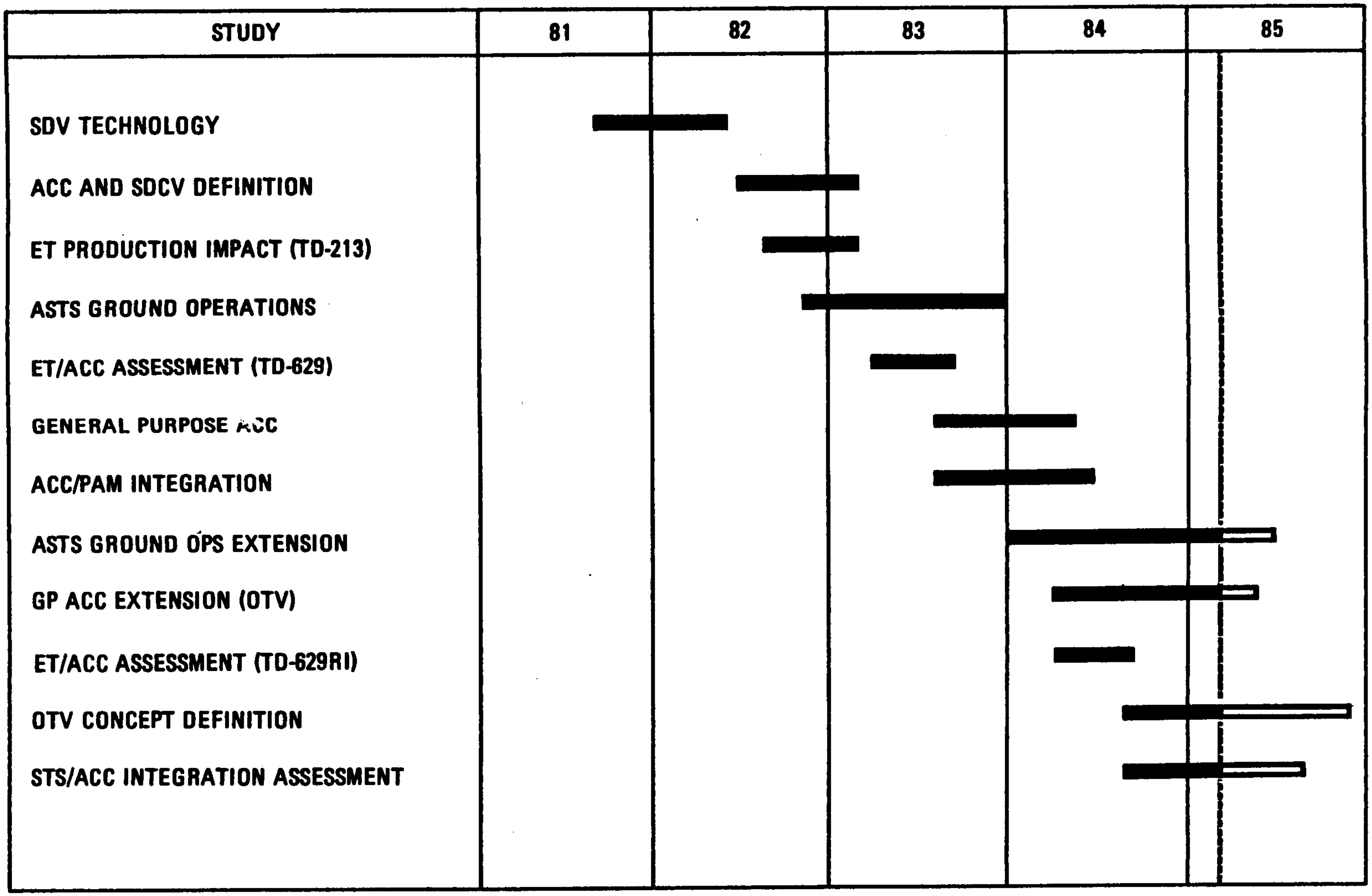
ACC RELATED STUDY CONTRACTS HISTORY

The ACC contracts focused on the following studies: concept feasibility, preliminary design, ACC operations, STS impacts, payload accommodation, payload integration and STS/ACC integration. Each contract used data from previous efforts and provided data to support ongoing and future studies.

The results provide detailed data on all phases of an ACC program from ACC development through STS/ACC mission operations.

ACC Related Study Contracts History



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ACC Related Study Contracts Accomplishments/Goals

- SDV Technology Requirements Study
  - Preliminary ACC/OTV Feasibility and Trades
- ACC/SDV Definition Study
  - Preliminary general purpose ACC configuration
  - General purpose/OTV dedicated configuration trades
  - ACC payload mission model analyses
  - Preliminary STS/ACC operations scenario
  - Preliminary KSC and VAFB facility impacts
  - Preliminary development plan and costs
- ET Production Impact Study (TD-213)
  - Preliminary assessment of introducing the ACC into the ET production flow
  - Preliminary ACC program facility and tooling requirements
  - Preliminary ACC manufacturing flow
- ASTS Ground Operations Study (ACC, SDCV, SDCLV, SRB-X)
  - Facilities modifications and additions
  - STS processing impacts
  - Ground support equipment
  - Ground support activities
  - Cost estimates and implementation plans

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ACC Related Study Contracts Accomplishments/Goals

- External Tank/ACC Assessment (TD-629)
  - ET/ACC build options trade
    - Baseline (two ET configurations)
    - Reversible (two ET configurations/reverseable)
    - Common (one configuration)
    - Baseline with minimum reconfiguration (two ET configurations/reverseable ACC to LWT)
  - ACC project facility, procurement, manufacturing plans
- General Purpose ACC Study
  - Requirements
  - Preliminary design
  - ACC payload identification
  - Preliminary STS/ACC/payload interfaces
  - STS/ACC mission operations
  - Implementation plan and costs

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ACC Related Study Contracts Accomplishments/Goals

- ACC/PAM Integration Study
  - Feasibility of transporting PAM payloads in the ACC
  - ACC/PAM interface
  - PAM-C costs
  - PAM-C user survey
- ASTS Ground Operations Study Extention (ACC, DACC, SDCV, SDCLV)
  - Update ACC data for configuration 101
  - Dedicated ACC/OTV study
- ACC Study Extension
  - STS/ACC integration coordination with JSC/RI
  - DACC trade studies and design update
  - DACC/OTV mission analysis and operations
  - DACC implementation plan and costs
  - DACC/OTV interface definition and coordination with OTV study contractors
- ET/ACC Assessment Extension (TD-629 RI)
  - Update ACC facility, tooling, and manufacturing plans to reflect configuration 101

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ACC Related Study Contracts Accomplishments/Goals

- OTV Concept Definition and Systems Analysis Study
    - Mission and system requirements
    - Ground-based OTV concept definition
    - Space-based OTV concept definition
    - Launch and flight operations
    - Space Station accommodations concept definition
    - Cost and schedule
- STS/ACC Integration Assessment
    - Evaluate MSFC/MMC generated data
        - Environments
        - Mission operations
        - Flight control
        - Interface definition
        - Payload accommodation
    - Perform supplementary analyses
    - Provide STS/ACC integration cost data
        - Orbiter modifications
        - STS software modifications
        - Level II requirements

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GENERAL PURPOSE ACC STUDY OBJECTIVES

The tasks for the initial GPACC study contract (August 1983 to April 1984) included: requirements definition, preliminary GPACC design, ACC payload definition and interface, preliminary STS/ACC integration, and ACC program plan and costs.

The contract extension (April 1984 to May 1985) studied the OTV DACC concept. Tasks included: preliminary DACC design, DACC/OTV interface, and a DACC implementation plan and costs. An additional task directed the coordination of Martin Marietta with other ACC-related study contractors to address STS/ACC integration and ACC/OTV interfaces and operations.

General Purpose ACC Study Objectives

- To develop a preliminary set of ACC requirements including ACC design requirements as well as STS vehicle (Level II) and payload interfaces
- To provide a preliminary design concept that satisfies the established requirements
- Perform selected structural trades to reduce the dedicated ACC weight and costs
- To identify specific payloads that can be carried in the ACC
- To define preliminary STS/ACC/payload interface
- To update the ACC development/qualification/implementation program to reflect updated requirements and design
- To update preliminary ACC costs
- To coordinate ACC/OTV interfaces with OTV study contractors
- To coordinate ACC/STS requirements and interfaces with the STS/ACC integration assessment study contractor

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Agenda

- Introduction
- ⇨ Requirements
- Payload Integration
- Design (General Purpose)
- Design (Dedicated OTV)
- Mission Analyses
- Planning
- Costs

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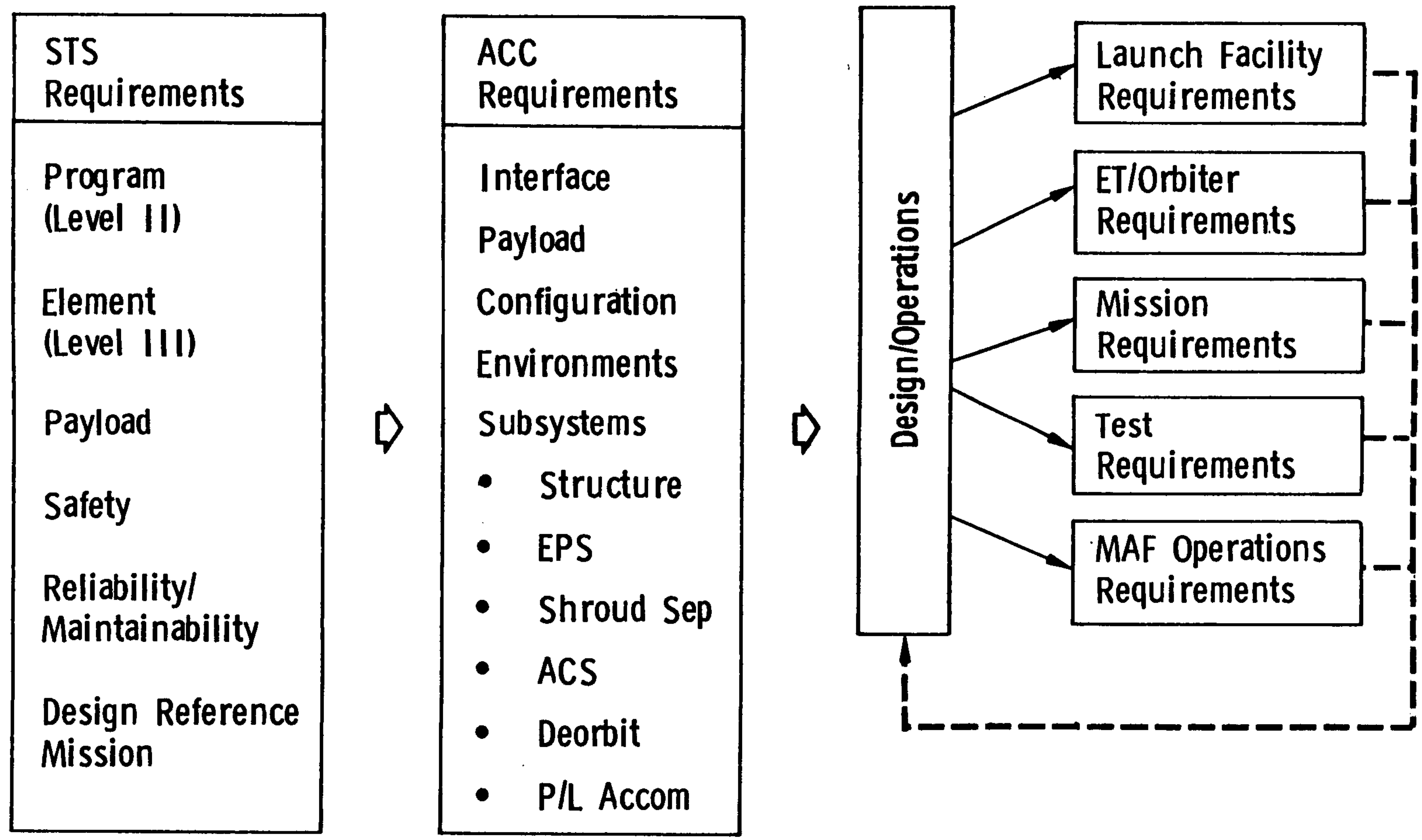
REQUIREMENTS FLOW LOGIC

The STS requirements documents were reviewed to determine their applicability to the ACC. Then the ACC requirements were developed to assure that all the appropriate STS requirements were met.

These requirements were used to drive the preliminary ACC design and STS/ACC operations. During the design and operational analyses, requirements emerged for ACC manufacture, launch facilities, STS elements, testing and STS/ACC missions. These requirements were evaluated for their cost and impact. Recommendations for ACC design and operational changes were incorporated.

Requirements Flow Logic



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STS Program Imposed ACC Requirements

STS Requirements	Requirements Imposed on ACC
(1) Performance (~ 65klb/160nm/28.5)	ACC P/L weight penalty to orbit shall be no more than 10,000 lb ACC/PL mass properties shall be such that the combined vehicle cg remains within SSME&SRB control envelopes
(2) Launch rate (24/year)	ACC shall not impact flt production rate ET/ACC launch site processing shall not impact STS turn-around times
(3) No ice/frost >1/16" thick	ACC design shall prevent I/F formation >1/16th thick
(4) Safe ET disposal	ET/ACC shall deorbit from 160nm or less ACC will not affect ET break-up altitude reqmt ET/ACC shall land in an ocean area ≅ 200nm from land

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STS Program
Imposed ACC Requirements(cont)

STS Requirements	Requirements Imposed on ACC
(5) STS requirements shall not impact other element envelopes	ACC shall not impact other element envelopes
(6) Natural & induced element environments	ACC shall withstand natural & induced thermal environments ACC shall accommodate the external acoustic environment ACC shall withstand structural load ACC shall accommodate aero loads
(7) Element/site interfaces	ET/Orbiter (ICD 2-12001) ET/SRB (ICD 2-24001) STS/VAB/MLP (ICD 2-0A001) STS/LP/MLP (ICD 2-0A002)

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STS Payload Imposed ACC Requirements (General Purpose)

STS Payload Requirement	Requirement imposed on ACC
(1) Dimension/Weight	The ACC shall provide the capability to carry cargos with the following dimensions: a) 15' diameter, 20' length b) 25' diameter, 15' length c) any combination of above The ACC shall be able to carry a payload mass of 45K lb
(2) Interface	The ACC shall provide the following interfaces with the payload: a) Structural b) Electrical c) Fluid
(3) Environments	The ACC shall accommodate P/L with the environments (acceleration, vibration, acoustic, thermal, and pressure) specified in ICD 2-19001

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STS Payload Imposed Requirements (General Purpose) (cont)

(4) Contamination	The ACC shall comply with contamination criteria specified in ICD 2-19001
(5) Orbital capability	The ACC shall deploy payloads at altitudes up to 160 nm
(6) Payload access	The payload shall be accessible for replacement of LRUs
(7) Communication/Data acquisition	The ACC shall provide capability for: a) Ground checkout and status b) Flight status c) On-orbit predeployment checkout

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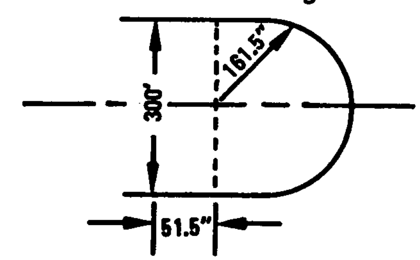
STS Payload Imposed ACC Requirements (Dedicated)

OTV Requirement		Requirement Imposed on ACC
(1)	Dimension/Weight	The ACC shall provide the capability to carry an OTV with the following envelope  The ACC shall be able to carry an OTV with a mass of 61, 350 lb
(2)	Interface	The ACC shall provide the following interfaces with the OTV a) Structure b) Electrical c) Fluid

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STS Payload Imposed ACC Requirements (Dedicated)

OTV Requirement		Requirement Imposed on ACC
(3)	Environments	The ACC shall accommodate the OTV with the environments (acceleration, vibration, acoustic, thermal and pressure) specified in ICD 80900000025, Orbiter Transfer Vehicle/ Dedicated Aft Cargo Carrier Interfaces
(4)	Contamination	The ACC shall comply with contamination criteria specified in ICD 2-19001
(5)	Orbital capability	None
(6)	Payload access	The payload shall be accessable for replacement of LRUs
(7)	Communication/Data acquisition	The ACC shall provide capability for: a) Ground checkout and status b) Flight status c) On-orbit predeployment checkout

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Reliability & Maintainability & Engineering Requirements

STS Requirements	Requirements Imposed on ACC
(1) Flight system reliability	ACC flight subsystem's redundancy shall not be less than fail safe for all mission phases (Exceptions: primary STR TPS & press. vessels) ACC redundant components shall be physically oriented or separated to reduce the chance of multiple failure from the same cause(s) ACC explosive devices shall be armed as near the time of use as is feasible with provisions for disarming
(2) System pyrotechnics	ACC pyrotechnics & assoc electrical circuits & electronics shall conform to STS spec JSC 08060
(3) STS element LRUs shall be accessible	ACC LRUs shall be accessible

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Safety Requirements

STS Requirements	Requirements Imposed on ACC
(1) STS element compartments shall be safe	ACC compartmental hazardous gas content shall be < 4%
(2) STS element compartments shall be safe for personnel entry	ACC shall provide a breathable air purge during entry
(3) STS elements shall prevent air liquefaction	ACC shall be purged prior to, during and subsequent to ET cryogenic tanking
(4) STS elements shall provide for on pad propellant unloading	ACC shall provide capability to drain propellants on pad

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STS Element Imposed ACC Requirements

STS Requirements	Requirement Imposed on ACC
External Tank	
(1) Aft dome differential pressure is limited to 0.19 psig when LH2 tank is depressurized prior to loading	ACC shall not violate the LH2 tank aft dome pressure requirement
Orbiter	
(2) Max power available is 50 kWh	ACC power provided by orbiter shall not exceed 50 kWh
(2) Controllability	ACC/PL mass properties shall be such that the mated orbiter & ET/ACC is controllable with the orbiter flight control system during all mission phases

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ACC PRELIMINARY REFERENCE MISSIONS

The general purpose mission is a payload delivery/sortie mission launched due east into a 160 nm circular orbit. The purposes of this mission are the placement of payloads in orbit from both the GPACC and the orbiter bay, and sortie return from orbit. Mission duration is 7 days.

The dedicated mission is a payload delivery mission launched due east into a 120 nm circular orbit. The purpose of this mission is to place a payload(s) in orbit for mating with an OTV. The OTV is suborbitally released from the DACC 400 sec after MECO. Mission duration is 3 days.

ACC Preliminary Reference Missions

- GENERAL PURPOSE MISSION
  - PAYLOAD DELIVERY/SORTIE
  - LAUNCHED DUE EAST INTO 160 NM CIRCULAR ORBIT
  - PURPOSES
    - -- PLACE PAYLOADS INTO ORBIT FROM ACC AND ORBITER BAY
    - -- SORTIE RETURN FROM ORBIT
  - DURATION = 7 DAYS

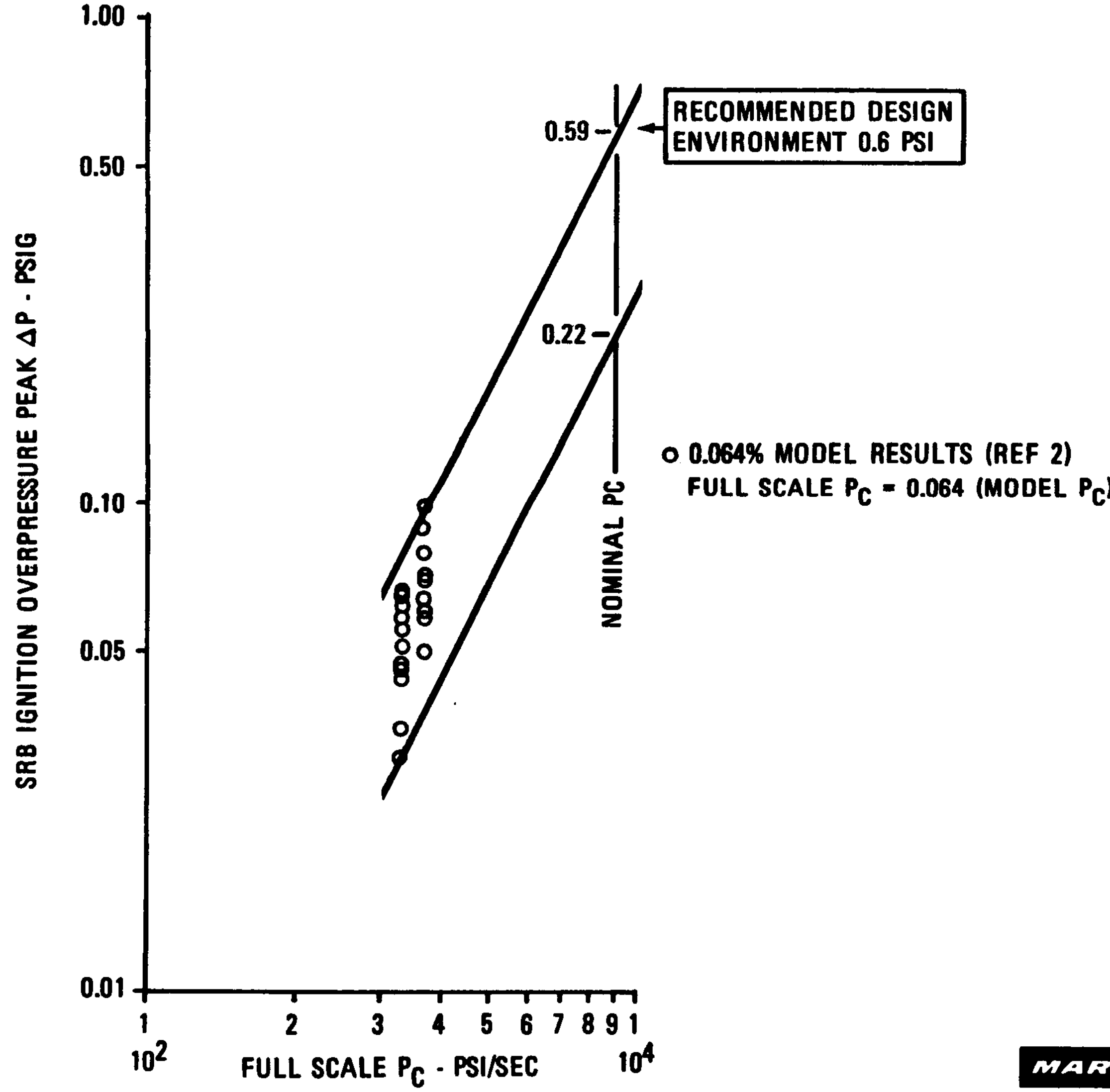
- DEDICATED MISSION
  - PAYLOAD DELIVERY
  - LAUNCHED DUE EAST INTO 120 NM CIRCULAR ORBIT
  - PURPOSE
    - -- PLACE PAYLOAD(S) INTO ORBIT FOR MATING WITH OTV
  - OTV SUBORBITALLY RELEASED FROM ACC 400 SEC AFTER MECO
  - DURATION = 3 DAYS

FULL-SCALE ACC OVERPRESSURE SCALING FROM MODEL RESULTS

A 6.4% scale model of the STS/ACC launch configuration was tested to determine the external overpressure to which the ACC should be designed. The test results were adjusted to full-scale values (as shown on the opposite page).

The recommended ACC design overpressure is 0.6 psi.

Full - Scale ACC Overpressure Scaling from Model Results



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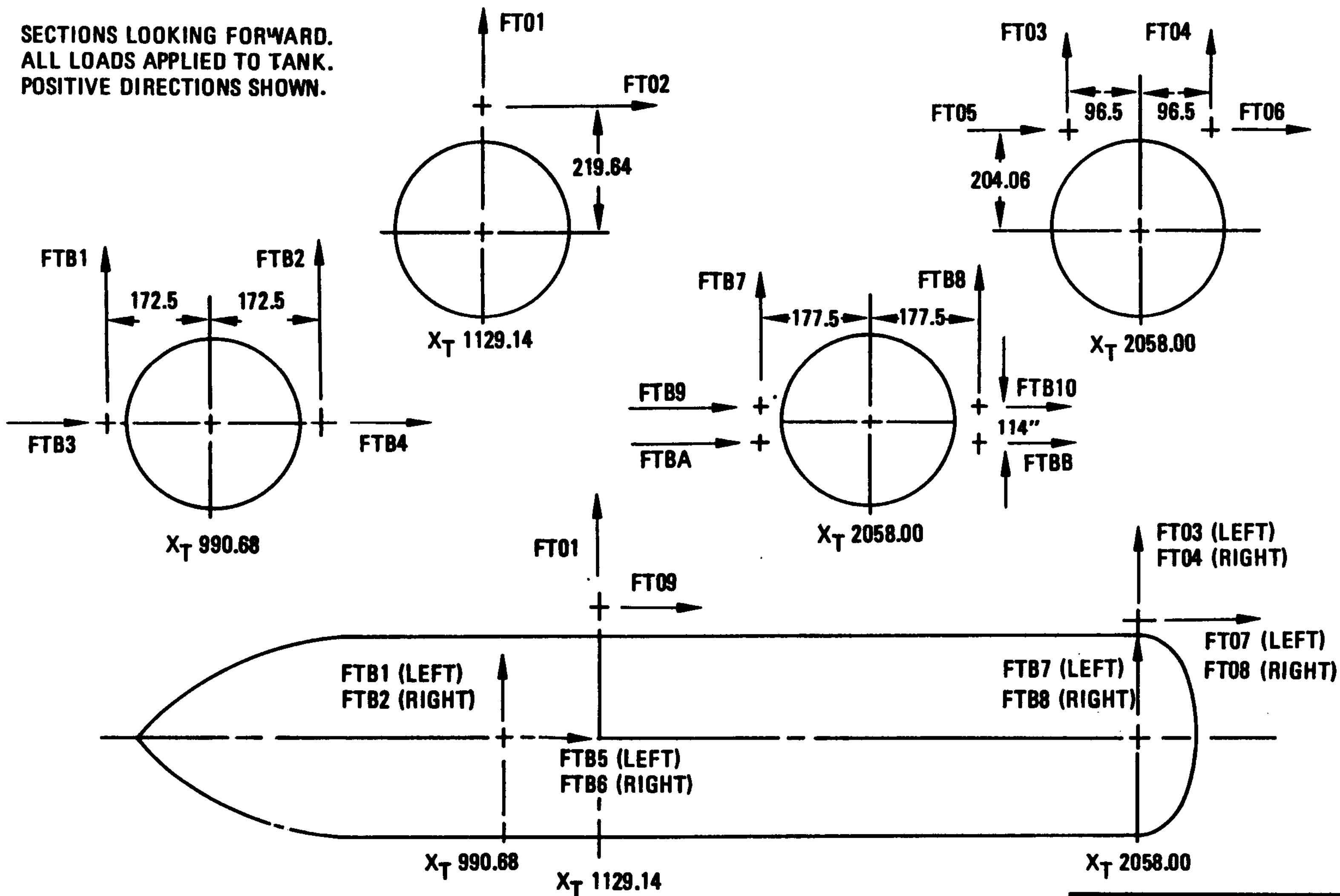
EXTERNAL TANK LOADS AND DIRECTIONS

The ET I/F Loads are defined at the specific locations shown on the opposite page.

External Tank Loads & Directions

SECTIONS LOOKING FORWARD.
ALL LOADS APPLIED TO TANK.
POSITIVE DIRECTIONS SHOWN.



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ACC EFFECT ON STS LIFT-OFF LOADS

The effect of an ACC on the STS lift-off loads was analyzed. The table on the opposite page presents the max/min STS (RI) load envelope compared to the max/min STS/ACC (MMA) lift-off loads.

Also presented for comparison of ACC effect are the nominal STS and STS/ACC lift-off loads. Although the STS/ACC lift-off loads exceed the STS-only lift-off loads at some locations, the max/min STS/ACC lift-off loads remain in the allowable STS loads envelope.

ACC Effect on STS Lift-Off Loads

MEMBER	MAX LOADS, ENVELOPE SUMMARY*				LIFT-OFF LOADS, NOMINAL LAUNCH COMPARISON			
	RI MAX	MMC MAX LIFTOFF	RI MIN	MMC MIN LIFTOFF	RI MAX	MMC MAX	RI MIN	MMC MIN
FT01	113	23.9	- 147	-110.0	32.	24.	-79.	-87.6
FT02	101	18.2	- 79	-16.2	3.	2.	-5.	-3.
FT03	298	25.8	- 364	-191.0	-14.6	-10.5	-159.	-111.
FT04	323	53.8	- 355	-209.0	-14.5	-10.6	-154.	-120.
FT05	99	13.0	- 120	-62.4	-9.4	-4.	-54.	-34.
FT06	102	89.0	- 94	-24.5	65.	42.	3.	4.
FT07	147	107.0	- 721	-472.	127.	100.	-442.	-474.
FT08	146	109.2	- 727	-475.	127.	104.	-437.	-465.
FT09	12	9.5	- 10	-2.1	3.	7.	-6.6	-2.
FTB1	257	251.	- 190	-105.	161.	185.	-48.	-31.2
FTB2	257	244.	- 206	-114.	157.	186.	-44.	-32.
FTB3	212	189.	- 95	-41.2	127.	136.	-19.	-14.
FTB4	86	42.8	- 219	-179.	23.2	13.5	-128.	-136.4
FTB5	178	-273.	-1754	-1262.	-375.	-402.	-977.	-1110.
FTB6	156	-281.	-1725	-1364.	-381.	-406.	-948.	-1101.
FTB7	247	144.	- 233	-132.	106.	80.5	-49.	-8.6
FTB8	245	161.	- 224	-162.	96.	79.	-27.	-18.6
FTB9U	216	181.	- 179	-185.	132.	123.6	-91.	-93.4
FTBA	98	86.	- 209	-197.	14.2	-12.3	-158.	-153.
FTB10U	161	128.	- 241	-233.	92.	102.4	-143.	-138.
FTBB	253	190.	- 121	-61.8	148.	152.	-7.	12.7

(ALL LOADS ARE IN KIPS)

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ACC EFFECT ON STS AERODYNAMICS

The performance parameter drag coefficient is shown. A slight increase results as the ACC increases the total STS wetted area.

The force and moment coefficients reflect small impacts. Stability and control margins are not appreciably affected.

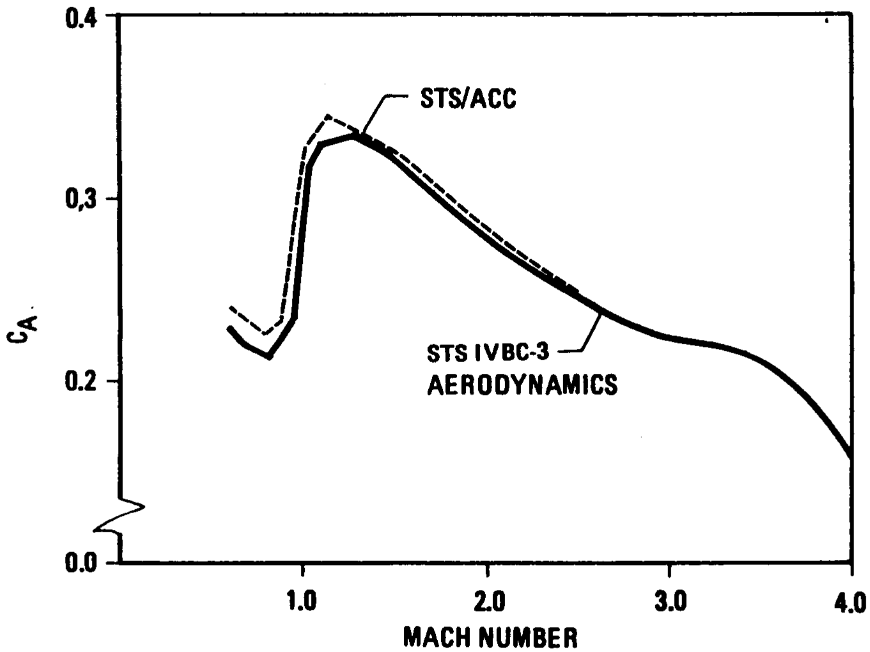
The result of adding an ACC to the ET is to produce an additional negative pitching moment. The control system must compensate by producing additional positive pitching moments using a mixture of control effectors, e.g., SRB gimbal deflection, orbiter SSME gimbal deflection, elevon deflection.

The required pitching moment could be generated by: deflecting the SRBs, approximately 1^{o} in both rock and tilt; deflecting all the SSMEs, approximately 2^{o} in pitch; or a combination of the above.

The end result is that the pitch control authority margin is slightly reduced since part of the margin must be used to compensate the additional negative pitching moment.

ACC Effect on STS Aerodynamics

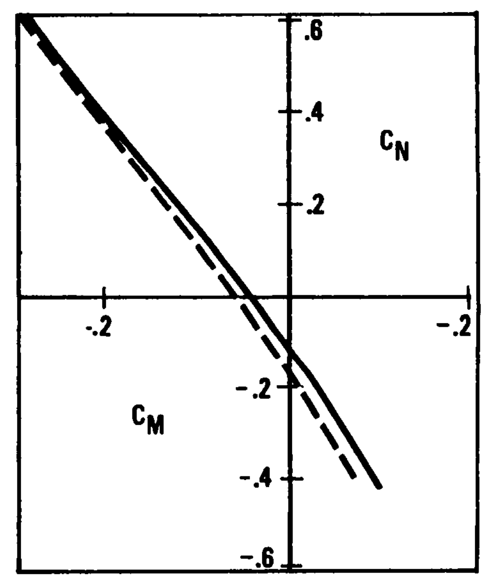
PERFORMANCE
DRAG COEFFICIENT
$\alpha = \beta = 0^0$



C_A – AXIAL FORCE COEFFICIENT

STABILITY & CONTROL
FORCE & MOMENT COEFFICIENTS
MACH = 1.05

S_{ref} = 2690 FT^2
L_{ref} = 107.5 FT



C_N – NORMAL FORCE COEFFICIENT
C_M – PITCHING MOMENT COEFFICIENT

MRC .XT = 976
.YT = 0
.ZT = 400

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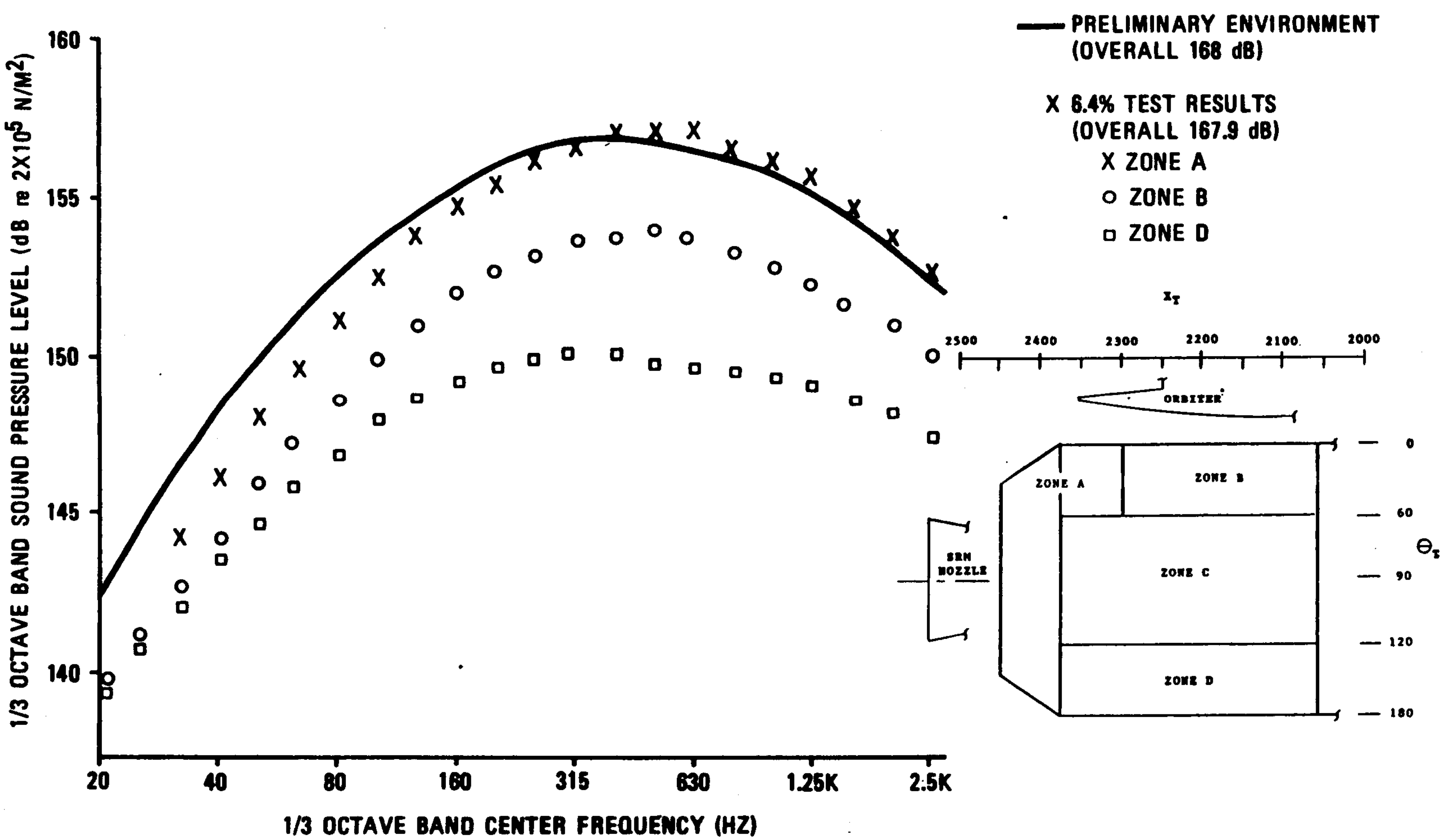
ACC EXTERNAL ACOUSTIC SOUND PRESSURE LEVEL

A 6.4% scale model of the STS/ACC launch configuration was tested to determine the ACC external acoustic environment. The test results are shown for four zones on the ACC. These test data show good correlation with the analytically predicted maximum environment.

ACC External Acoustic Sound Pressure Level



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SHROUD SIDEBODY HEATING

The curves show the total heating to the ACC skirt sidewall and the components of the total heating. The heating is based on an assumed initial ACC skin temperature of $0^{\circ}F$.

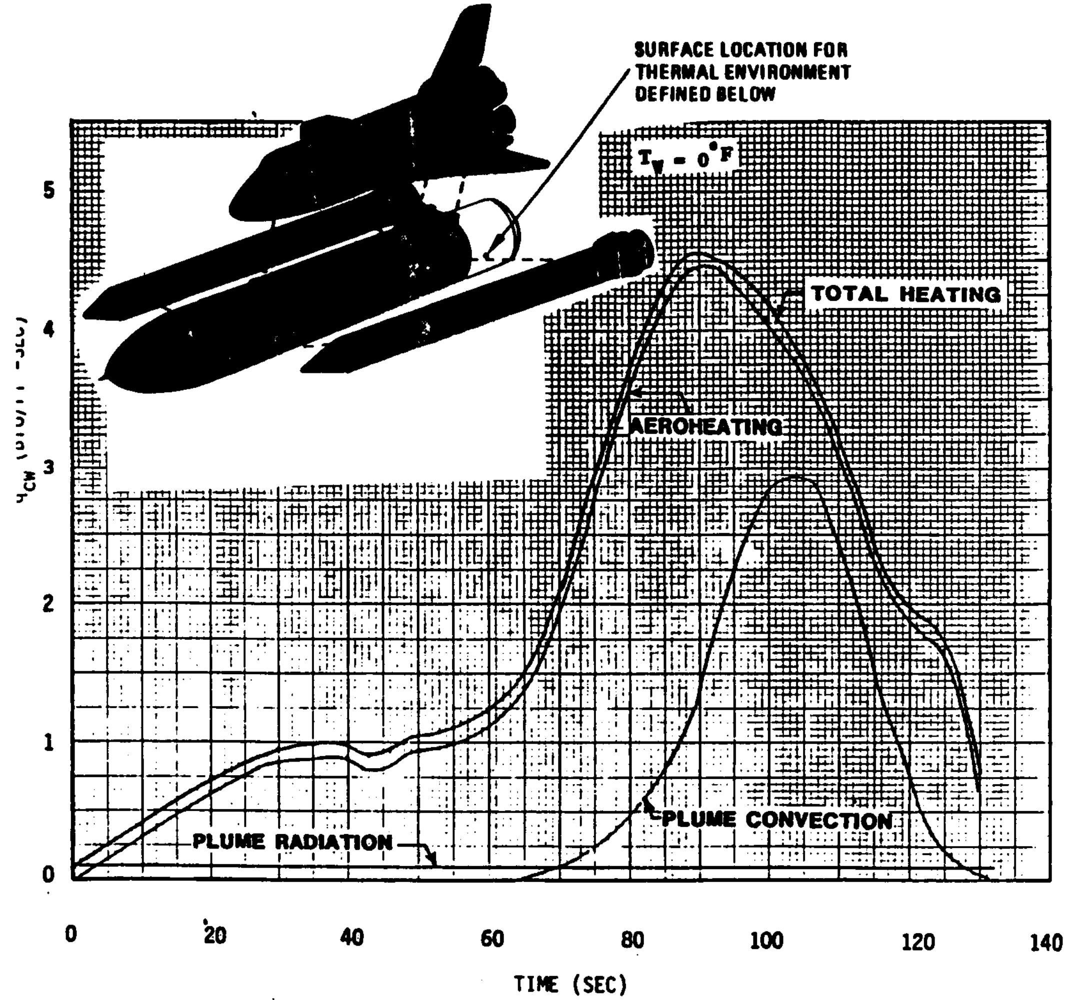
The components of heating are:

A) Plume radiation which is considered constant;

B) Plume convection which varies with altitude; and

C) Aeroheating which varies with velocity and altitude.

Shroud Sidebody Heating



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SHROUD AFT HEATING

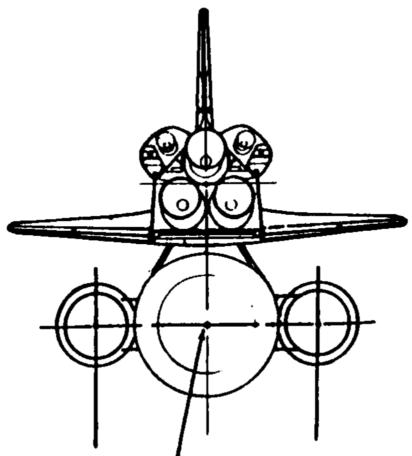
The curves show the total shroud aft surface heating from lift-off through shroud separation and the components of total heating. An initial ACC skin temperature of $0^{o}F$ was assumed.

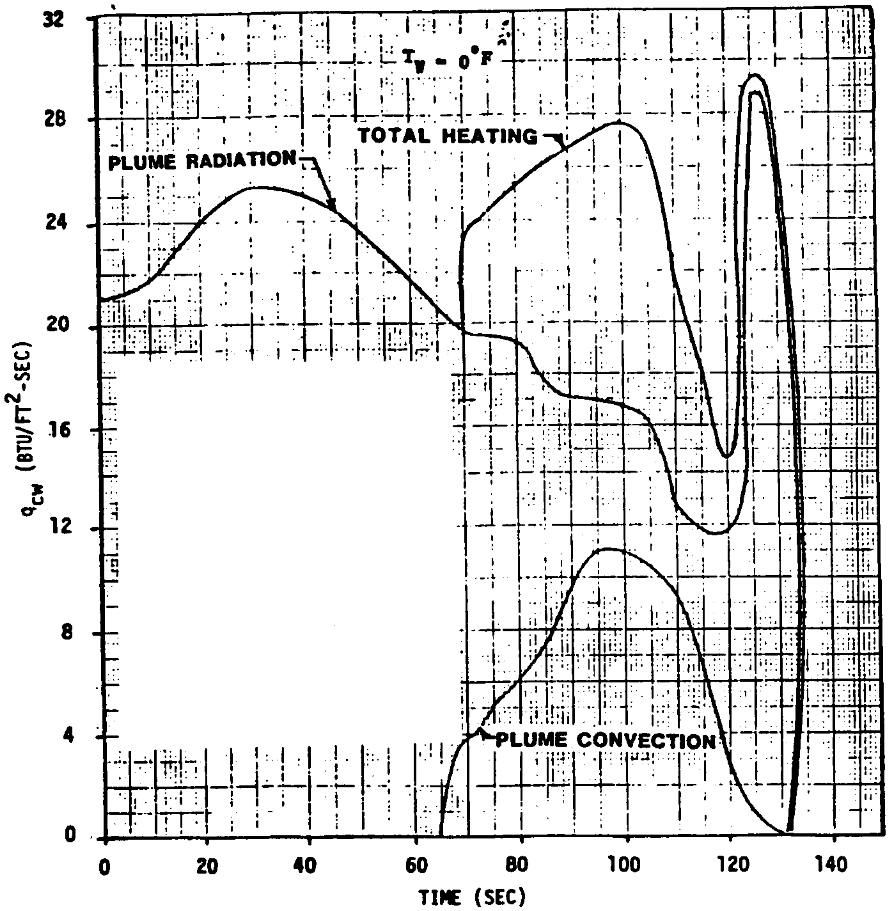
The components of shroud aft heating are:

A) Plume radiation which varies with time; and

B) Plume connection which varies with altitude.

Shroud Aft Heating





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STS/ACC FLIGHT CONTROL - OMS MANEUVER

On the STS/ACC flights where the ET is taken to orbit, the OMS engine thrust vector may not pass through the STS cg. As a result, the orbiter RCS is used to maintain STS control during OMS firings.

The RCS propellant required to maintain control is a function of the ACC cargo weight (shown opposite).

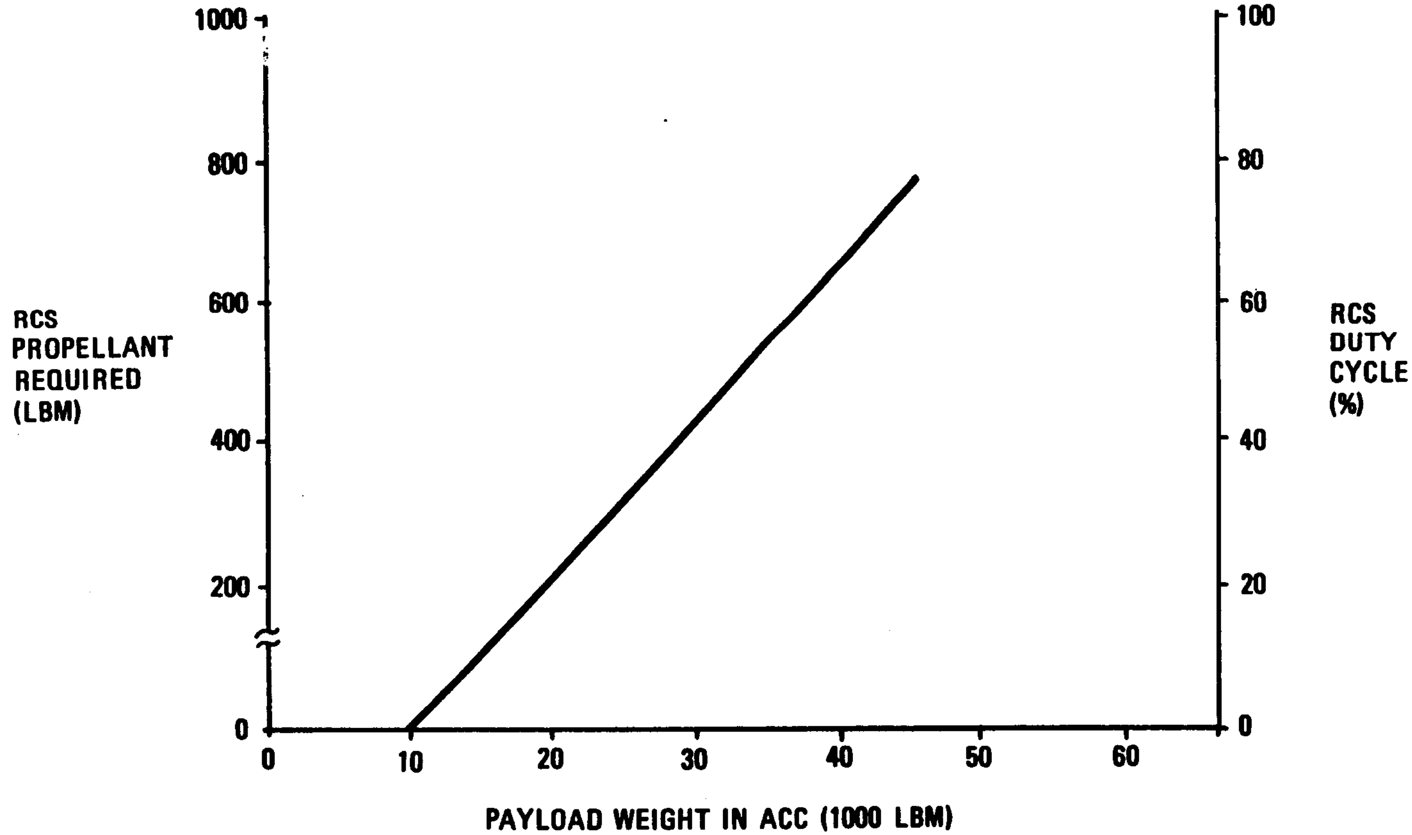
STS/ACC Flight Control - OMS Maneuver

UTILIZES RCS TO CONTROL STS/ACC

TOTAL PAYLOAD WT - 65,000 LB

MECO WT - 353,000 LB

MECO ORBIT - 57 NM X 160 NM



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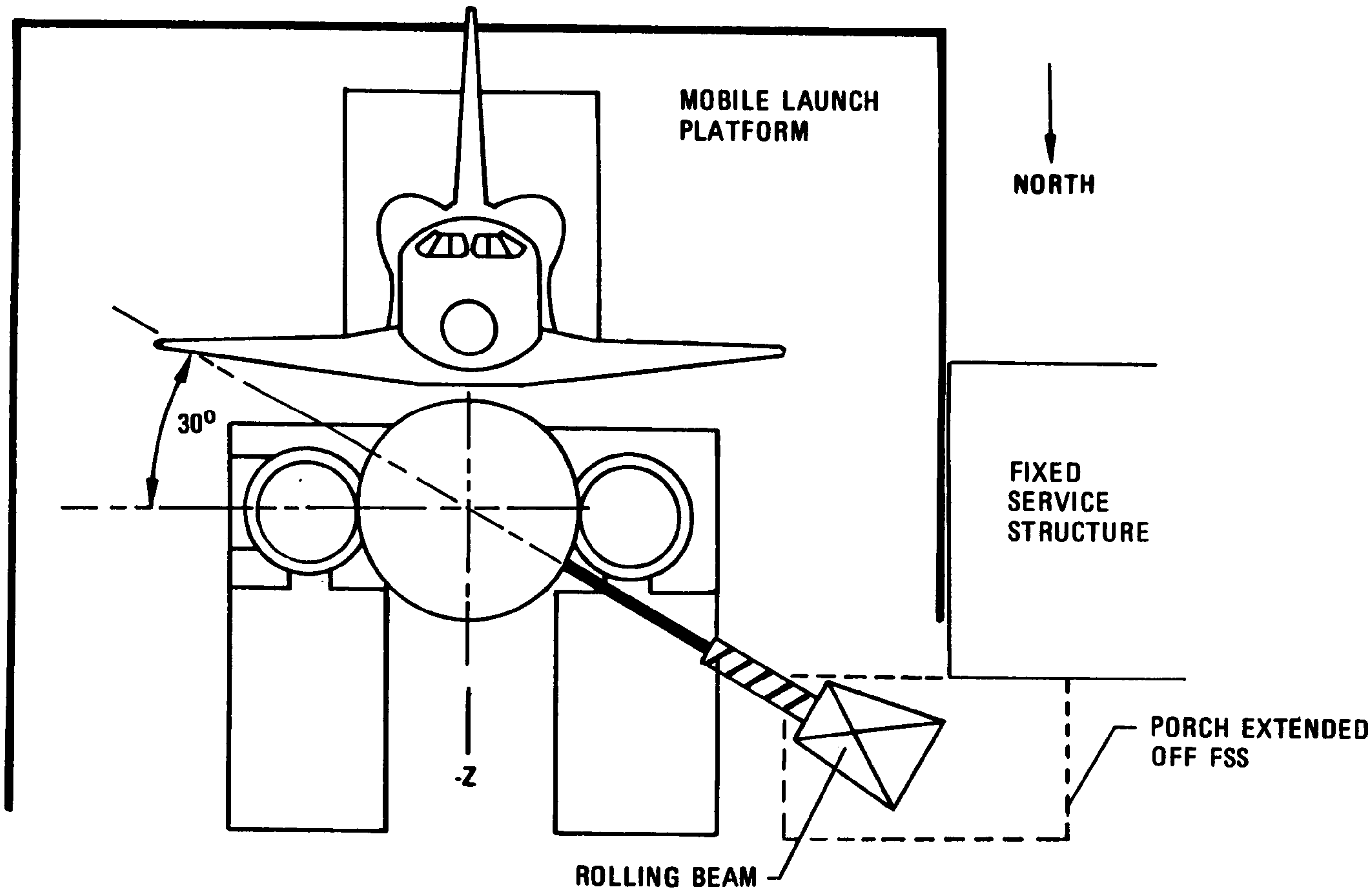
ACC/MLP INTERFACE

A ground umbilical disconnect is located on the ACC in the -Y & -Z quadrant. The centerline of the disconnect is located 30^{o} from the -Y centerline. The motion of the new umbilical arm is a direct retraction to clear the ACC. A new rolling beam arm support platform is required.

ACC/MLP Interface



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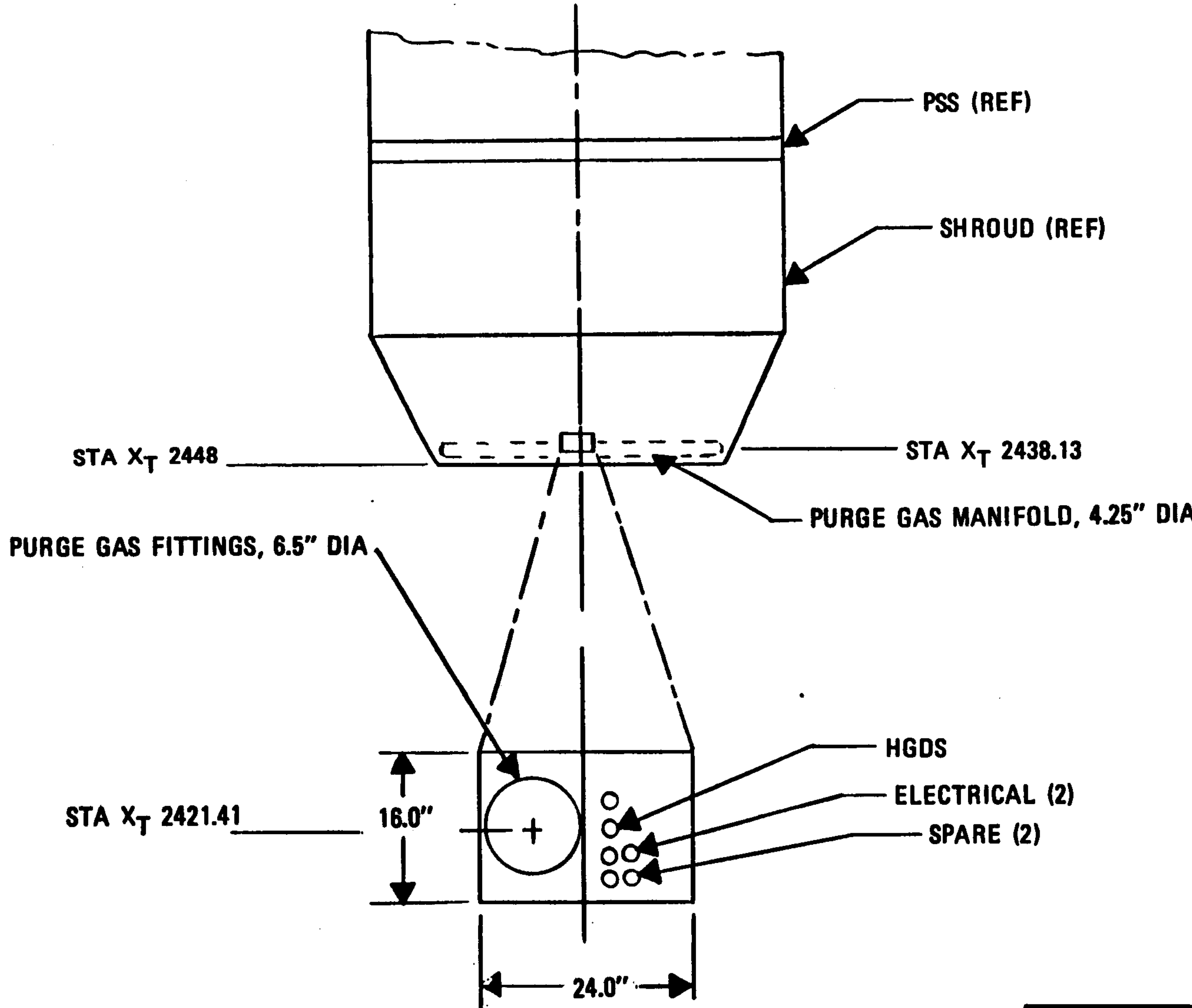
KSC OPERATIONS

GPACC SHROUD - GROUND UMBILICAL DISCONNECT

The GPACC umbilical disconnect provides fittings for purging the ACC volume, electrical disconnects, electrical spares and two 3/8 inch fluids disconnects. One fluid disconnect is used for the HGDS, the other is a spare.

Low pressure purge gas (air, GN_2, GHe) is admitted to the GPACC purge gas manifold via the umbilical purge gas fitting, and is vented to the atmosphere just below the ET LH_2 tank aft dome outer perimeter.

GPACC Shroud - Ground Umbilical Disconnect



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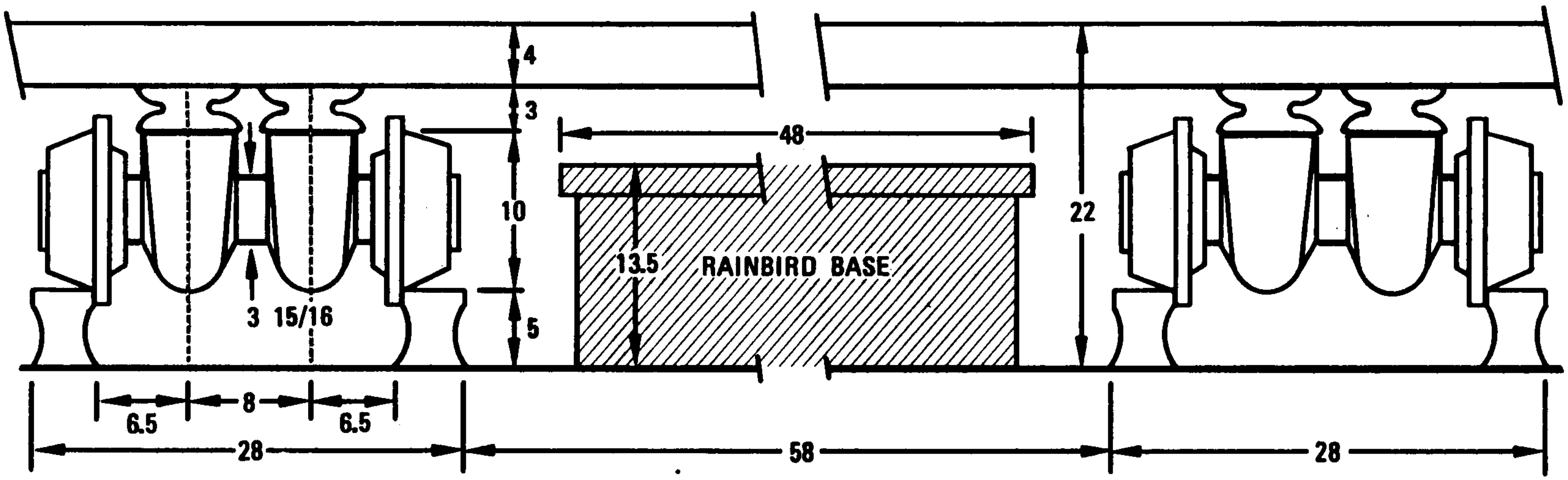
ACC MODEL 101 RAIL MOUNTED TROLLEY

A rail mounted trolley (RMT) using Huwood-Irwin Model DA-102 wheel assemblies will be used on the MLP deck for GPACC payload installation at the launch pad. The RMT provides a 7 in. clearance between the ET aft dome and the PSS.

ACC Model 101 Rail Mounted Trolley



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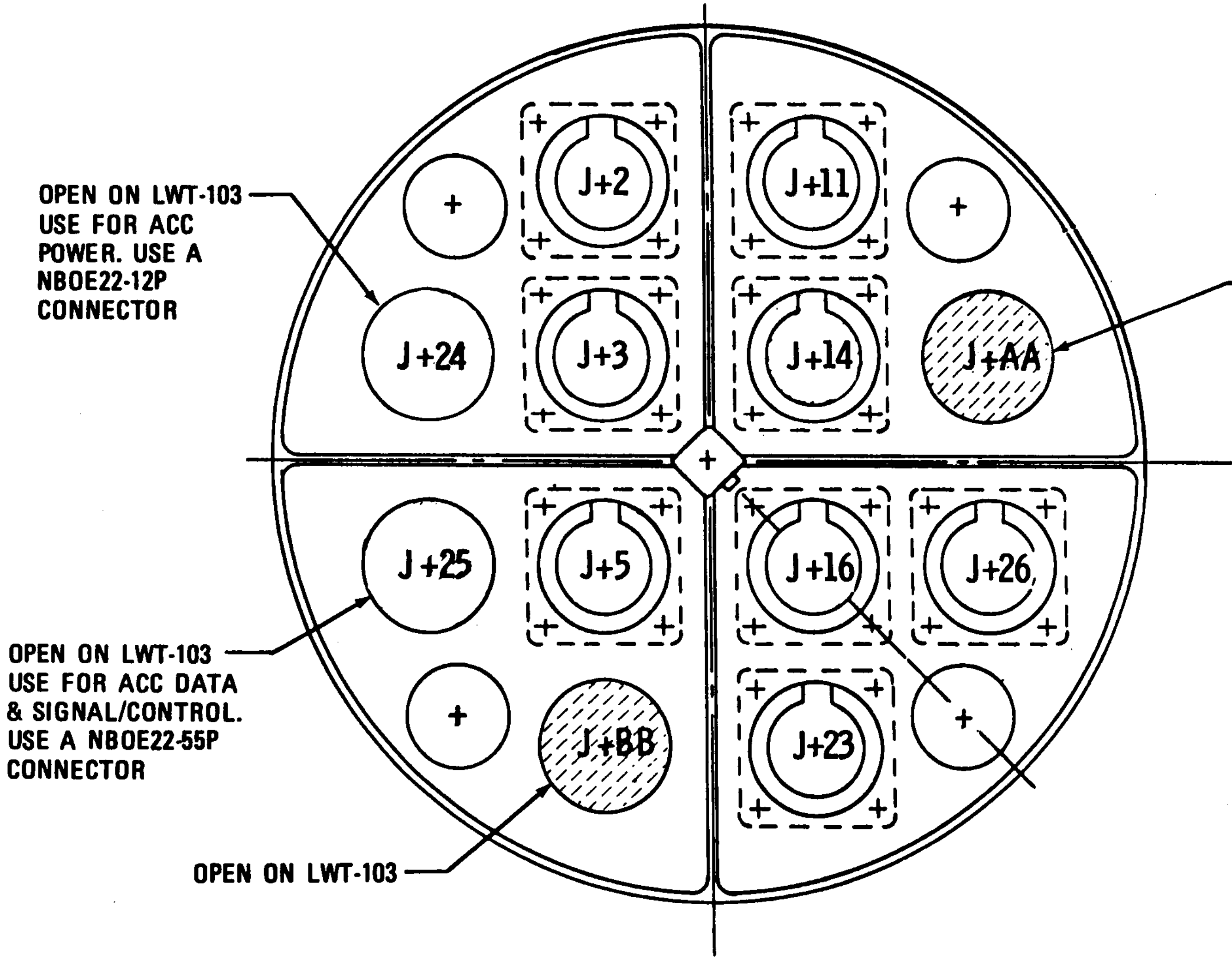
KSC OPERATIONS

ET/ACC TO ORBITER ELECTRICAL INTERFACE (EO-4)

In order to accommodate ACC Systems and Payloads, new wires are required to/from the Orbiter/ACC through EO-4 connectors. This wiring requirement can be accommodated by utilizing two of the four open holes to install a power circuit connector (NBOE22-12P) and a Data/Signal/Control Connector (NBOE22-55P).

ET/ACC to Orbiter Electrical Interface (EO-4)



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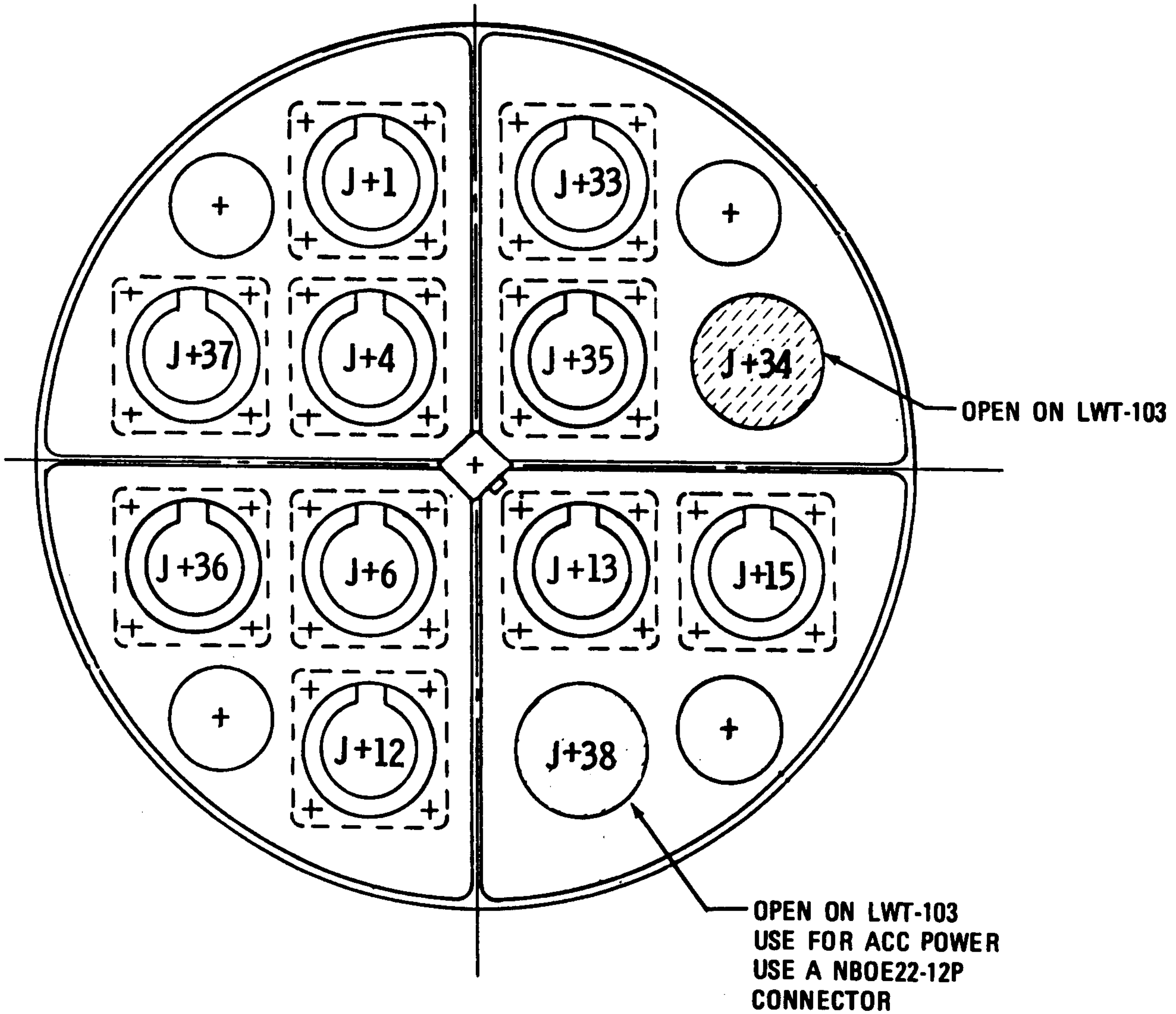
ET/ACC TO ORBITER ELECTRICAL INTERFACE (EO-5)

In order to accommodate ACC Systems and Payloads, new wires are required to/from the Orbiter/ACC through EO-5 connectors. This wiring requirement can be accommodated by utilizing one of the two open holes to install a power circuit connector (NBOE22-12P).

ET/ACC to Orbiter Electrical Interface (E0-5)



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Agenda

- Introduction
- Requirements
- ⇨ Payload Integration
- Design (General Purpose)
- Design (Dedicated OTV)
- Mission Analyses
- Planning
- Costs

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Payload Integration

- Payload Manifest Analysis
- Payload Accommodations/Interface
  - General Purpose
    - Generic
    - PAM-C
  - OTV dedicated

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Mission Manifest & Payload Analysis

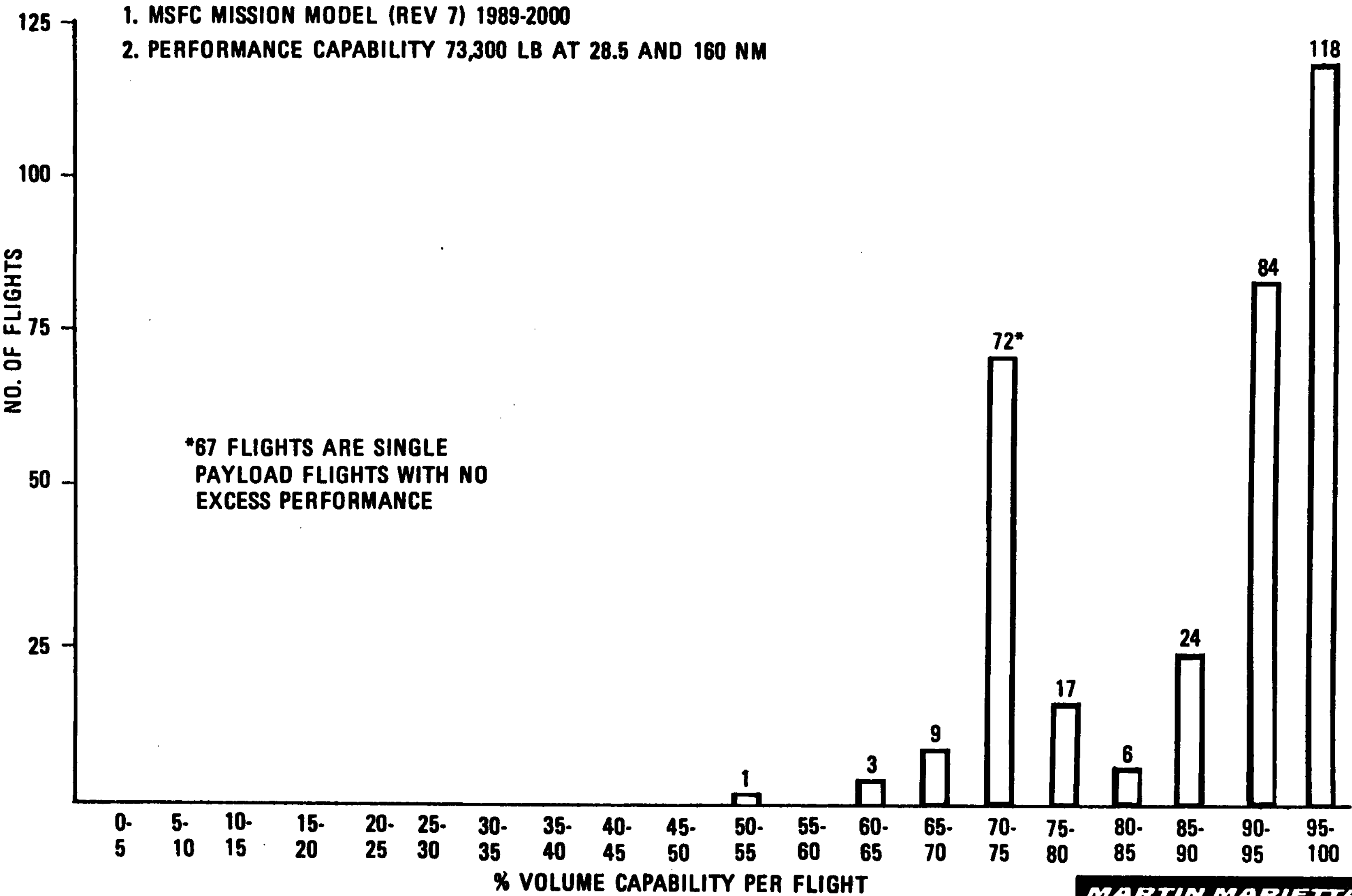
ACC Payload Manifest Ground Rules

- Basic shuttle system: FWC high performance motors; SSME perf-109%; SSME Isp - 452.5
- ACC performance penalty - 10,000 lb at 160 nm
- MSFC (PS-01) mission model (rev 7); ETR; non-DOD; 1989-2000
- ACC IOC - 1989
- STS always manifested to volume capacity prior to ACC consideration
- ACC internal environment equivalent to orbiter cargo bay

VOLUME UTILIZATION FOR STS NON-DOD ETR FLIGHTS

Sixty-seven percent of the 334 total flights exceeded 85% volume usage. Among the 108 low volume utilization flights (below 85% volume usage), there were 67 flights carrying a single payload that was 37 feet long and weighed 60,000 pounds. These were typically propellant delivery flights to the space station. The remaining flights under 85% volume utilization resulted primarily from a few high density payloads, e.g., EOS production resupply which is 10 feet long and 32,000 pounds.

Volume Utilization for STS Non-DOD ETR Flights



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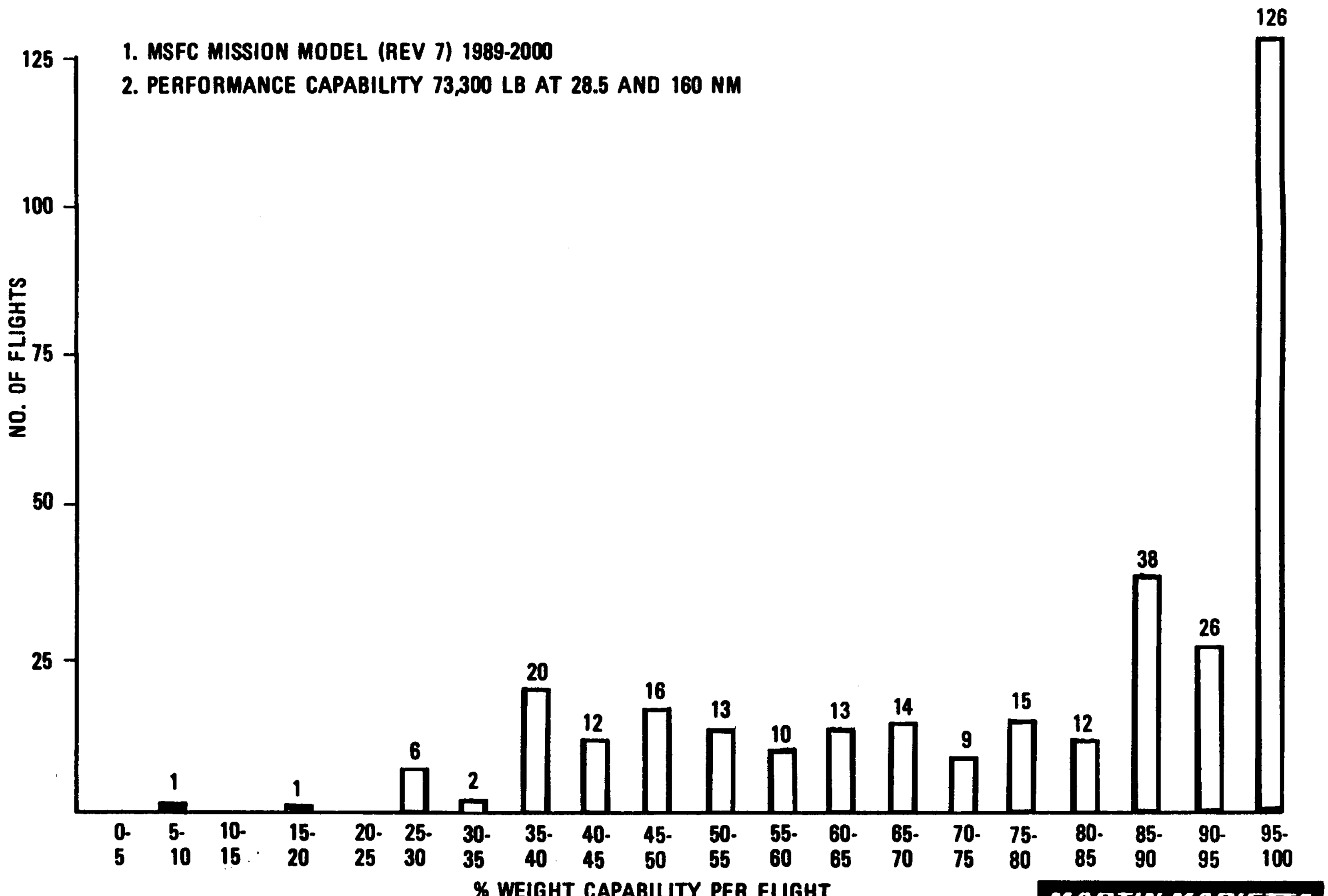
WEIGHT UTILIZATION FOR STS NON-DOD ETR FLIGHTS

Only 42% (152 flights) of the total 334 flights exceeded 90% performance utilization. Seventy-four of these 152 flights carried a single payload weighing 60,000 pounds. There were 117 flights using less than 75% of the available performance. The large number of low performance utilization flights resulted from the quantity of high volume, low density payloads. The wide variation in payload density permits selective manifesting for optimum usage of an ACC in some cases.

Weight Utilization for STS Non-DOD ETR Flights



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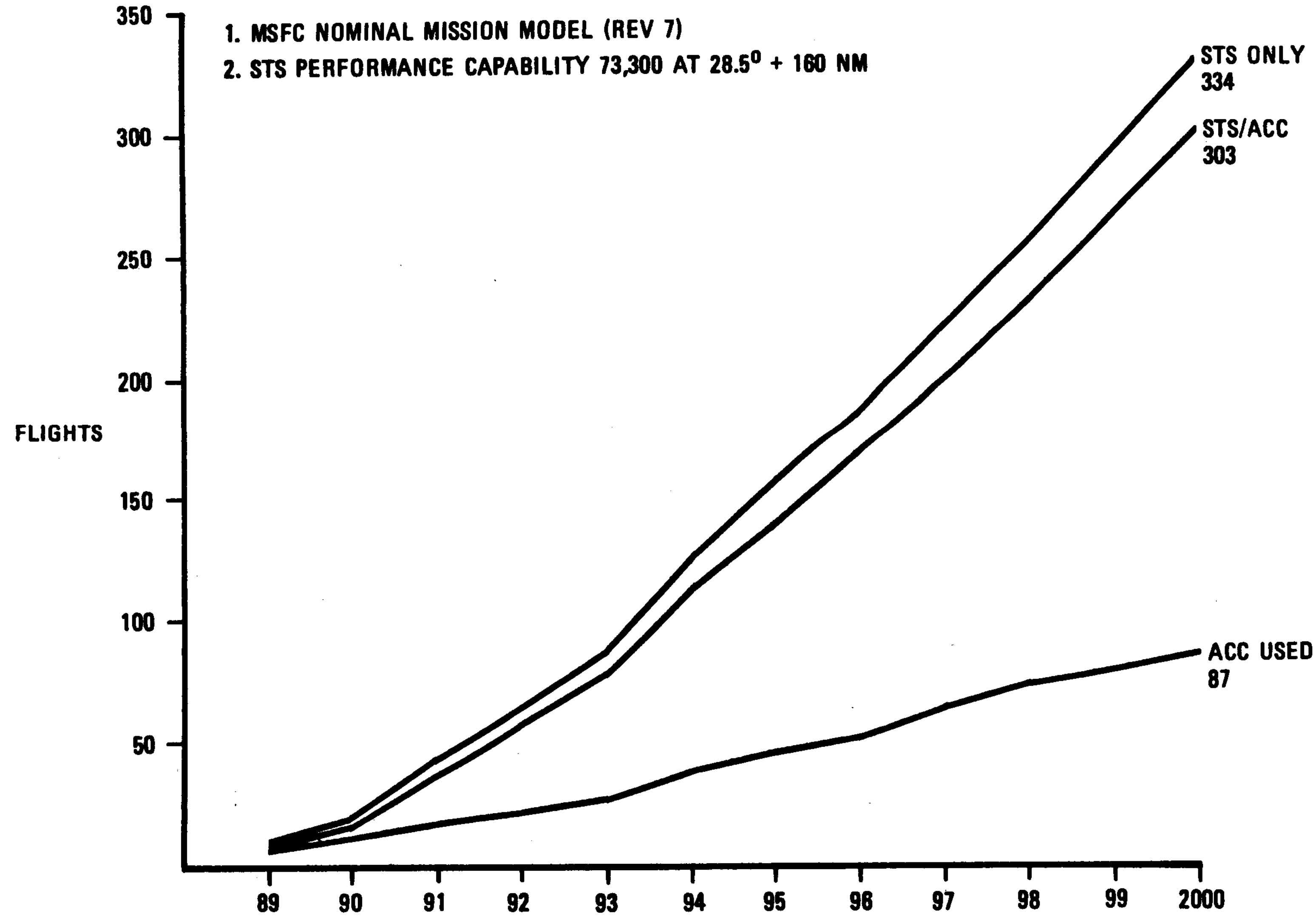
STS AND STS/ACC FLIGHT RATES

The availability of an ACC could save 31 flights during this twelve year period, which is an average of 2.8 ACC's used per STS flight saved. The use of the ACC could provide even greater savings with revised scheduling of payloads. In this mission model capture, some years had ACC opportunities but no unmanifested ACC type payloads; other years had some unmanifested ACC type payloads because they exceeded the STS/ACC lift capability.

STS and STS/ACC Flight Rates



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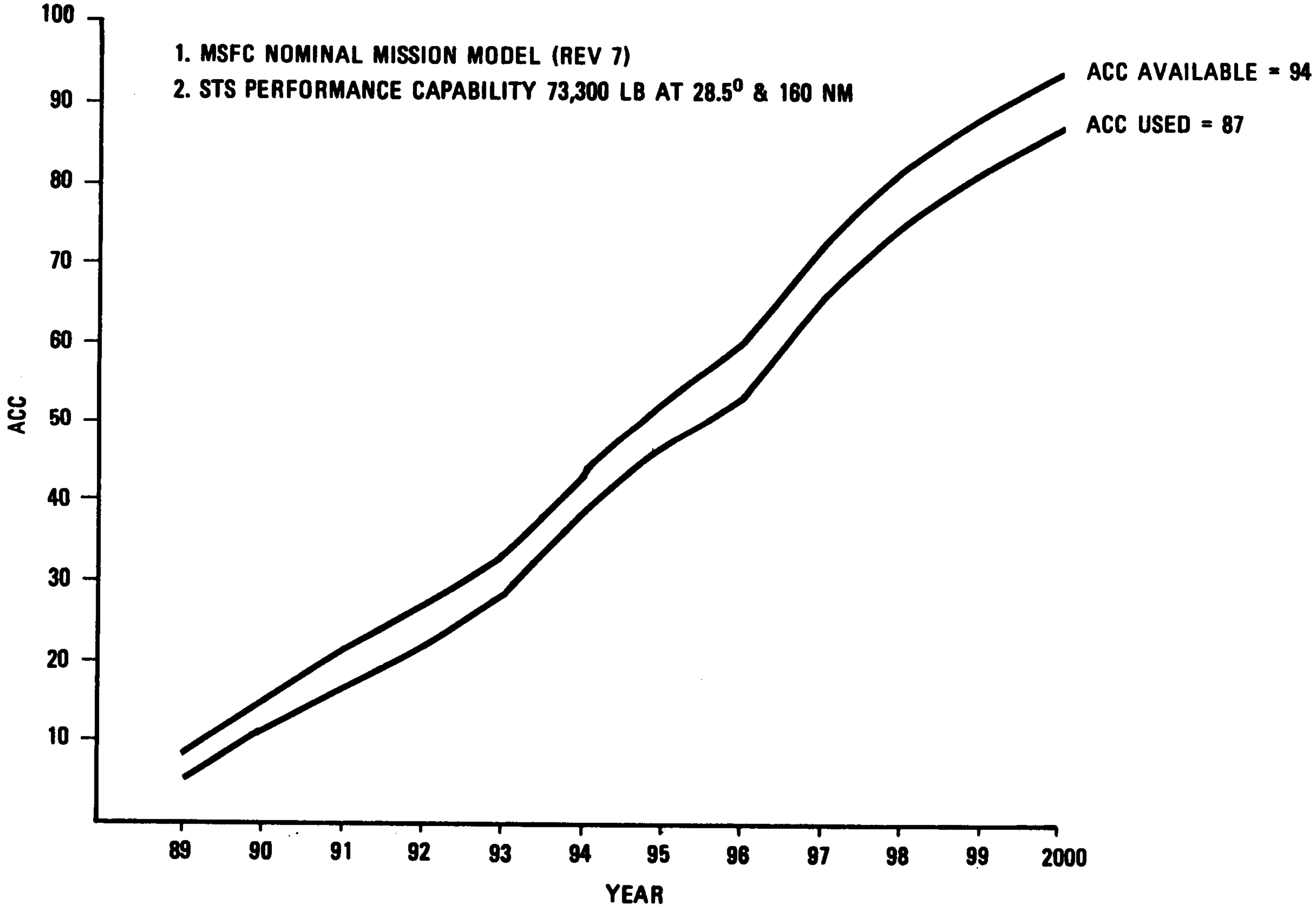
ACC FLIGHT RATES - USED/AVAILABLE

There were seven ACC oppotunities (flights with sufficient excess performance) that could not be used because of an insufficient number of unmanifested ACC type payloads in the particular year of the excess performance. These seven ACC opportunities could have been utilized either by shifting unmanifested ACC type payloads to those years of excess ACC opportunities or by scheduling additional ACC type payloads which may have originated at some later date.

The space station altitude reduces available excess flight performance and thereby reduces the number of opportunities to use an ACC. This disadvantage of space station altitude is offset to some extent by the number of low density payloads scheduled to space station.

ACC Flight Rates - Used/Available



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PAYLOADS MANIFESTED IN ACC (1989-2000)

There were 45 types of payloads manifested in the ACC. Ninety-three of the 159 total payloads manifested in the ACC were scheduled for GEO destination. Seventy-nine of these had SSUS-D upper stages. Most of the payloads were less than 10 ft long and all of them had been assigned a diameter of 15 ft. The cargo weights for the individual payloads varied from 2700 to 29,100 pounds. The number of small light weight payloads (2500-5000 pounds) provided greater flexibility in the utilization of ACC opportunities.

Payloads Manifested in ACC (1989 - 2000)

			ORBIT			CARGO		
ID	NO.	SPACECRAFT NAME	INC DEG	ALT NM	UPPER STAGE	LEN FT	DIA FT	WT LB
B704	10	ECG PRODUCTION RESUPPLY (MPS)	28.50	270.00		4.00	15.00	3,500.00
B705	1	DSCG PRODUCTION UNIT (MPS)	28.50	270.00		5.00	15.00	4,490.00
B706	9	DSCG PRODUCTION RESUPPLY (MPS)	28.50	270.00		4.00	15.00	2,700.00
B708	8	VCG PRODJCTION RESUPPLY (MPS)	28.50	270.00		4.00	15.00	2,900.00
B709	1	SOLUTION CRYSTAL GROWTH PROD. UNIT (MPS)	28.50	270.00		5.00	15.00	8,010.00
B710	9	SCG PRODUCTION RESUPPLY (MPS)	28.50	270.00		4.00	15.00	3,230.00
B712	3	IC PRODUCTION UNIT (MPS)	28.50	270.00		5.00	15.00	4,710.00
B714	3	BP PRODUCTION RESUPPLY (MPS)	28.50	270.00		4.00	15.00	4,930.00
B716	3	MT-C PRODUCTION RESUPPLY (MPS)	28.50	270.00		5.00	15.00	8,100.00
C002	1	GEO PLATFORM REVISIT	0.00	19323.00		6.00	15.00	4,190.00
C701	1	GEO PLATFORM REVISIT (COMM'L)	0.00	19323.00		6.00	15.00	4,190.00
D021	1	OMV PROPELLANT DELIVERY (NASA)	28.50	270.00		10.00	15.00	29,100.00
D052	3	TDM PAYLOAD DEPLOY (TECH DEV MISSION)	28.50	270.00		15.00	15.00	15,000.00
D053	4	TDM PAYLOAD RETRIEVAL (TECH DEV MISSION)	28.50	270.00		10.00	15.00	2,500.00
E006	1	EQUIP/ORU FOR GEO SORTIE	0.00	19323.00		10.00	15.00	3,930.00
F020	1	OVLBI RETR'AL (ORB VERY LONG BASE INTER)	28.50	216.00		10.00	15.00	1,700.00
F022	1	LARGE OBSERVATORY SERVICING: 28.5D	28.50	270.00		9.40	15.00	12,000.00
H008	1	OPEN-1:2:3 (ORIGIN OF PLASMA EARTH NBHD)	28.50	42000.00	PAM-D2	8.00	15.00	15,870.00
H009	1	XTE (XRAY TIMING EXPLORER)	28.50	216.00		6.60	15.00	2,210.00
H040	1	GEOS (GEOSYNCH EARTH OBSERVATION SYS)	0.00	19323.00		20.00	15.00	20,000.00
H048	1	WINDSAT (ENVIRONMENTAL OBSERVATIONS)	57.00	310.00		14.60	15.00	4,980.00
H063	1	FUSE (FAR UV SPECTRAL EXPLORER)	28.50	270.00		10.00	15.00	4,400.00
H067	1	SXSE (SOFT XRAY SURVEY EXPLORER)	28.50	216.00		5.00	15.00	2,870.00
H300	5	GOES GEOSTATIONARY ORB ENVIRON SAT)	0.00	19323.00	PAM-D	7.80	15.00	9,830.00
H501	1	INSAT (INDIAN MULTISERVICE)	0.00	19323.00	PAM-D	7.80	15.00	9,884.00
H502	3	PALAPA (INDONESIAN COMM)	0.00	19323.00	PAM-D	7.80	15.00	9,990.00
H503	2	ARABSAT (ARAB COMM)	0.00	19323.00	PAM-D	9.50	15.00	10,158.00
H504	1	TELESAT (CANDADIAN COMM) (PAM-D2)	0.00	19323.00	PAM-D2	11.50	15.00	15,867.00
H505	2	AUSSAT (AUSTRALIAN COMM)	0.00	19323.00	PAM-D	7.80	15.00	10,200.00

Payloads Manifested in ACC (1989 - 2000) (concl)

ID	NO.	SPACECRAFT NAME	ORBIT INC DEG	ORBIT ALT NM	UPPER STAGE	CARGO LEN FT	CARGO DIA FT	CARGO WT LB
H537	2	EURECA DELIVERY (ESA:MPS)	28.50	260.00		7.50	15.00	7,716.00
H701	1	OTHER DBS & NEW COMM	0.00	19323.00	PAM-D	8.00	15.00	10,110.00
H702	3	SATCOM (RCA COMM) (PAM-D)	0.00	19323.00	PAM-D	7.80	15.00	6,554.00
H703	2	SBS (SATELLITE BUSINESS SYSTEM:COMM)	0.00	19323.00	PAM-D	7.80	15.00	9,651.00
H706	4	TELSTAR (AT&T:COMM)	0.00	19323.00	PAM-D	7.80	15.00	9,928.00
H710	1	STC DBS (SATELLITE TELEVISION CORP:COMM)	0.00	19323.00	PAM-D	10.90	15.00	10,024.00
H713	2	WESTAR (WESTERN UNION:COMM)	0.00	19323.00	PAM-D	7.80	15.00	9,731.00
H727	3	GALAXY (HUGHES:COMM)	0.00	19323.00	PAM-D	7.80	15.00	10,113.00
H732	2	BANKING (COMMUNICATIONS)	0.00	19323.00	PAM-D	8.00	15.00	10,110.00
H740	1	FORDSAT (FORD AEROSPACE:COMM)	0.00	19323.00	PAM-DII	11.50	15.00	15,867.00
H741	1	MOBILSAT (MOBILE SAT CORP:COMM)	0.00	19323.00	PAM-D	8.00	15.00	10,110.00
H744	2	MAIL (COMMERCIAL ELECTRONIC MAIL)	0.00	19323.00	PAM-D	8.00	15.00	10,110.00
H904	2	SMALL LEO SAT SERVICING	28.50	270.00		3.00	15.00	5,000.00
H905	42	PAM-D VIA SS	0.00	19323.00	PAM-D	8.00	15.00	10,110.00
H907	2	LEASAT VIA SS	0.00	19323.00	LEASAT	14.10	15.00	16,960.00
H910	9	UNMANNED GEO SERVICING	0.00	19323.00		6.00	15.00	4,190.00

TOTAL	159

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Summary of Payloads Manifested in ACC

- 45 Payload types; 159 total payloads
- 93 of 159 go to GEO
- 79 SSUS-D upper stages used
- Most payloads are less than 10 feet long; all are 15 feet in diameter
- Cargo weights for individual payloads are 2,700 - 29,100 lb

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ACC Payload Accommodations

- Interfaces
- Loads
- Environments

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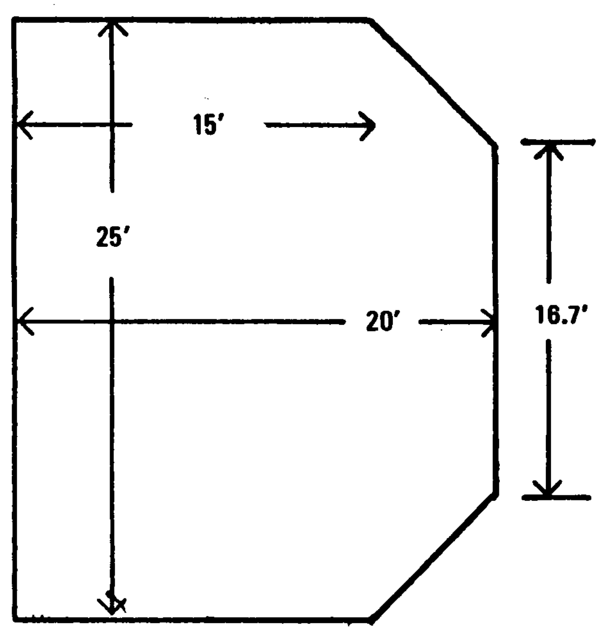
ACC PAYLOAD ENVELOPE

The GPACC provides within the shroud a payload envelope of 25 ft dia X 15 ft long, with a truncated cone 5 ft long x 25 ft wide, narrowing to 16.7 ft wide at the aft end. This envelope also allows accommodation of a 15 ft wide X 20 ft long cargo element.

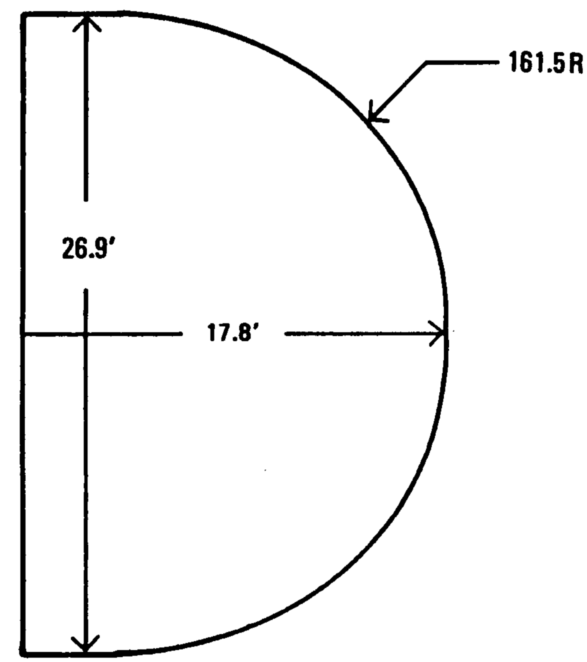
The DACC shroud provides a payload envelope 26.9 ft dia X 4.31 ft long, within an attached 13.49 ft radius clear dome.

ACC Payload Envelope

GENERAL PURPOSE



OTV DEDICATED



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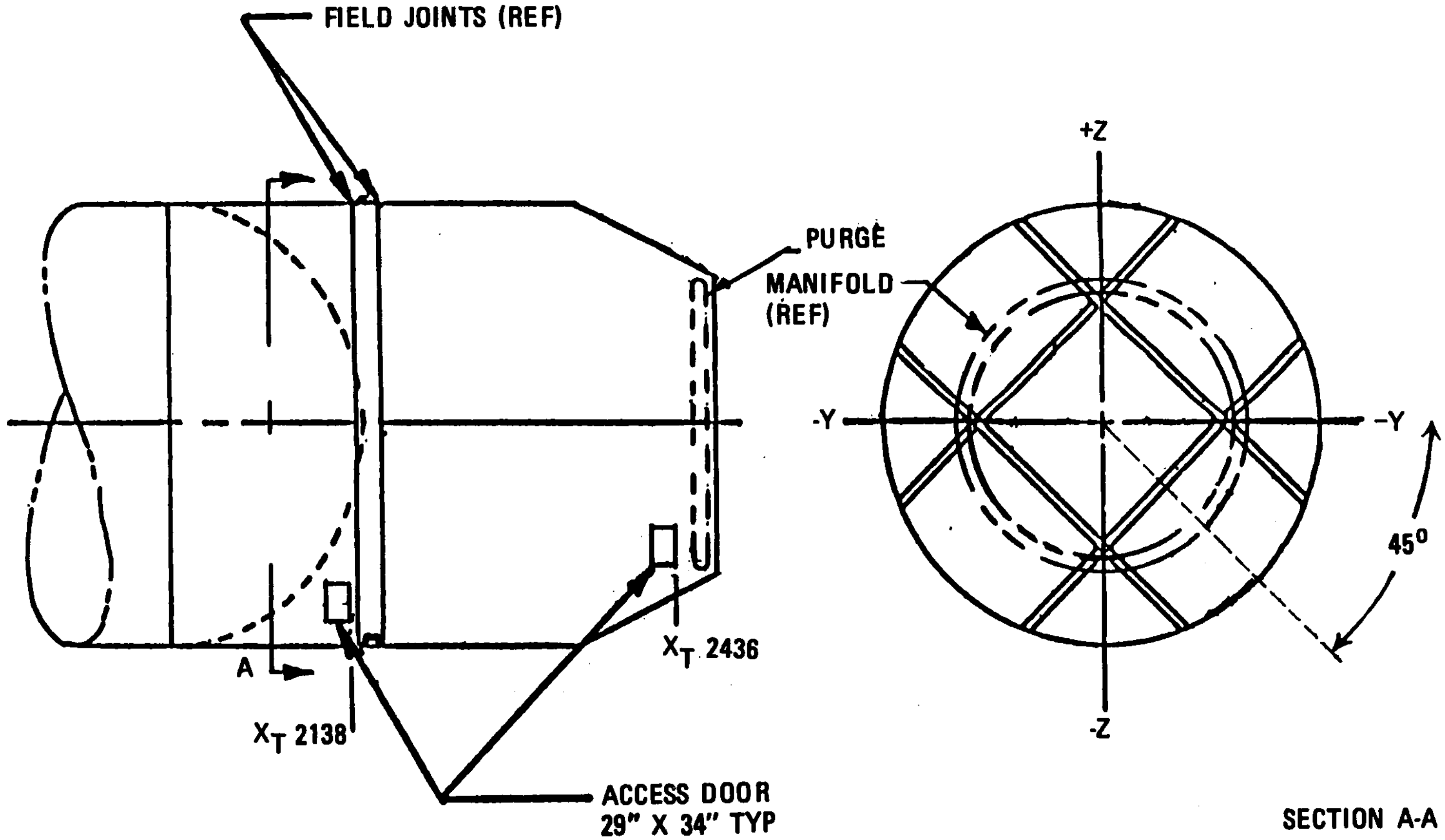
GPACC ACCESS REQUIREMENTS FOR GENERIC & PAM

Ground access is required into both the shroud volume, and the ACC skirt and PSS volume These requirments are met by providing doors at $X_T 2436$ and $X_T 2138$, respectively. The doors are located in the -Y, -Z quadrant and are centered 45^o from the -Y ACC centerline.

GPACC Access Requirements for Generic & PAM



SECTION A-A

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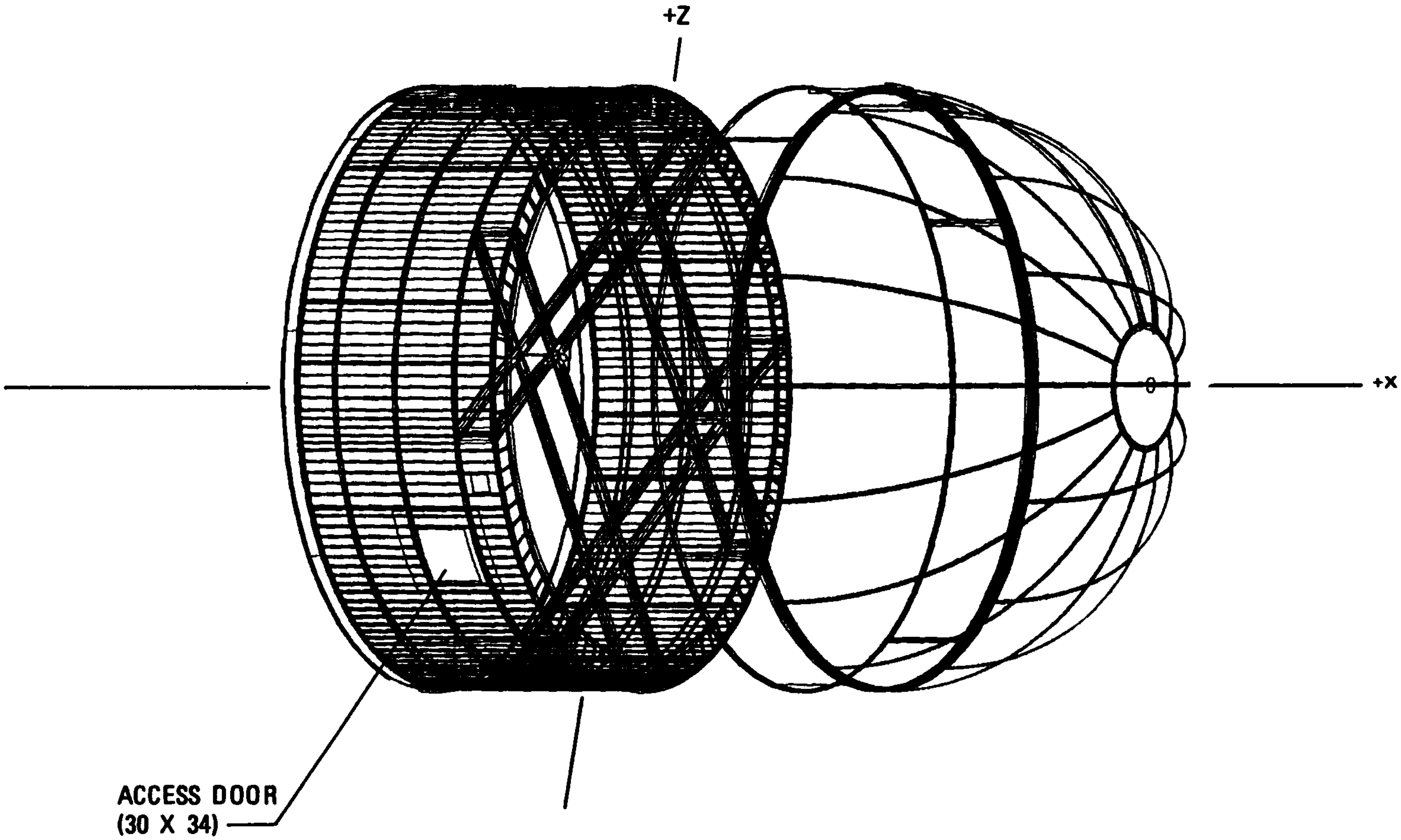
DACC ACCESS

The DACC design incorporates only one opening through the structure to access the internal area. The opening is 30 in. X 34 in. in size and is located in the -Y, -Z quadrant of the DACC skirt assembly.

DACC Access



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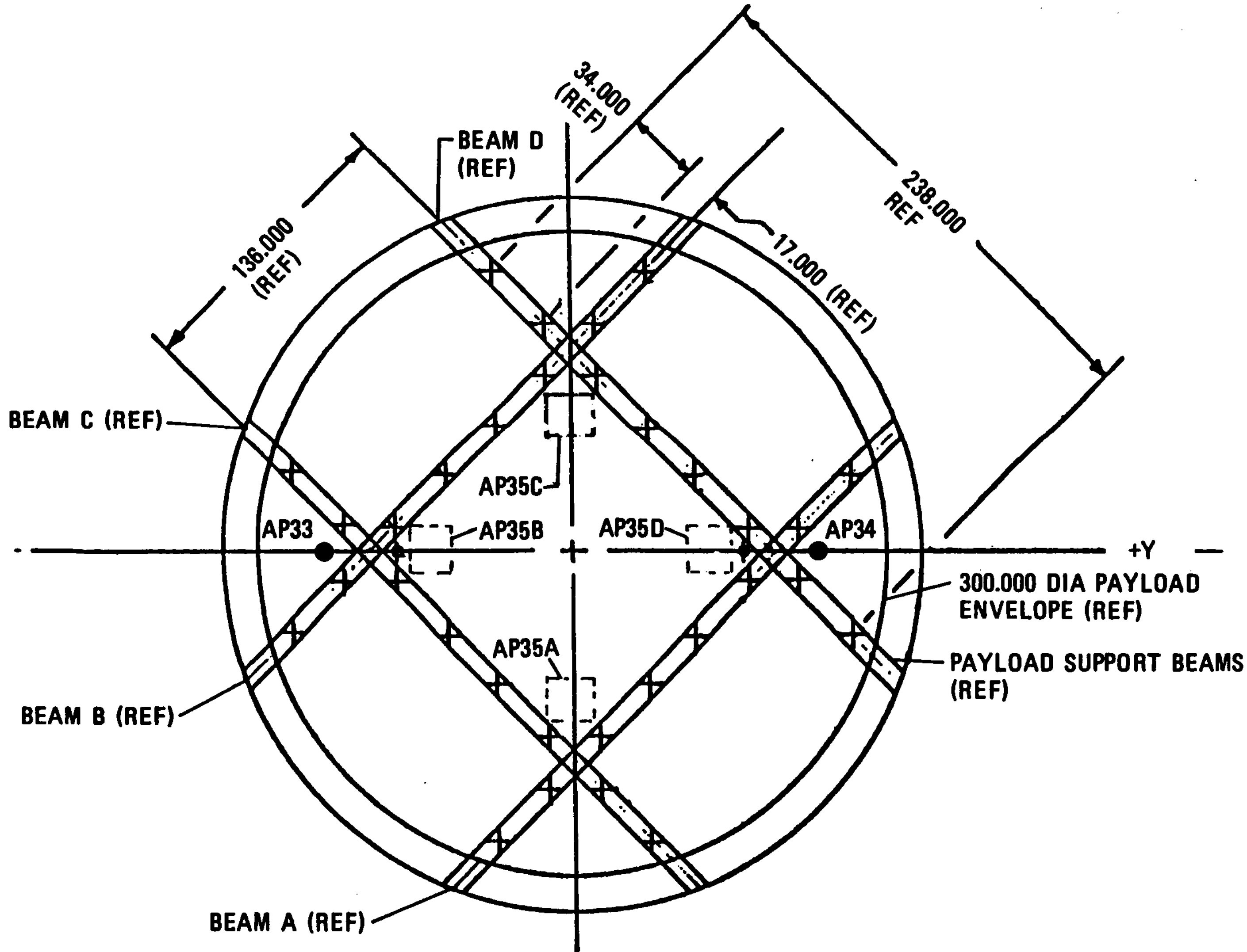
GPACC/PAM-CLASS INTERFACE LOCATIONS (GENERAL)

There are 32 structural attach fitting locations. The "X" in the figure represents the center of the attach fitting. Each fitting has holes for four 1/2 in. bolts. The fittings are located on 34 in. centers. The attach fittings are designated as I/Fs AP1 through AP32.

Interfaces AP33 and AP34 are cargo unique purge spigots which are attached to the PSS. These purge spigots are provided as kits and support cargo element needs.

Interface AP35 is the electrical interface panel (EIP). The EIP may be located at any/all of the locations AP35A through AP35D. The EIP supports single/multiple cargo elements.

GPACC/PAM - Class Interface Locations (General)



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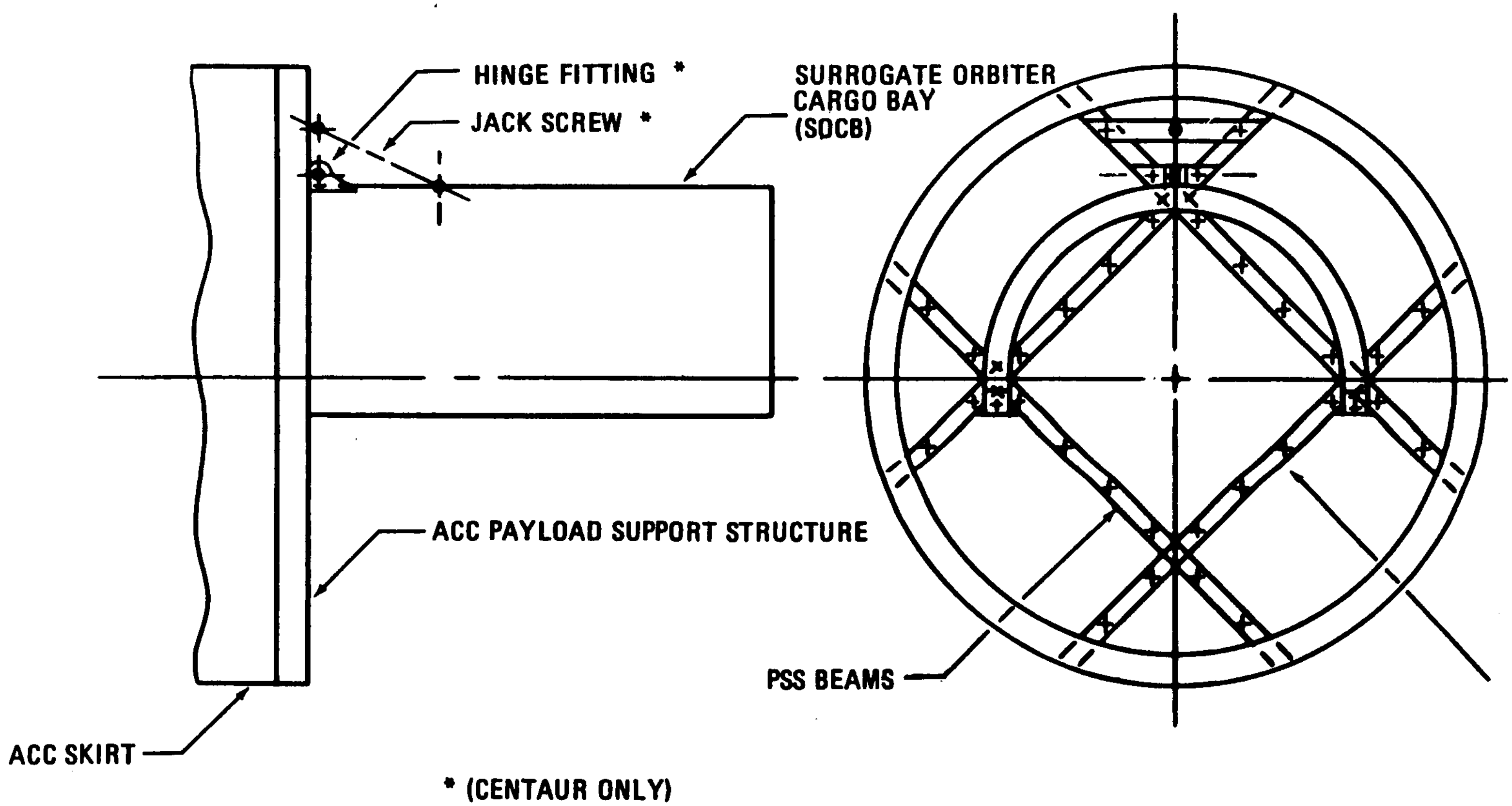
GPACC SURROGATE ORBITER BAY

The surrogate orbiter cargo bay (SOCB) is designed to simulate a 20 ft section of the orbiter cargo bay. As such, the SOCB provides longerons, a keel and locations identical to those in the orbiter bay for longeron and keel fittings. Further, the EIPs are provided which simulate the orbiter SIPs.

The SOCB can provide, as a kit, a tilt capability to facilitate deploying payloads, such as the Centaur.

GPACC Surrogate Orbiter Bay



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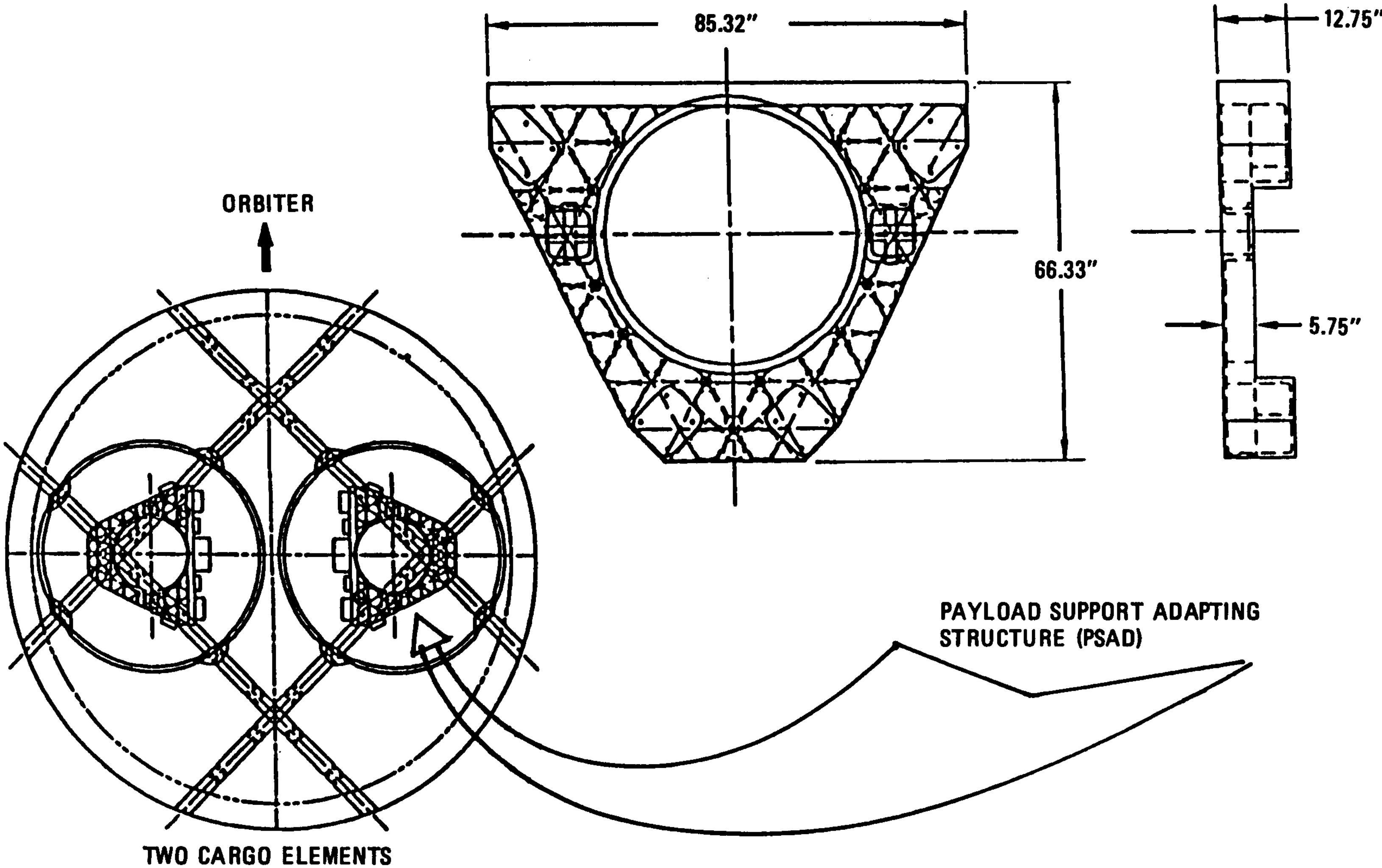
GPACC/PAM-C MANIFEST CONFIGURATION

The basic manifest configuration for two PAM-C cargo elements is shown. The cargo elements are mounted as close to the beam intersections as possible for better load distribution, and they are also oriented away from the Orbiter to minimize heating rates during ascent. Adequate dynamic clearance exists between the two for deployment operations.

GPACC/PAM-C Manifest Configuration



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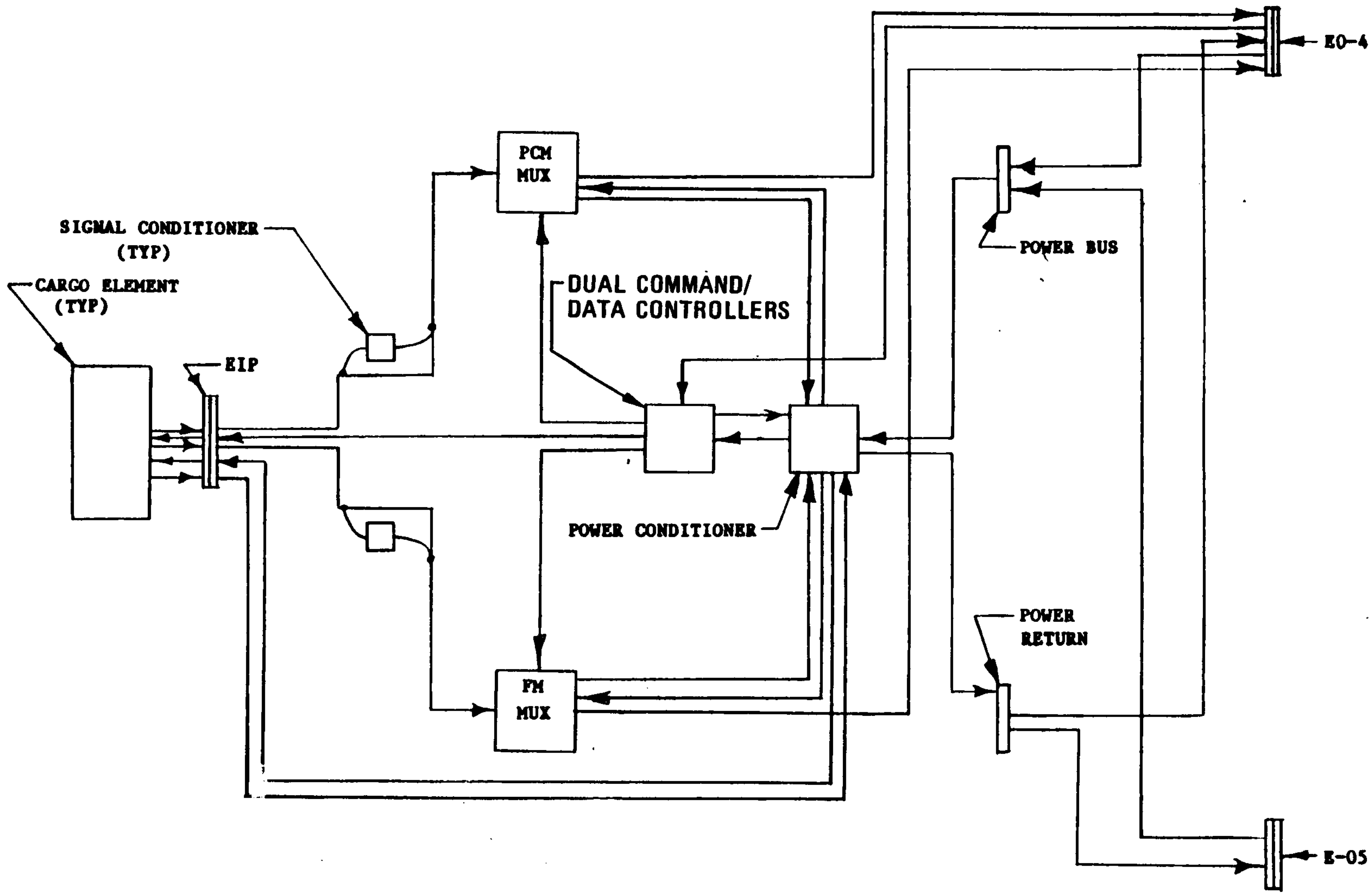
ACC CARGO AVIONICS SCHEMATIC

The ACC avionics system provides one standard mixed cargo harness capability for the cargo element, and does this within the constraints of the available connector spaces and pins at EO-4 and EO-5.

Provision is made for redundant hardwiring of critical command and criteria data through EO-4 and EO-5 in addition to accommodating the requirements for the ACC's power, command and data.

ACC Cargo Avionics Schematic



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DACC Interfaces

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DACC INTERFACE LOCATIONS

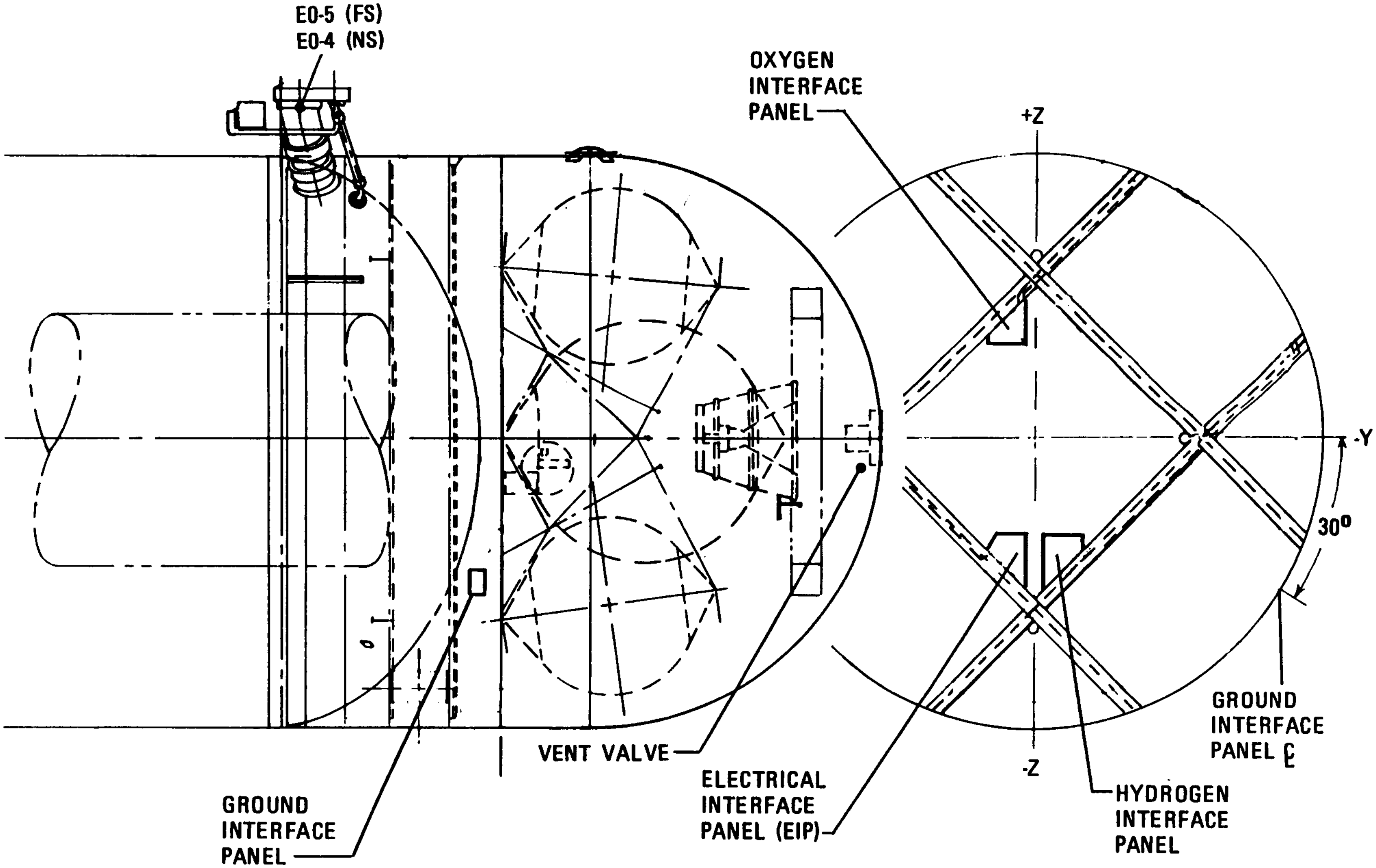
There are two DACC/facility I/Fs: the dual umbilical fluids disconnect in the PS structure and the ground vent value in the aft dome. The dual umbilical fluids disconnect provides all the fluids needed for the OTV and ACC from arrival on the launch pad through lift-off. The ground vent valve provides ACC volume purge venting until T-2 minutes when it closes (prior to lift-off).

There are four OTV/ACC PS structural I/Fs consisting of special bolts. Two bolts are retained by explosive nuts, and two bolts on the Z centerline are retained by explosive nut thrusters.

Two OTV/ACC fluids I/Fs are used. The LO2 I/F is located in the +Y and +Z quadrant of the PS beam diamond; the LH2 I/F is located in the -Y and -Z quadrant of the PS diamond.

A single EIP is located in the +Y and -Z quadrant of the PS diamond. The EIP has provisions for 16 connectors, and has the capability of two orbiter standard interface panel (SIP).

DACC Interface Locations



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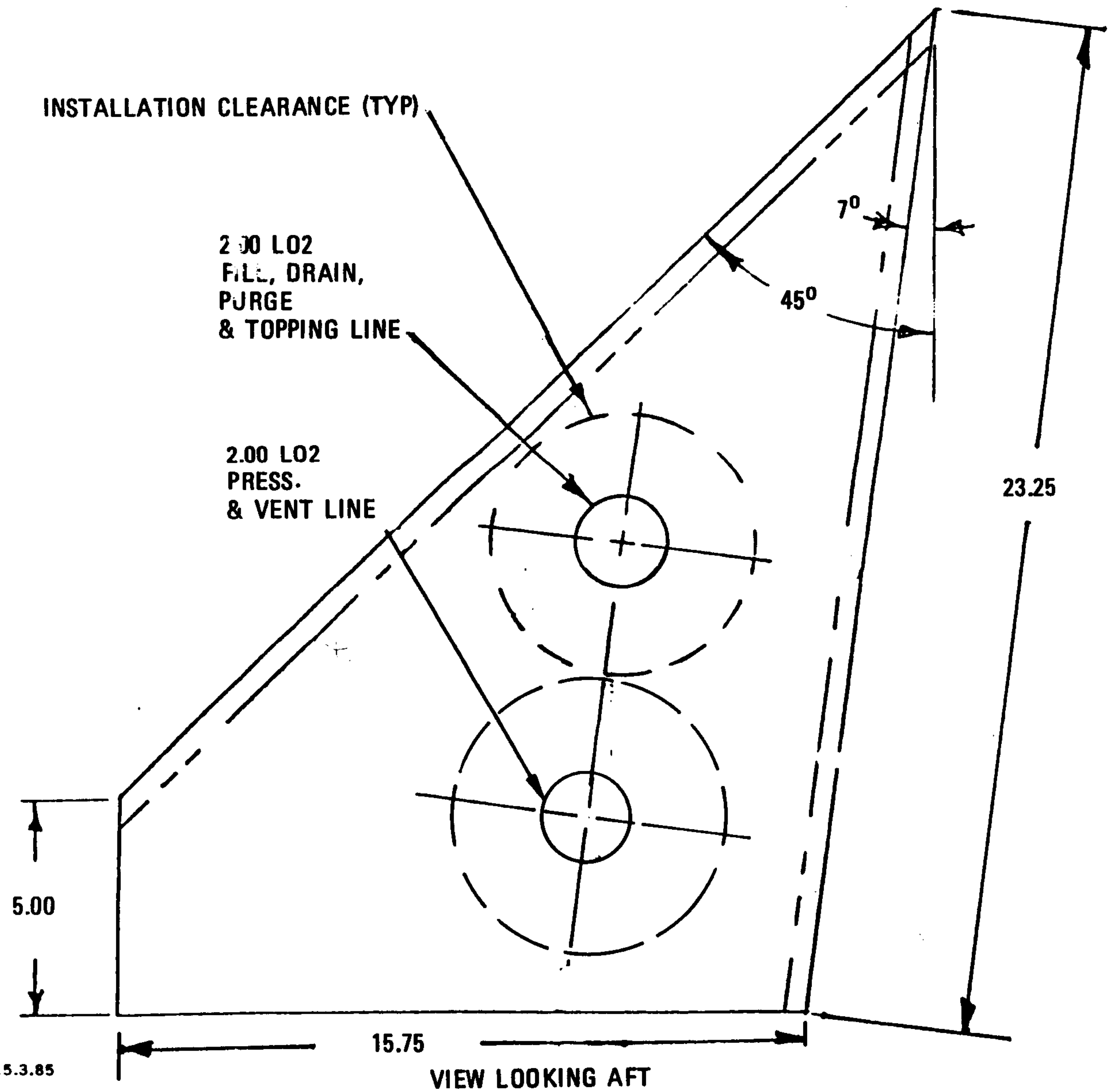
DACC/OTV FLUIDS INTERFACE PANEL (OXYGEN)

The LO2 I/F panel is designed to allow assembly between the OTV and DACC PS beams. Two rise-off type fluid disconnects are used, each 2 in. in dia.

Multiple functions are accomplished through each line: The LO2 fill line is also used for LO2 tank topping off and purge, and the LO2 pressurization line is also used as the LO2 tank vent line.

DACC/OTV Fluids Interface Panel (Oxygen)



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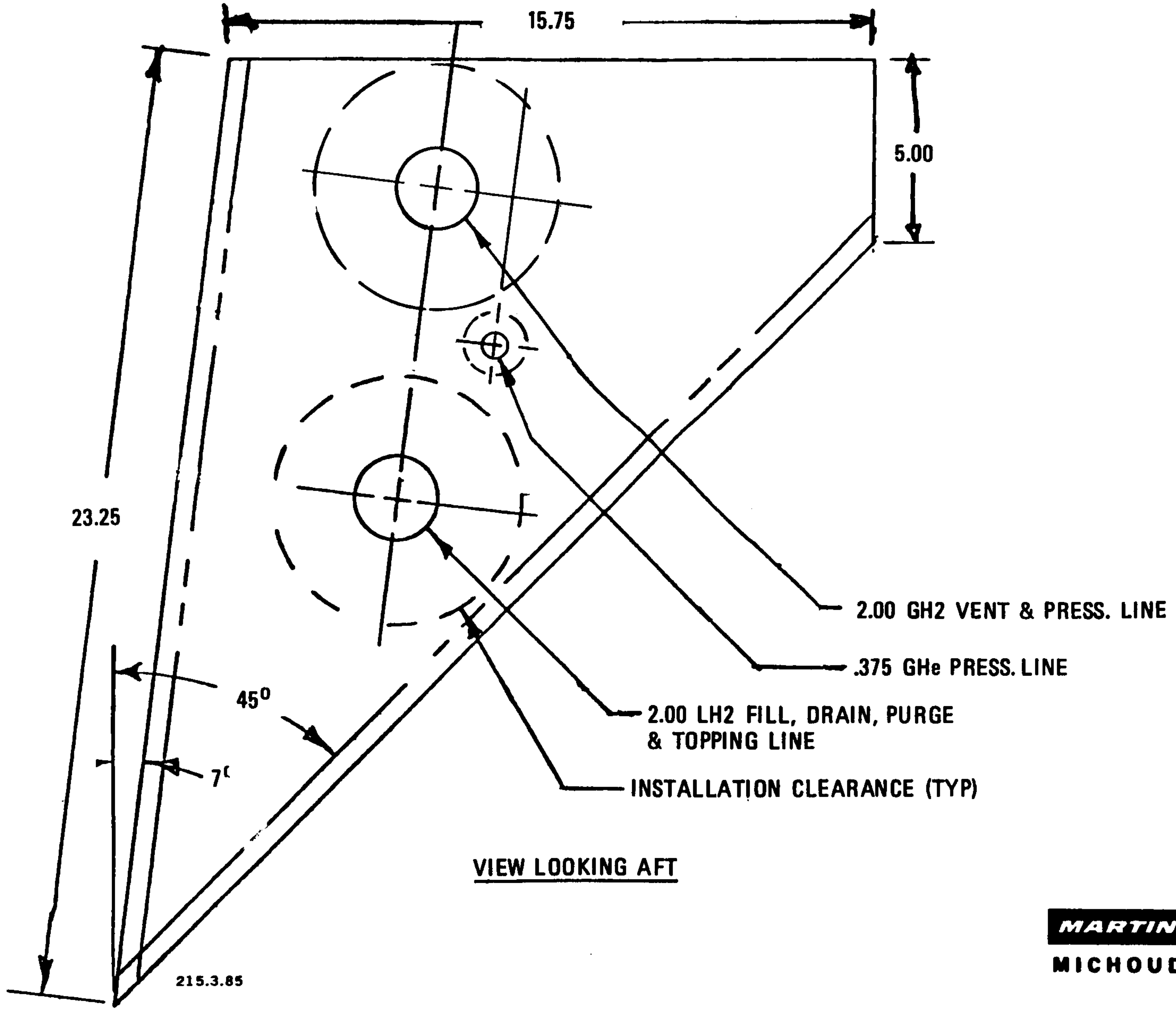
DACC/OTV FLUIDS INTERFACE PANEL (HYDROGEN)

The LH_2 I/F panel is designed to allow assembly between the OTV and the ACC PS beams.

This I/F panel contains three rise-off type fluids line/disconnects. Two of the line/disconnects are 2 in. dia, the third is 0.375 in. dia. Each 2 in. line/disconnect connects lines having multiple functions. GH_2 venting and pressurization is handled through one of the 2 in. dia line/disconnects. The other line/disconnect handles LH_2 fill, drain, purge and topping. The 0.375 in. dia line/disconnect is only for GHe pressurization.

DACC/OTV Fluids Interface Panel (Hydrogen)



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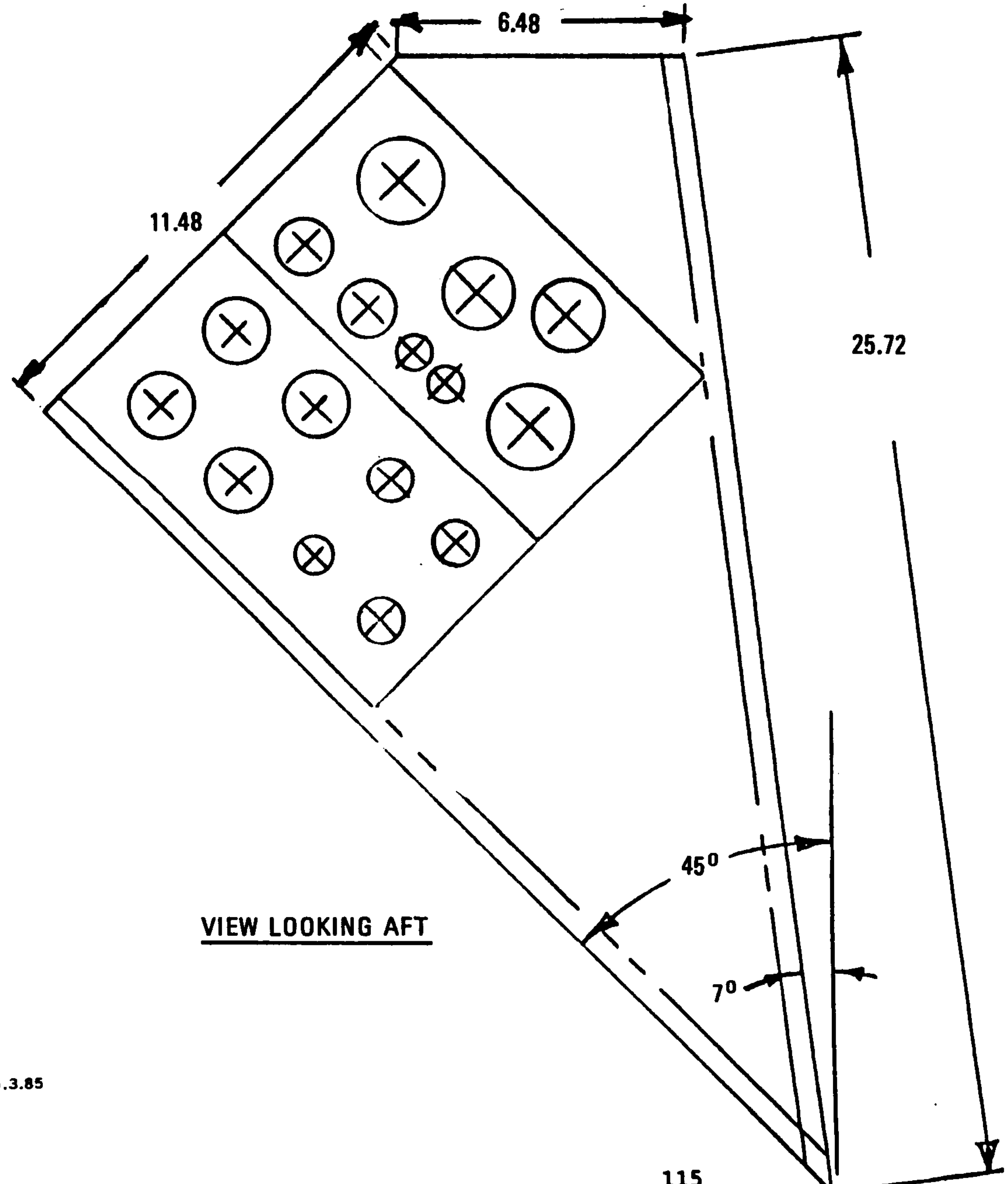
DACC/OTV ELECTRICAL INTERFACE PANEL (EIP)

The mounting structure for the EIP is designed to be mounted on the OTV rack and the PS beams.

The EIP accommodates all the electrical connectors for one complete orbiter standard mixed cargo harness with spares. The EIP connector hole pattern is identical to one port and one starboard orbiter SIP.

DACC/OTV Electrical Interface Panel (EIP)



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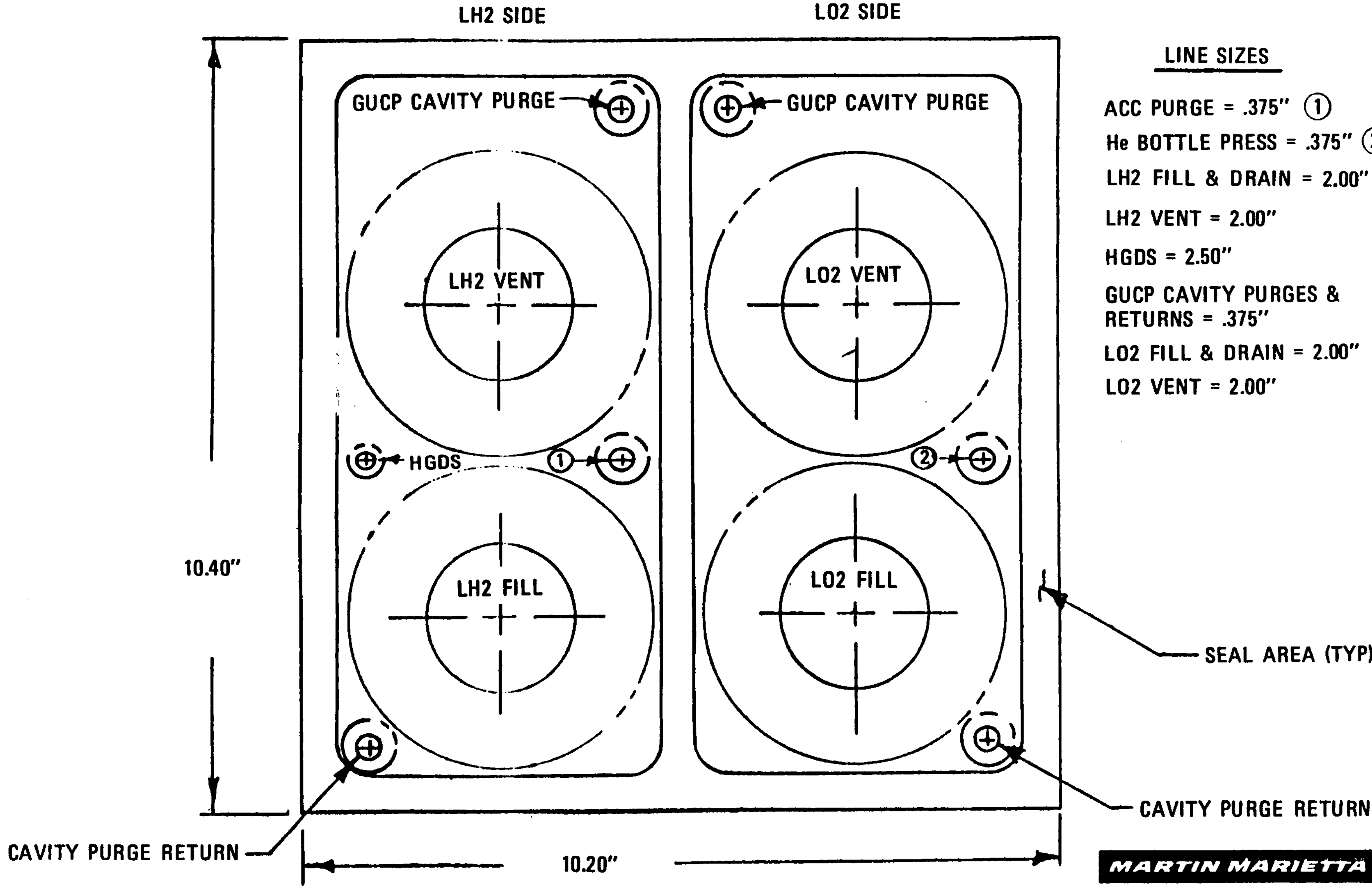
DACC/GROUND INTERFACE PANEL

The DACC ground interface panel is a dual disconnect type that provides oxygen and hydrogen services to the OTV.

Other services lines provided at this I/F are: the HGDS, OTV GHe bottle pressurization, ACC purge gas, and the ground umbilical carrier plate (GUCP) cavity purge.

DACC/Ground Interface Panel



LINE SIZES

ACC PURGE = .375" ①
He BOTTLE PRESS = .375" ②
LH2 FILL & DRAIN = 2.00"
LH2 VENT = 2.00"
HGDS = 2.50"
GUCP CAVITY PURGES & RETURNS = .375"
LO2 FILL & DRAIN = 2.00"
LO2 VENT = 2.00"

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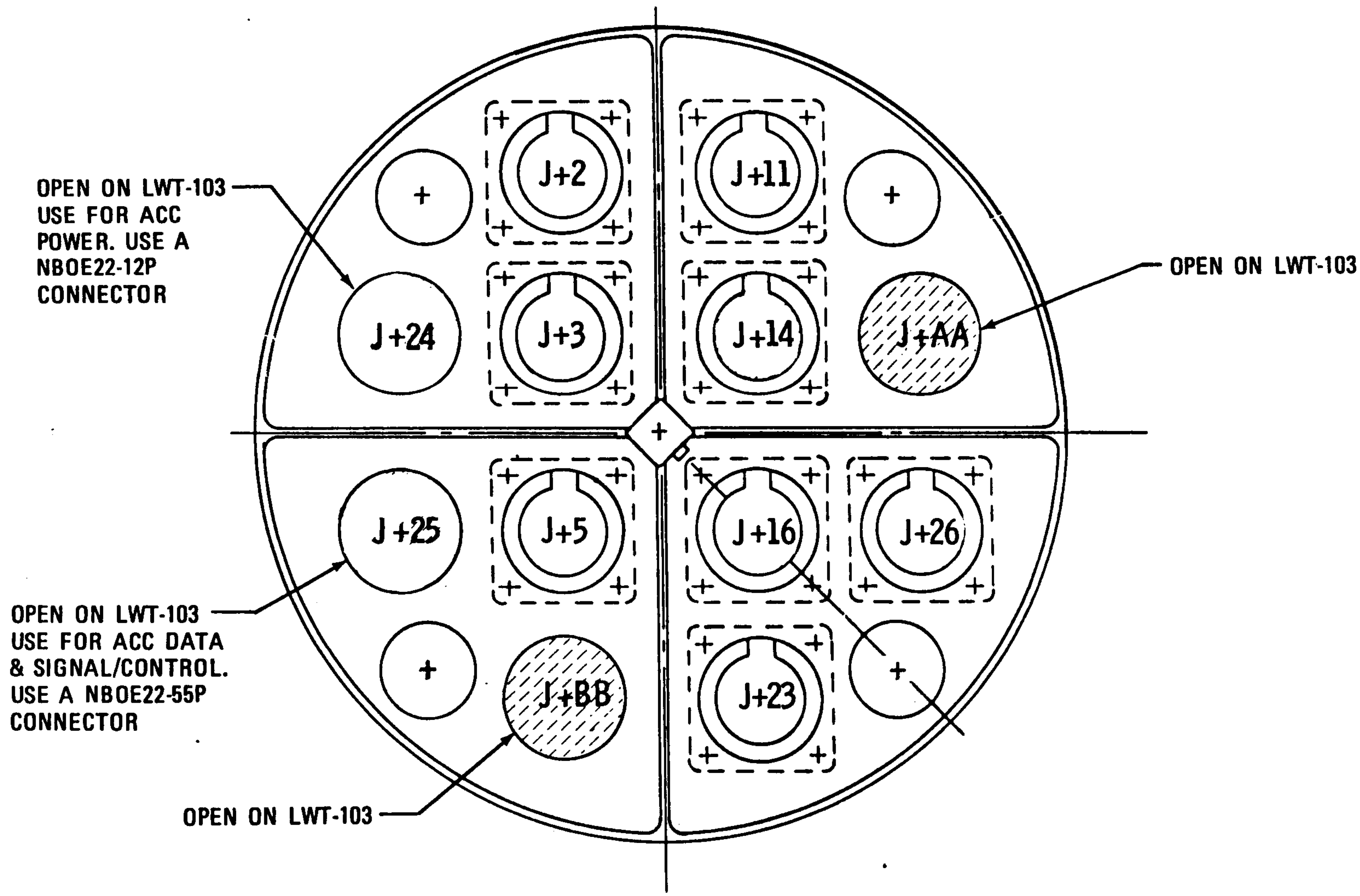
DACC/EO-4 ELECTRICAL INTERFACE

In order to accommodate DACC systems and payloads, new wires are required to/from the Orbiter/DACC through EO-4 connectors. This wiring requirement can be accommodated by utilizing two of the four open holes to install a power circuit connector (NBOE22-12P) and a Data/Signal/Control connector (NBOE22-55P).

DACC/EO-4 Electrical Interface



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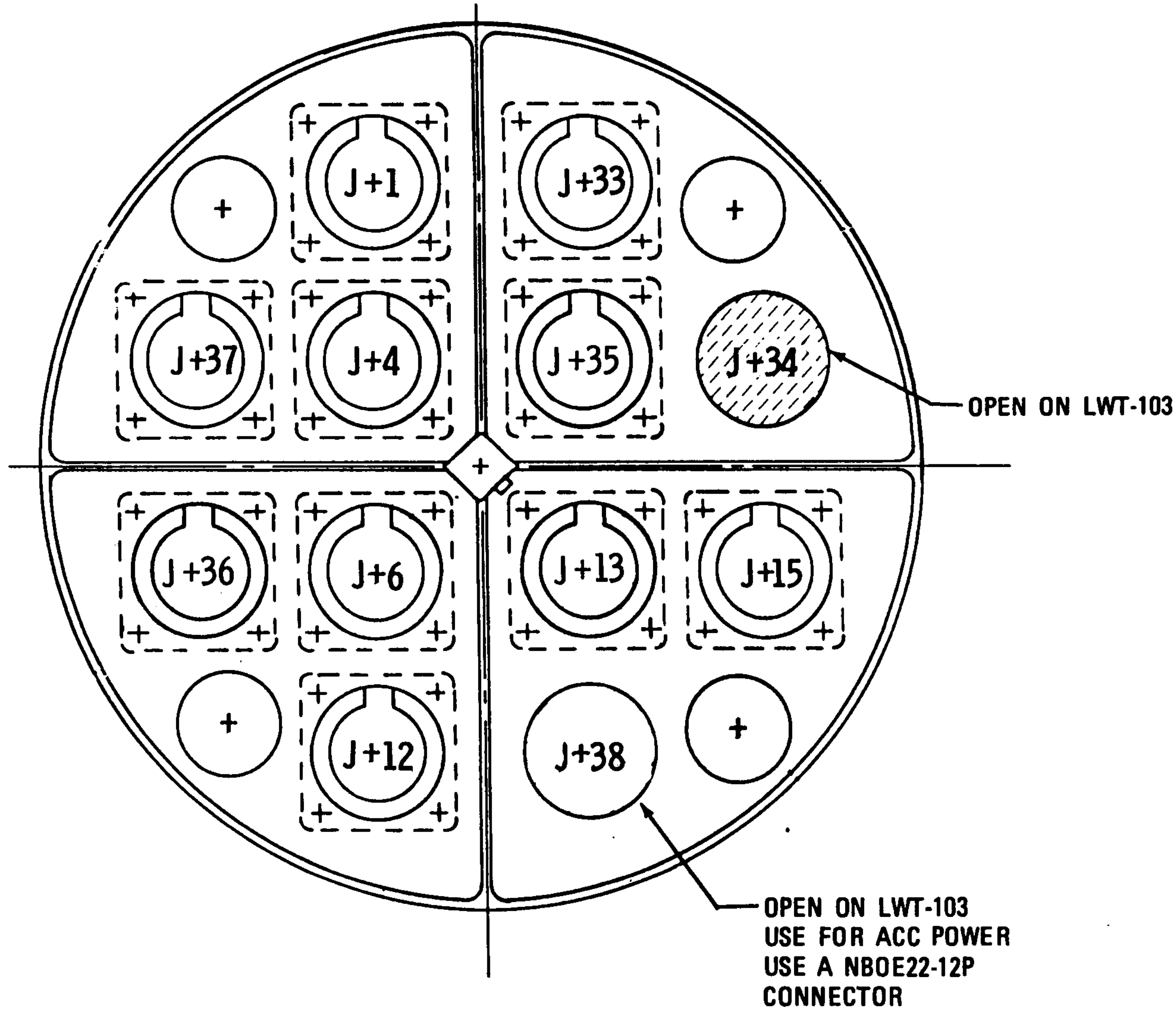
DACC/EO-5 ELECTRICAL INTERFACE

In order to accommodate DACC Systems and Payloads, new wires are required to/from the Orbiter/DACC through EO-5 connectors. This wiring requirement can be accommodated by utilizing one of the two open holes to install a power circuit connector (NBOE22-12P).

DACC/EO-5 Electrical Interface



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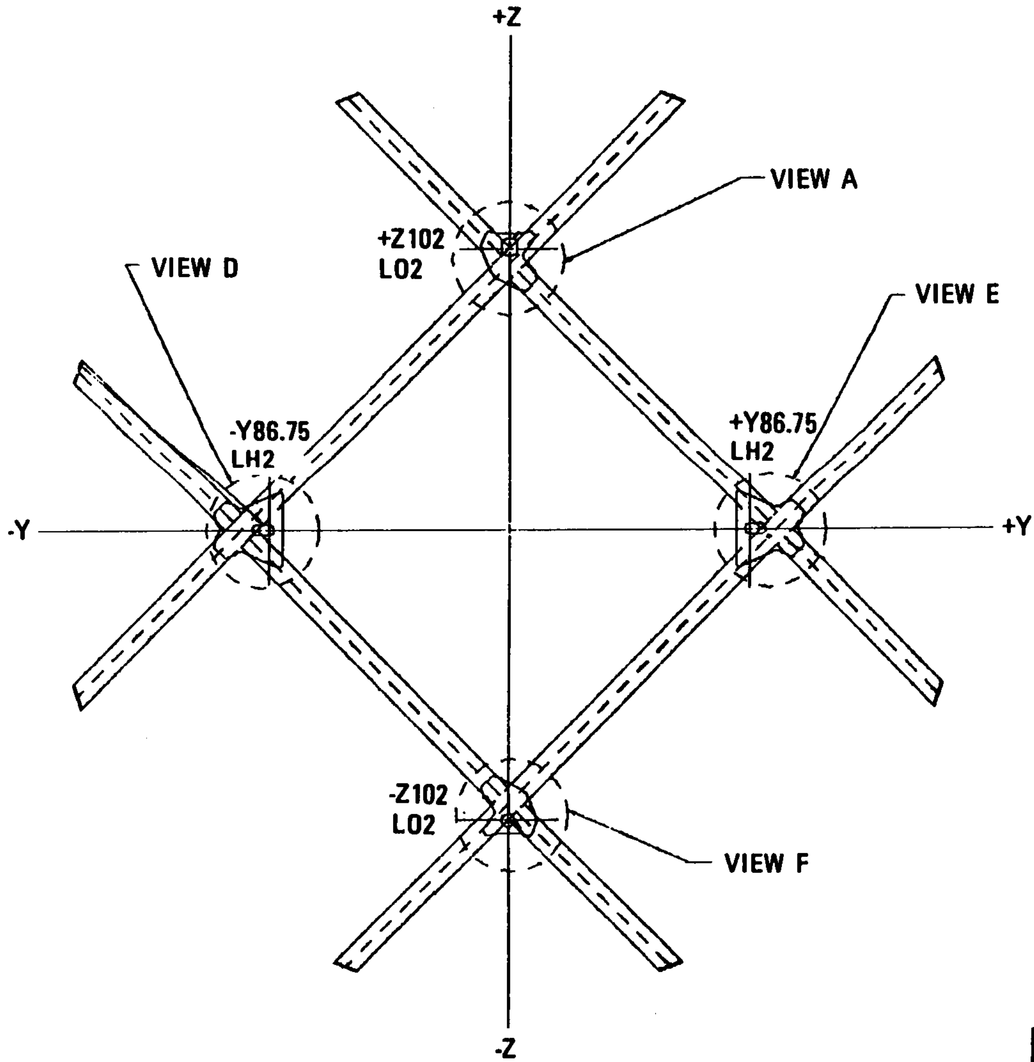
DACC/OTV STRUCTURAL INTERFACE

Four OTV structural attach points are located on the ACC PS beams. The attach points located in the $\pm Z$ attach points react the loads imposed by the OTV LO_2 tanks. The attach points located at the $\pm Y$ areas react the OTV LH_2 tank loads. In a clockwise direction beginning at the top (+Z location), the attach points have I/F designations of AT1, AT2, AT3 and AT4.

DACC/OTV Structural Interface



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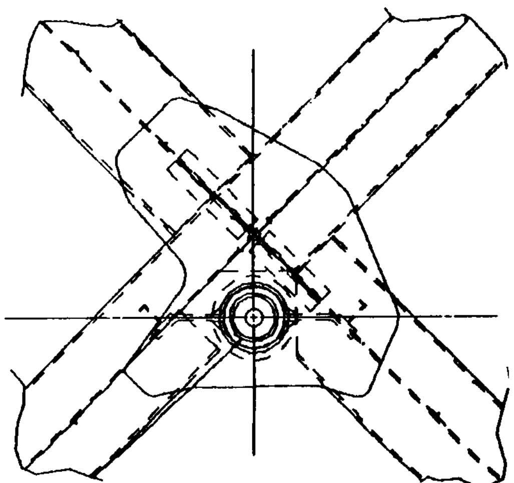
DACC/OTV STRUCTURAL INTERFACE (CONCL)

VIEW A – AT1 attach point: A slot, provided in the structure supporting the attach bolt retainer, allows movement of the bolt in the ±Z directions.

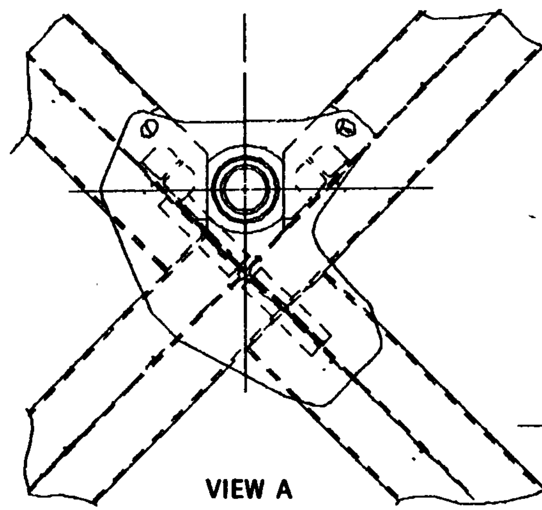
VIEW D – Slotted structure: This structure allows ±Y movement of the bolts at AT2 and AT4.

VIEW F – Installation of the bolt at AT3: This bolt is fixed against movement in any direction.

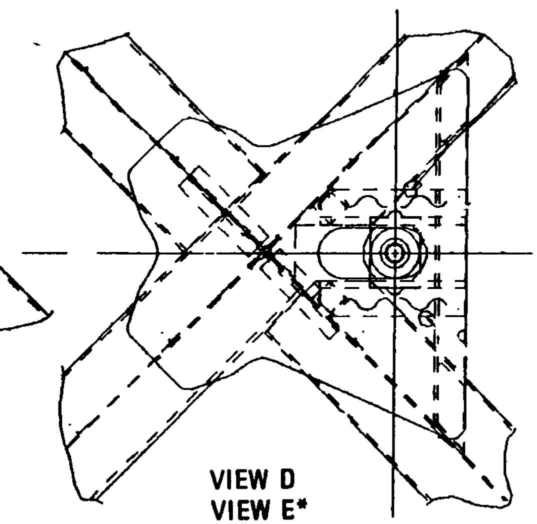
DACC/OTV Structural Interface



VIEW F



VIEW A



VIEW D
VIEW E*
*ROTATED 180°

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Loads

- PAM
- OTV

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PAM-C LOADS

The load factors are presented for lift-off, high-Q and post-high-Q conditions. These load factors are applied at the cargo element cg.

PAM-C Loads

ACC HIGH-Q LOAD FACTORS

DESCRIPTOR	DIRECTION	LOAD FACTOR (G)
ALL ELEMENTS	X (AFT)	+ 1.75
ALL ELEMENTS	Y (YAW)	± 0.12
ALL ELEMENTS	X (PITCH)	∓ 0.33

ACC POST HIGH-Q LOAD FACTORS

DESCRIPTOR	DIRECTION	SRB/SSME	SSME ONLY
ALL ELEMENTS	X (AFT)	+ 3.15G	+ 3.15G
ALL ELEMENTS	Y (YAW)	± 0.10G	± 0.10G
ALL ELEMENTS	Z (PITCH)	∓ 0.25G	∓ 1.00G

ACC LIFT-OFF LOAD FACTORS

DESCRIPTOR	DIRECTION	LOAD FACTOR (G)
ALL ELEMENTS	X (AFT)	+ 2.68, - 0.0
ALL ELEMENTS	Y (YAW)	± 0.71, - 0.71
ALL ELEMENTS	Z (PITCH)	∓ 1.42, - 1.07

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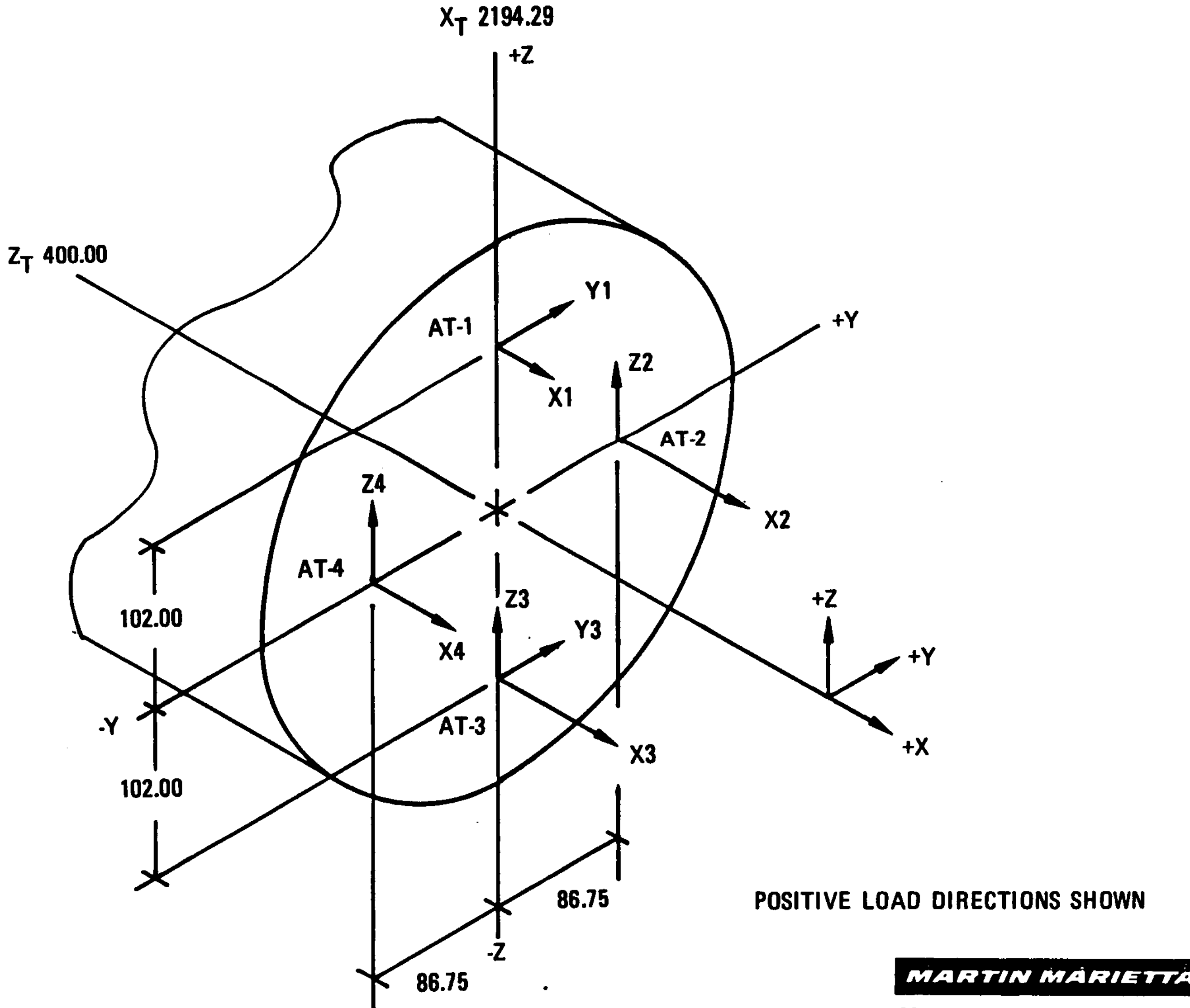
STRUCTURAL ATTACHMENT LOCATIONS AND OTV ATTACH LOAD DIRECTIONS

The OTV is attached to the DACC at four points, AT1 through AT4. These points lie in the Y-Z plane at X_T2194.29. The attachment points are designed to restrain a total of 9-DOF.

The loading in the X direction is reacted by all four attach points. The Y direction loading is only reacted by the OTV/LO2 tank fittings (AT1, AT3). The only attach points reacting all Z direction loading are the OTV/LH2 tank fittings and -Z OTV/LO2 tank fitting.

Structural Attachment Locations & OTV Attach Load Directions



POSITIVE LOAD DIRECTIONS SHOWN

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OTV LOAD FACTORS AND LOADS

This table lists the bolt location, load factor, load direction and resulting OTV/DACC bolt load limit for lift-off, maximum SSME thrust and high-Q conditions.

OTV Load Factors/Loads

ITEM	LIFT-OFF (WITH +NZ)		LIFT-OFF (WITH -NZ)		SSME (MAX NX)		HIGH-Q	
	LOAD FACTOR	LIMIT LOAD	LOAD FACTOR	LIMIT LOAD	LOAD FACTOR	LIMIT LOAD	LOAD FACTOR	LIMIT LOAD
X1	2.68	95050	0.0	-21070	3.15	98545	1.75	50305
X2	2.68	34793	0.0	-19726	3.15	20487	1.75	13172
X3	2.68	39126	0.0	21070	3.15	59162	1.75	37309
X4	2.68	-4660	0.0	19726	3.15	14930	1.75	6504
Y1	0.852	26118	-0.852	-26118	0.12	3679	0.144	4414
Y3	0.852	26118	-0.852	-26118	0.12	3679	0.144	4414
Z2	1.42	3166	-1.07	- 2385	1.00	2229	0.33	736
Z3	1.42	80727	-1.07	-60830	1.00	56850	0.33	18761
Z4	1.42	3166	-1.07	- 2385	1.00	2229	0.33	736

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Environment

- Thermal
- Compartment Pressure
- Acoustic
- Vibration

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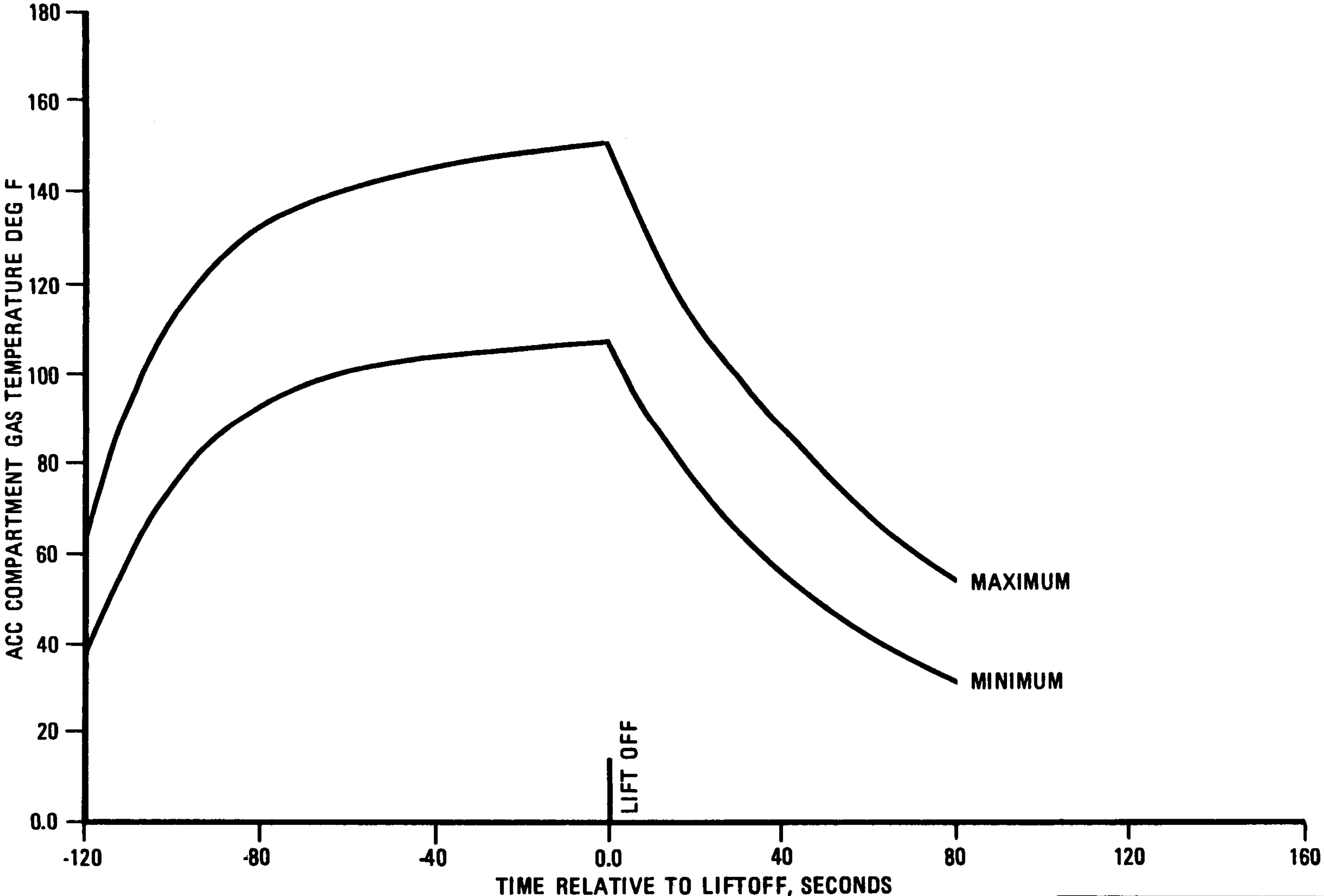
DACC/OTV TRANSIENT COMPARTMENT GAS TEMPERATURE

The DACC compartment gas temperature varies on the ground and during ascent.

The curves show the DACC compartment gas temperature variation with time for 120 seconds prior to lift-off through approximately 80 seconds of the ascent flight. Beyond 80 seconds, the compartment gas temperature is not shown because the concentration of gas is assumed negligible.

DACC/OTV Transient Compartment Gas Temperature



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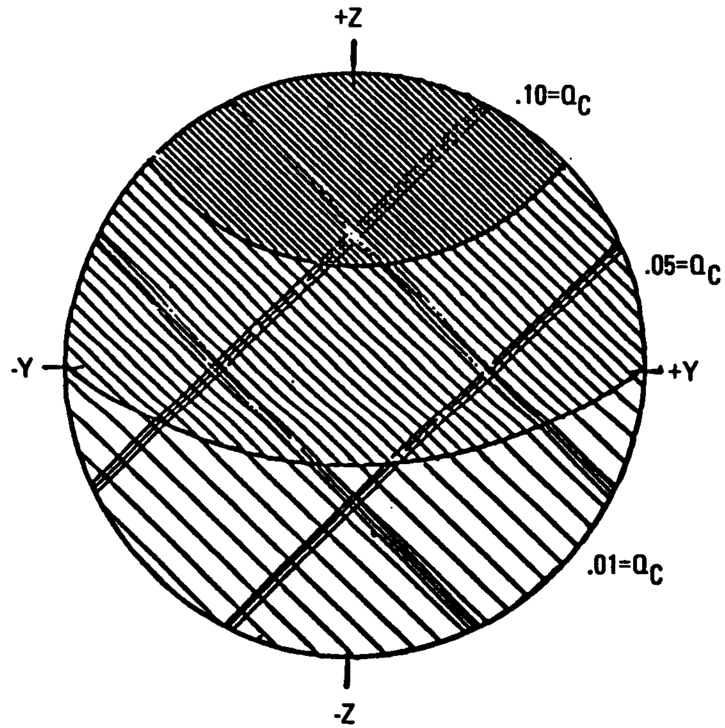
HEATING RATES TO PSS FOLLOWING SHROUD SEPARATION (WITHOUT PAYLOAD)

This figure shows the heating rates to the ACC structure after shroud separation and without a payload. Three zones of heating were defined with a heating rate range of 10 from +Z to -Z.

The varying heating rates will result in structural temperature variations. In turn, these variations will result in unsymmetrical structural thermal distortions.

When an OTV is present, it is estimated that the unsymmetrical structural distortions will be increased due to partial "shading" of the ACC by the OTV.

Heating Rates to Payload Support Structure Following Shroud Separation (Without a Payload)



NOTES:

1) SHADED CONTOURS ARE COVECTIVE HEATING = Q_C IN BTU/SEC-FT^2

2) PREDICTED PLUME AND SOLAR RADIATION HEATING NORMAL TO PSS SURFACE PLANE IS 0.15 BTU/SEC-FT^2

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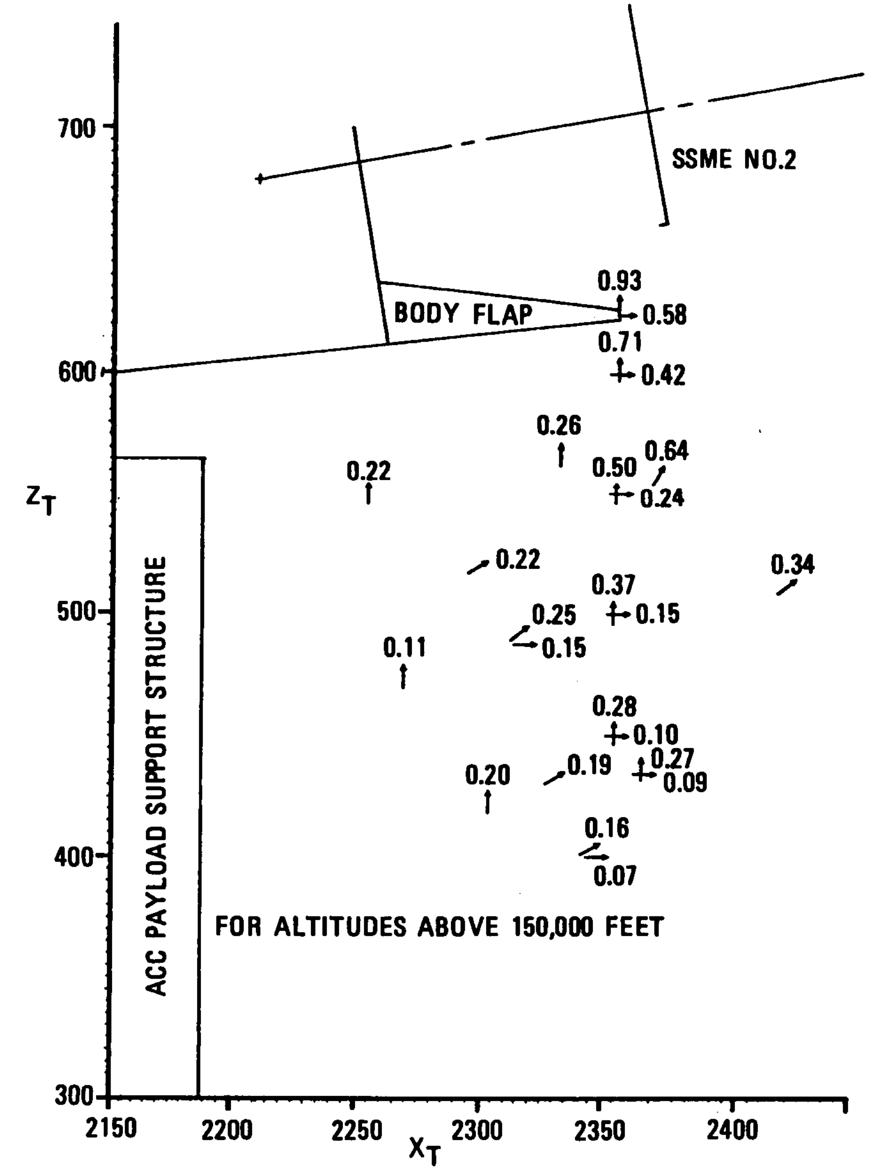
INCIDENT SSME PLUME RADIATION RATES

This figure shows the incident SSME plume radiation rates in the vicinity of the ACC PSS after ACC shroud separation. These rates are applied to cargo elements located within the ACC cargo volume.

Incident SSME Plume Radiation Rates



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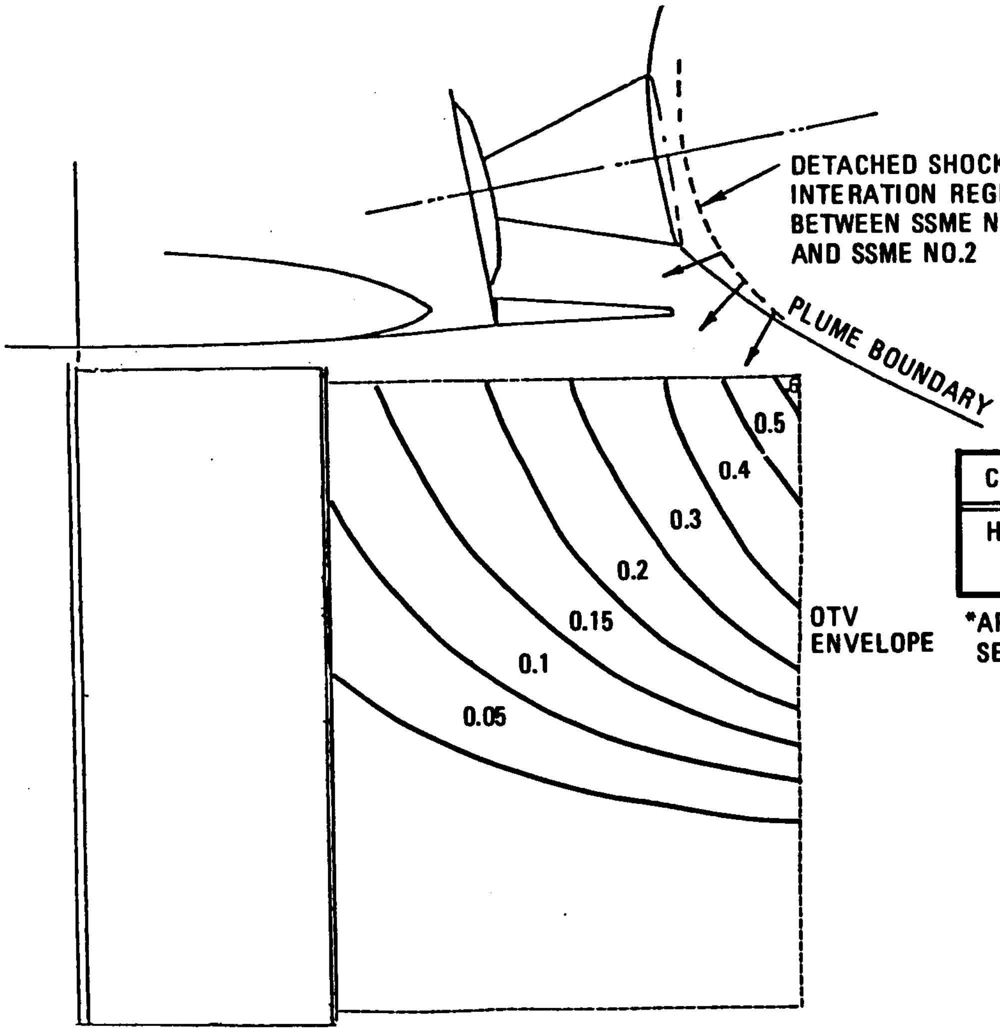
CONVECTIVE ENVIRONMENT

The figure gives the convective heating environment to a "cold" ACC cargo element from shroud separation through MECO.

Convective Environment



CONVECTIVE ENVIRONMENT* TO COLD SURFACES
HEATING CONTOURS TO ACC PAYLOAD ENVELOPE Q = BTU/SEC-FT^2

*APPLICABLE FROM SHROUD SEPARATION TO SSME SHUTDOWN

$T_A = 3000^0R$

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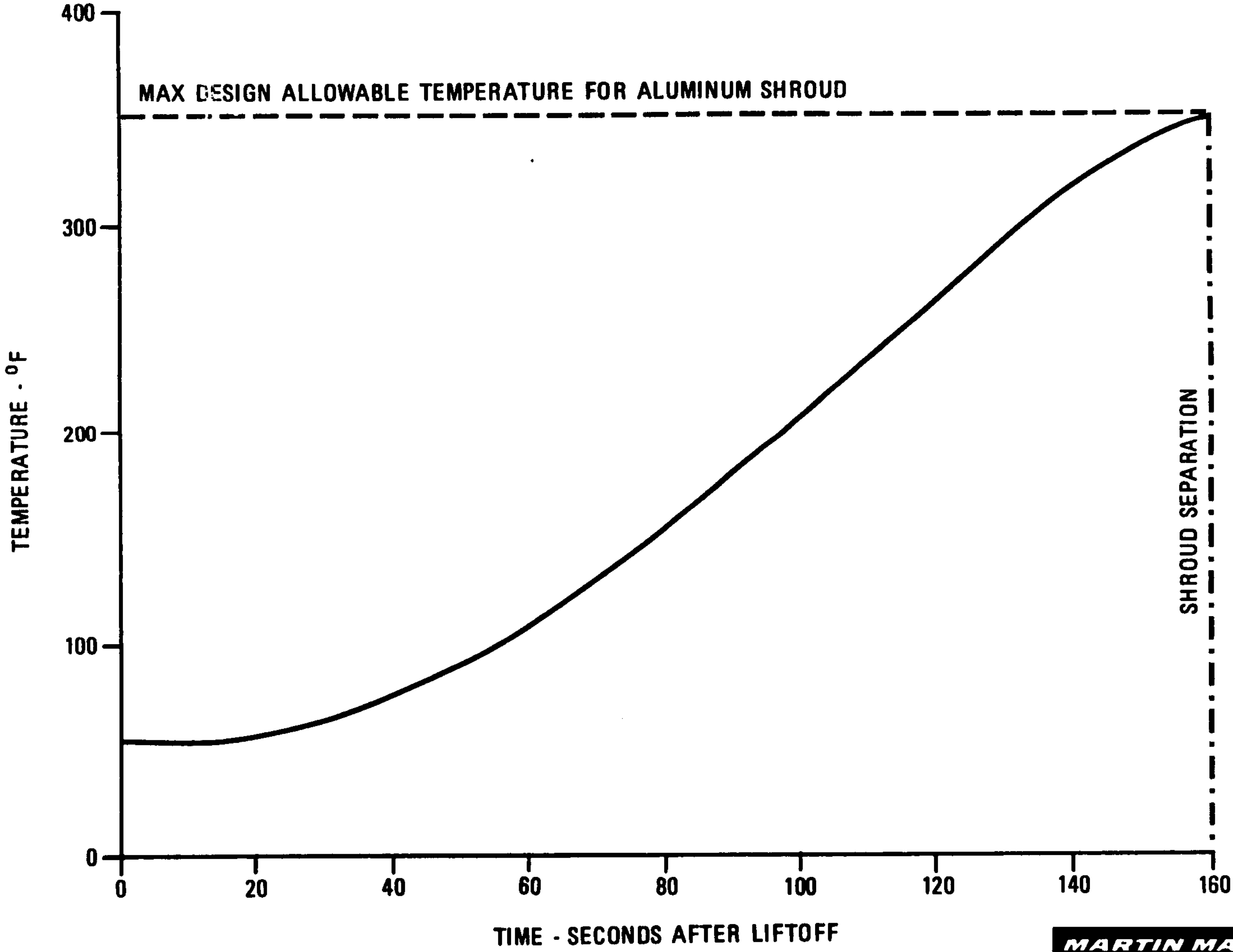
GPACC SHROUD SKIN TEMPERATURE DURING ASCENT

The GPACC maximum allowable shroud skin temperature is shown in this figure. The lift-off temperature is nominal. Insulation will be placed on the shroud (as required) to control the maximum skin temperature.

GPACC Shroud Skin Temperature during Ascent



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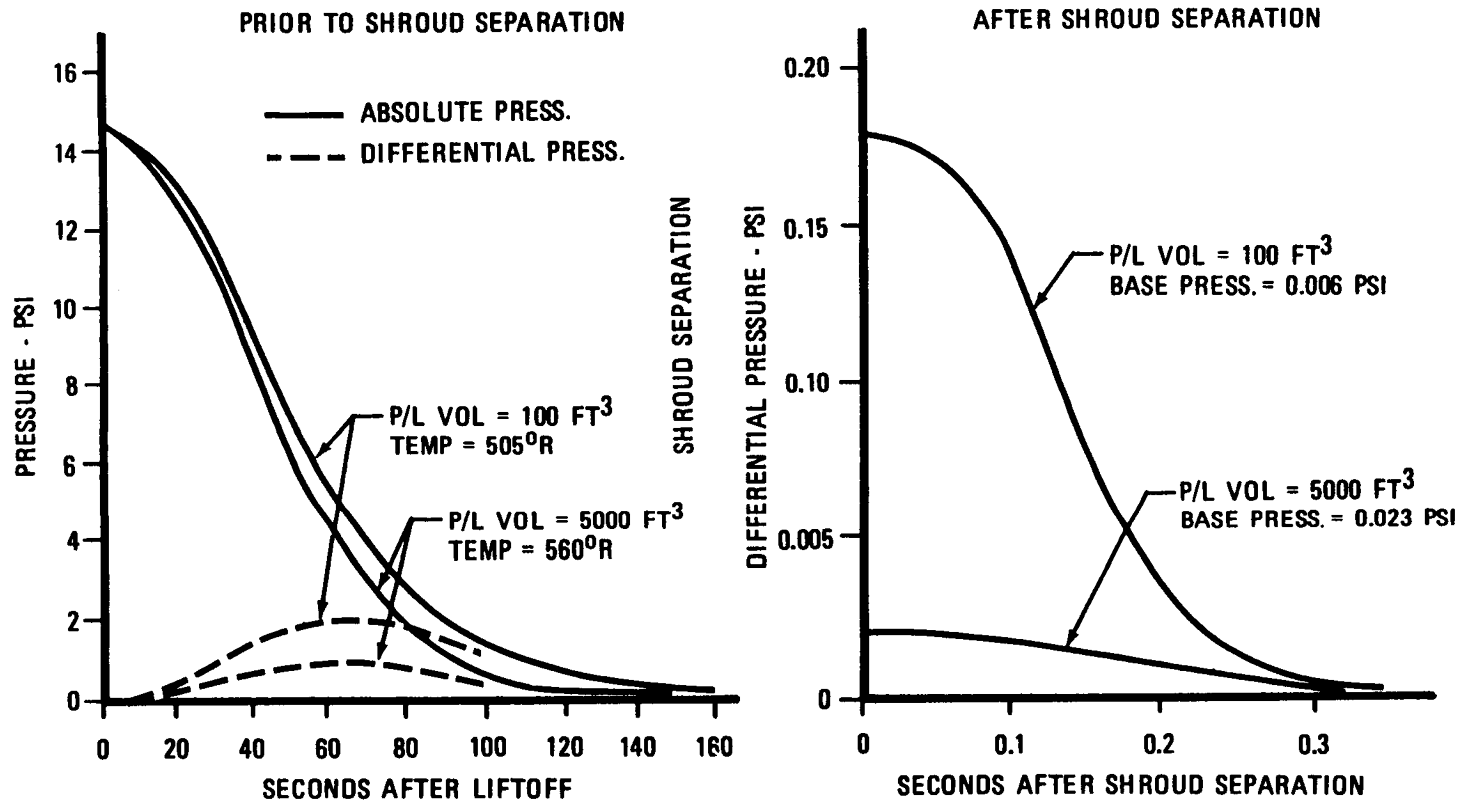
GPACC PRESSURE HISTORY PRE- AND POST-SHROUD SEPARATION

The curve on the left shows the absolute and differential pressure for the GPACC volume from lift-off until shroud separation. Two cargo element volumes were used in the analysis.

The curve on the right shows the pressure decay as the shroud separates. Again, two cargo element volumes were used in the analysis.

GPACC Pressure History, Pre & Post Shroud Separation



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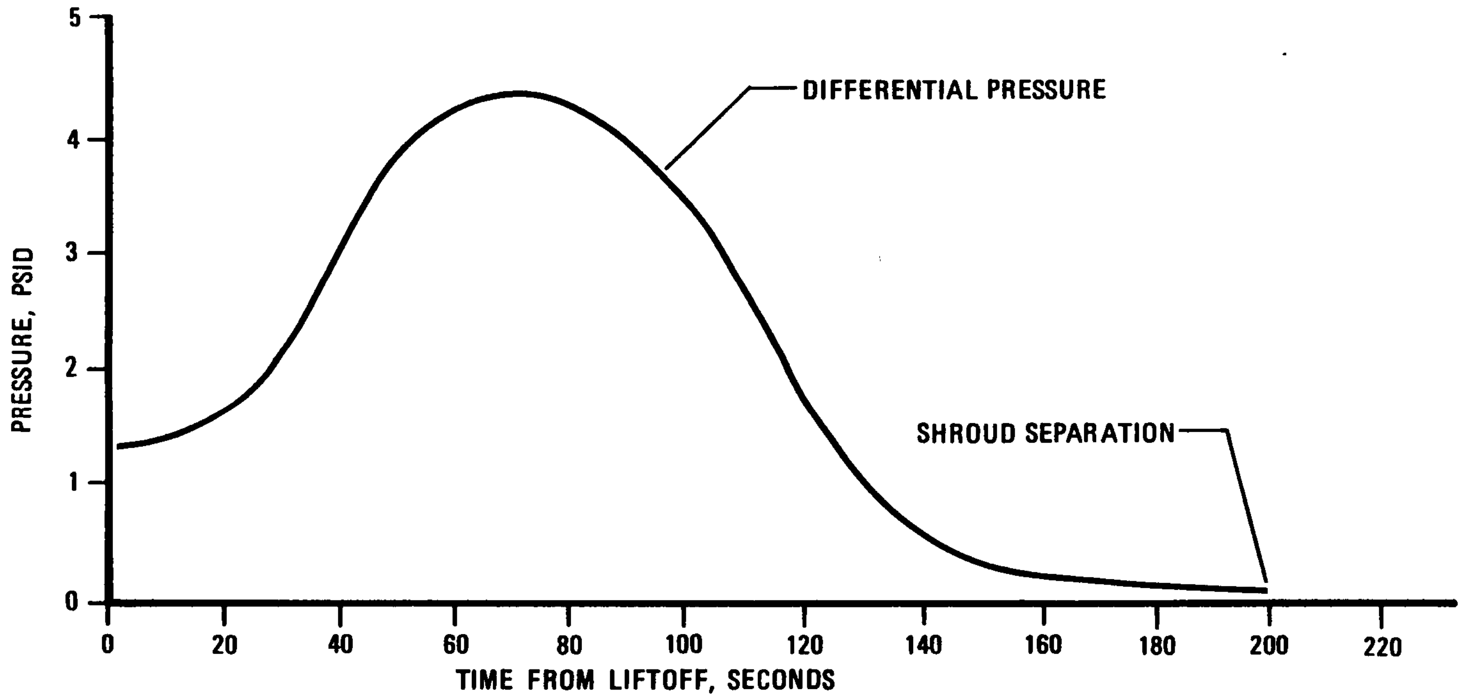
DACC COMPARTMENT PRESSURE TIME HISTORY

The curve displays the shroud internal differential pressure from lift-off through shroud separation. Pressure variations with time are controlled by varying the ACC volume bleed-down rates through the DACC motorized vent valve.

DACC Compartment Pressure Time History



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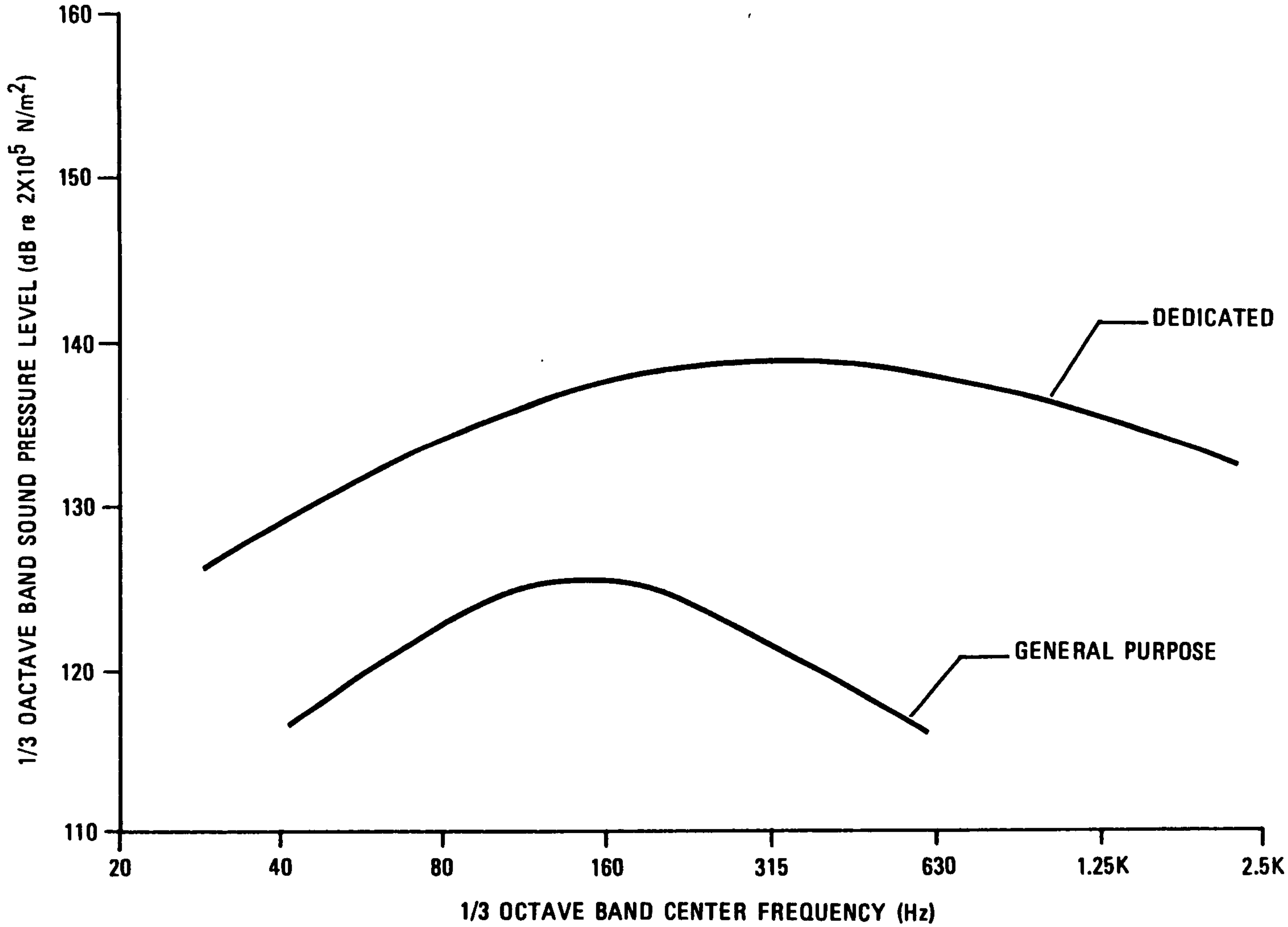
ACOUSTIC ENVIRONMENT WITHIN THE ACC CARGO COMPARTMENT

One-third octave band sound pressure levels are shown as a function of one-third octave band center frequency for the GPACC and DACC.

Acoustic Environment within the ACC Cargo Compartment



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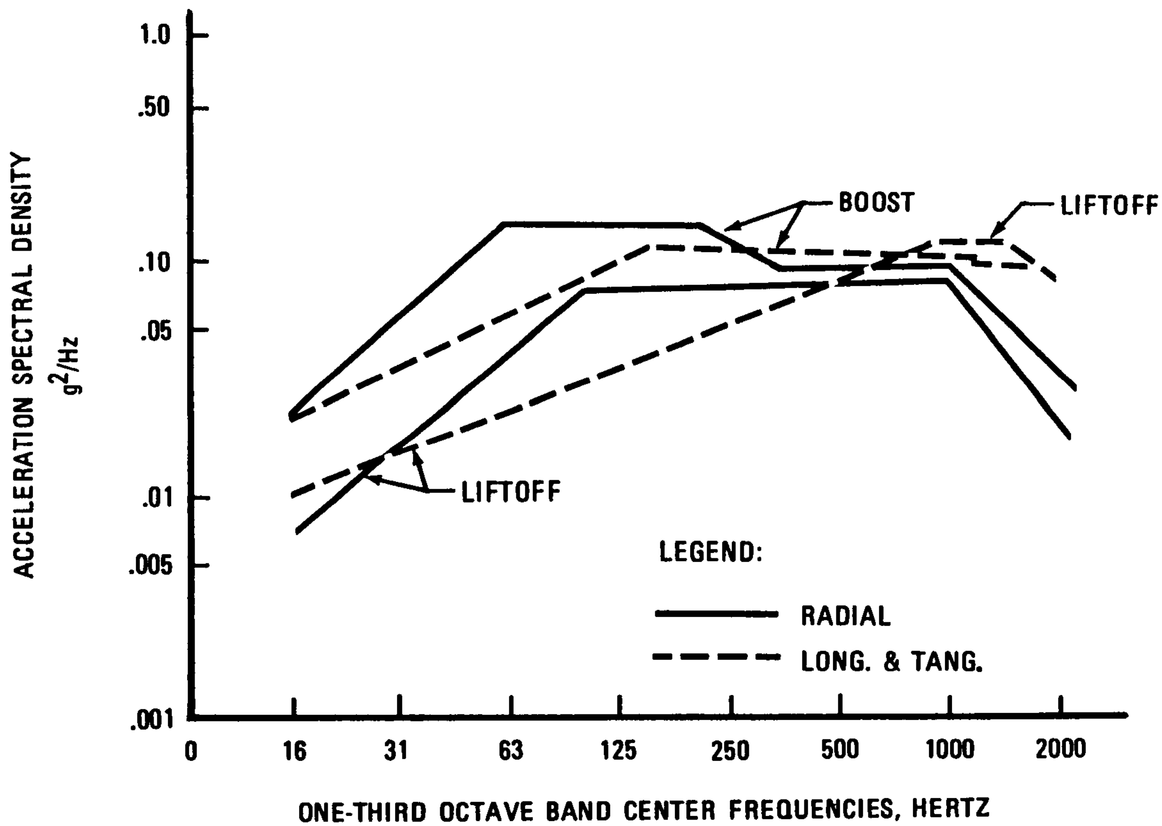
LAUNCH AND ASCENT VIBRATION ENVIRONMENT FOR ACC CARGO VOLUME

The curve shows the acceleration spectral density as a function of one-third octave band center frequencies in the radial, longitudinal and tangential directions. Data are provided for lift-off and boost conditions.

Launch & Ascent Vibration Environment for ACC Cargo Volume



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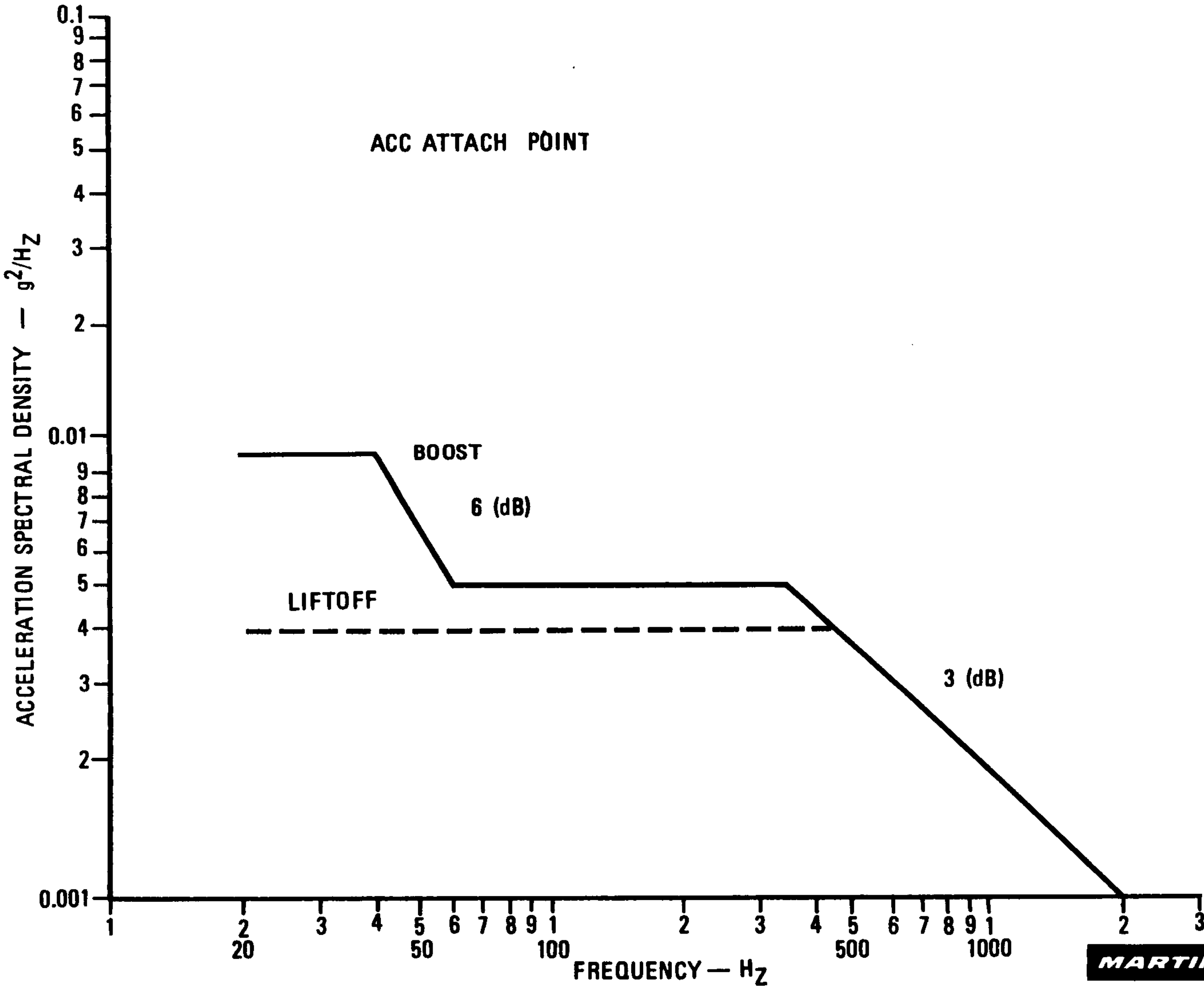
RADIAL (VEHICLE Y AND Z) VIBRATION SPECTRA

The curve displays acceleration spectral density as a function of frequency for lift-off and boost conditions. These data are given for the ACC attach points.

Radial (Vehicle Y and Z) Vibration Spectral



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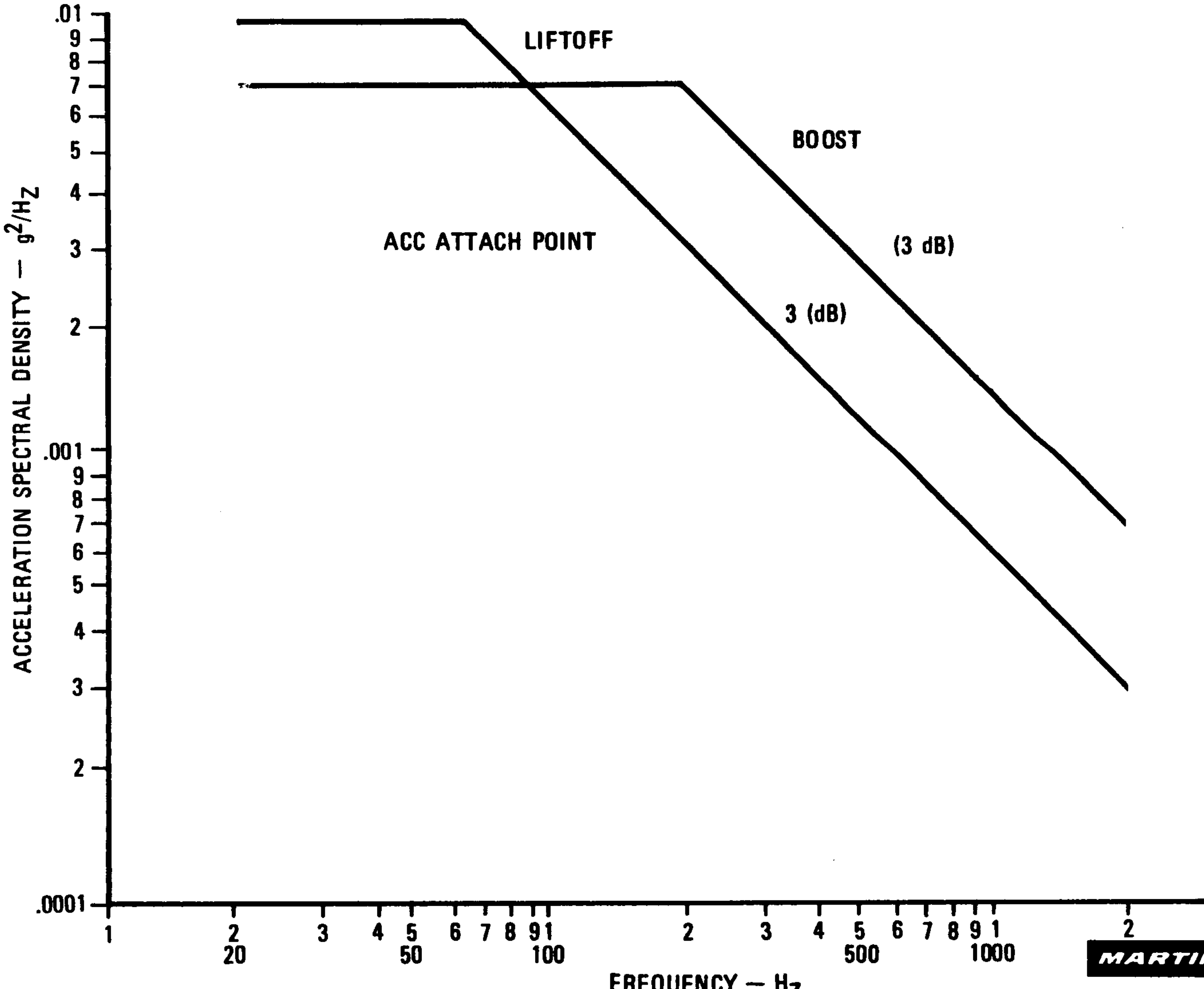
LONGITUDINAL (VEHICLE X DIRECTION) VIBRATION SPECTRA

The curve shows acceleration spectral density as a function of frequency for lift-off and boost conditions. These data are given for the ACC attach points.

Longitudinal (Vehicle X) Vibration Spectra



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Agenda

- Introduction
- Requirements
- Payload Integration
- ⇨ Design (General Purpose)
- Design (Dedicated OTV)
- Mission Analyses
- Planning
- Costs

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ACC General Purpose Design

- Configuration
- Structural Details
- Subsystems

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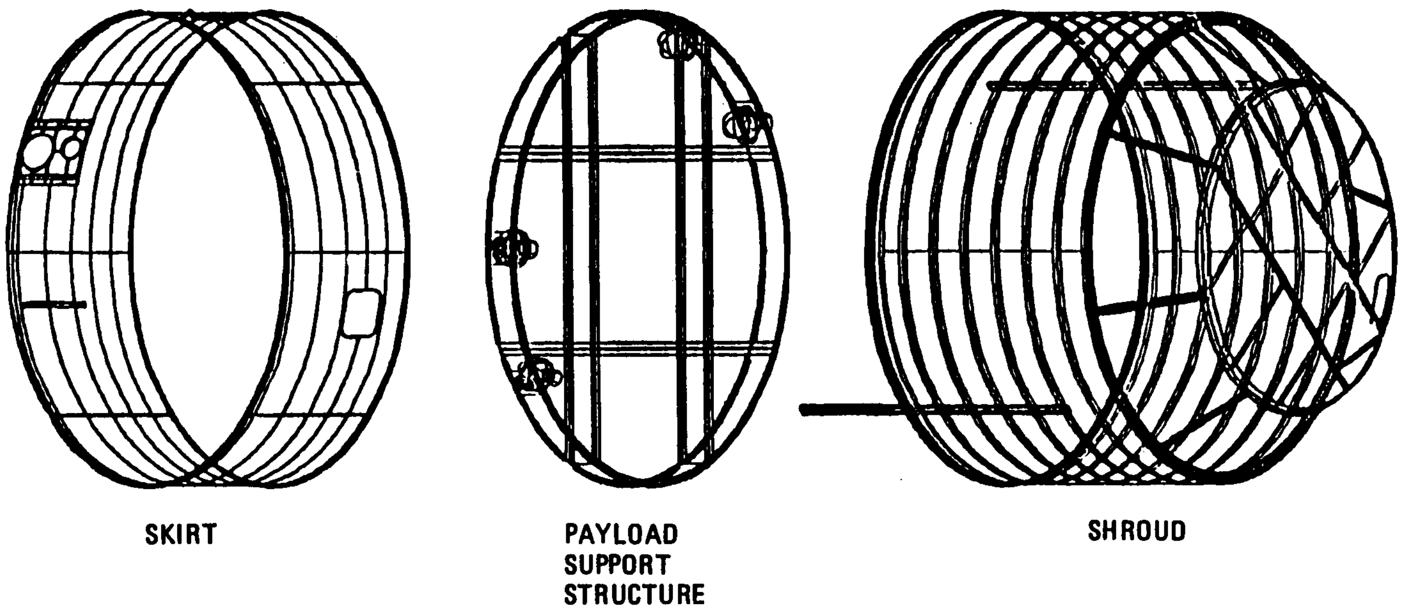
GENERAL PURPOSE ACC CONFIGURATION

The three major elements comprising the GPACC are the skirt, PSS, and shroud assemblies.

General Purpose ACC Configuration



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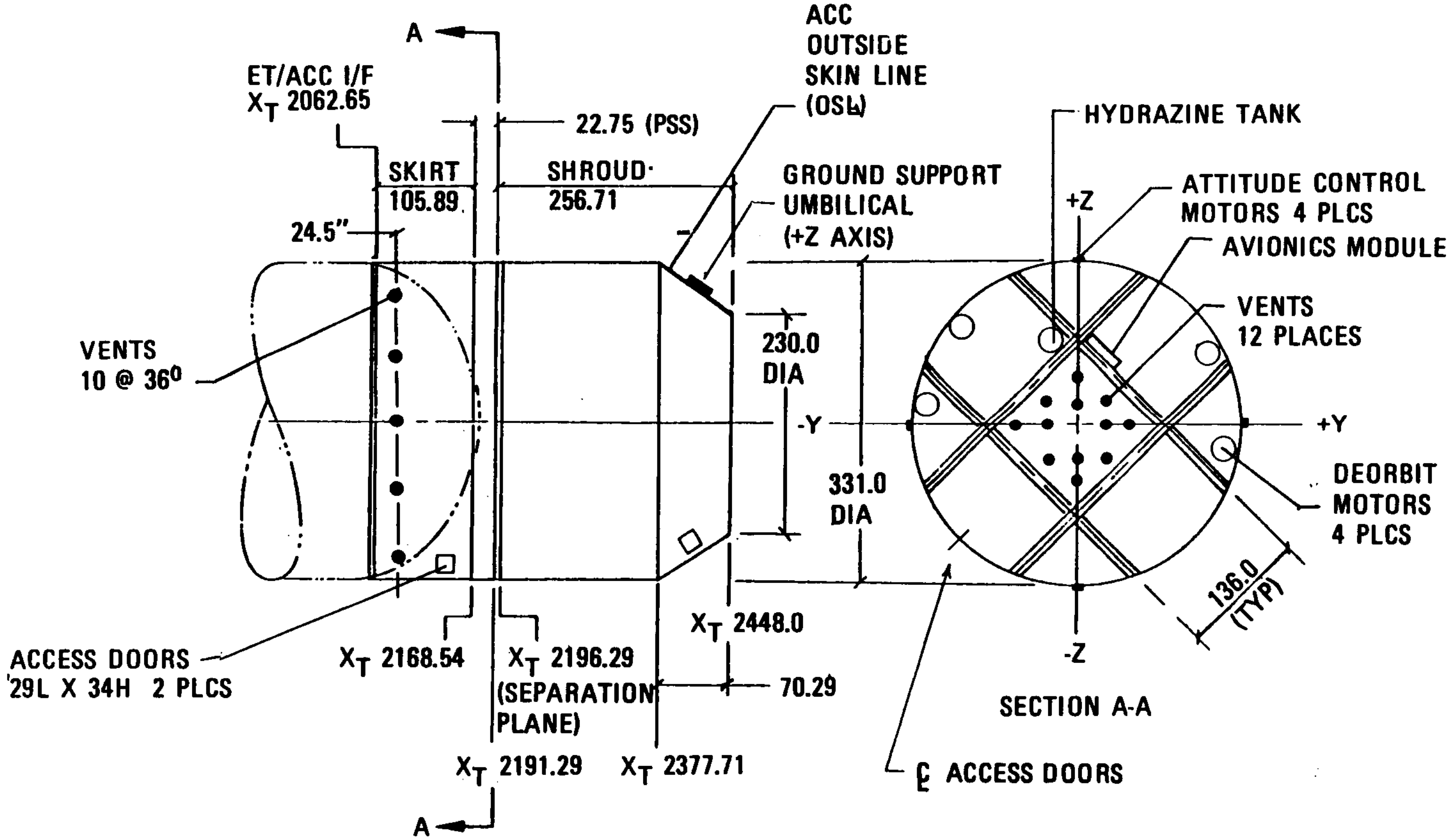
ACC MODEL 101 GENERAL ARRANGEMENT

The ACC Model 101 will have a volume of 9100 cu ft, adequate to carry multiple payloads and a variety of payloads including: STS orbiter-type, PAM-type and ACC unique. Model 101 will accommodate any combination of payloads which can be fitted into a volume of 25 ft dia X 15 ft long, or 15 ft dia X 20 ft long, or any combination of the two. Model 101 will consist of three major assemblies: skirt, PSS and shroud. The skirt will contain an access door for servicing LRUs and provide interfaces between the ET and ACC. The PSS will be 22.75 in. deep and will contain double cruciform beams with a bulkhead (panel) affixed to the forward face of the cruciform. The aft face of the cruciform will provide payload attachment at multiple locations. Housed inside the PSS will be the: attitude control system, deorbit motors, avionics package and electrical disconnect panel. The PSS will provide the payload attachment interface, the shroud interface, and will attach to the ACC skirt. The shroud contains the purge manifold, ground umbilical, staging rails and access door in the frustum section.

The skirt is comprised of skin panels with integrally machined internal ribs. The shroud barrel section is constructed of skin with internal corrugations. The shroud frustum, baseplate and PSS bulkhead are constructed of honeycomb-type panels.

ACC Model 101 General Arrangement



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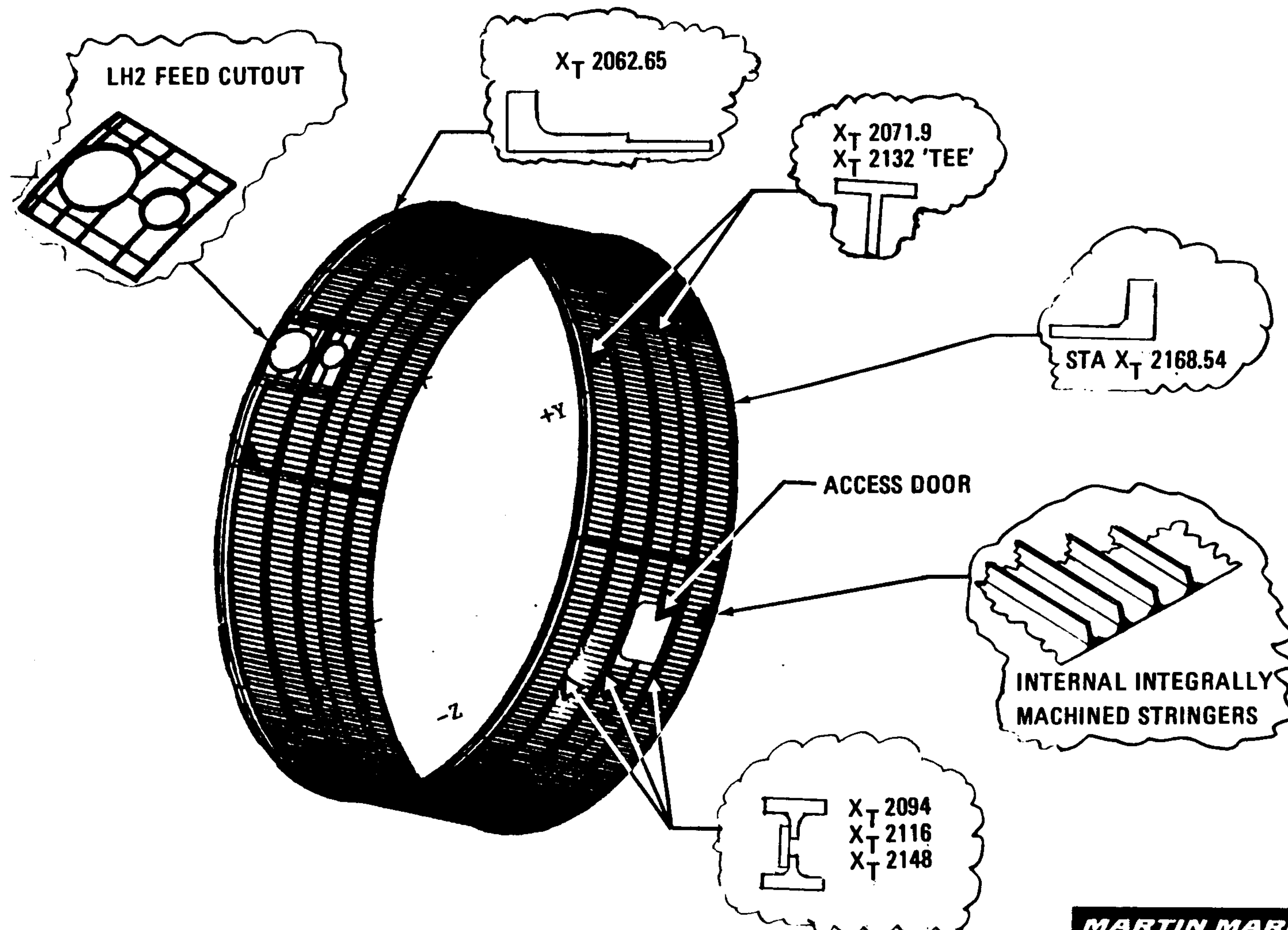
GPACC SKIRT

The GPACC skirt assembly is a monocoque cylinder and consists of eight aluminum alloy panels stiffened with integrally machined stringers and rolled to form a 331 in. diameter cylinder when butted and spliced together. Five intermediate ring frames are riveted to the internal surface of the skin to provide additional structural rigidity. The forward and aft edges of the skirt contain angle ring flanges which provide additional stiffness to the skirt assembly as well as mating surfaces for bolting the skirt assembly to the ET at station Xt 2062.65 and the PSS assembly to the skirt at station Xt 2168.54. The skirt assembly contains two cutouts in the skin; a 29.0 in. wide x 34.0 in. high opening for an access door and a 48.23 in. wide by 54.85 in. high opening for a sealing cover around the LH2 feedline and LH2 recirculation line.

GPACC Skirt



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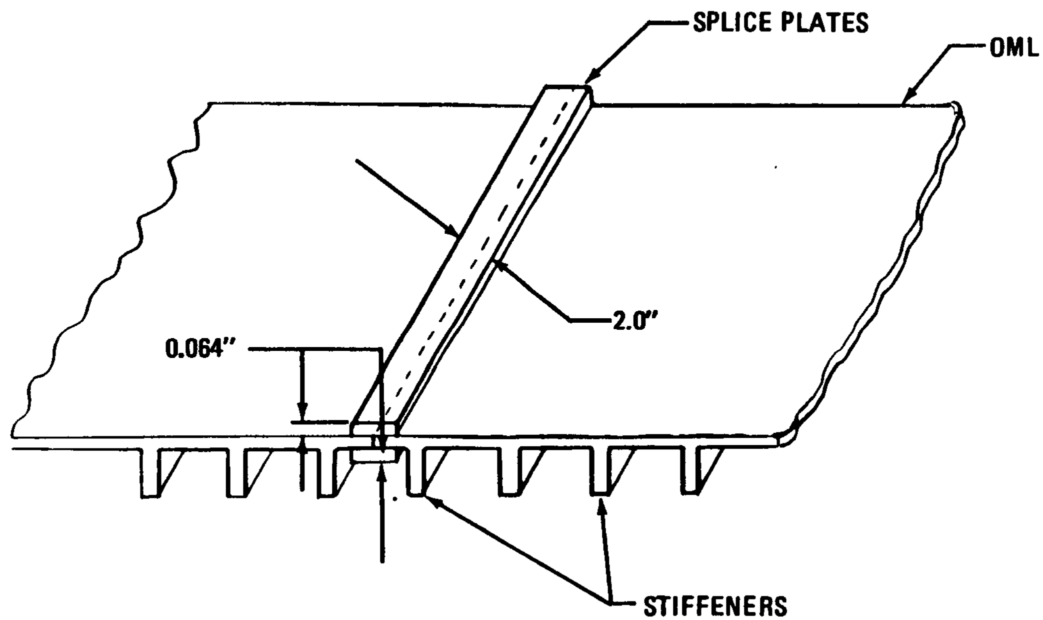
SKIN PANEL SPLICE

Each ofthe eight butt joints in the skirt skin is held together with two 2.0 in. wide by 0.064 in. thick splice plates (one on the external surface of skin and one on the interior surface). The splice plates sandwich the butt joint and are riveted together through the butt joint by a row of rivets on either side of the joint. The accompaning chart shows a typical panel splice of the GPACC skirt assembly.

Skin Panel Splice



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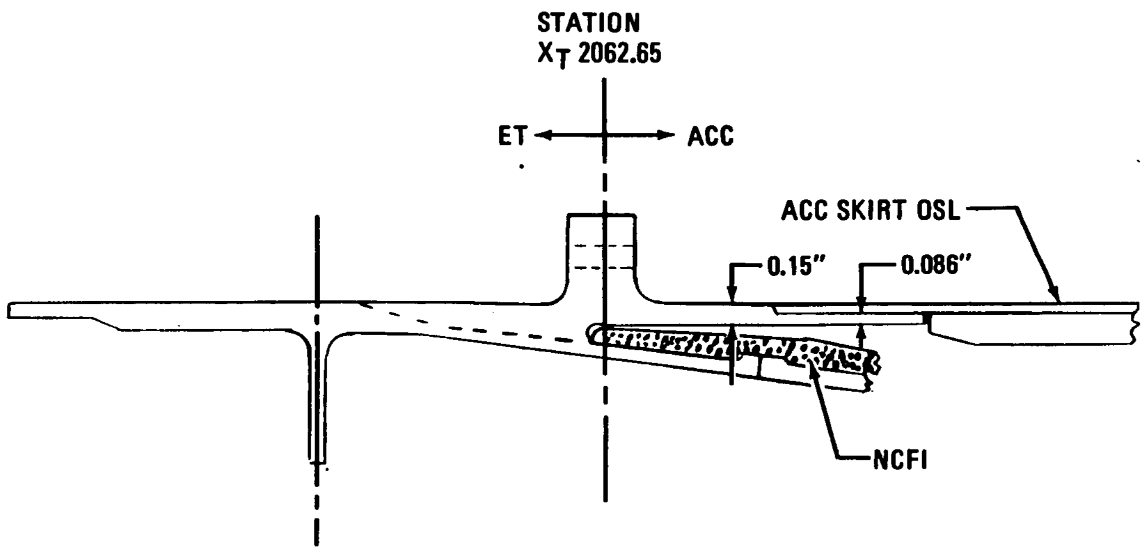
ET/GPACC STRUCTURAL ATTACHMENT

The forward ring flange ofthe GPACC skirt assembly mates with and is attached to the aft main ring flange of the ET at station Xt 2062.65. The bolting surface extends beyond the skin OML 1.41 in. and the mating ring flanges bolt together with 3/8 in. diameter bolts. The bolt hole pattern in all mating flanges between the three GPACC major assemblies (skirt, PSS and shroud) will be the same as used on the ET to utilize existing ET tooling. The skirt skin OML is mounted flush with the outer surface of the forward ring flange apron as shown in the accompanying view graph by machining the aft area of the apron to accommodate the thickness of the skin.

ET/GPACC Structural Attachment



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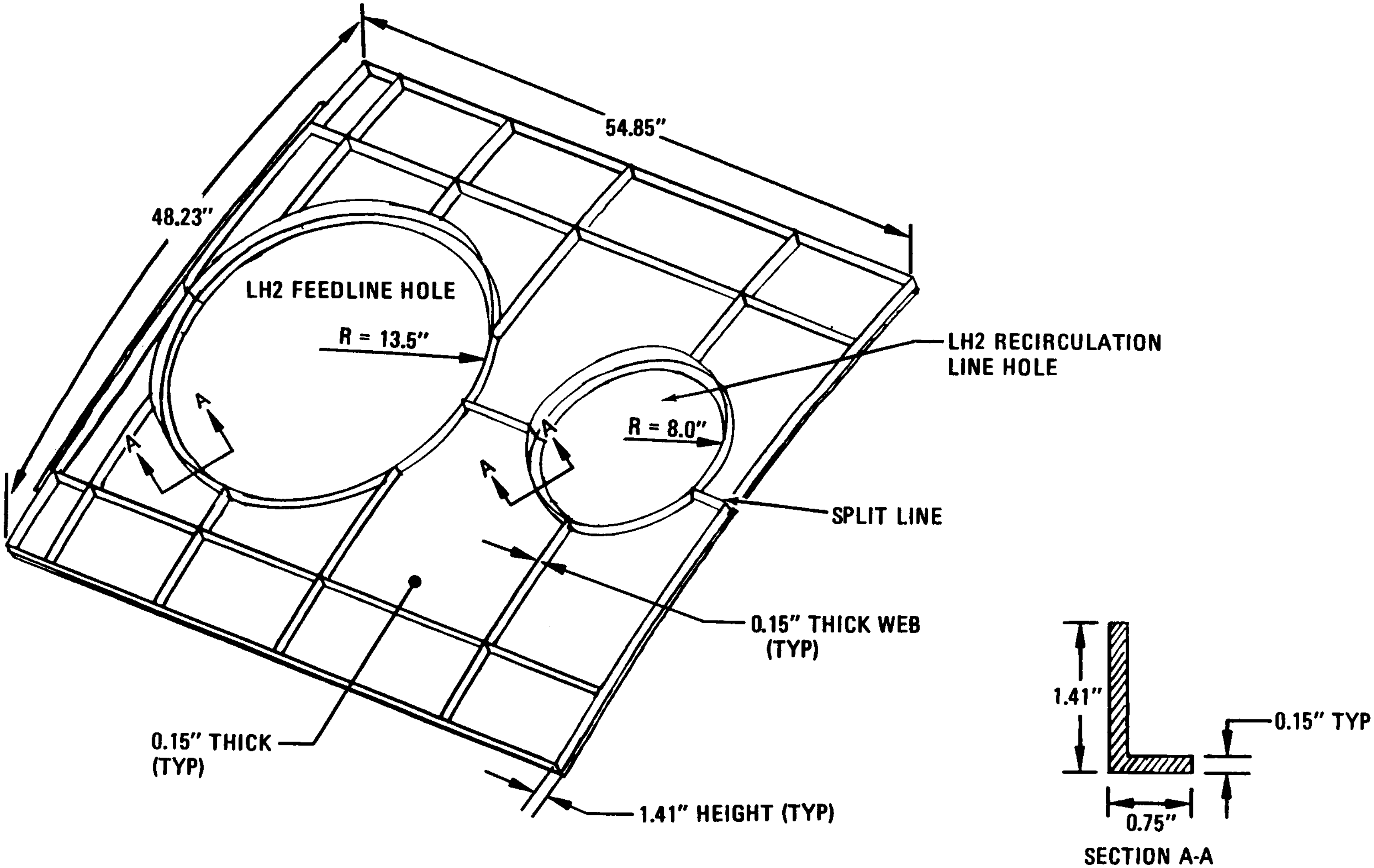
LH2 FEEDLINE AND RECIRCULATION LINE COVER

The LH2 feedline and recirculation line cover serves as a fairing around the LH2 feedline and the LH2 recirculation line which feed the STS main engines. The cover is fabricated using integrally machined aluminum alloy material. The cover is made in two halves to facilitate installation and is made of aluminum alloy similar to that used in the skirt skin. Neoprene seals will be used to seal the joints in the cover around the LH2 feedline and recirculation line and also the cover/skin joint. The cover is curved to the contour of the skin panel and is bolted to the panel with 1/4 in. diameter bolts. The angle lining each opening affords a retaining surface for the neoprene seals.

LH2 Feedline and Recirculation Line Cover



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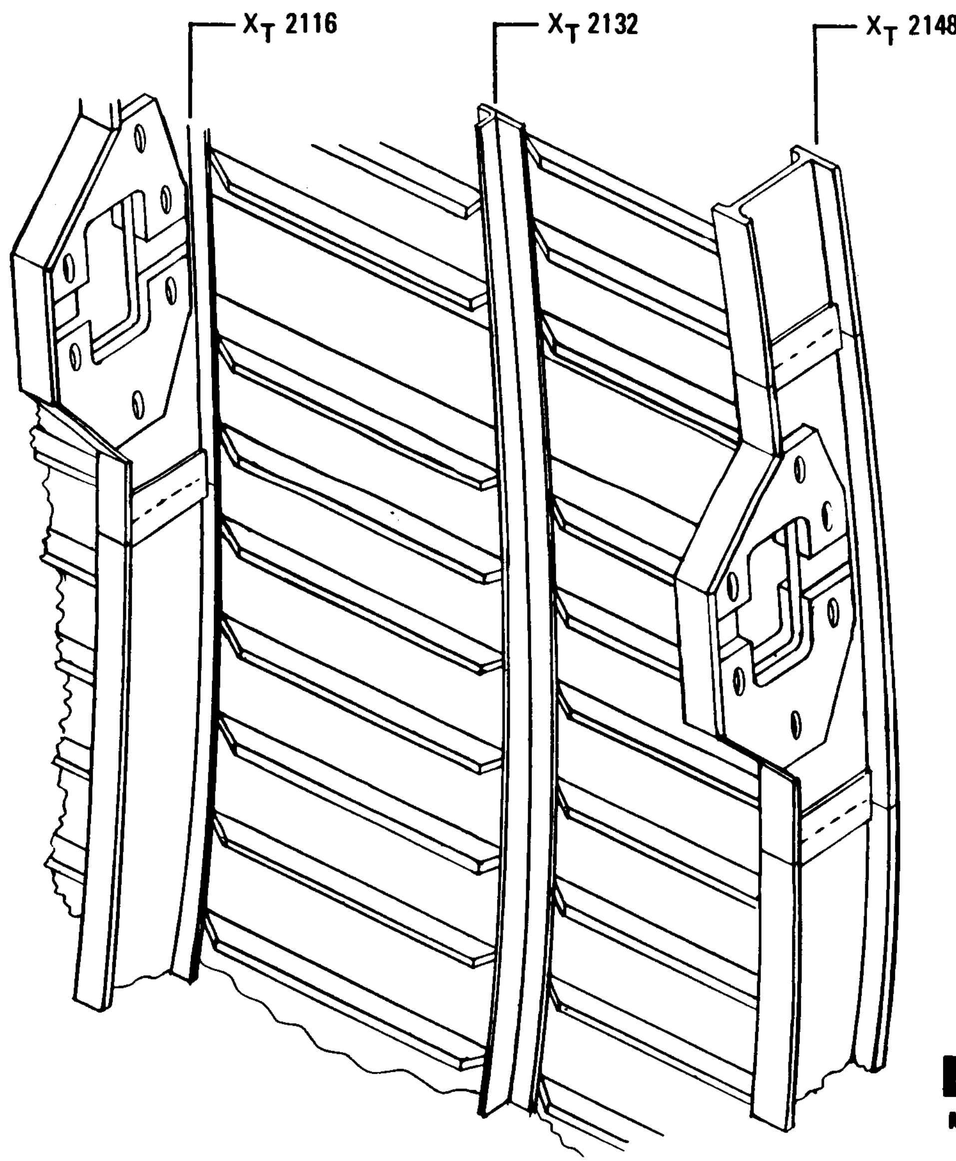
STAGING RAIL GUIDES INSTALLATION

Staging rails attached to the GPACC shroud maintain control of the shroud during separation. These rails are supported in the GPACC skirt by rail guides (illustrated on the opposite page).

Staging Rail Guides Installation



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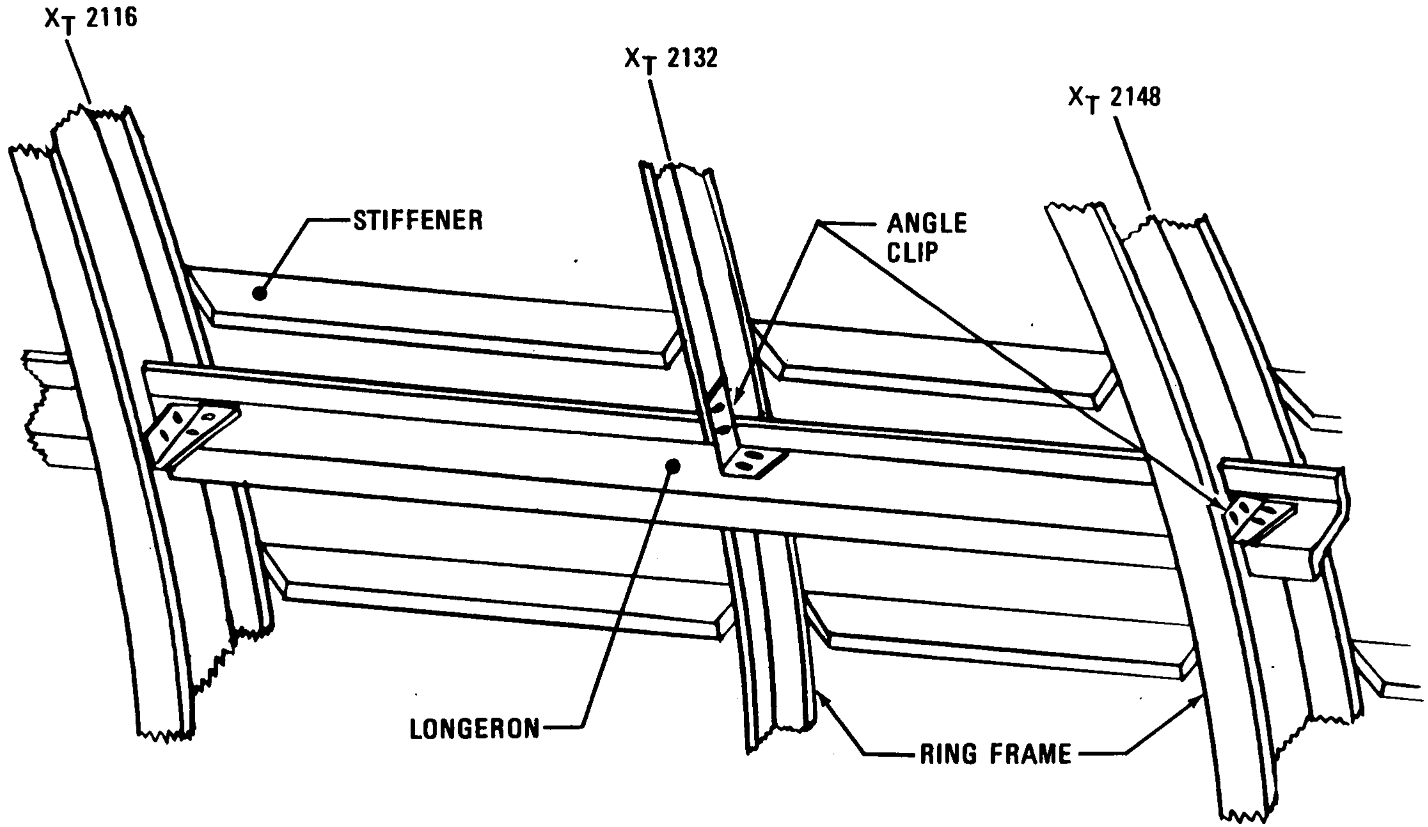
TYPICAL LONGERON INSTALLATION

Eight longerons are used to aid in the transfer of structural loads to the skirt skin during the launch and ascent phases of the mission. The longerons are riveted to the inside surface of the skirt skin and located immediately forward of each PSS support beam fitting. The longerons are tapered Z-sections with the largest cross section area at the aft ring flange.

Typical Longeron Installation



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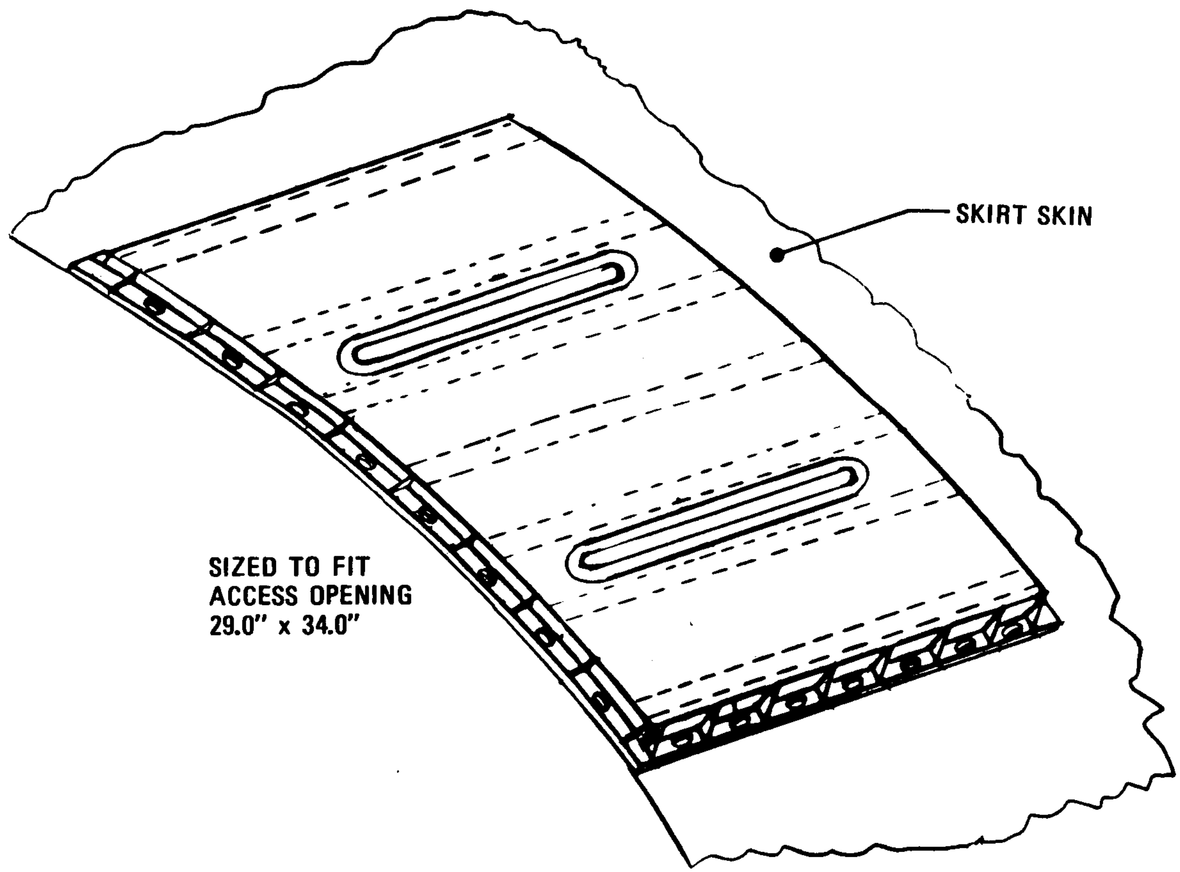
SKIRT ACCESS DOOR

The access doors in the skirt and in the shroud are nonstructural units and contain two flush-type handles to facilitate installation and removal. Each access door is 29.0 in. wide and 34.0 in. long and is installed by bolting the door to the external surface of the skin, similar to the access door on intertank of the ET. The door is contoured to fit the skin curvature and a neoprene gasket is used to seal the door to the skin surface.

Skirt Access Door



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GPACC PSS

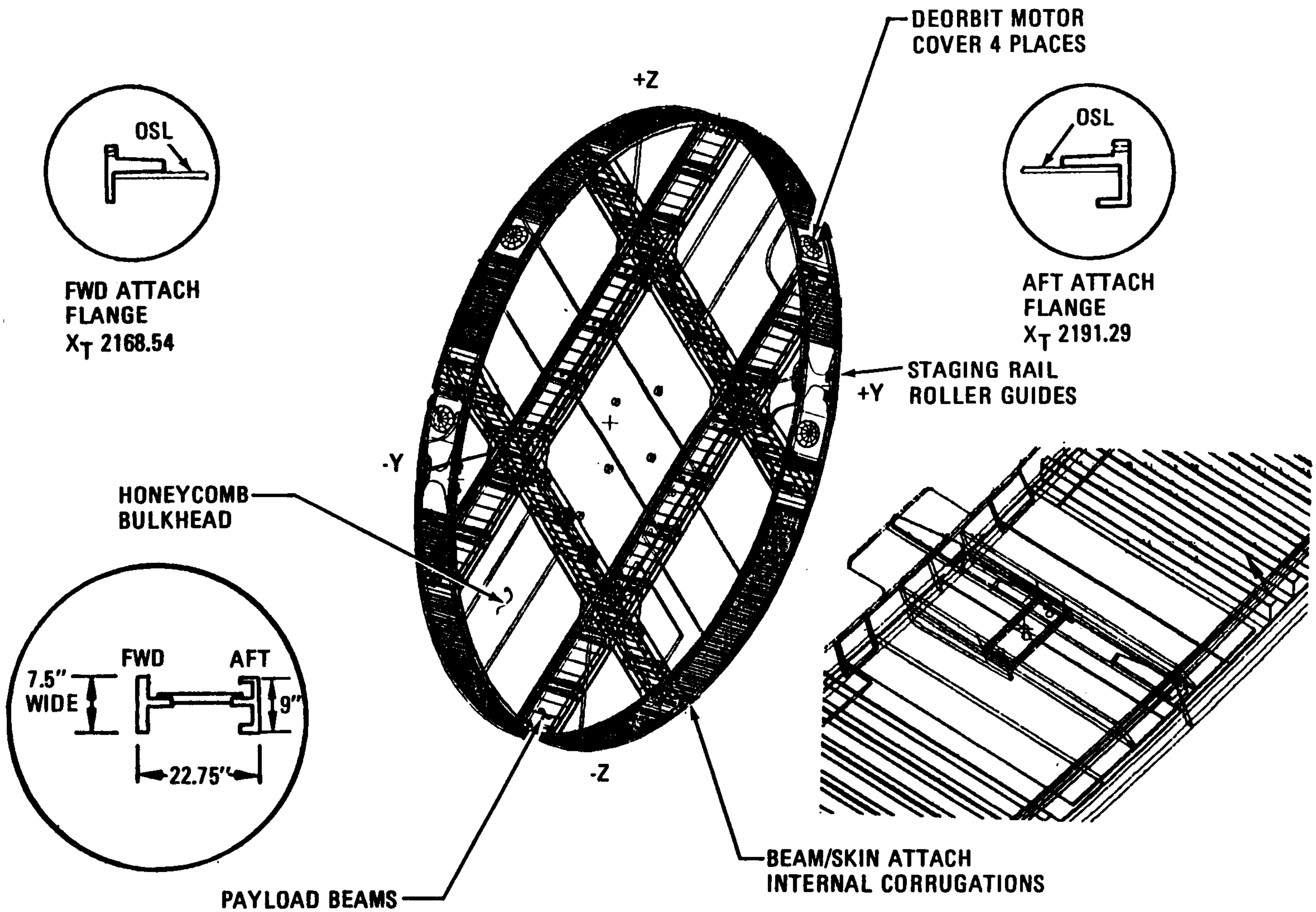
The payload support structure assembly is a monocoque cylindrical structure 22.75 in. long and 331 in. diameter, OSL. The PSS consists of three major subassemblies. The skin assembly, double cruiform support beam assembly and the honeycomb bulkhead assembly.

The skin assembly is composed of aluminum alloy panels reinforced with internal corrugated panels riveted to the inside surface of the skin. The skin panels are approximately 22.75 in. wide and are butt spliced together. Eight payload support beam attachment fittings are included in the skin assembly and provide for payload support beam attachment to the skin assembly as well as to disburse the structural loads. Four protective fairings (covers) for the deorbit motors and two attachment ring flanges are also included in the PSS skin assembly.

The payload support beam double cruciform assembly provides the interface for mounting payloads in the GPACC. The aft surface of the payload beams contain attachment holes for various payloads. The payload support beams are of I-type configuration with forward and aft T-type caps of extruded aluminum alloy material and a web of aluminum alloy flat stock reinforces with T-angles.

The PSS honecomb bulkhead is made up of 23 panels of two in. thick 3/8 in. 5052 hexagonal aluminum honeycomb core material sandwiched between two 2024 aluminum sheets.

GPACC PSS



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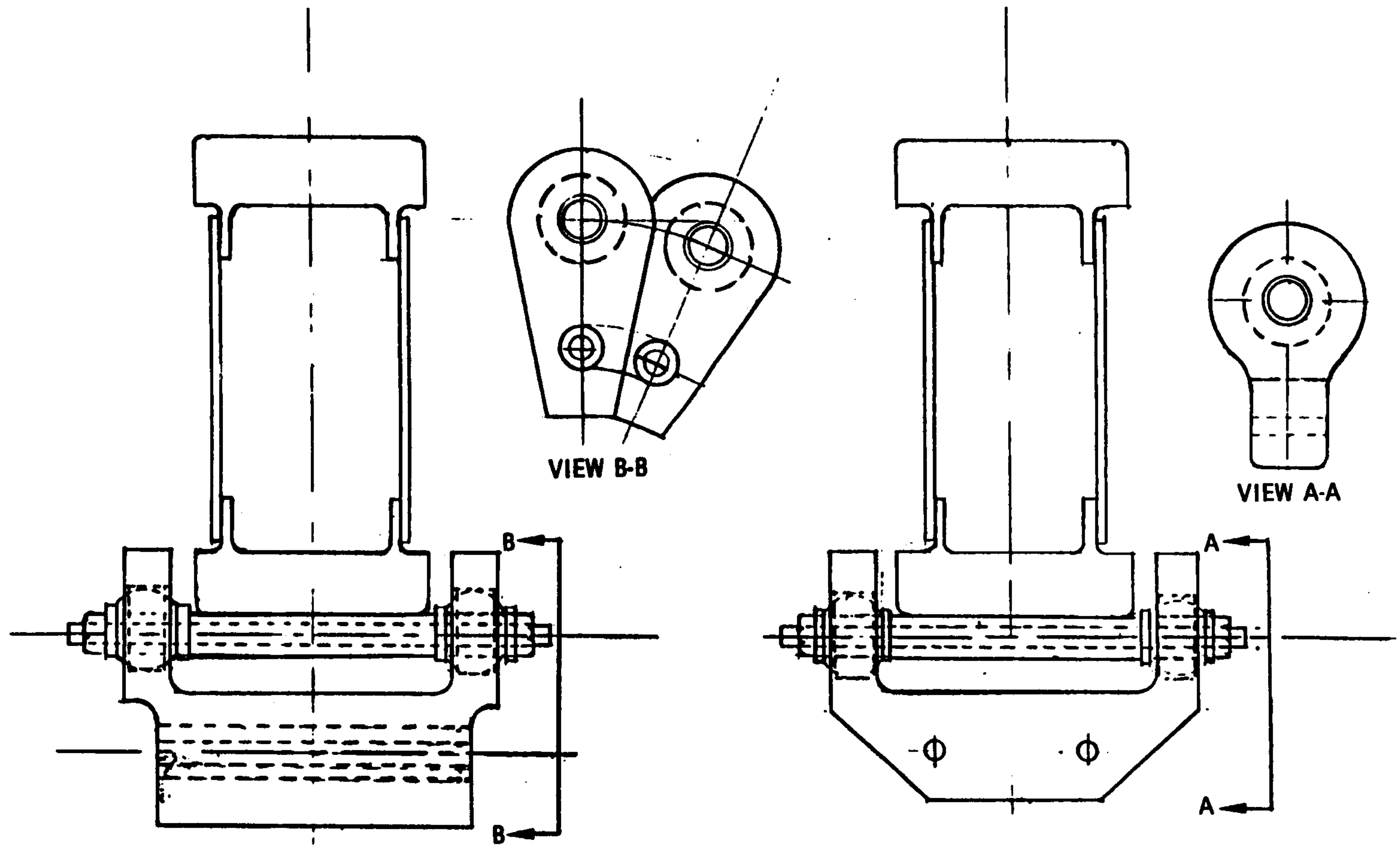
STAGING RAIL ROLLER GUIDES

The GPACC shroud staging rails are supported in the PSS as illustrated on the opposite page. The roller guides are located at X_T2175 and X_T2193.

Staging Rail Roller Guides



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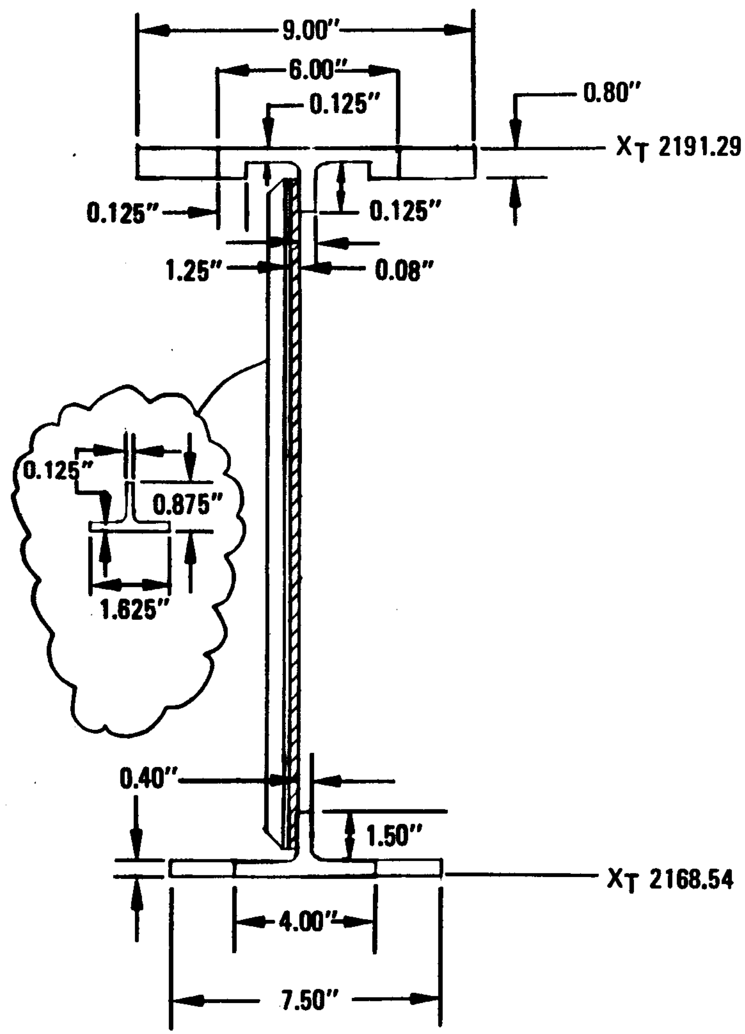
PAYLOAD SUPPORT BEAM - TYPICAL CROSS SECTION

The payload support beam consists of two extruded aluminum caps and a web reinforced with T-extrusions riveted to the web. The width of the aft cap (Sta X_T2191.29) varies from 6 in. at each end to 9 in. at the center segment. The aft cap surface interfaces with the payload mounting bracketry. The forward cap varies in width from 4 in. at each end to 7.5 in. at the center segment. The web is riveted to the caps to form the basic support beam.

Payload Support Beam - Typical Cross Section



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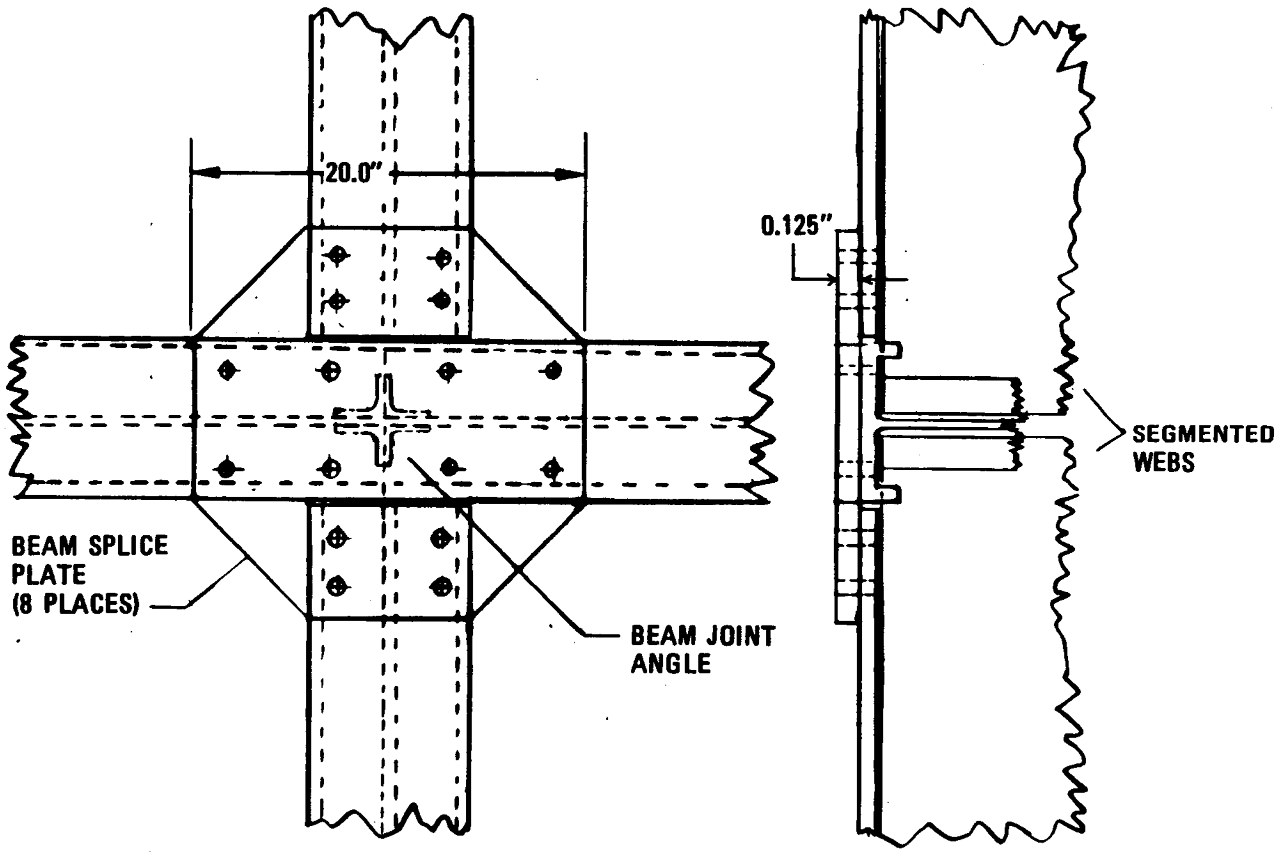
PAYLOAD SUPPORT BEAM - JOINT SPLICE PLATE INSTALLATION

Each of the four intersecting joints of the payload support beam assembly are additionally reinforced with two beam splice plates: one located on the forward cap of the beam, and one on the aft cap.

The spliced plates are fabricated from aluminum flat stock that is 0.125 in. thick, hexagonal in shape, and 20 in. wide. The plates are bolted onto the beam caps.

Payload Support Beam – Joint Splice Plate Installation



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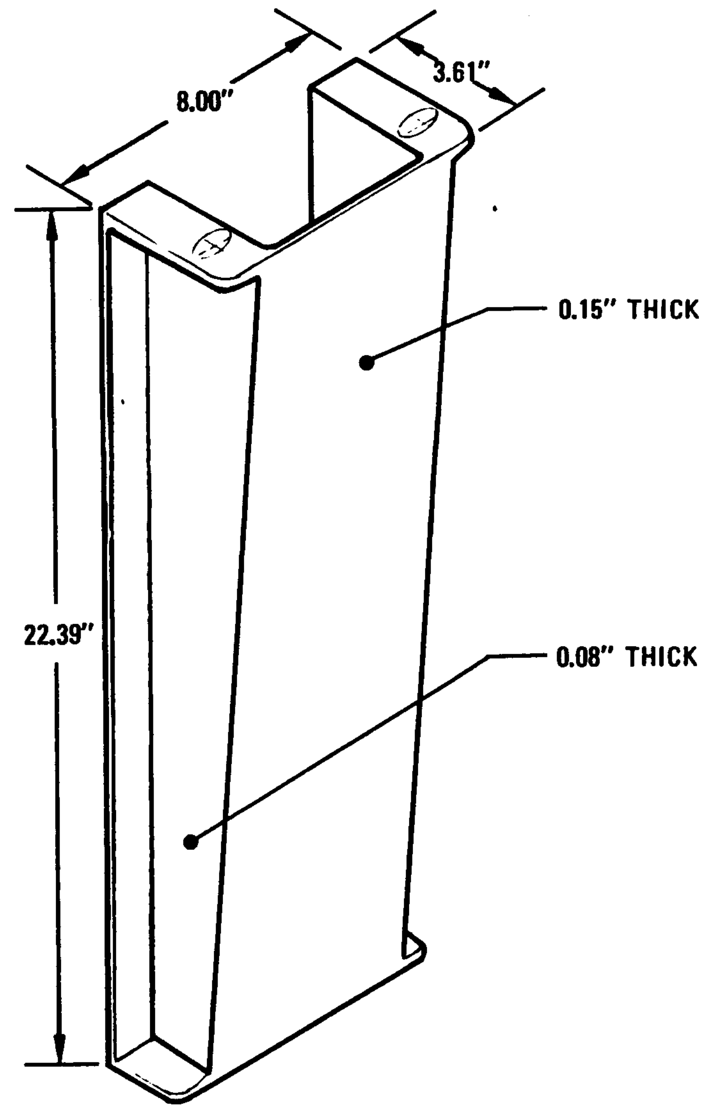
PAYLOAD SUPPORT BEAM – TYPICAL FITTING

The "bathtub" fitting shown in this chart is used as an additional beam reinforcement at the payload/payload support beam attachment points.

The total number of fittings required per flight is a function of the number of attach points required by the cargo manifested.

Payload Support Beam - Typical Fitting



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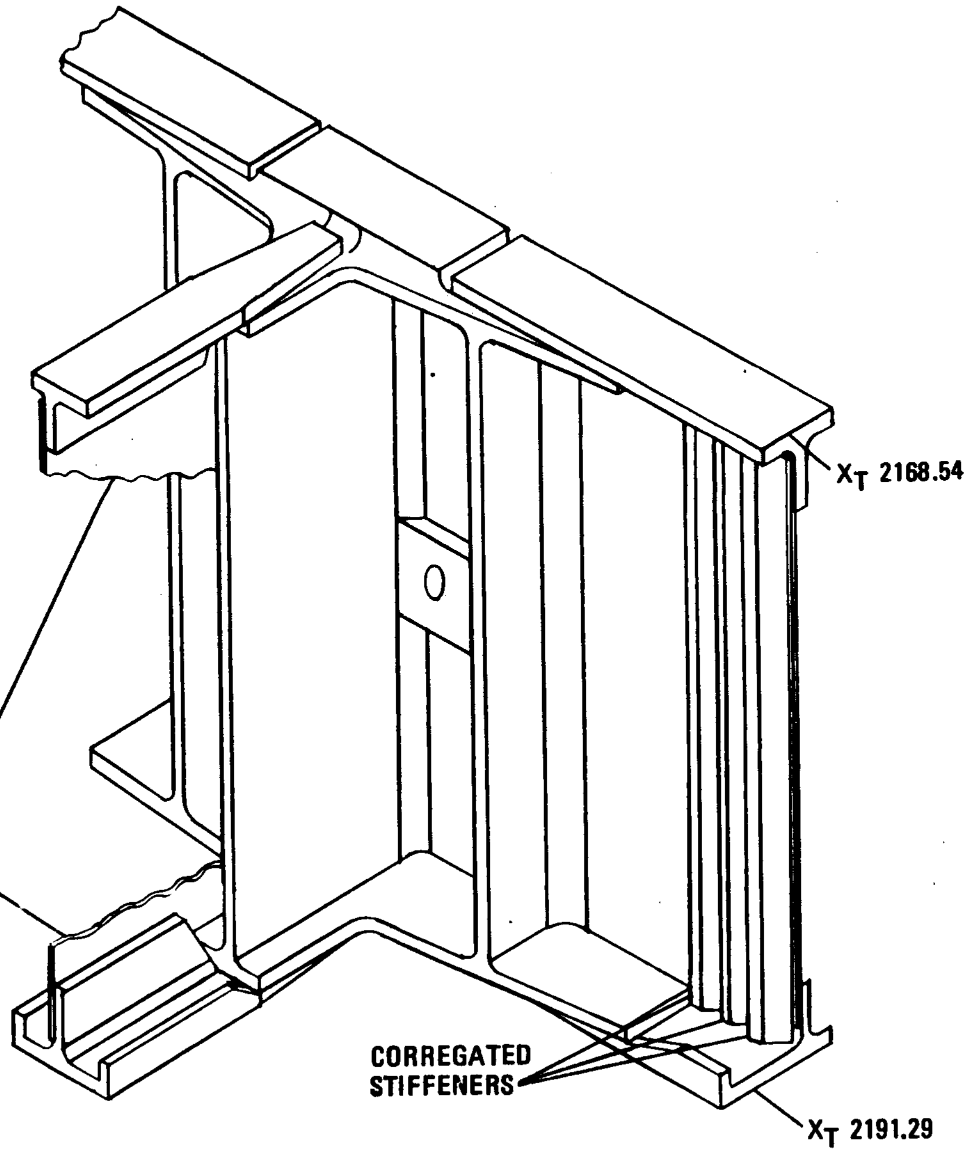
TYPICAL PAYLOAD SUPPORT BEAM - SKIN ATTACHMENT FITTING

Eight PSS beam-to-skin attachment fittings attach the ends of the payload support beams to the PSS skin assembly to provide load distribution to the GPACC skin panels.

The fitting is an aluminum alloy forging machined to mate with the ends of the payload support beams and fit into the skin ring frame assembly.

Typical Payload Support Beam - Skin Attachment Fitting



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ACC MODEL 101 SHROUD

The shroud functions as a thermal and acoustical protection cover for the payload during the launch and ascent phases of the mission.

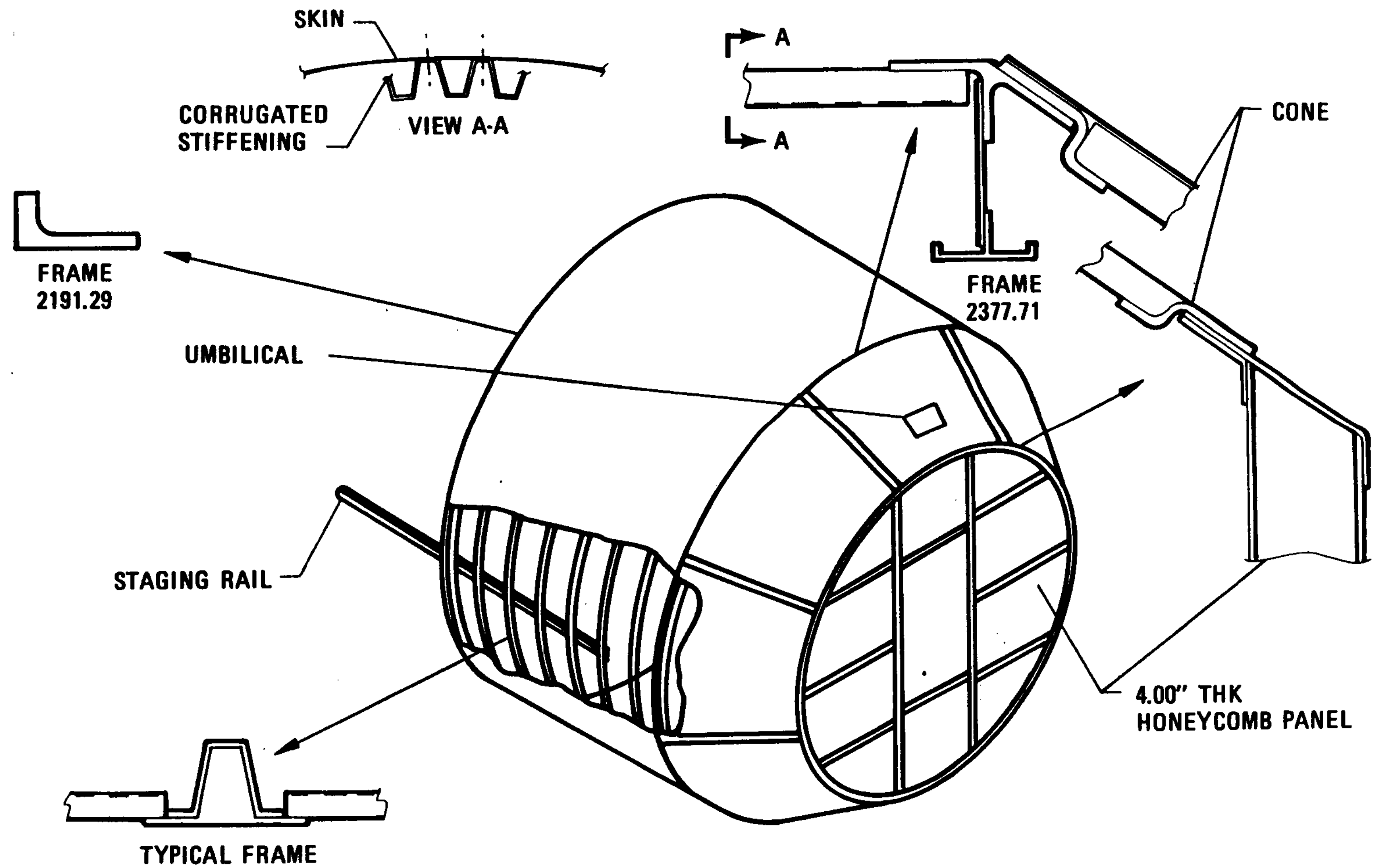
The three structural elements of the shroud assembly are: (1) a cylindrical barrel assembly, (2) a truncated cone assembly, and (3) an aft bulkhead assembly.

The barrel assembly is 186.42 in. long X 331 in. dia and is composed of 8 panel assemblies. The panel assemblies consist of aluminum skin reinforced with aluminum corrugated stiffening. Seven hat-type intermediate ring frames extend radially around and are riveted to the inside surface of the barrel skin. The forward ring frame at Sta X_T2192.29 is riveted to the external surface of the barrel skin and mates with the PSS aft ring frame. The oblique ring frame at Sta X_T2377.71 is also riveted to the external surface of the barrel skin aft edge and provides a mounting surface for attachment of the cone assembly forward edge. Two separate staging rails are located at the $\pm$Y axes and extend parallel to the X axis along the inner surfaces of the ring frames.

The truncated cone is 70.29 in. long and tapers from a 331 in. dia to a 230 in. dia. The assembly is composed of eight 1.0 in. thick honeycomb panels with openings for an access door and umbilical plate.

The aft bulkhead is 230 in. dia and is composed of eleven 4.0 in. thick honeycomb panels.

ACC Model 101 Shroud



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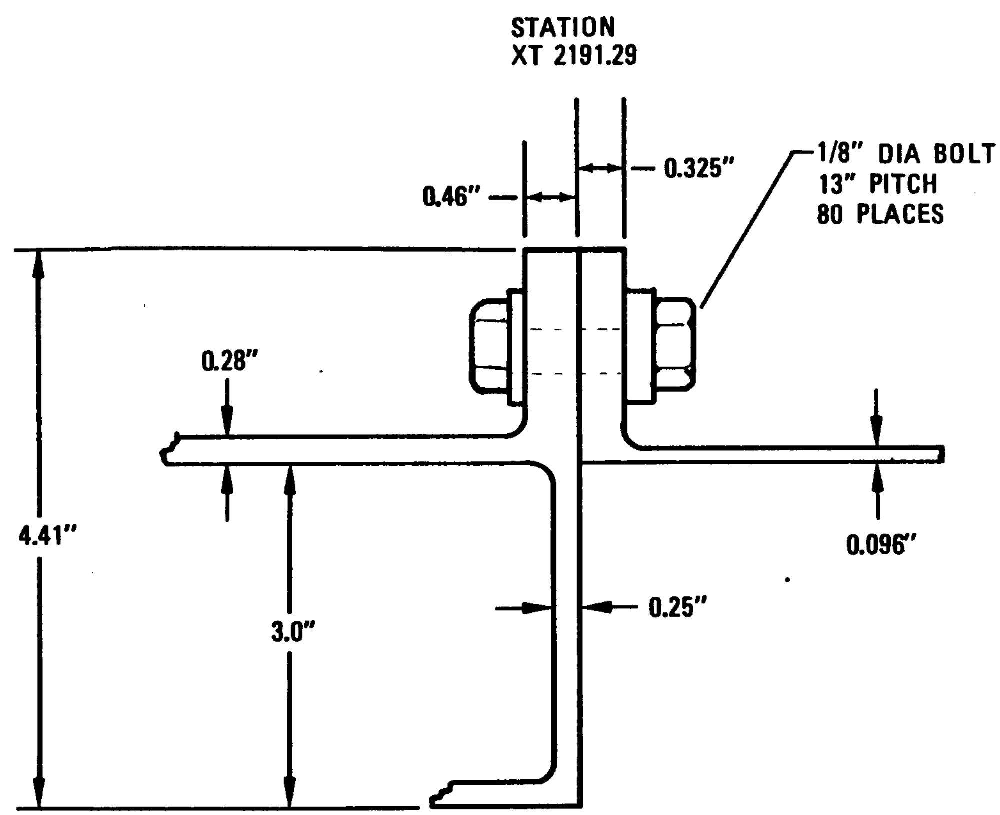
SHROUD-TO-PSS INTERFACE

THE PSS-to-Shroud connection is made at Sta X_T2191.29. This mechanical joint requires eighty 1/8 in. dia bolts installed on 13 in. centers in the flanges.

Shroud-To-PSS Interface



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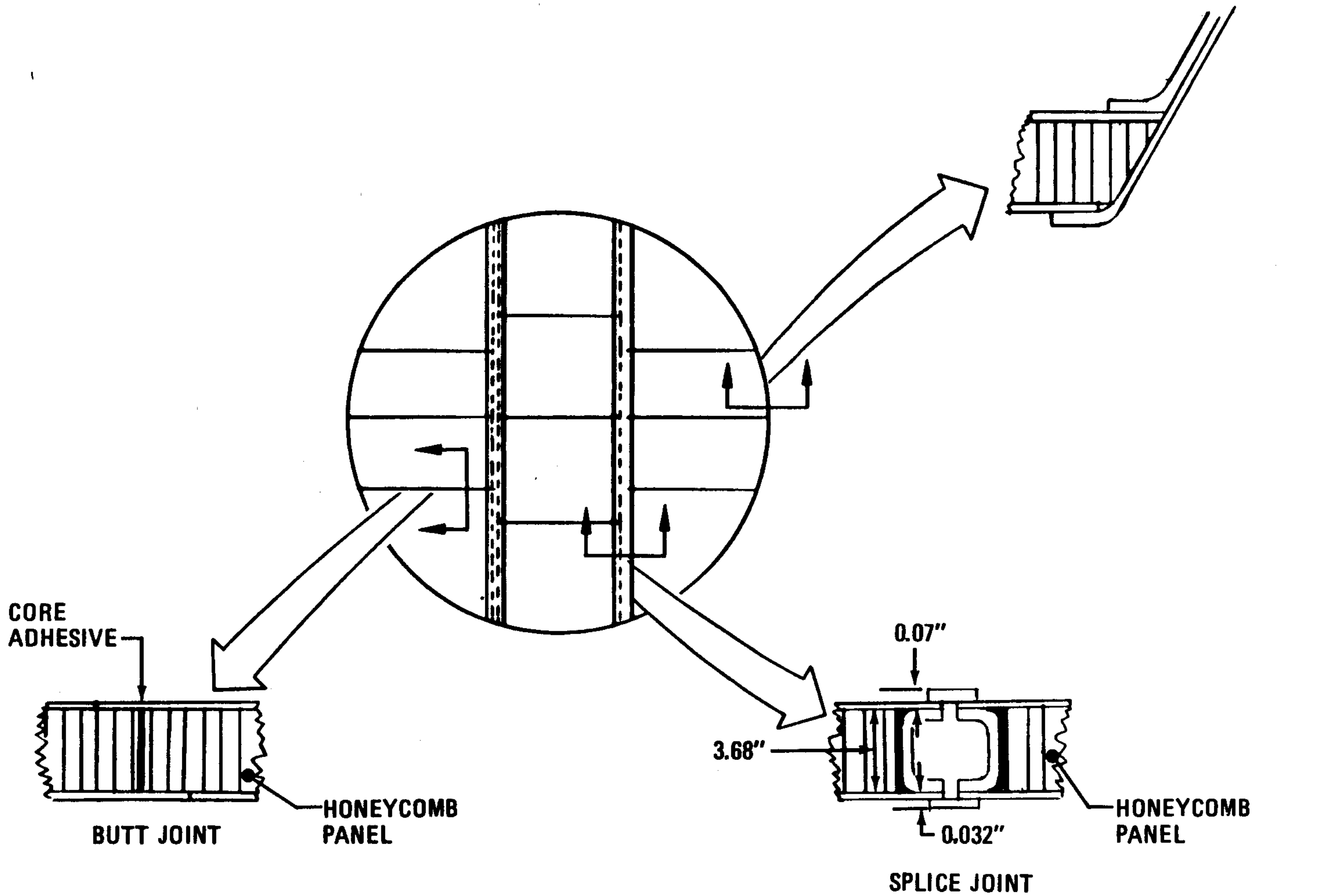
AFT BULKHEAD

The GPACC shroud aft bulkhead is manufactured and shipped to Michoud as three major honeycomb panels. These panels are spliced together (as illustrated in this chart) to complete the aft bulkhead assembly.

Aft Bulkhead



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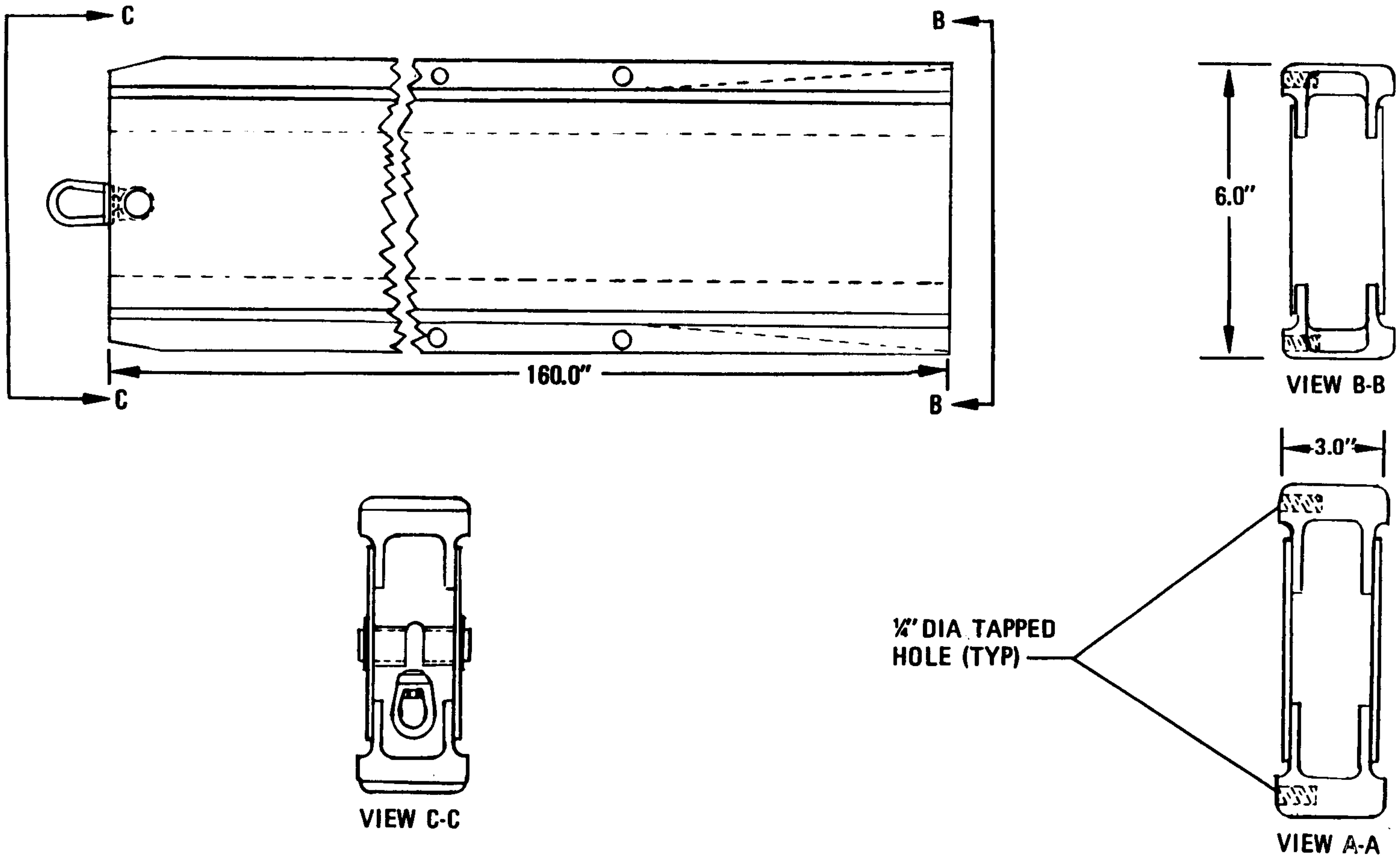
SEPARATION RAIL

The GPACC shroud is controlled during separation by guide rails mounted to the shroud structure. The separation rail design is illustrated on the opposite page.

Separation Rail



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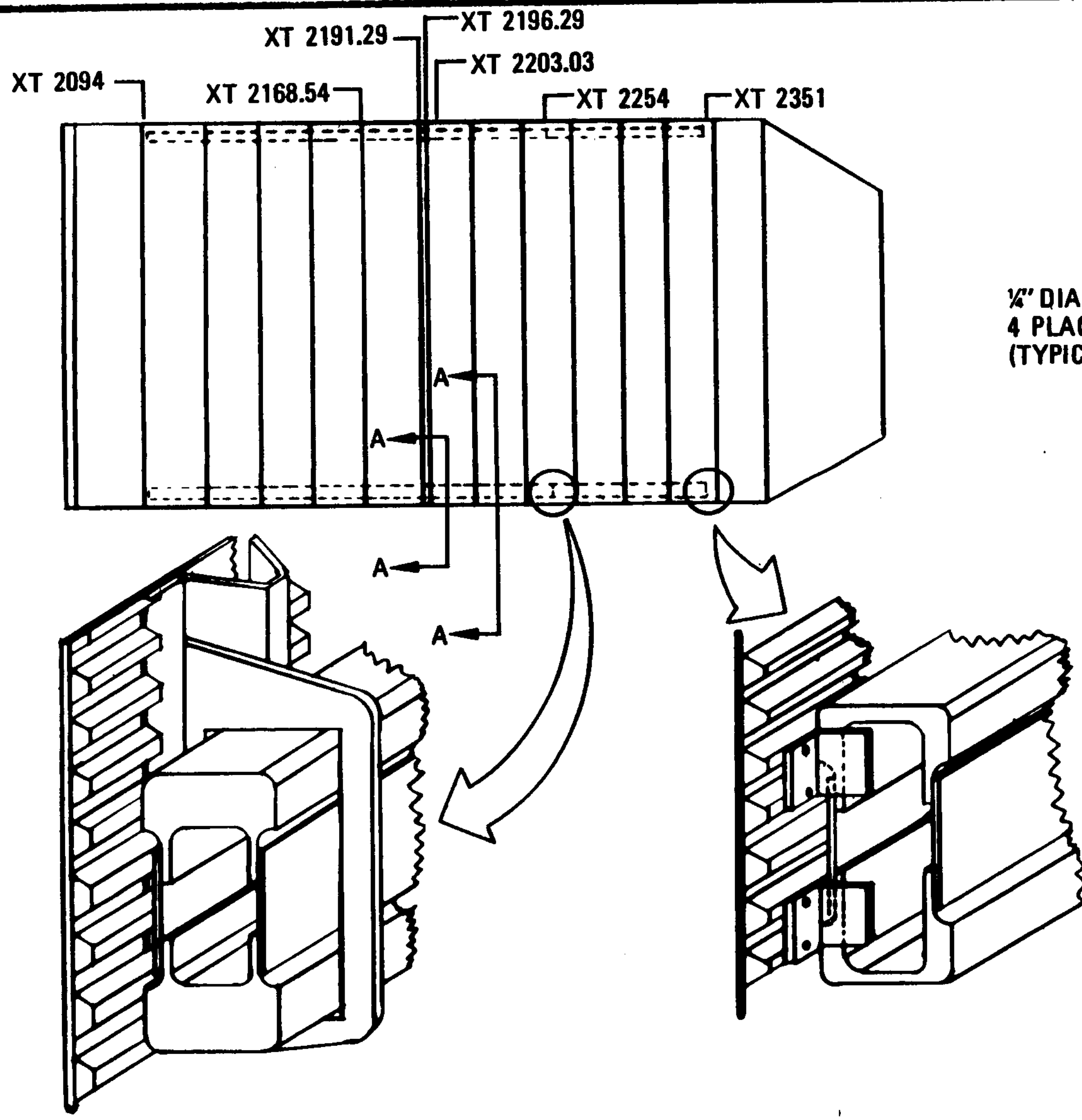
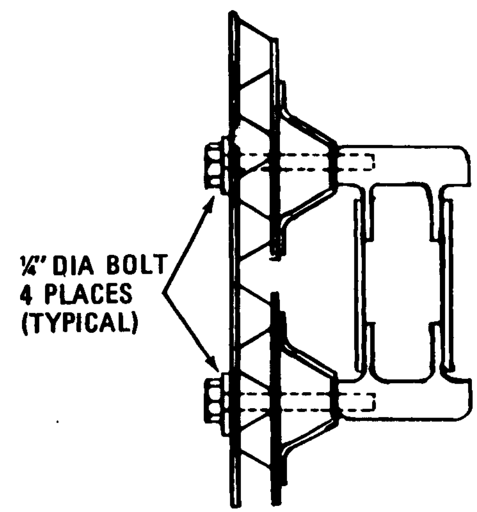
SEPARATION RAIL MOUNTING/GUIDE DETAILS

A typical GPACC shroud separation rail is mounted to the shroud structure, as illustrated on the opposite page.

Separation Rail Mounting/Guide Details





RAIL ATTACHMENT
TO SHROUD SKIN

VIEW A-A

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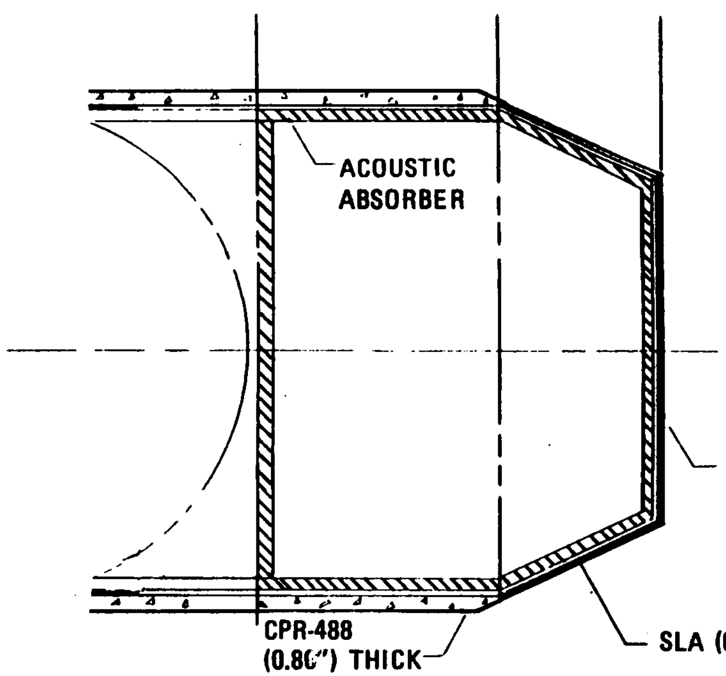
GPACC ENVIRONMENTAL PROTECTION SYSTEM

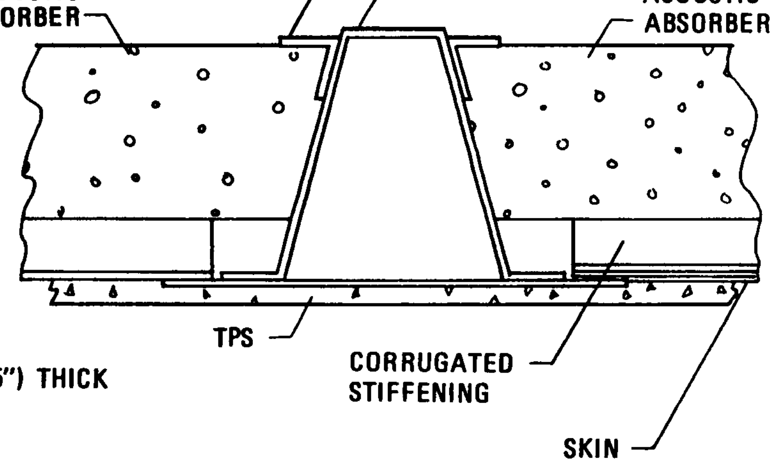
The environmental protection system (EPS) is designed to provide acceptable sound levels in the GPACC payload compartment and to maintain the aluminum structural skin at or below 350°F.

The entire shroud inner surface and the PSS bulkhead are lined with an acoustical absorption blanket. The blanket is held in place with special clips and restraining cables. The blanket material is similar to that used in aircraft.

The skirt and cylindrical portion of the shroud have a 0.8 in. thick coating of CPR-488 foam sprayed to the outside skin line (OSL). The conical section of the shroud is coated with 0.35 in. SLA-561 ablator. The aft bulkhead is coated with 0.45 in. SLA-561.

GPACC Environmental Protection System





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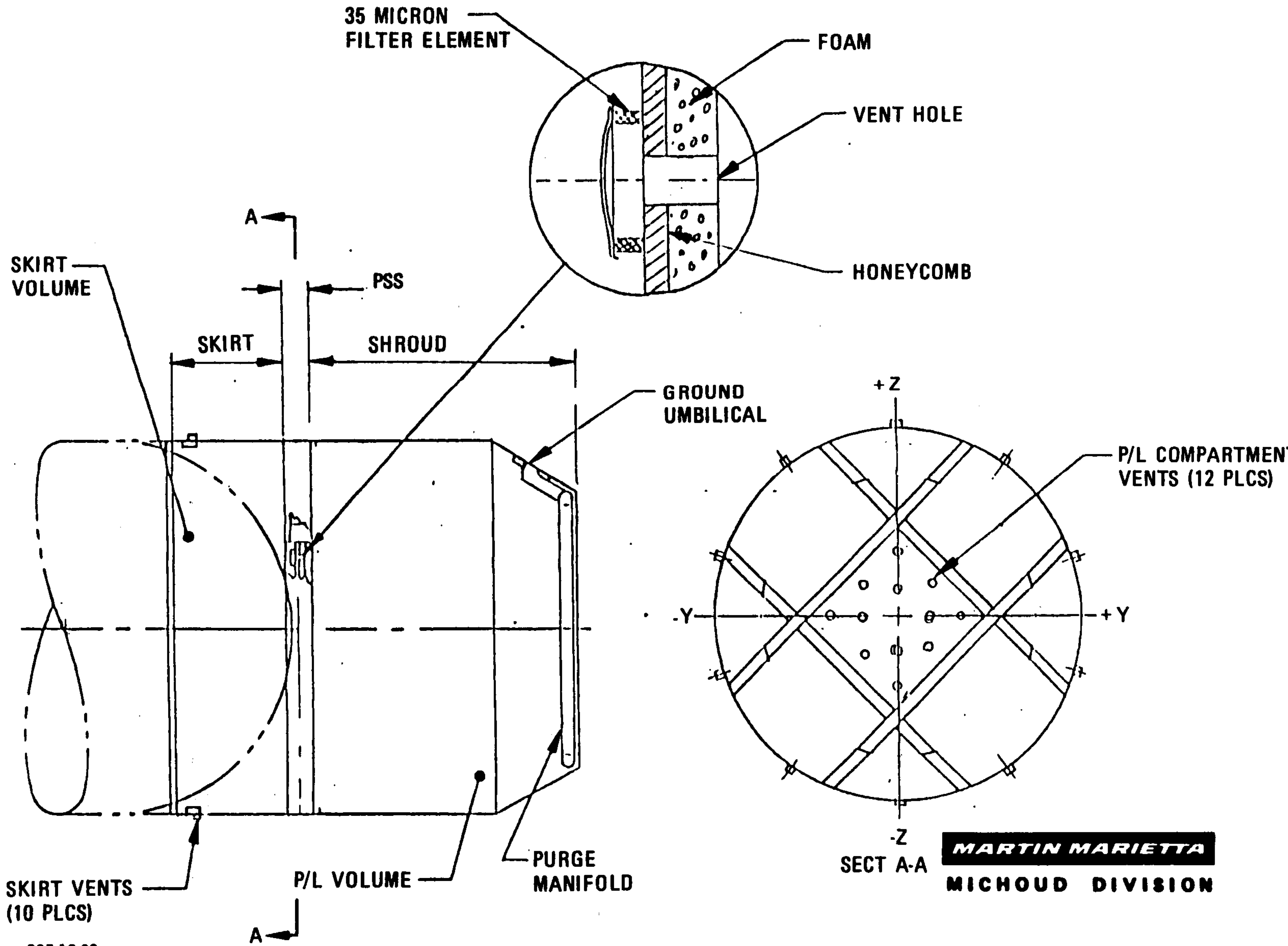
ACC MODEL 101 PURGE AND VENT SUBSYSTEM

The GPACC purge system provides an inert environment inside the ACC prior to launch. Purge is provided through a ground support umbilical located on the lower portion of the GPACC shroud.

The payload compartment is vented into the skirt through filtered penetrations in the PSS cover. The skirt is vented to ambient through 10 vents located in the upper portion of the skirt structure.

ACC Model 101 Purge & Vent Subsystem



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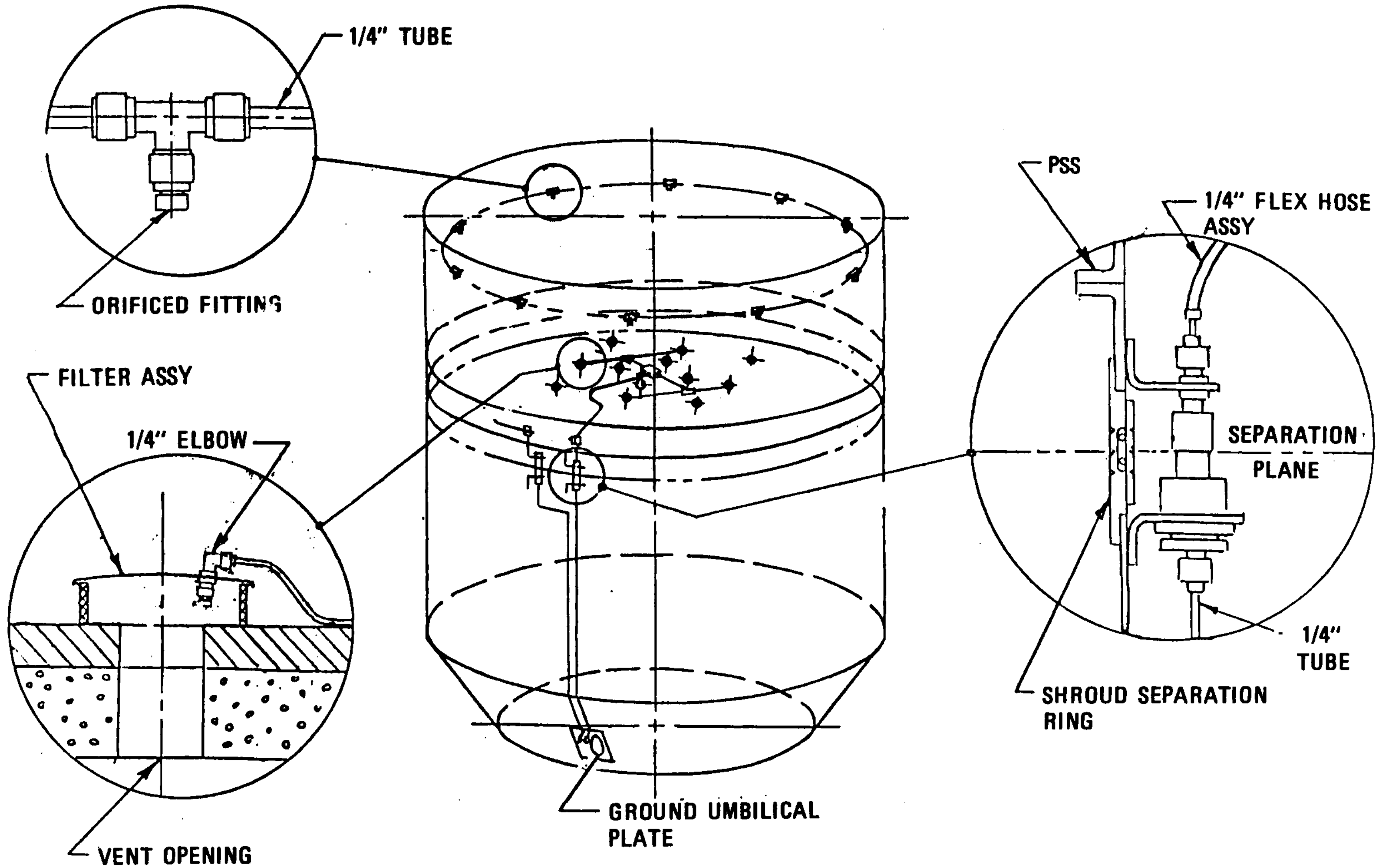
ACC MODEL 101 HAZARDOUS GAS DETECTION SYSTEM

The ACC payload compartment and skirt compartment have a HGDS (shown opposite) that monitors the inertness of the internal environment.

ACC Model 101
Hazardous Gas Detection System



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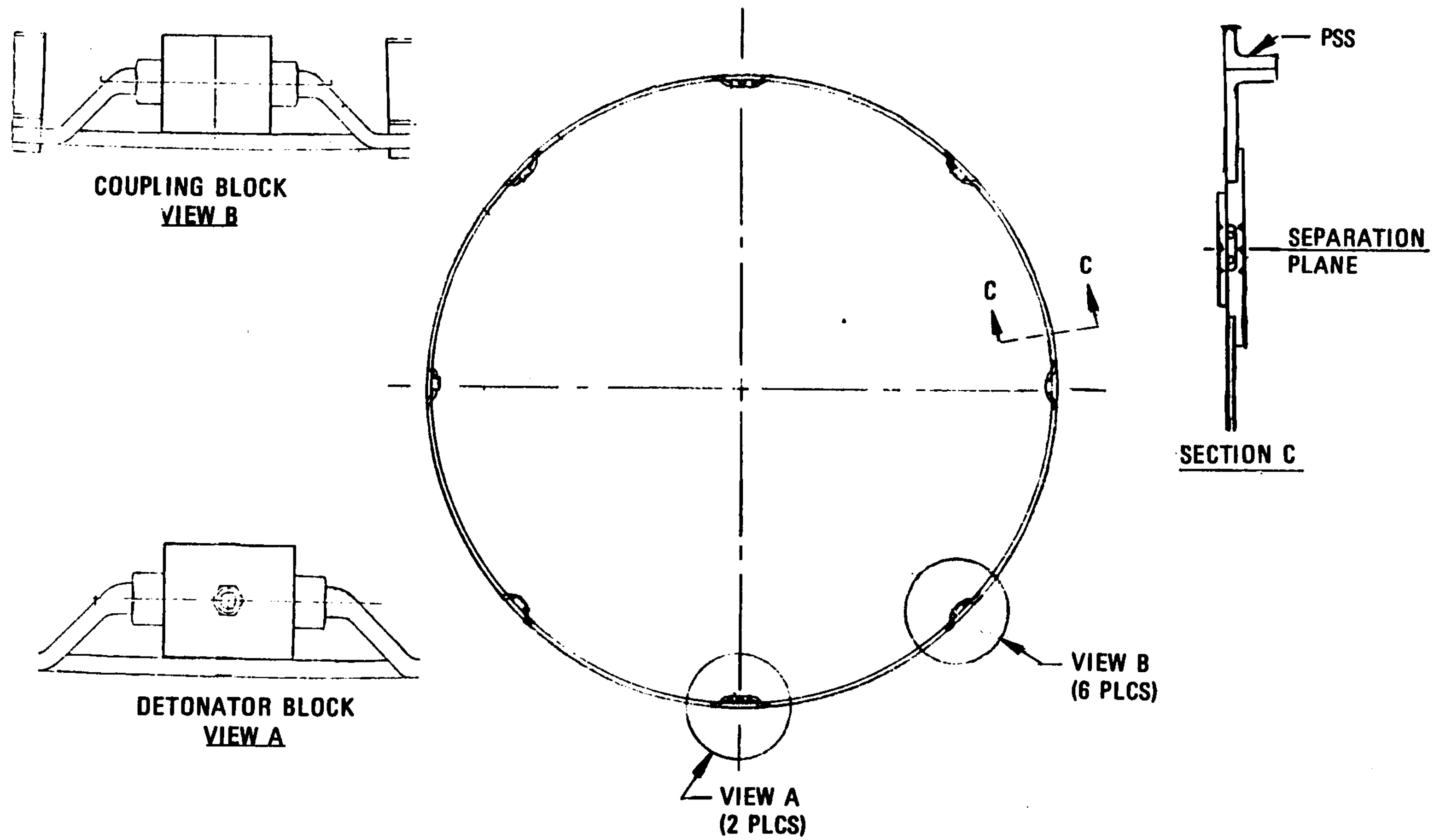
SHROUD SEPARATION ORDNANCE SUBSYSTEM

The shroud separation ordnance is designed to fracture the structural joint between the retained and staged portions of the shroud.

Initiation is accomplished through two PICs, two NSIs, a safe and arm device, and two detonator blocks (placed 180° apart). Coupling blocks join the equal lengths of the expanding tube charges together and assure explosive propagation across the joints.

Shroud Separation Ordnance Subsystem



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DEORBIT/ACS SUBSYSTEM COMPONENTS

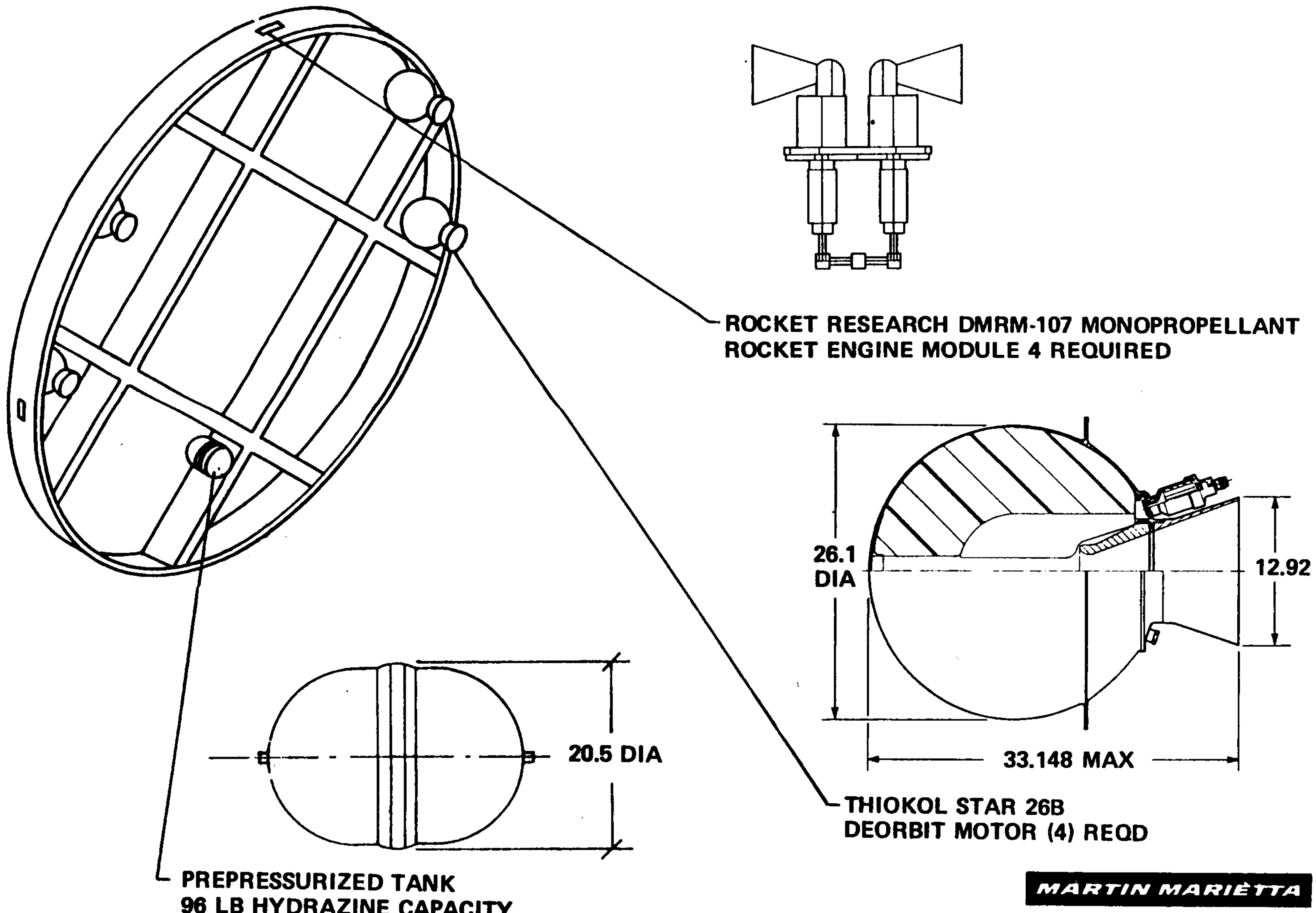
The major components for the ET/GPACC deorbit are shown.

The deorbit impulse is provided by four Thiokol STAR 26B solid rocket motors (SRM). Each SRM provides an average thrust of 7970 lb for approximately 18 seconds. The units are located so the resultant thrust vector passes through the nominal ET/GPACC deorbit cg.

The functions of the ACS are: to arrest separation disturbances, to achieve and maintain the required reference attitudes within $\pm 10^{\circ}$ in all axes, and to provide a vehicle spin rate of 20°/second prior to deorbit motor firing. A baseline hydrazine monopropellant system provides these capabilities. Each Rocket Research module has two opposing thrust units to provide a thrust which varies between 25 lbf and 15.5 lbf when operating with a prepressurized tank in a blowdown mode.

The ACS uses a total of 94.8 lb propellant in performing its functions.

Deorbit/ACS Subsystem Components



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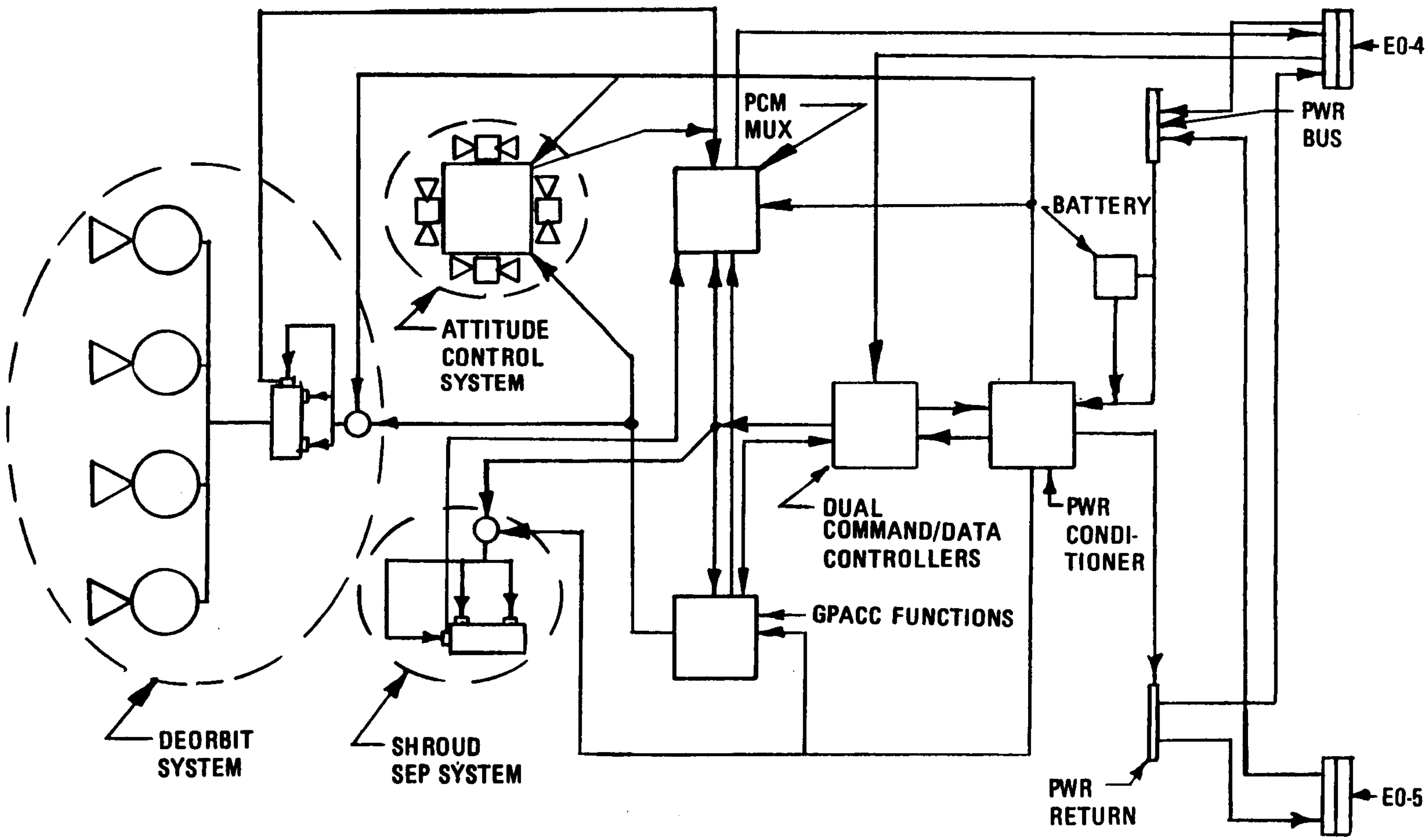
GPACC AVIONICS SCHEMATIC

The GPACC avionics (dedicated to GPACC use) shares dual command/data controllers and the PCM MUX with the cargo elements.

The GPACC systems that require avionics support are: the shroud separation system, ACS, and deorbit system. Redundant critical command and critical data paths are provided.

GPACC Avionics Schematic



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GPACC WEIGHT SUMMARY

The weight summary is presented for the GPACC, which is designed to carry a variety of payloads. In addition to the total GPACC weight and its functional breakdown, the weight is also shown for that part of the shroud which is staged during ascent.

The weights were established by estimating/calculating from detailed drawings, stress data, configuration layouts and subsystem descriptions. Within each functional weight breakdown, a weight allowance is estimated for inaccuracies in weight resulting from a lack of detail in current design data.

The assembly attach hardware is that which is needed to mate the skirt to the ET, the PSS to the skirt, and the shroud to the PSS.

The growth figure is the predicted weight allowance for design and weight changes due to design deficiencies and manufacturing variations.

GPACC Weight Summary

DESCRIPTION	WEIGHT (LB)	
SKIRT		1,769
STRUCTURE	1,539	
THERMAL PROTECTION	148	
ELECTRICAL	53	
PROPULSION/MECHANICAL	29	
PAYLOAD SUPPORT STRUCTURE		5,822
STRUCTURE	2,371	
THERMAL PROTECTION	34	
ACOUSTICAL PROTECTION	530	
PROPULSION/MECHANICAL	11	
AVIONICS/ELECTRICAL	228	
ATTITUDE CONTROL (INCLUDES PROPELLANT)	261	
DEORBIT	2,362	
ORDNANCE	25	
SHROUD		5,887
STRUCTURE	4,471	
THERMAL PROTECTION	801	
ACOUSTICAL PROTECTION	420	
PROPULSION/MECHANICAL	117	
ORDNANCE	78	
ASSEMBLY ATTACH HARDWARE		39
GROWTH		1,112
TOTAL ACC WEIGHT		14,629
ACC JETTISONED WEIGHT		6,088
ACC RETAINED WEIGHT		8,541

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Agenda

- Introduction
- Requirements
- Payload Integration
- Design (General Purpose)
- ⇨ Design (Dedicated OTV)
- Mission Analyses
- Planning
- Costs

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Dedicated ACC Design

- Configuration/General Arrangement
- Trades
- Structural Details
- Subsystems

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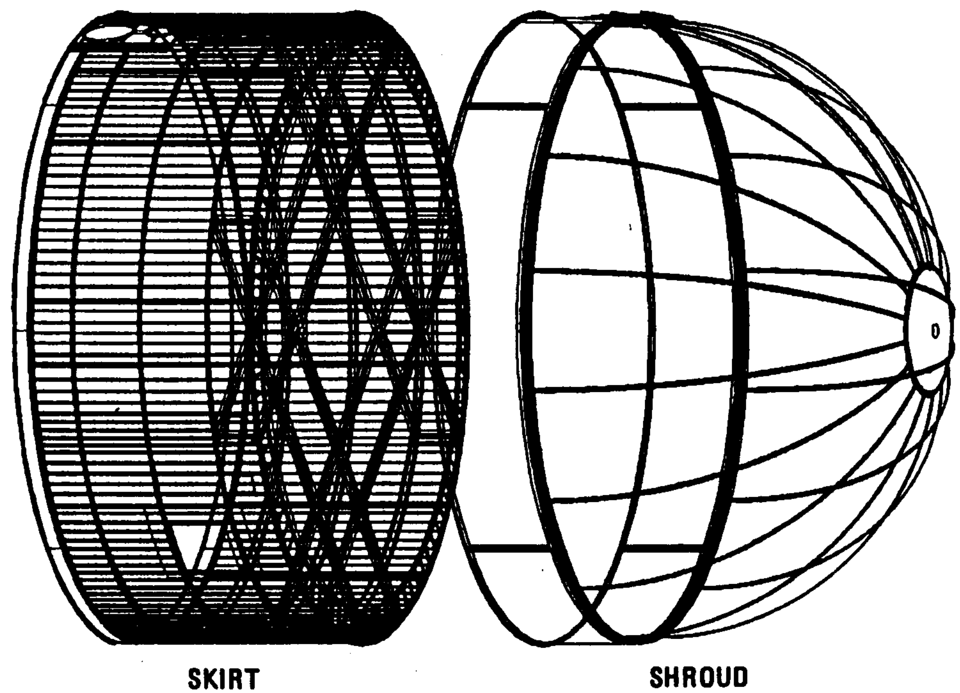
DACC CONFIGURATION

The two major elements comprising the DACC are the skirt and shroud assemblies.

DACC Configuration



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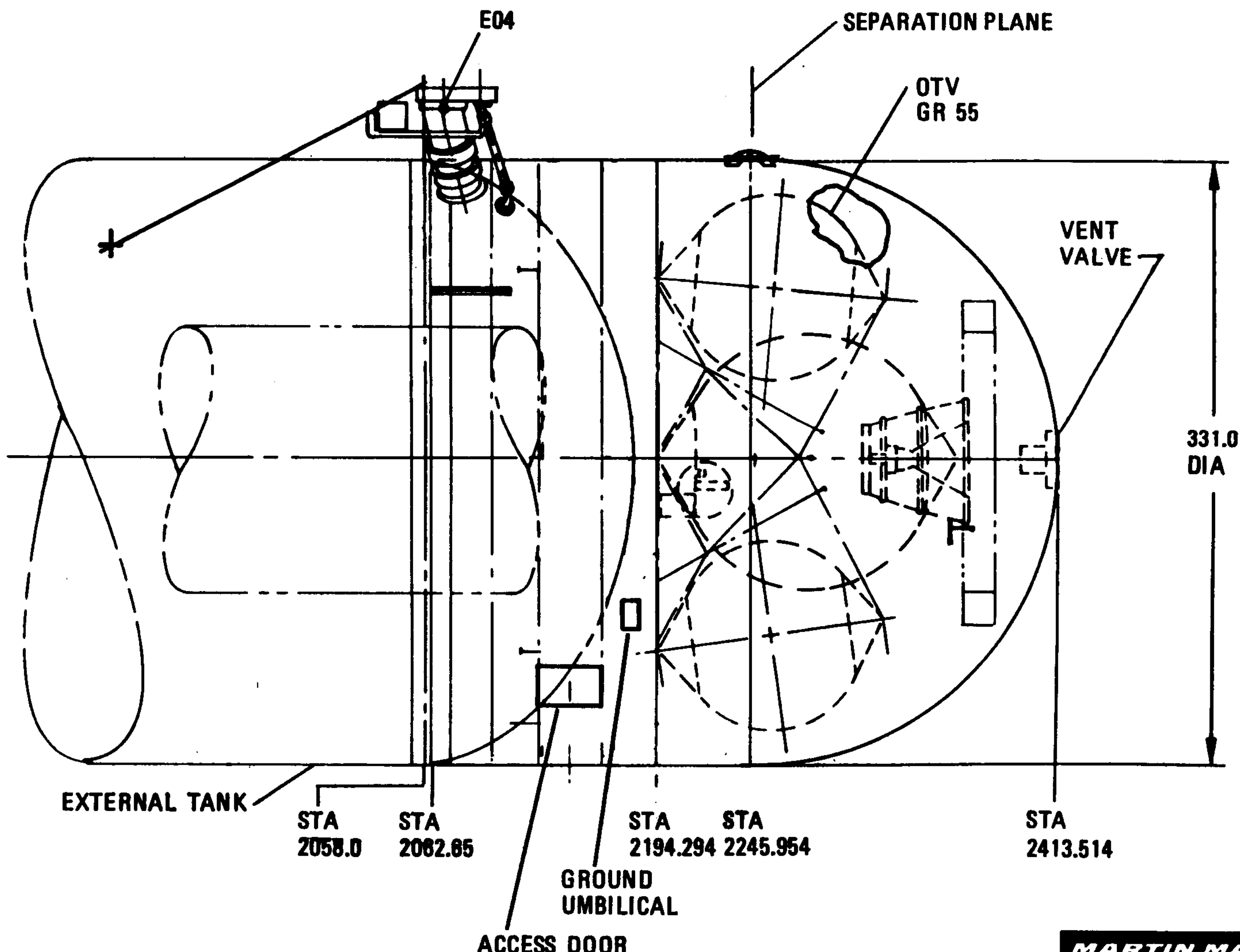
DACC GENERAL ARRANGEMENT

The DACC is an OTV dedicated, pressure stabilized, structural design. It is sized to accommodate only an OTV. The enclosure provides 18.3 ft behind the structural attachment plane, which transitions from a 27.5 ft cylinder to a hemispherical dome.

The DACC consists of two major assemblines, the skirt and a stageable shroud. The skirt provides the structural attachment to the ET via modification of the Sta 2058 ring frame. A door in the skirt provides on pad access to the payload, but does not provide on pad payload changeout. The skirt also provides a payload mounting surface at X_T2194.294 (a double cruciform beam).

The OTV services are routed from an umbilical plate (on the skirt) to an internal I/F that separates when the OTV is deployed. The ground support umbilical provides the following services: cryogenic loading/unloading, purge, venting and pressurization.

DACC General Arrangement



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DACC Structural Trades

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Trade Study - Low Profile Flange Joint Configuration

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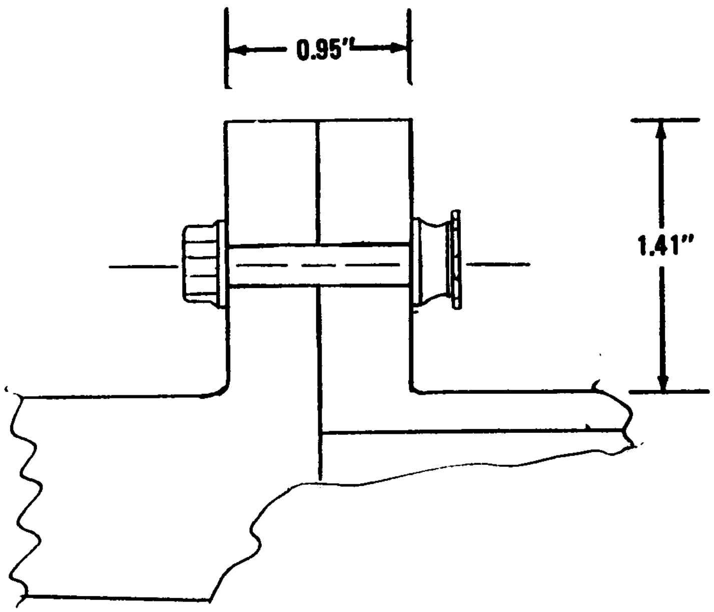
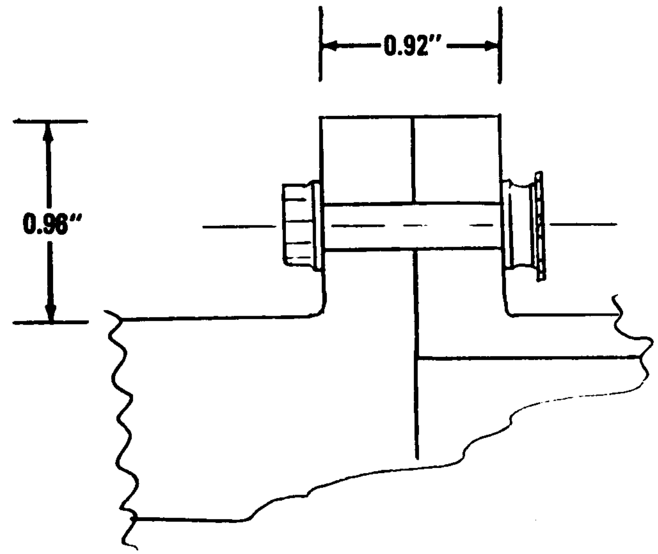
ET/ACC FLANGES

Shown are the two flanges at X_T2062.65 to be considered in the trade study. The baseline joint uses the existing ET drill fixture while the "low profile" joint requires a new drill fixture with a pitch circle radius (PCR) less than 166.21 in.

ET/ACC Flanges



"BASELINE" JOINT AT STA 2062.65
(UTILIZE EXISTING DRILL FIXTURE)



"LOW PROFILE" JOINT AT STA 2062.65
(REQUIRES NEW DRILL FIXTURE)

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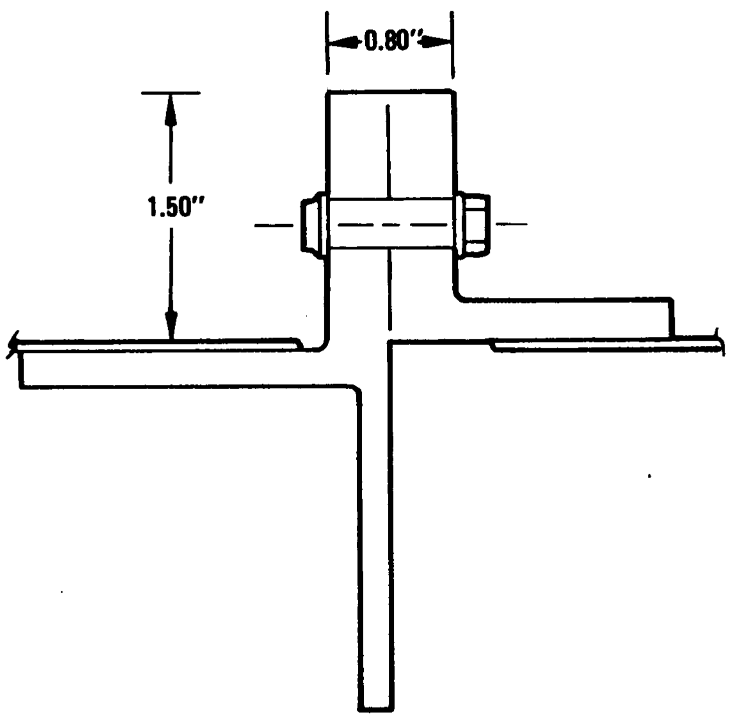
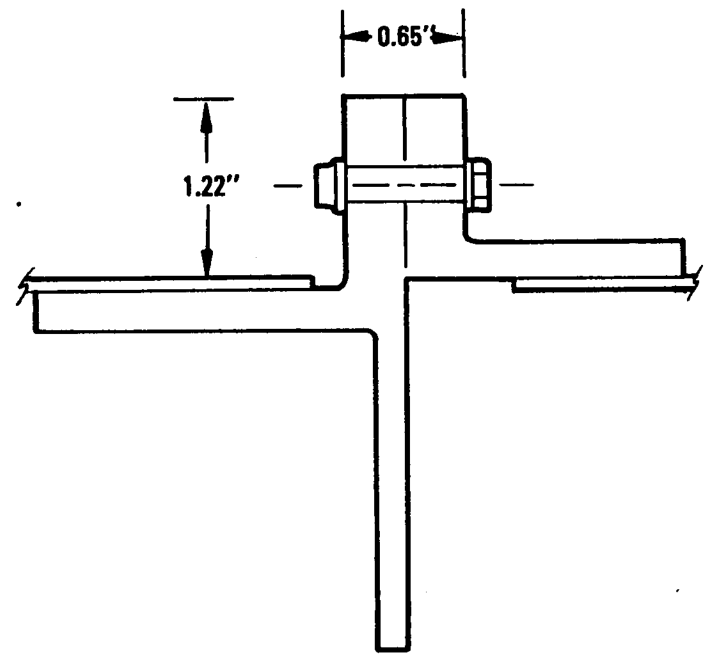
ACC SKIRT/SHROUD FLANGES

Shown are the two flanges at X_T2194.29 to be considered in the trade study. The low profile joint would require a PCR less than the ET radius of 166.21 in.

ACC Skirt/Shroud Flanges



"BASELINE" JOINT AT STA 2194.294



"LOW PROFILE" JOINT AT STA 2194.294

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TRADE STUDY - COST AND WEIGHT SUMMARY

The study results indicate that the weight savings do not merit the additional increase in program cost.

Trade Study - Cost and Weight Summary

	TOTAL ADDITIONAL DOLLARS		WEIGHT SAVINGS/FLT
	NON-RECURRING	RECURRING	
ET /ACC FLANGES	$2.7M	$0.4M	-53 LB
ACC SKIRT/SHROUD FLANGES	$0.4M	$-0.1M	-33 LB
TOTALS	$3.1M	$0.3M	-86 LB

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Alternate Shroud Skin Panel Joining Methods

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Shroud Trade Study–Objective

OBJECTIVE: DEVELOP MANUFACTURING APPROACH, TOOLING AND FACILITY REQUIREMENTS, COSTS FOR DIRECT COMPARISON OF ALTERNATE CONFIGURATIONS.

- WELDED
- RIVETED

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Shroud Trade Study–Ground Rules and Assumptions

- THE ACC WILL BE BUILT AT MAF
- PRODUCTION CAPABILITY - 6 PER YEAR
  - ASSUME NO CONCURRENT PRODUCTION OF GENERAL PURPOSE ACC
  - ET PRODUCTION - 24 PER YEAR
    - PROTECT 40 PER YEAR CAPABILITY
- TPS AND SYSTEMS INSTALLATIONS WILL BE SIMILAR FOR ALL CONSTRUCTION CANDIDATES AND THEREFORE WILL BE EXCLUDED FROM TRADE STUDY
- SHROUD TOOLING THAT IS SIMILAR FOR ALL CONFIGURATIONS WILL BE EXCLUDED FROM TRADE STUDY

  E.G. - HANDLING TOOLS
  - TPS AND SYSTEMS INSTALLATION

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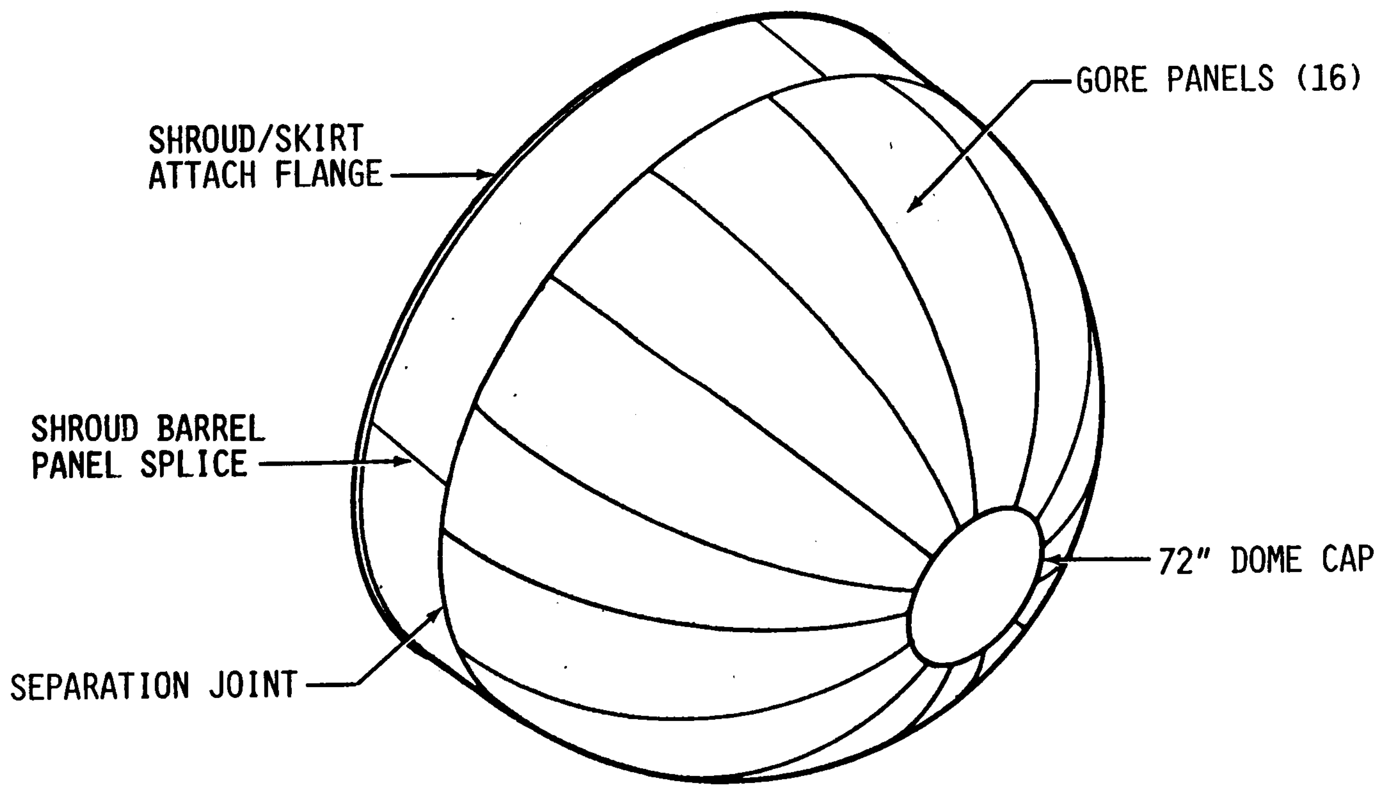
RIVETED SHROUD CONSTRUCTION

The riveted shroud configuration, used in the trade study for comparison with alternate construction methods, is shown in this chart.

Riveted Shroud Construction



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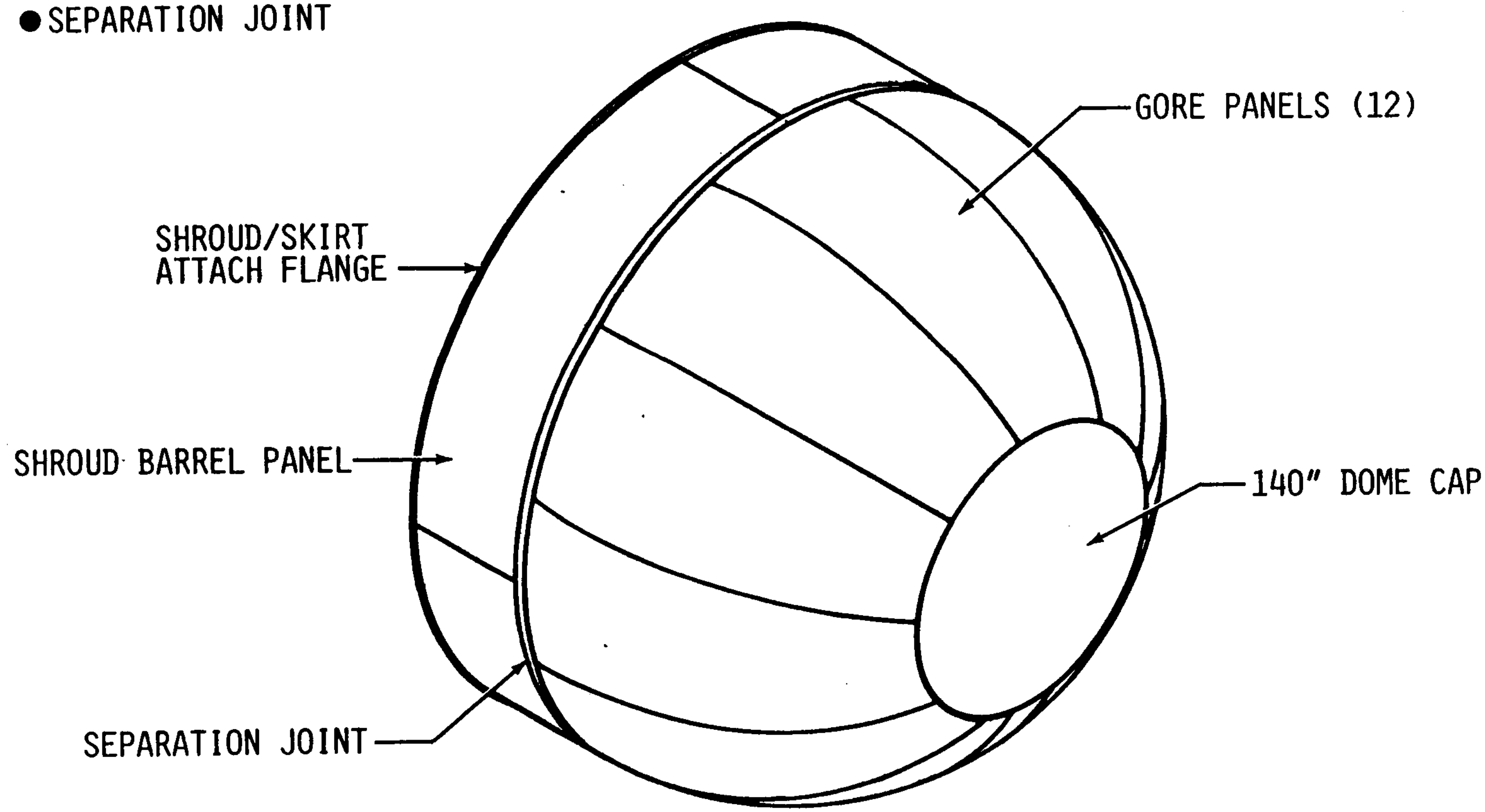
WELDED SHROUD CONSTRUCTION

The welded shroud configuration, used in the trade study for comparison with alternate construction methods, is shown in this chart.

Welded Shroud Construction

- CHEM-MILLED MONOCOQUE
- PLASMA ARC WELDED
- SEPARATION JOINT



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FACILITIES REQUIREMENTS - TRADE SUMMARY

Facilities requirements for both trade study candidates are shown.

Construction of Facilities (C of F) funding required for a riveted shroud is only 66% of the total funding required for a welded shroud.

Facilities Requirements–Trade Summary

- WELDED VS RIVETED

	SHROUD ONLY						
	AREA	FACILITIES CONSTR/MODIFICATIONS					COST
CONFIGURATION TRADE	SQ.FT	# TOOLING FOUNDATIONS	# POSITIONS REQ DURING UTILITIES	# CRANES REQUIRED	RELOCATION ACTIONS	EQUIPMENT REMOVAL	FY 84 C of F BUDGET
WELDED	14,000	6 EA.	8 EA	3 EA	NO	NO	$3.2
RIVETED	10,400	4 EA	7 EA	3 EA	NO	NO	$2.1

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SHROUD CONSTRUCTION COST COMPARISON

A DACC shroud using riveted construction is estimated to cost less in all major cost areas.

An estimated total cost reduction of 66% is feasible if a riveting technique is used instead of welded construction.

Shroud Construction Cost Comparison

GROUND RULES AND ASSUMPTIONS

- COSTS ARE IN FY 1984 DOLLARS
- PRODUCTION OF 69 UNITS (6 PER YEAR)
- ET PRODUCTION OF 24 PER YEAR (PROTECT 40 PER YEAR CAPABILITY)
- TPS AND SYSTEMS INSTALLATION ARE SIMILAR FOR ALL CANDIDATES AND ARE THEREFORE EXCLUDED FROM TRADE STUDY
- SHROUD TOOLING THAT IS SIMILAR FOR ALL CONFIGURATIONS HAS BEEN EXCLUDED FROM TRADE STUDY

RESULTS

THE ESTIMATED COSTS FOR THE TWO TECHNIQUES ARE AS FOLLOWS:

	WELDED SHROUD		RIVETED SHROUD	
NONRECURRING		$30.2M		$ 7.6M
TOOL DESIGN & FAB	$ 8.5M		$1.1M	
SUBCONTRACT	2.0M		3.7M	
TOOL MATERIAL	1.1M		0.3M	
PRODUCTION OPERATIONS SUPPORT	12.2M		1.6M	
ALL OTHER SUPPORT	6.4M		0.8M	
RECURRING		9.3M		4.9M
LABOR	4.1M		2.7M	
MATERIAL	5.2M		2.2M	
FACILITIES		3.2M		2.1M
		$42.7M		$14.6M

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SHROUD CONSTRUCTION WEIGHT COMPARISON

The riveted DACC shroud structure is estimated to weigh 18% less than a welded structure.

Shroud Construction Weight Comparison

DESCRIPTION	WEIGHT (LB) WELDED CONSTRUCTION	WEIGHT (LB) RIVETED CONSTRUCTION
ATTACH FLANGE & HDWE	94	94
BARREL PANELS (4)	294	274
BARREL PANEL SPLICE STRAPS & HDWE	N/A	5
GORE PANELS	596	387
GORE PANEL SPLICE STRAPS & HDWE	N/A	20
DOME CAP INSTALLATION	15	9
SEPARATION JOINT ASSEMBLY	186	186
GROWTH (10%)	119	98
(TOTAL SHROUD STRUCTURE)	(1304)	(1073)

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OTV Support Beam Trade Study

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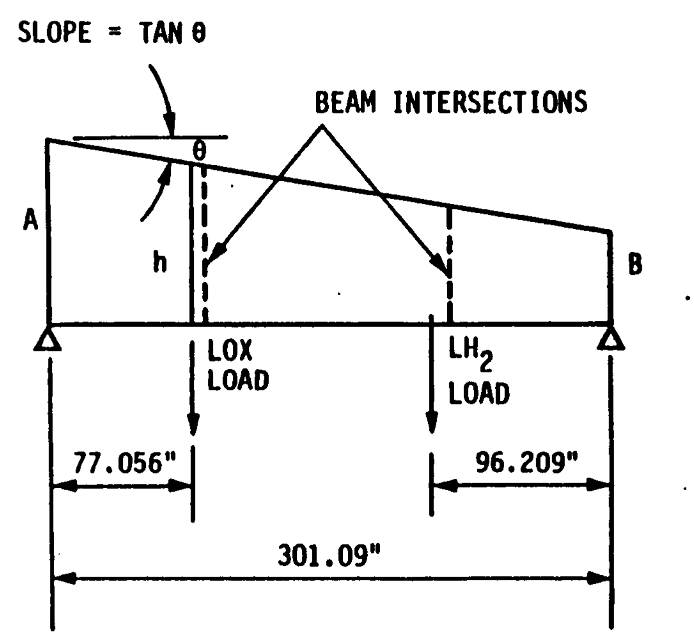
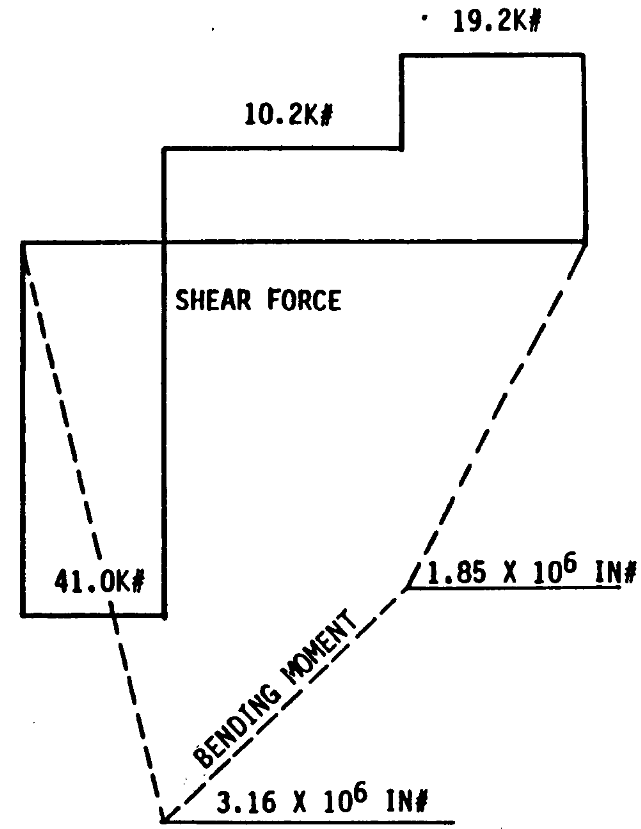
INDIVIDUAL ACC BEAM GEOMETRY AND LOADING DIAGRAM

This sketch shows the individual ACC beam geometry and loading diagram for X accelerations only. The slope of the beam was varied from a slope greater than the baseline configuration to a beam with parallel caps. Also, the beam depth (h) at the LO2 fitting was varied from 20 in. to 33 in. The loading diagram was used to calculate stresses and gages for the beam, and to determine weights.

Individual ACC Beam Geometry and Loading Diagram





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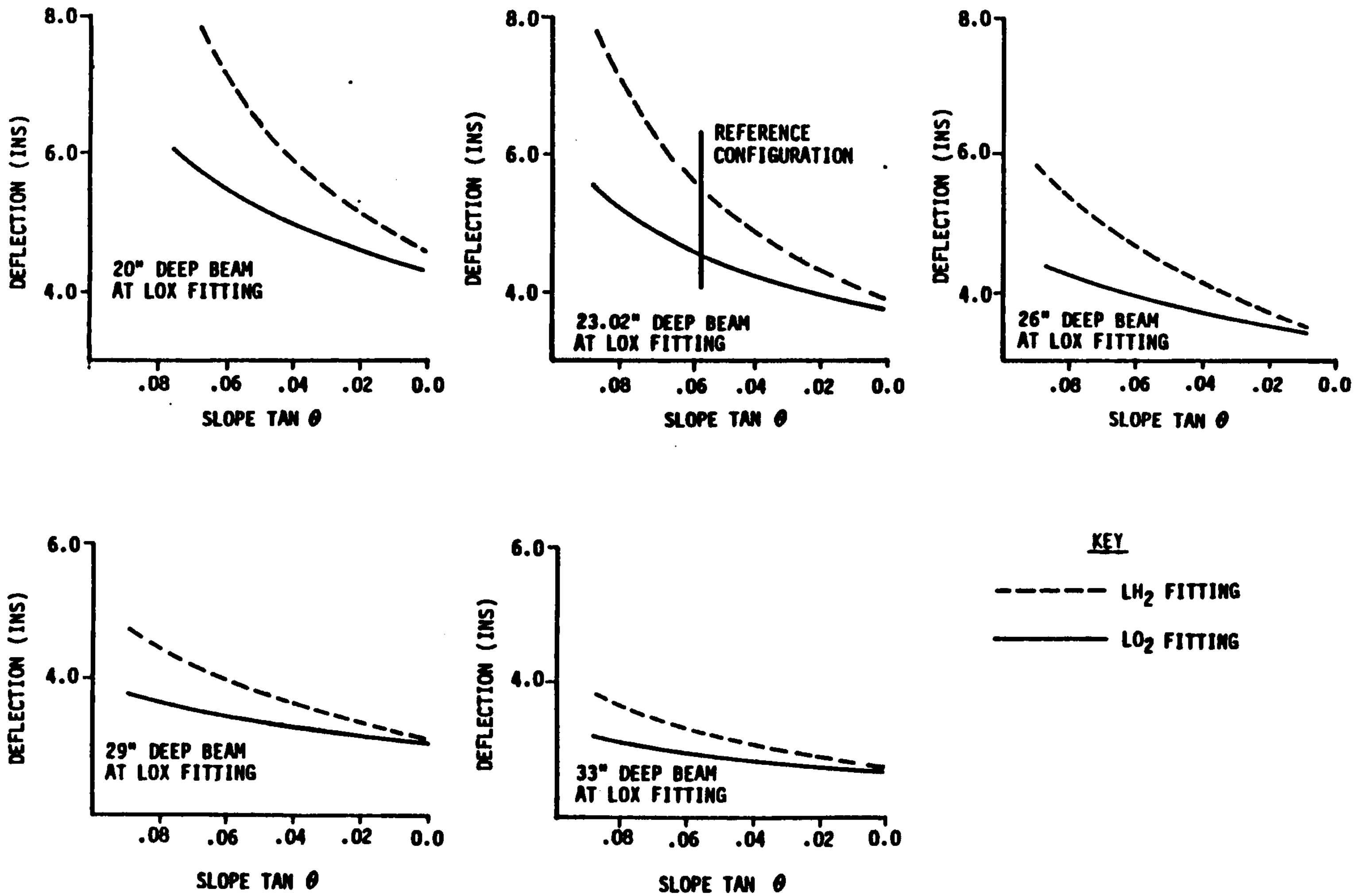
BEAM DEFLECTIONS VS SLOPE FOR VARIOUS BEAM DEPTHS

Each graph shows that the deflections and relative deflection between the LH2 and LO2 fittings decrease as the beam slope decreases. As the beam depth increases, the series of graphs show a trend towards smaller total and relative deflections of the fittings. This reduction in the relative displacements produces smaller out-of-plane deflections of the four OTV attach points.

Beam Deflections vs Slope for Various Beam Depths



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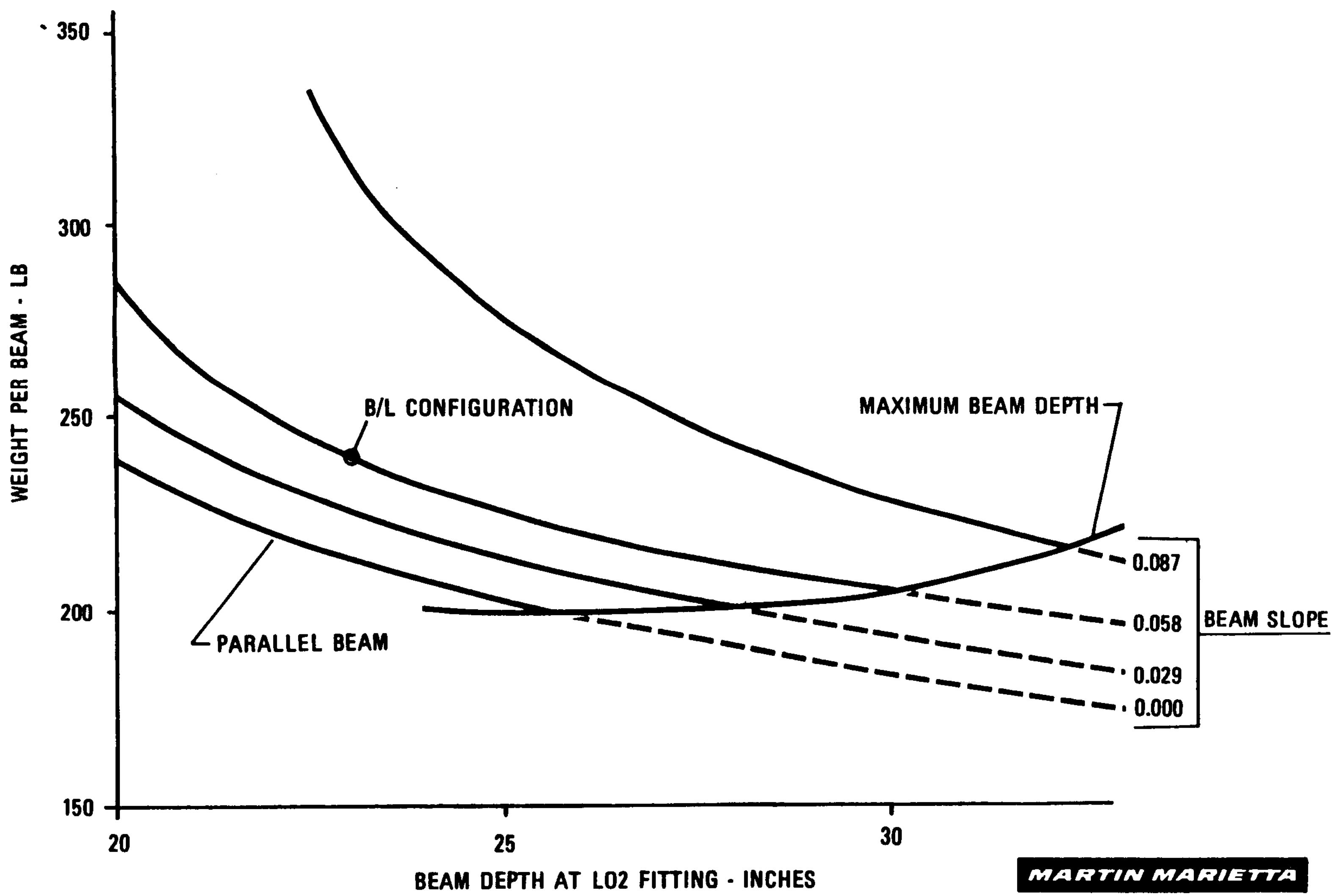
BEAM WEIGHT VS BEAM DEPTH

These curves reflect the beam weight vs the beam depth for various beam slopes. This family of curves indicates that the lightest beam is a parallel beam of maximum depth. There is a maximum aft station (Sta 2194) for the aft caps of these beams (ACC/OTV interface) that does not impact facilities. Sta 2194 involves a 9 in. move aft from the baseline configuration. Similarly, for the top of the beams, there is a maximum forward location (Sta 2168.5) that prevents interference between the LH2 aft dome and the ACC beams' top caps during launch loads. The maximum depth beam line on the graph shows the deepest beam possible for the various slopes within these constraints. Therefore, the minimum weight beam is the parallel beam that is 25.5 in. deep and weighs 204 lb.

Beam Weight vs Beam Depth



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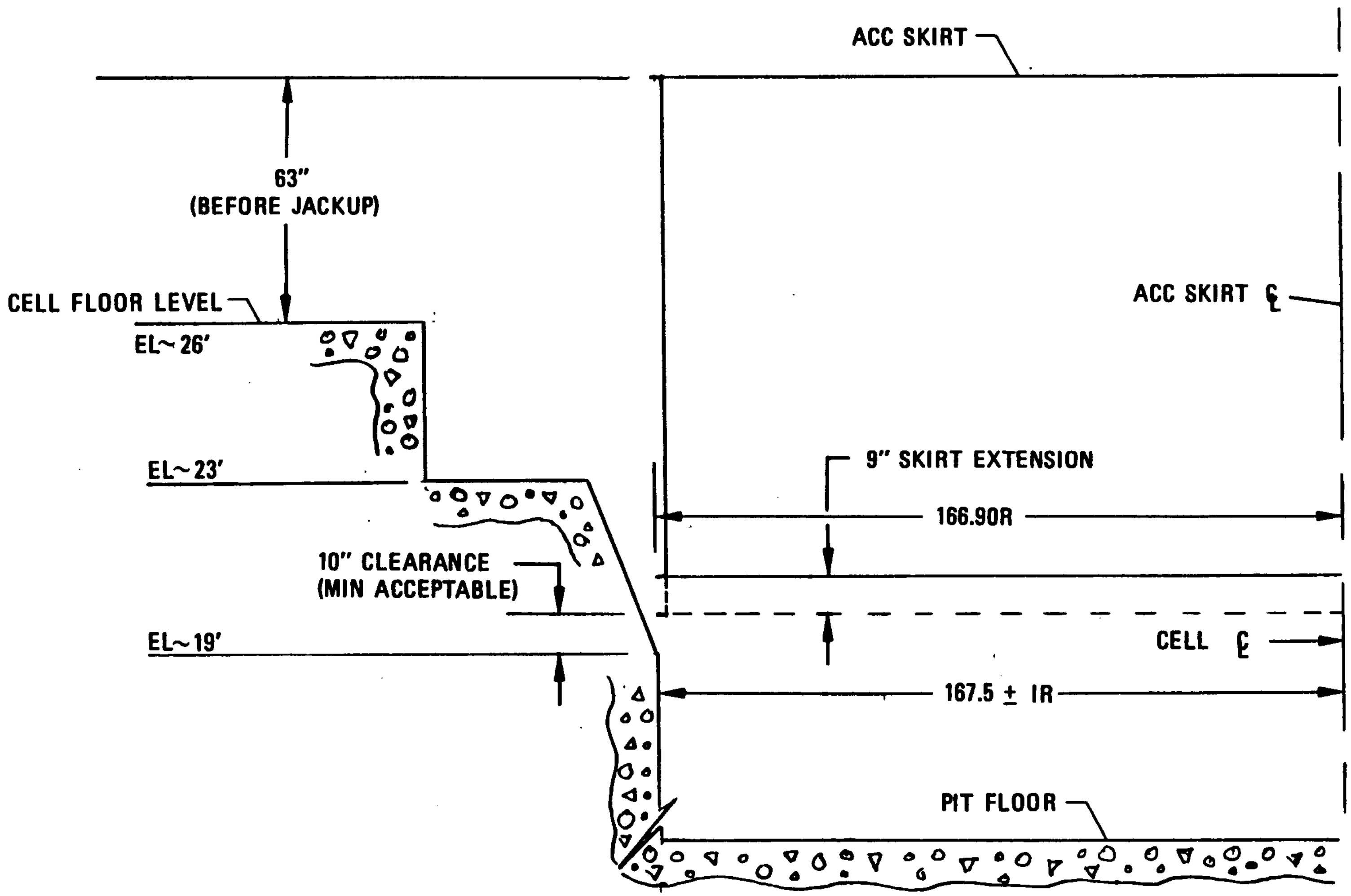
DACC/CELL B – CLEARANCE

The DACC skirt-to-Cell B clearances are shown. In order to increase the depth of the PS beams, the skirt length was extended to the minimum acceptable clearance level for Cell B in the MAF Vertical Assembly Building.

DACC/Cell B - Clearance



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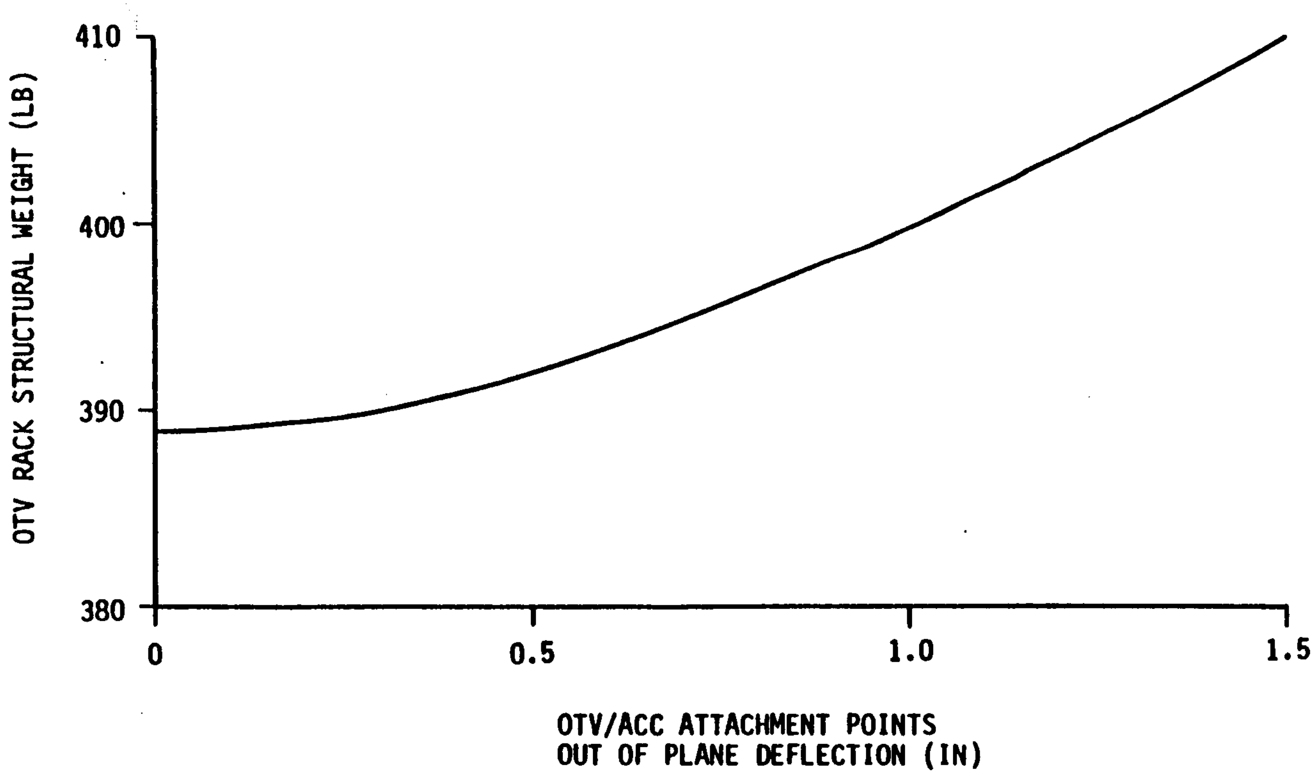
OTV RACK WEIGHT VS INTERFACE OUT-OF-PLANE DEFLECTION (9-DOF INTERFACE RESTRAINT)

This curve shows the OTV aluminum rack weight vs the OTV/ACC I/F out-of-plane deflection for the 9-DOF restraint I/F. By going from the baseline configuration to the 25.5 in. parallel beam, the I/F out-of-plane deflection is reduced from 1.5 in. to 0.5 in. This reduction results in a saving of 18 lb in the OTV rack structure.

OTV Rack Weight vs Interface Out of Plane Deflection



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WEIGHT SUMMARY

The OTV support beam trade study resulted in a net weight savings for both the DACC and OTV.

Weight Summary

o DACC BEAM WEIGHT SAVINGS (APPROXIMATELY 36 LB/BEAM)	145 LB
o DACC SKIRT WEIGHT PENALTY (9" INCR)	60 LB
o NET DACC WEIGHT SAVINGS	85 LB
o OTV WEIGHT SAVINGS (1.5" TO 0.5" DEFLECTION)	18 LB

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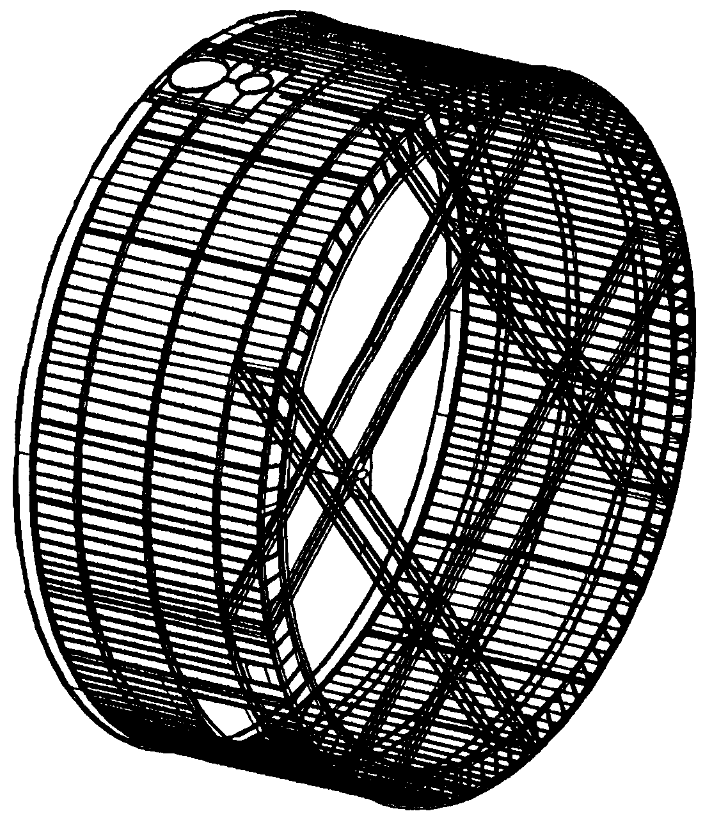
DACC SKIRT

The skirt (approximately 11 ft long) is a builtup aluminum structure consisting of skins reinforced by Z-stiffeners and three intermediate Z-rings. This structural element (containing the payload support beams) is the I/F between the ET and the cargo element.

DACC Skirt



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DACC SKIRT STRUCTURAL DRAWINGS

This list contains all preliminary drawings relating to the DACC skirt assembly and includes: the drawing number, a brief description of the drawing content and the total number of sheets for each drawing.

DACC Skirt Structural Drawings

DRAWING DESCRIPTION	DRAWING NUMBER	NO. OF SHEETS
0 XT2194 FRAME ASSY	826AP00335	1
0 SKIN PANELS AND DETAILS	826AP00336	7
0 STRINGER DETAILS	826AP00337	2
0 LH2 FEEDLINE CVR	826AP00338	1
0 FRAMES XT2062 THROUGH XT2194 DETAILS	826AP00339	17
0 LONGERON DETAILS	826AP00340	2
0 SKIRT ASSEMBLY	826AP00341	1
0 SKIN PANEL LOCATIONS	826AP00343	1

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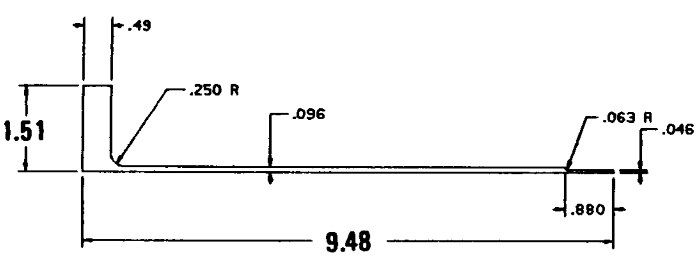
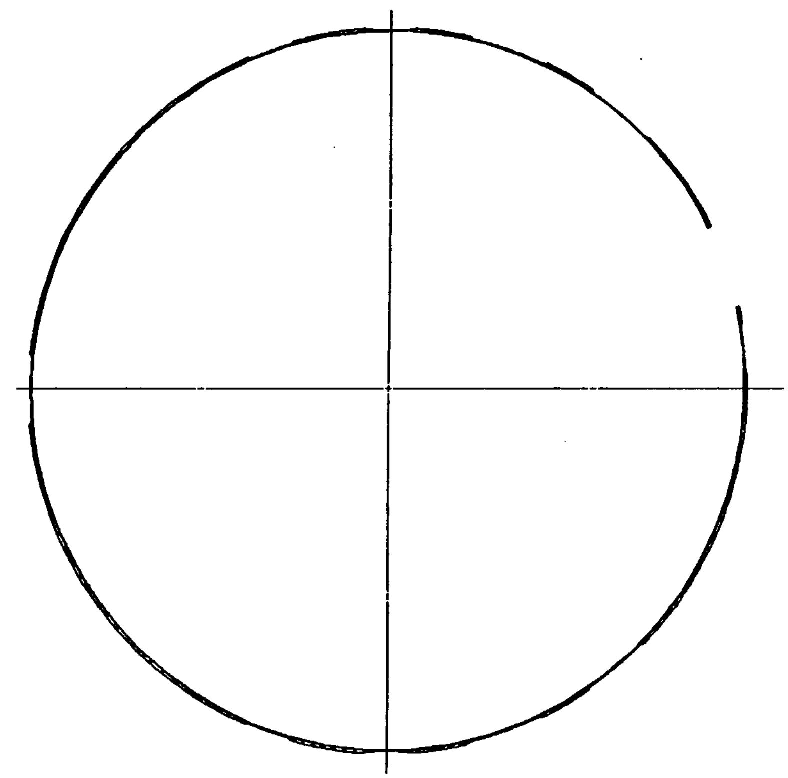
ET/DACC ATTACHMENT FLANGE

The attachment flange provides the structural I/F for the DACC skirt to the ET at X_T2062.65. The attachment flange is composed of four ring segments and contains a total of 137 bolt holes. The holes are located on a pitch circle radius of 166.21 in.

ET/DACC Attachment Flange



TYPICAL SECTIONAL VIEW



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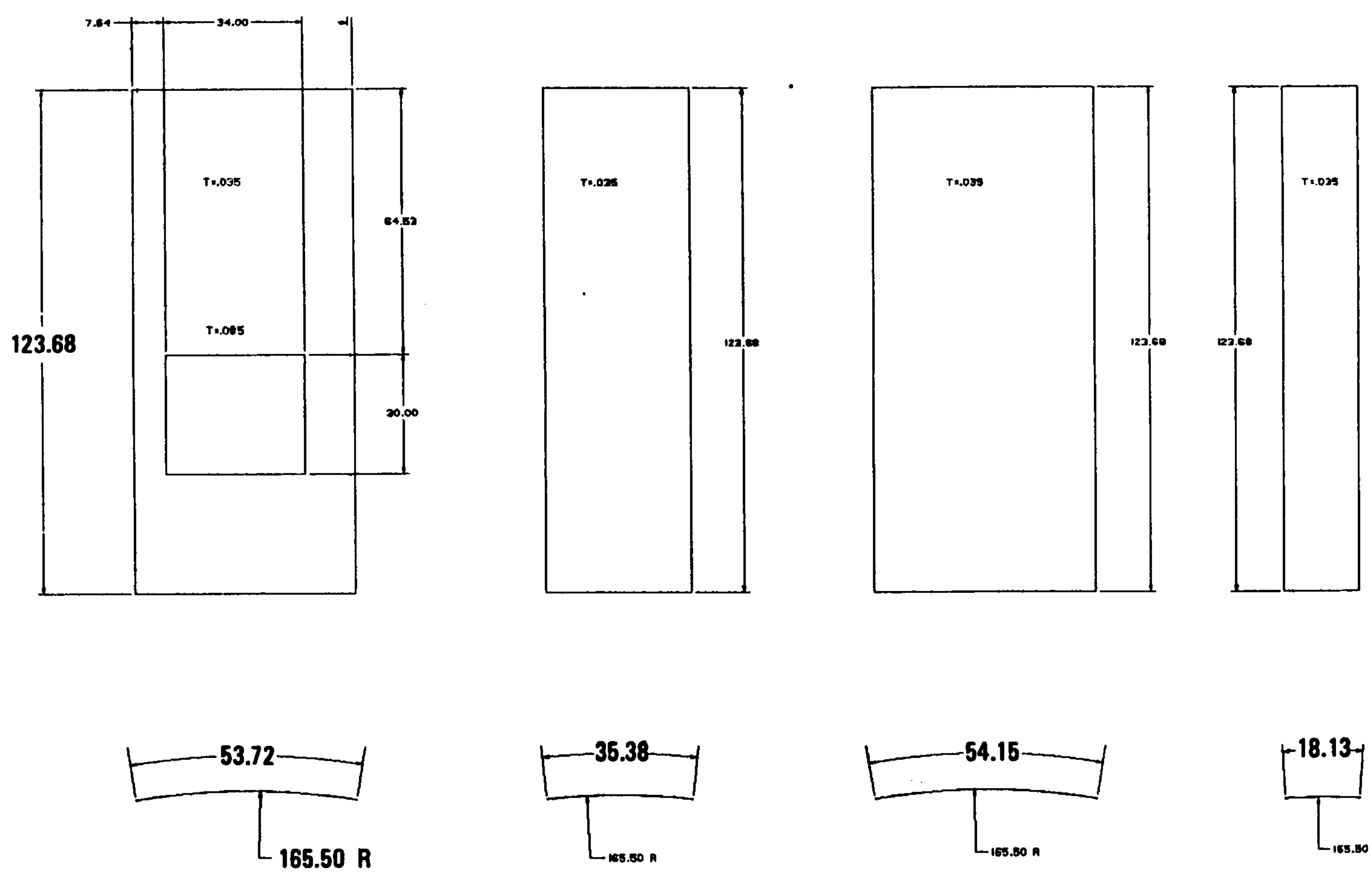
BARREL SKIN PANELS (PLAIN)

The skirt cylindrical section contains eight plain skin panels, 123.68 in. long. The panels are cut from aluminum stock 0.035 in. thick with varying circumferential widths. The skin panels are located in those areas not subjected to the payload support beam end loads. The access door opening (30 in. X 34 in.) is in one of these panels.

Barrel Skin Panels (Plain)



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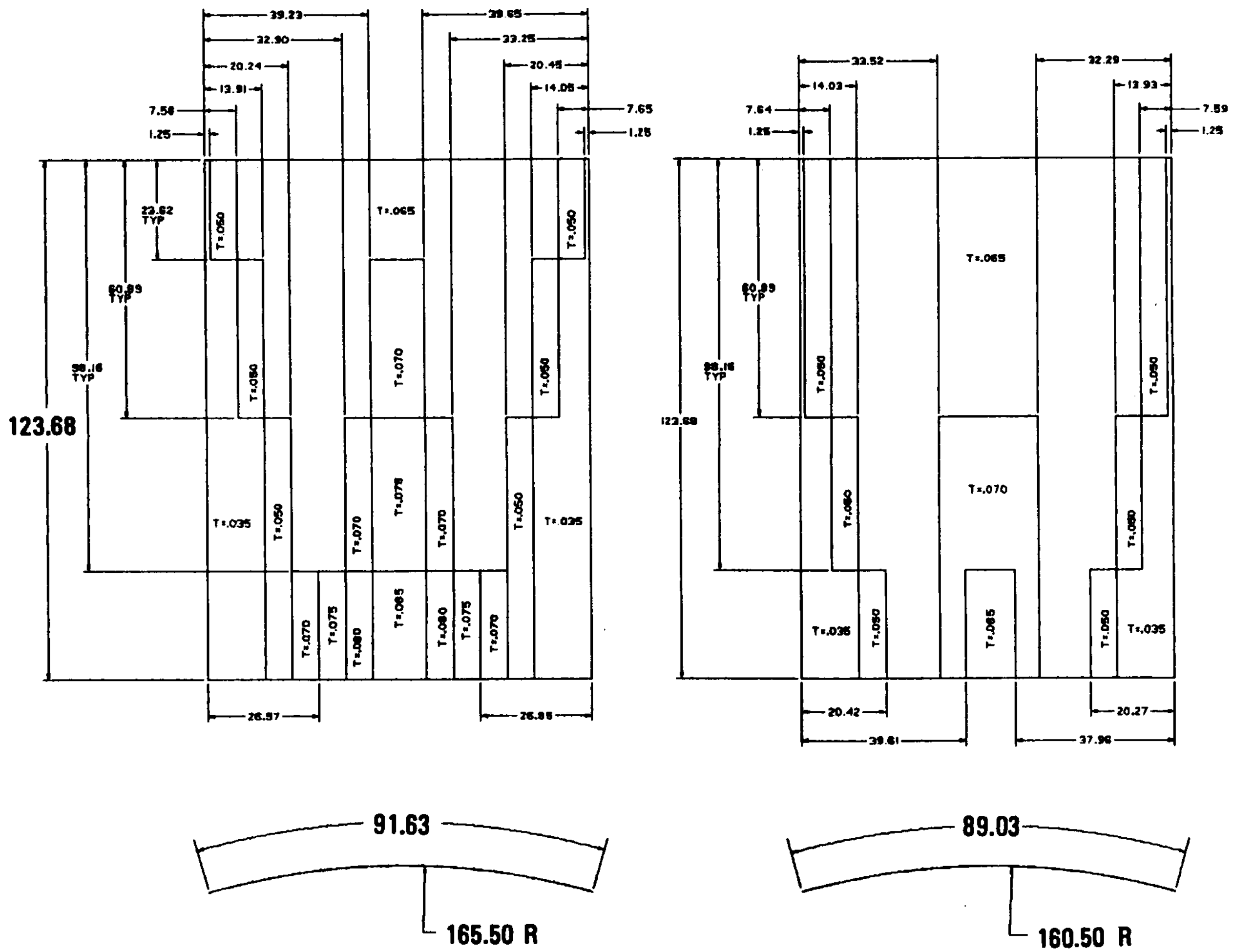
BARREL SKIN PANELS (REINFORCED)

The skirt cylindrical section contains eight reinforced skin panels which are 123.68 in. long. The panels are chem milled from stock aluminum to the various required thicknesses which are driven by the payload support beam end loads.

Barrel Skin Panels (Reinforced)



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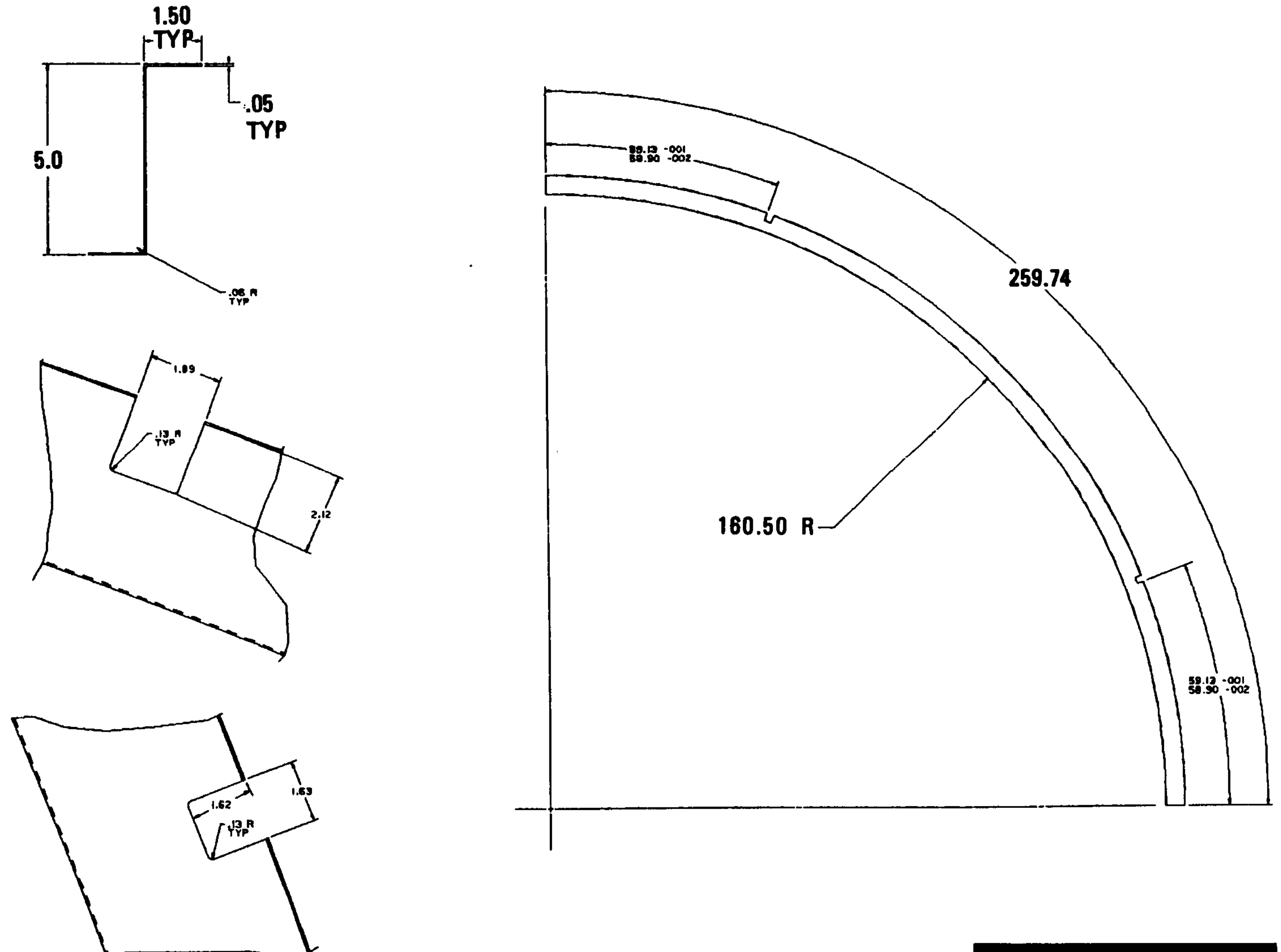
Z-RING

A typical Z-ring quarter segment is shown. The 5 in. deep ring is formed from 0.050 in. thick stock aluminum. The ring is notched to allow installation over the LO2 and LH2 longerons.

Zee Ring



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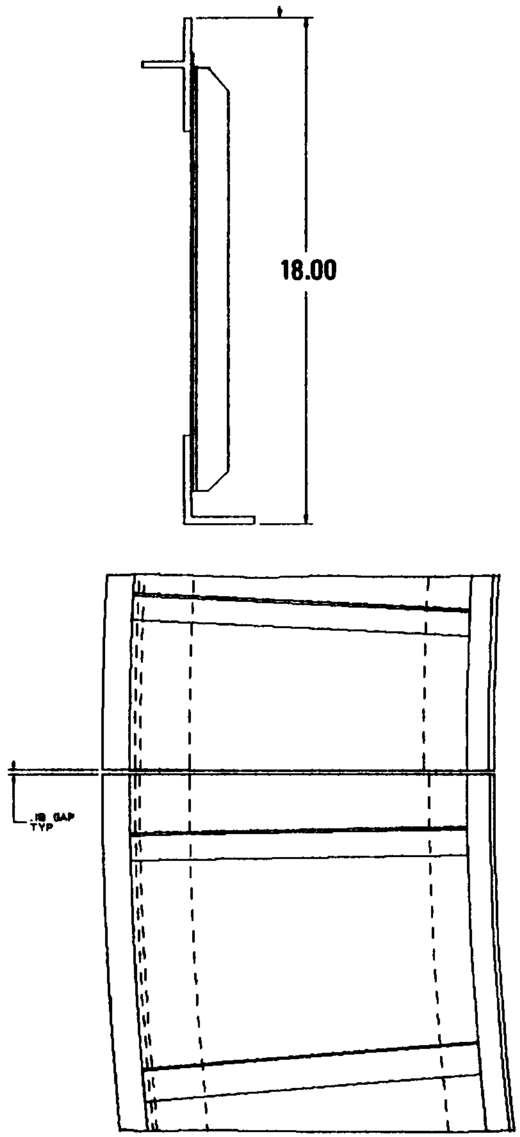
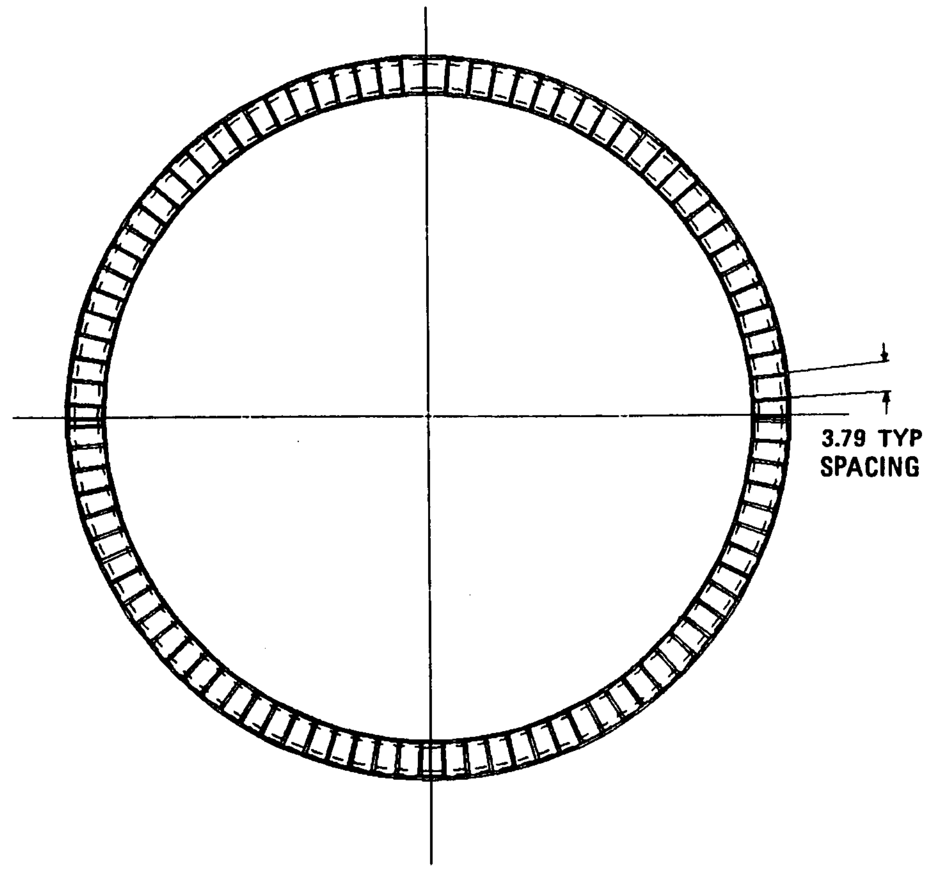
X_T2194 RING FRAME

The X_T2194 ring frame reacts the beam and skirt loads and also provides the attachment I/F between the skirt and shroud structure. The frame depth is 18 in. and contains web stiffeners located on 3.79 in. spacing.

XT 2194 Ring Frame





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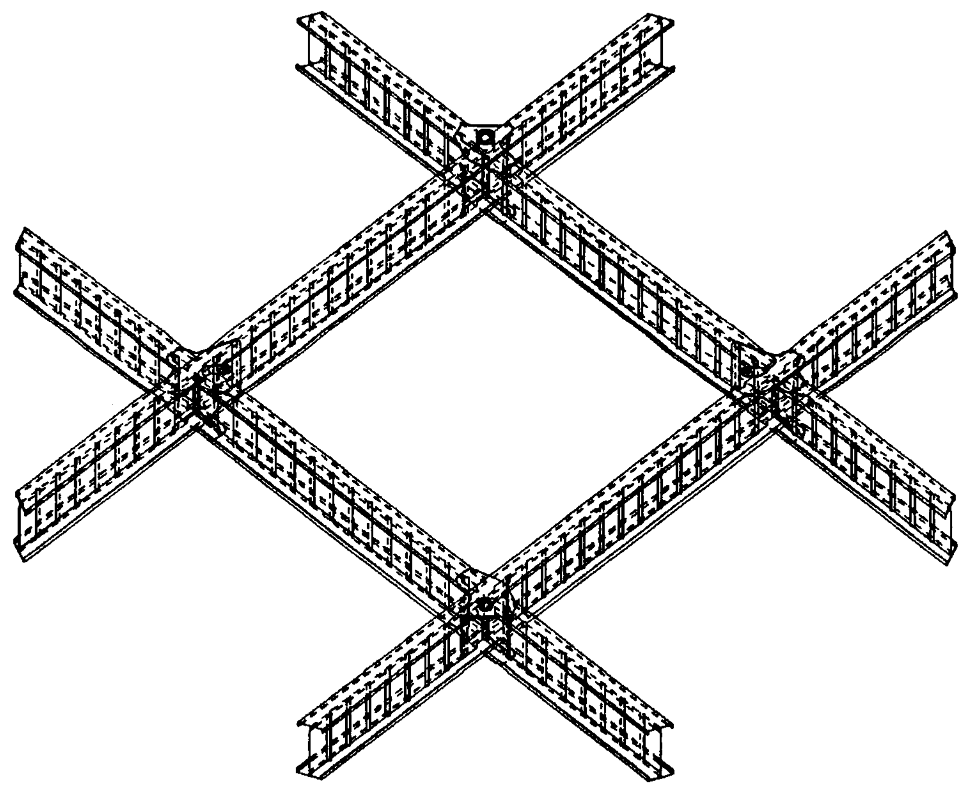
DACC PAYLOAD SUPPORT BEAMS

The double cruciform beam arrangement consists of two continuous beam assemblies and two segmented beam assemblies.

DACC Payload Support Beams



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DACC PAYLOAD SUPPORT BEAM STRUCTURAL DRAWINGS

This list contains all preliminary drawings related to the DACC payload support beam assembly and includes: the drawing number, a brief description of the drawing content and the total number of sheets for each drawing.

DACC Payload Support Beam Structural Drawings

DRAWING DESCRIPTION	DRAWING NUMBER	NO. OF SHEETS
0 PAYLOAD BEAM FWD CAP	826AP00307	4
0 PAYLOAD BEAM AFT CAP	826AP00308	3
0 PAYLOAD BEAM WEB	826AP00309	3
0 PAYLOAD BEAM MISC DETAILS	826AP00310	14
0 CONT.-BEAM ASSY	826AP00323	2
0 SEGMENT BEAM ASSY	826AP00324	2
0 PAYLOAD BEAM ASSY	826AP00334	3
0 OTV EXPLOSIVE NUT/ THRUSTER DETAILS	826AP00342	1

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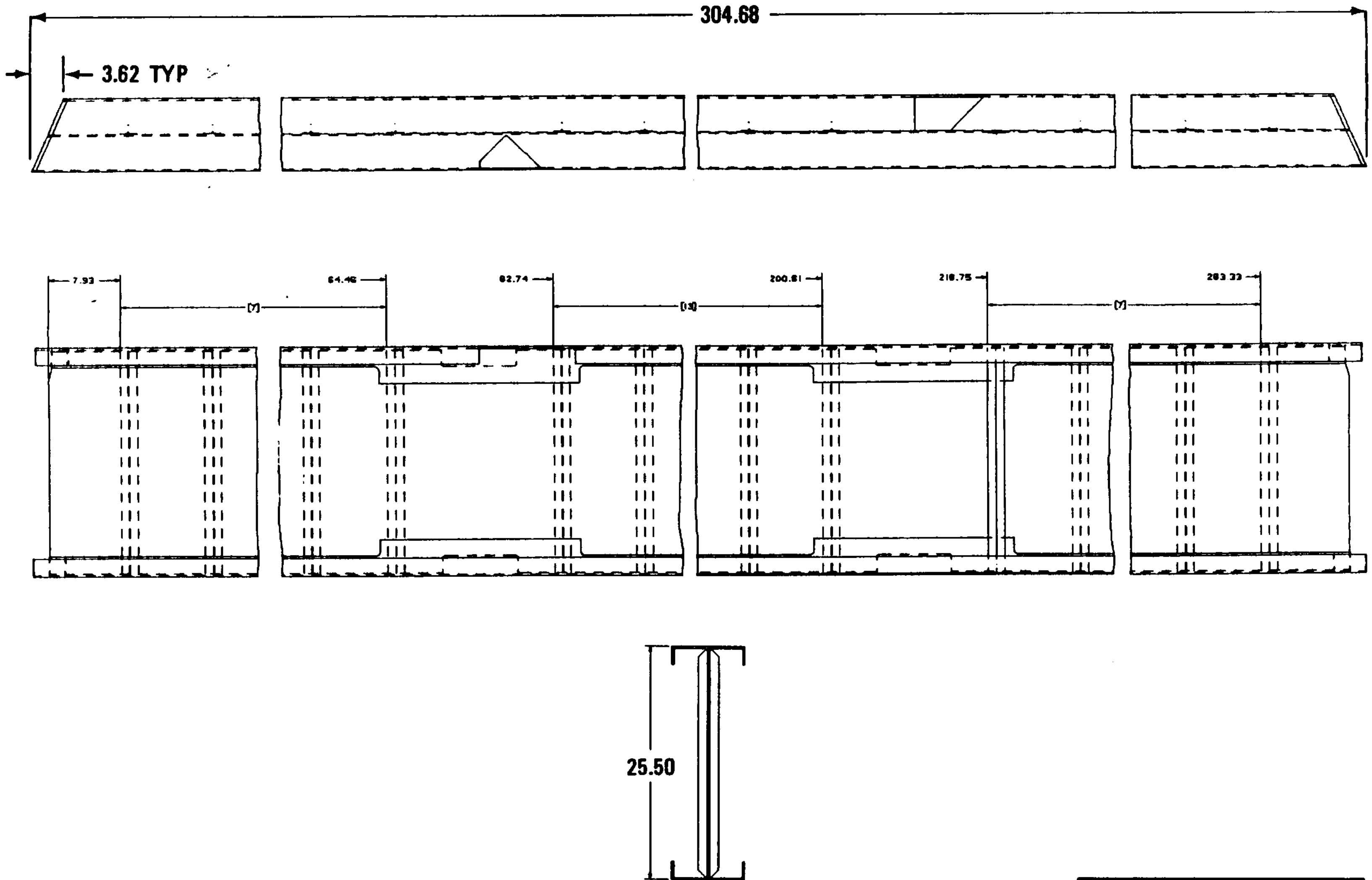
PAYLOAD SUPPORT BEAM

The payload support beam is 25.5 in. deep and approximately 300 in. long. It is a builtup structure consisting of forward and aft cap sections, a web, and web stiffeners.

Payload Support Beam



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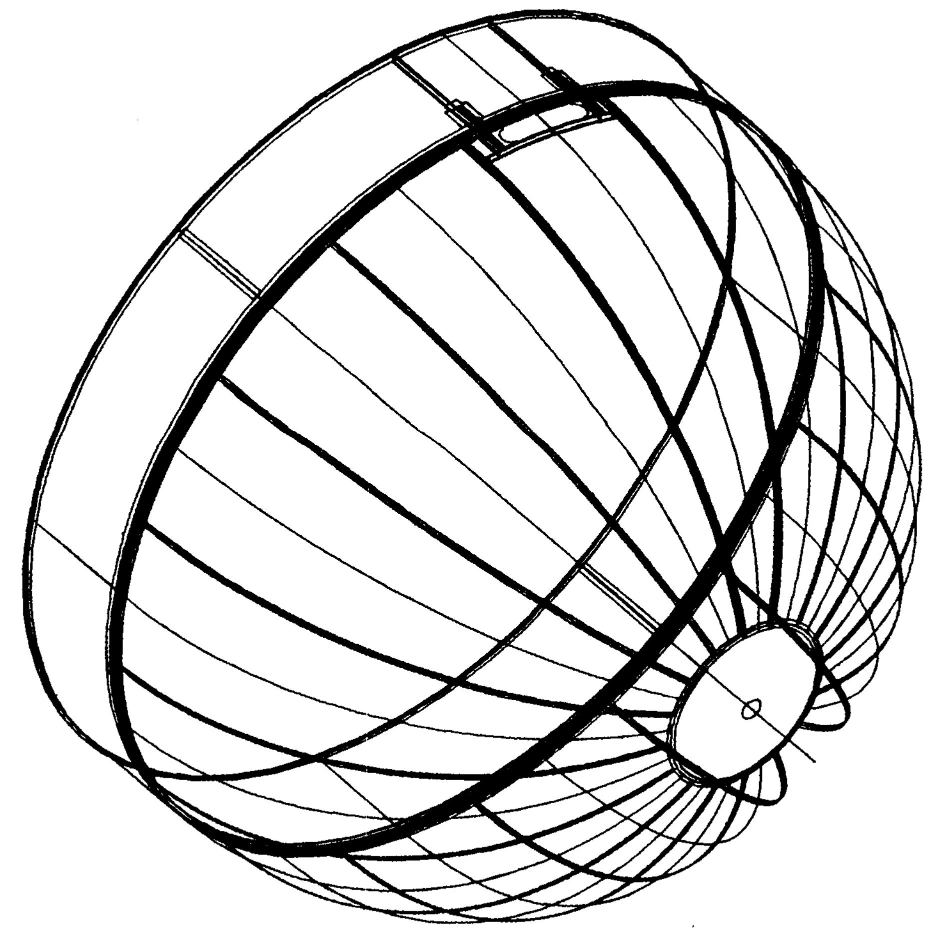
DACC SHROUD

The shroud is a riveted aluminum structure consisting of a cylindrical section and hemispherical dome section. The shroud is approximately 18 ft long. This structural element protects the OTV during the launch and ascent flight phases.

DACC Shroud



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DACC SHROUD STRUCTURAL DRAWINGS

This list contains all preliminary drawings related to the DACC shroud assembly and includes: the drawing number, a brief description of the drawing content and the total number of sheets for each drawing.

DACC Shroud Structural Drawings

DRAWING DESCRIPTION	DRAWING NUMBER	NO. OF SHEETS
o XT2194 FRAME	826AP00311	1
o SEPARATION JOINT	826AP00312	2
o BARREL SKIN PANEL	826AP00314	1
o BARREL SKIN PANEL BUTTSTRAP	826AP00315	1
o DOME GORE PANEL	826AP00316	1
o DOME CAP	826AP00317	1
o DOME GORE BUTTSTRAP	826AP00318	1
o SHROUD ASSEMBLY	826AP00319	4
o AFT HINGE FITTING	826AP00320	1
o FWD HINGE FITTING	826AP00321	1
o HINGE SUPPORT DETAILS	826AP00322	9
o DOME CAP ATTACHMENT DETAILS	826AP00325	4

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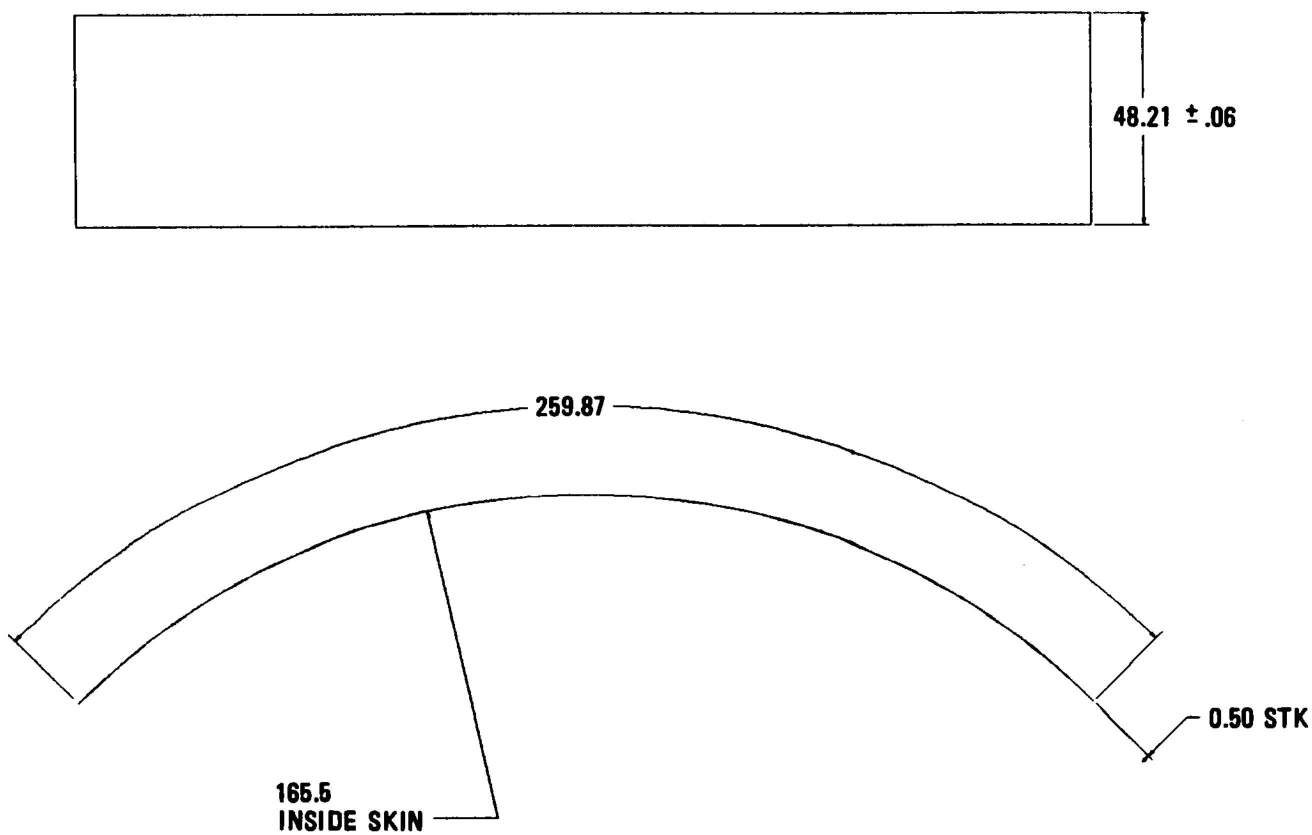
BARREL SKIN PANEL

The shroud barrel section is composed of four skin panels, 48.21 in. X 259.87 in. The panels are formed from stock aluminim which is 0.050 in. thick.

Barrel Skin Panel



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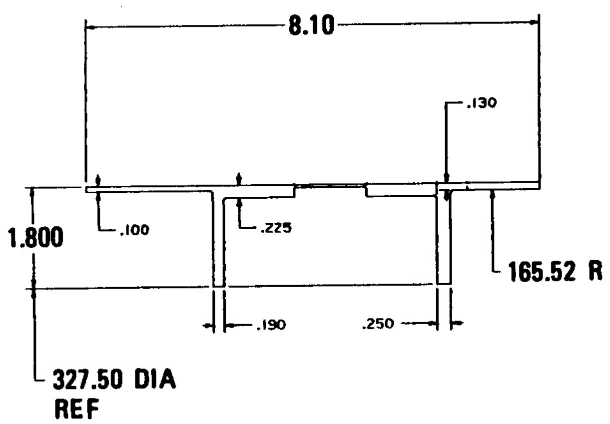
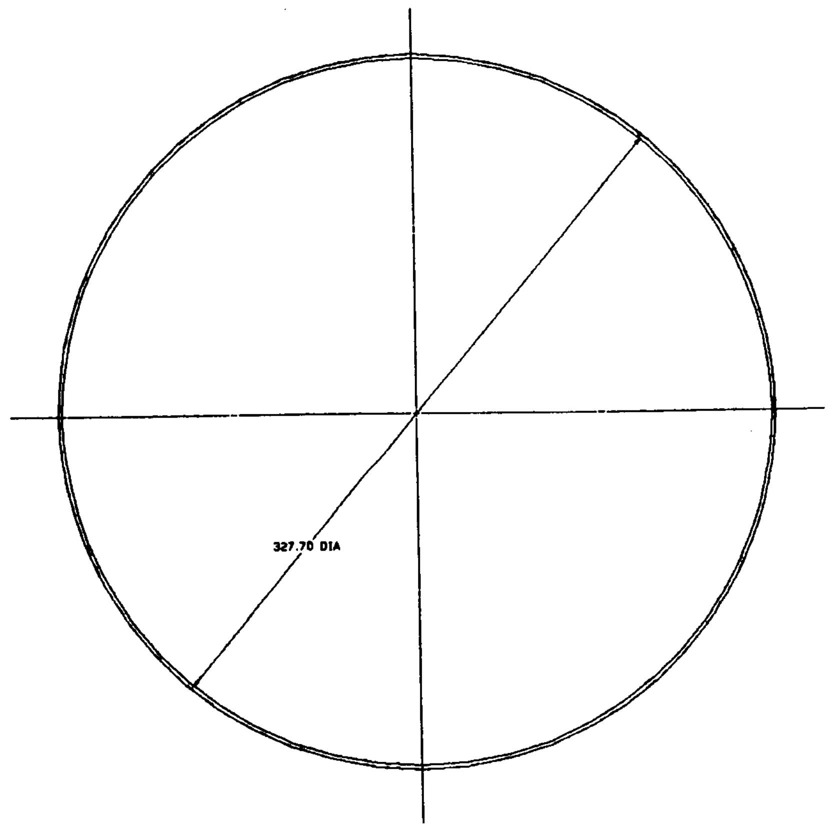
SEPARATION JOINT

To allow staging of a portion of the shroud during flight, an aluminum extrusion (containing the cavity for the expanding tube charge) is riveted into the shroud structure between the cylindrical and hemispherical sections at X_T2245.954. The cavity is closed out by installing a frangible plate to the inner surface of the extrusion.

The extrusion also has stiffening flanges (1.8 in. deep) which stabilize the shroud shape at staging and prevent impact with the OTV.

Separation Joint





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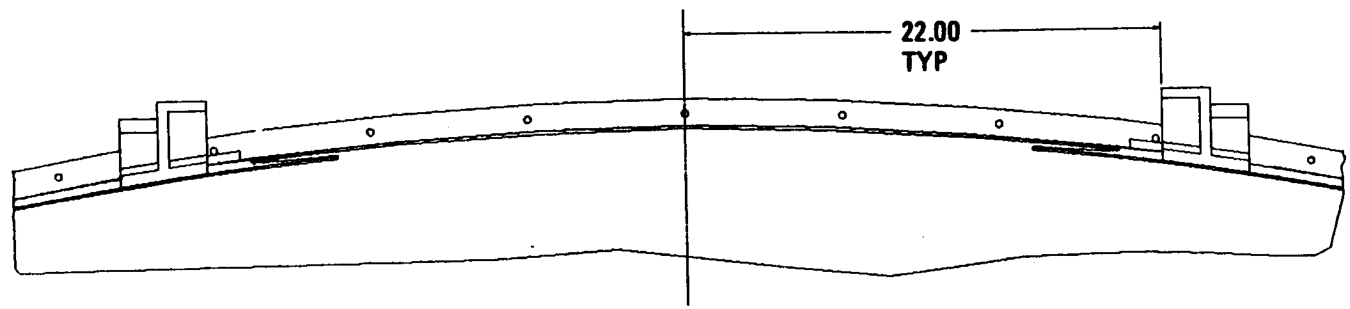
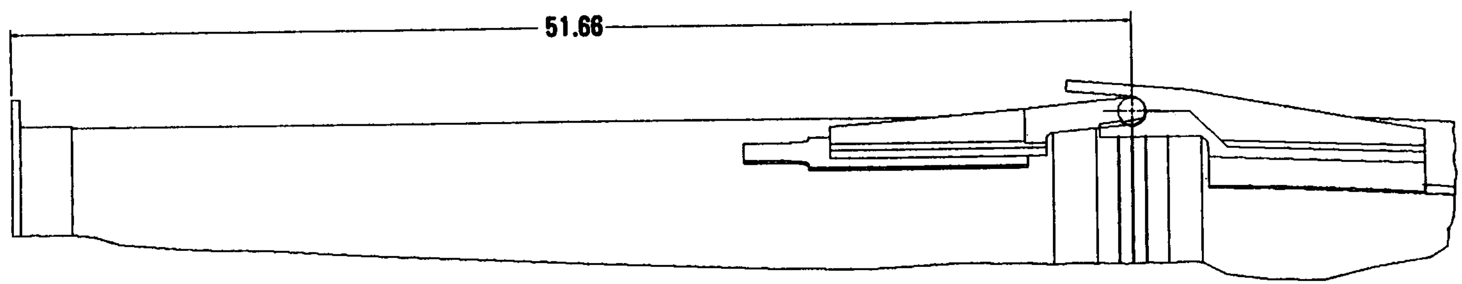
SEPARATION HINGES

The shroud is hinged to provide controlled initial clearance between the staged portion of the shroud and the OTV. The two hinges release after rotating 14.5°, the angle required to align the staged shroud longitudinal centerline parallel to the SSV thrust vector. The hinges are installed across the $X_T 2245.95$ separation plane at $Y = \pm 22.0$ in.

Separation Hinges





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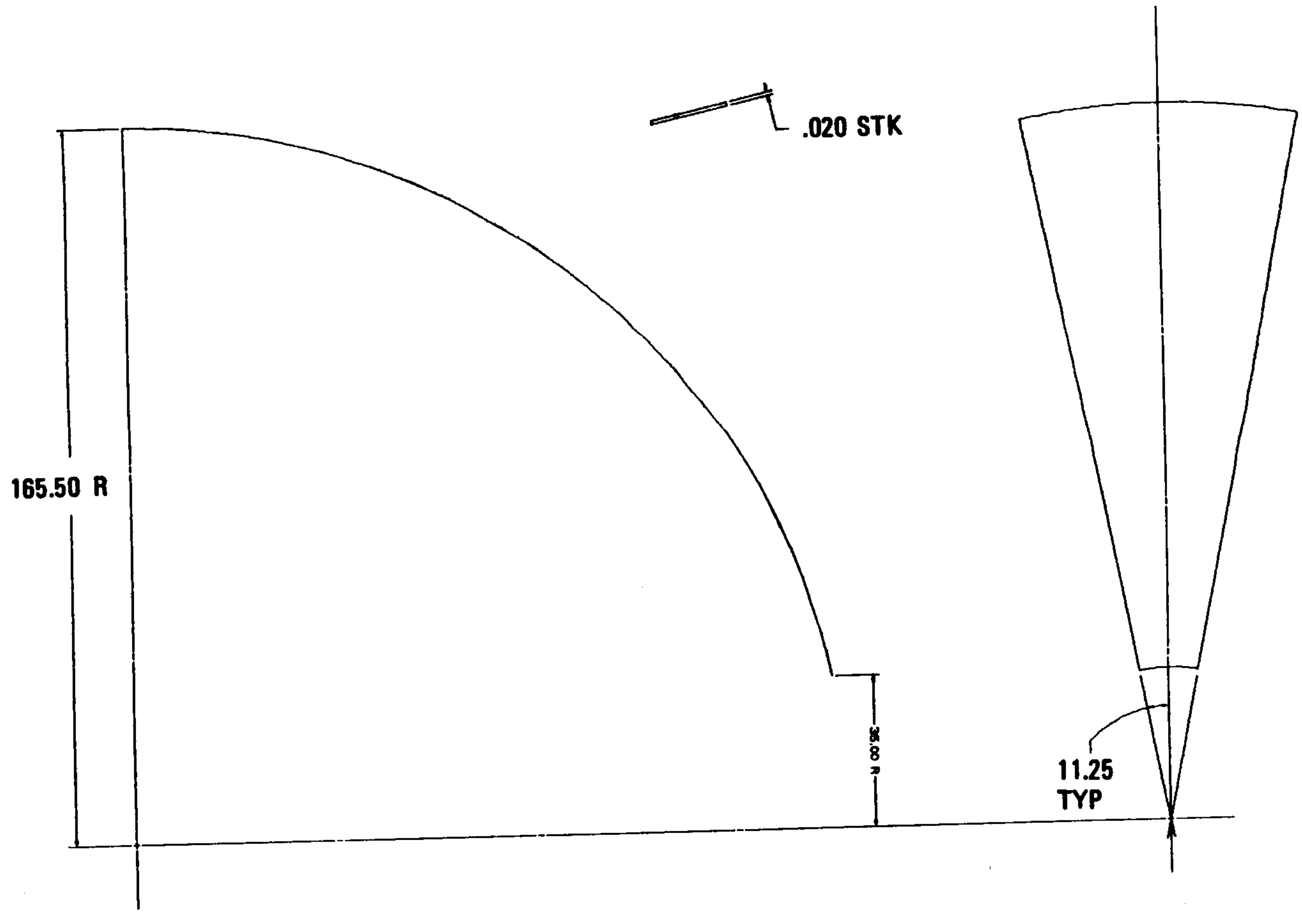
DOME SKIN GORE

The shroud dome section is composed of 16 gore sections. Each gore is cut from stock aluminum which is 0.020 in. thick.

Dome Skin Gore



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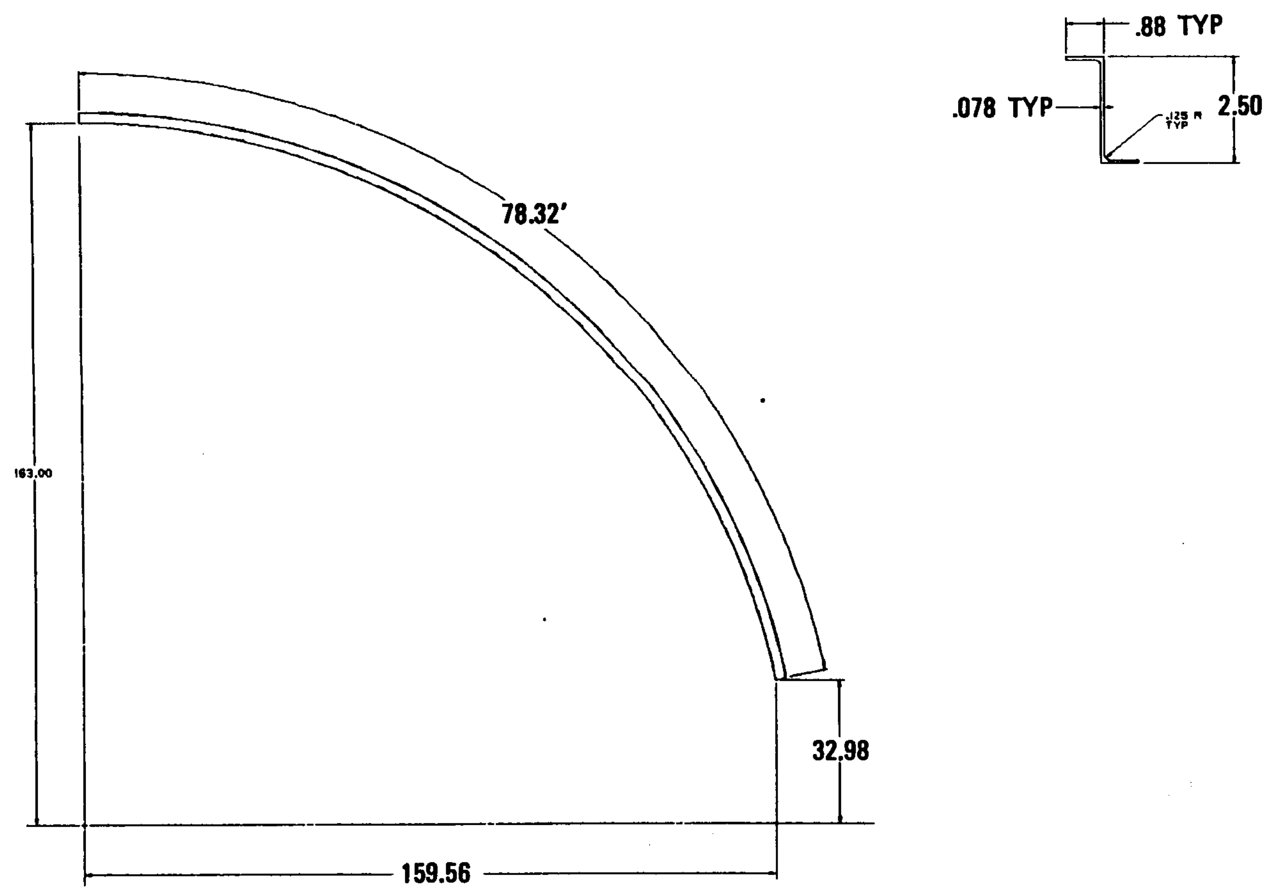
AFT HINGE SUPPORT Z-SECTION

The staged portion of the DACC shroud has two beams installed to the inside surface of the dome section. These beams react the hinge loads at staging. Each beam is a Z-section, 2.5 in. deep.

Aft Hinge Support Zee



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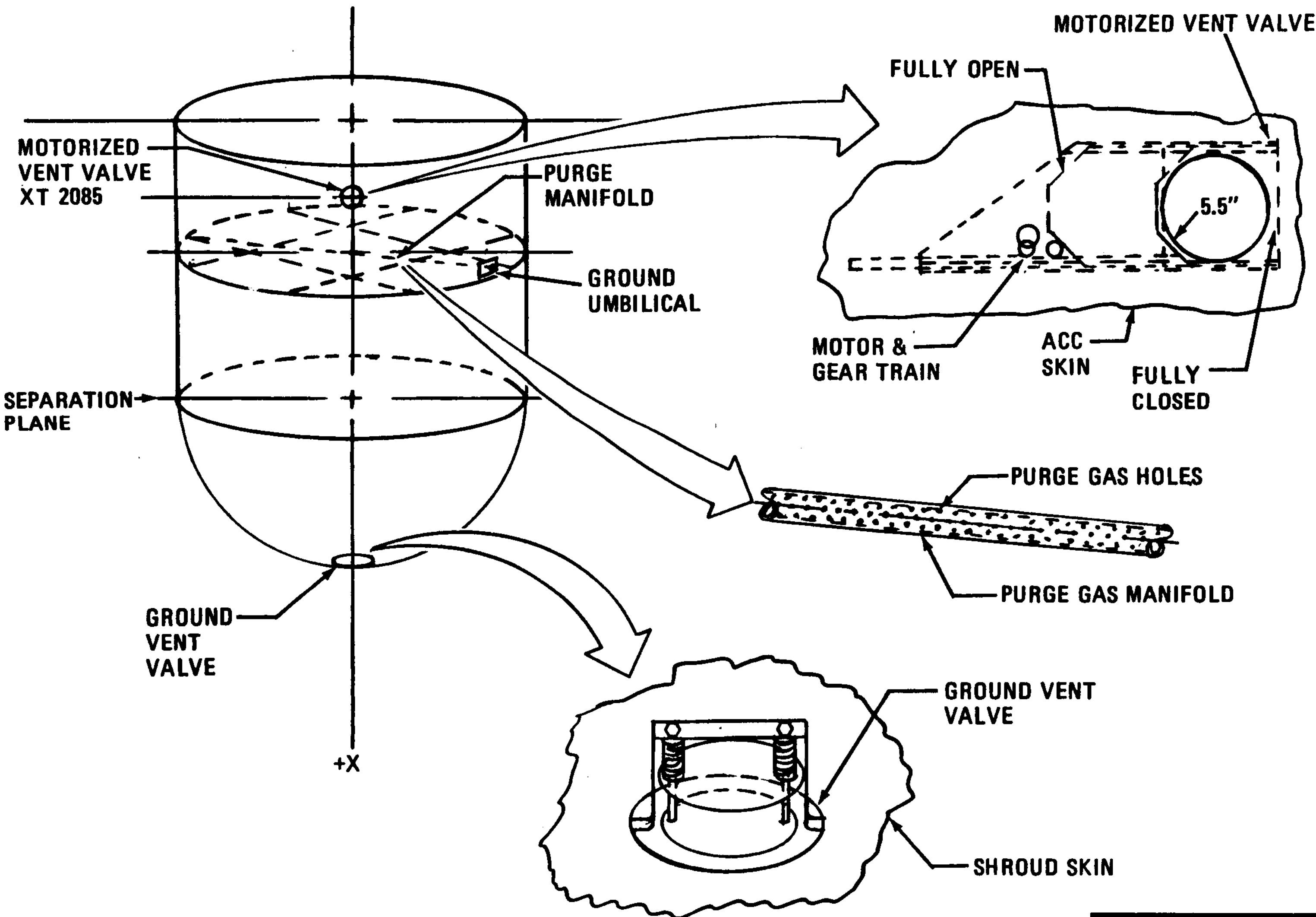
DACC PURGE AND VENT SYSTEM

The selected purge and vent system for the pressurized DACC design is shown.

The purge system supplies air, GN2 and He for various operational sequences. Gaseous nitrogen is used for compartment inerting prior to OTV propellant loading. At T-2:09 hours, the purge is changed to He.

The internal volume is vented prior to T-2 minutes through vent openings in both the skirt and shroud. At T-2 minutes, the shroud vent valve is closed by a motorized lanyard concept located on the MLP deck. During flight, the skirt vent opening is controlled by a motorized vent valve.

DACC Purge and Vent System



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DACC MAIN PROPULSION FLUIDS SYSTEM

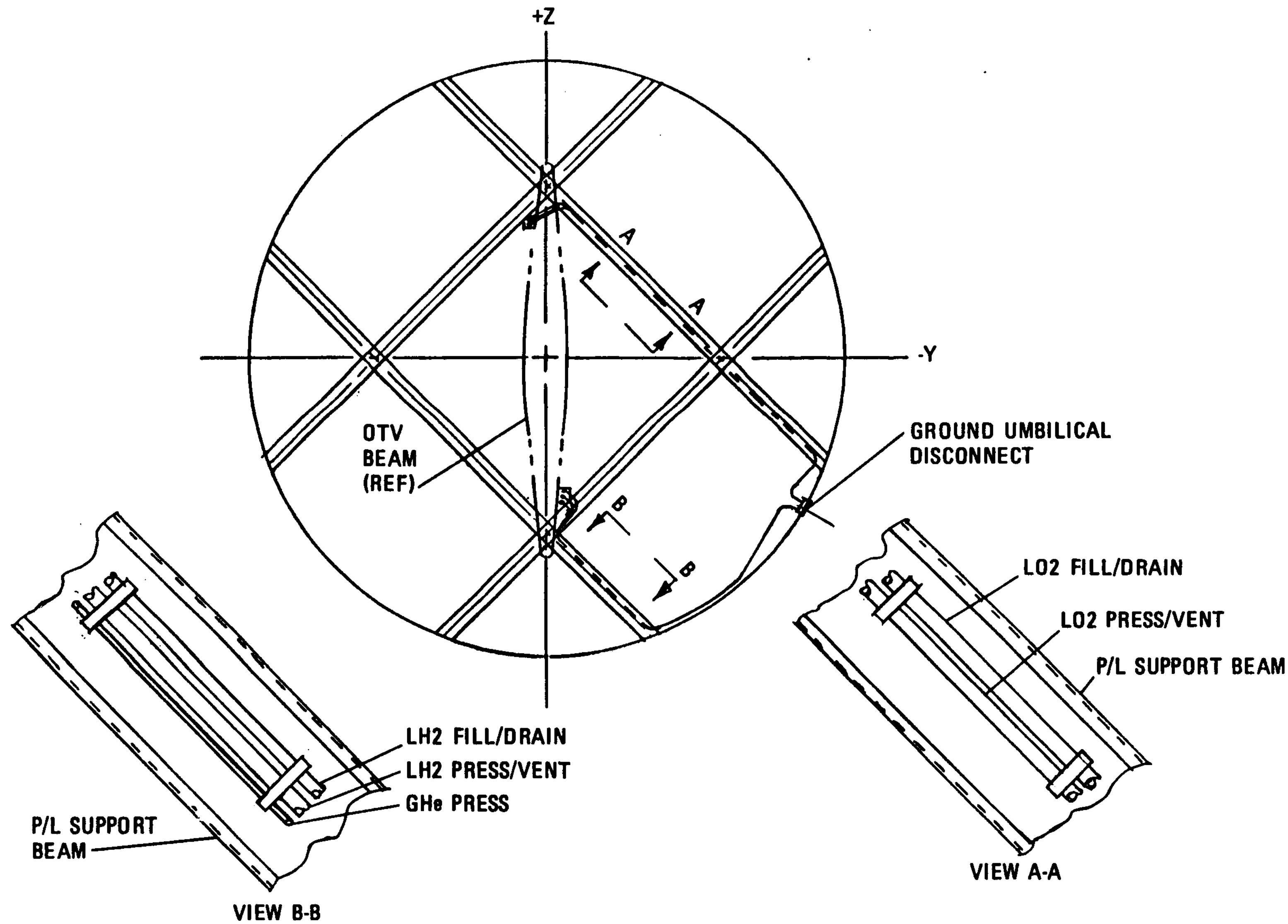
The LO2 and LH2 are transferred from the DACC dual umbilical disconnect area (AGUCP) to the OTV LO2 and LH2 tanks via the lines shown.

The LO2 and LH2 on pad tank pressurization is accomplished through one line to each tank.

Inflight venting utilizes the same line used for pressurization on the ground. On pad venting also uses the ground pressurization line.

Gaseous helium to pressurize the GHe bottle is transferred from the AGUCP to the bottle via the GHe pressurization line.

DACC Main Propulsion Fluids System



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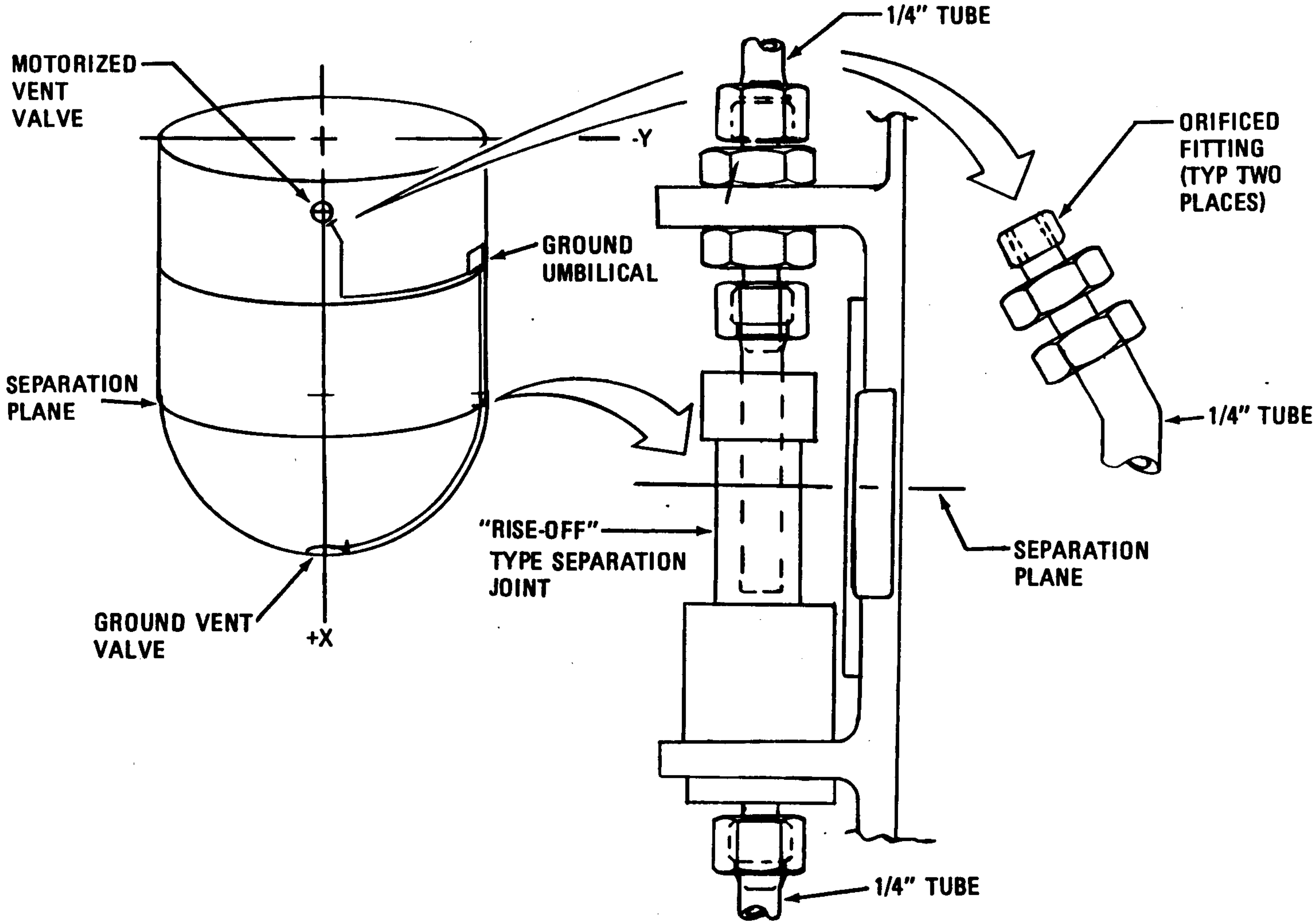
DACC HAZARDOUS GAS DETECTION SYSTEM

Hazardous gas "sniffers" are placed in the vicinity of the motorized vent valve and the ground vent valve. The sniffers' in-take is routed through the AGUCP to a hazardous gas analyzer on the facility.

A rise-off type separation joint allows the aft HGDS lines and fittings to pull free at DACC shroud separation.

DACC Hazardous Gas Detection System



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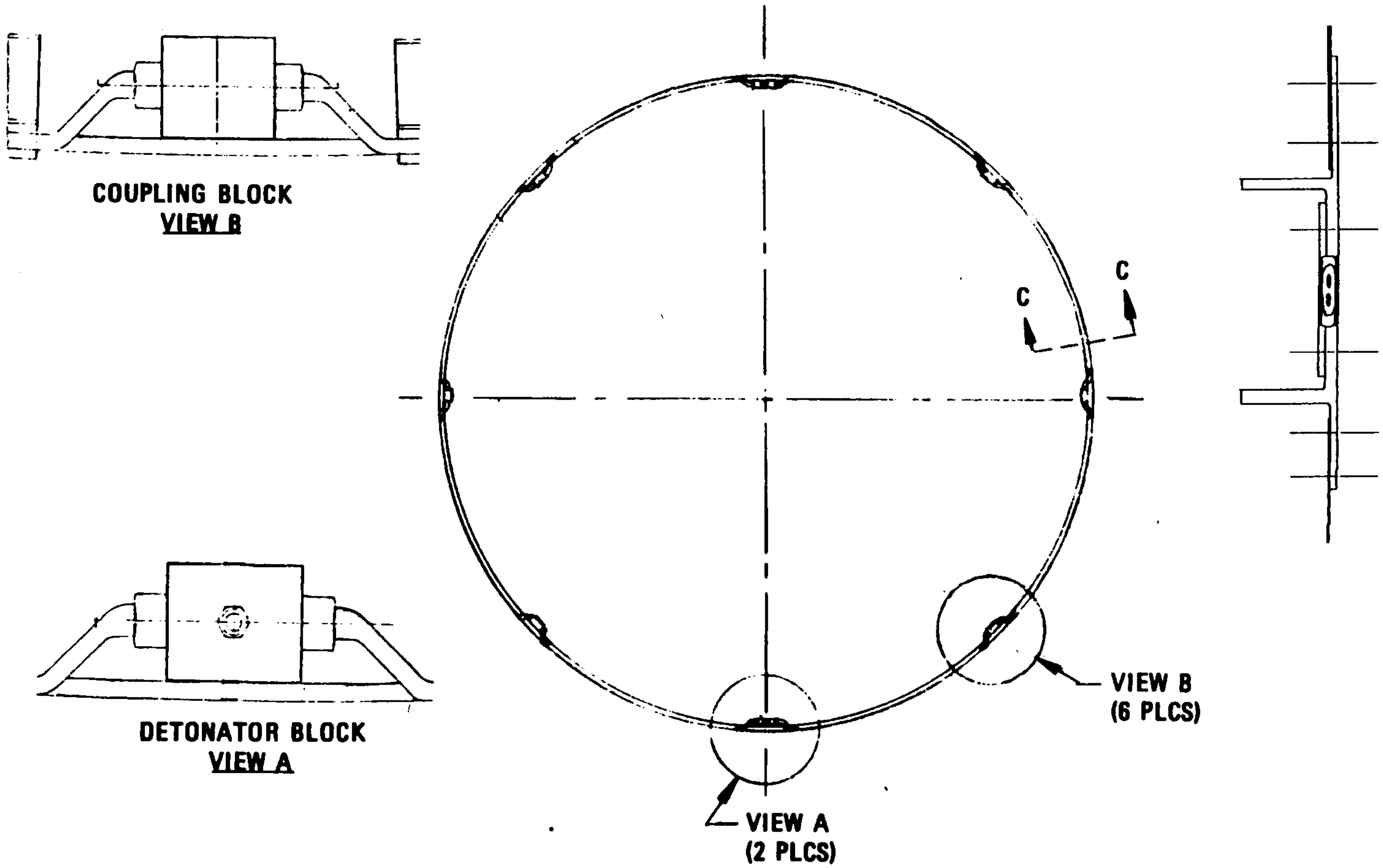
SHROUD SEPARATION ORDNANCE SUBSYSTEM

The shroud separation ordnance is designed to fracture the structural joint between the retained and staged portions of the shroud.

Initiation is accomplished through two PICs, two NSIs, a safe and arm device, and two detonator blocks (placed 180^{o} apart). Coupling blocks join the equal lengths of the expanding tube charges together and assure explosive propagation across the joints.

Shroud Separation Ordnance Subsystem



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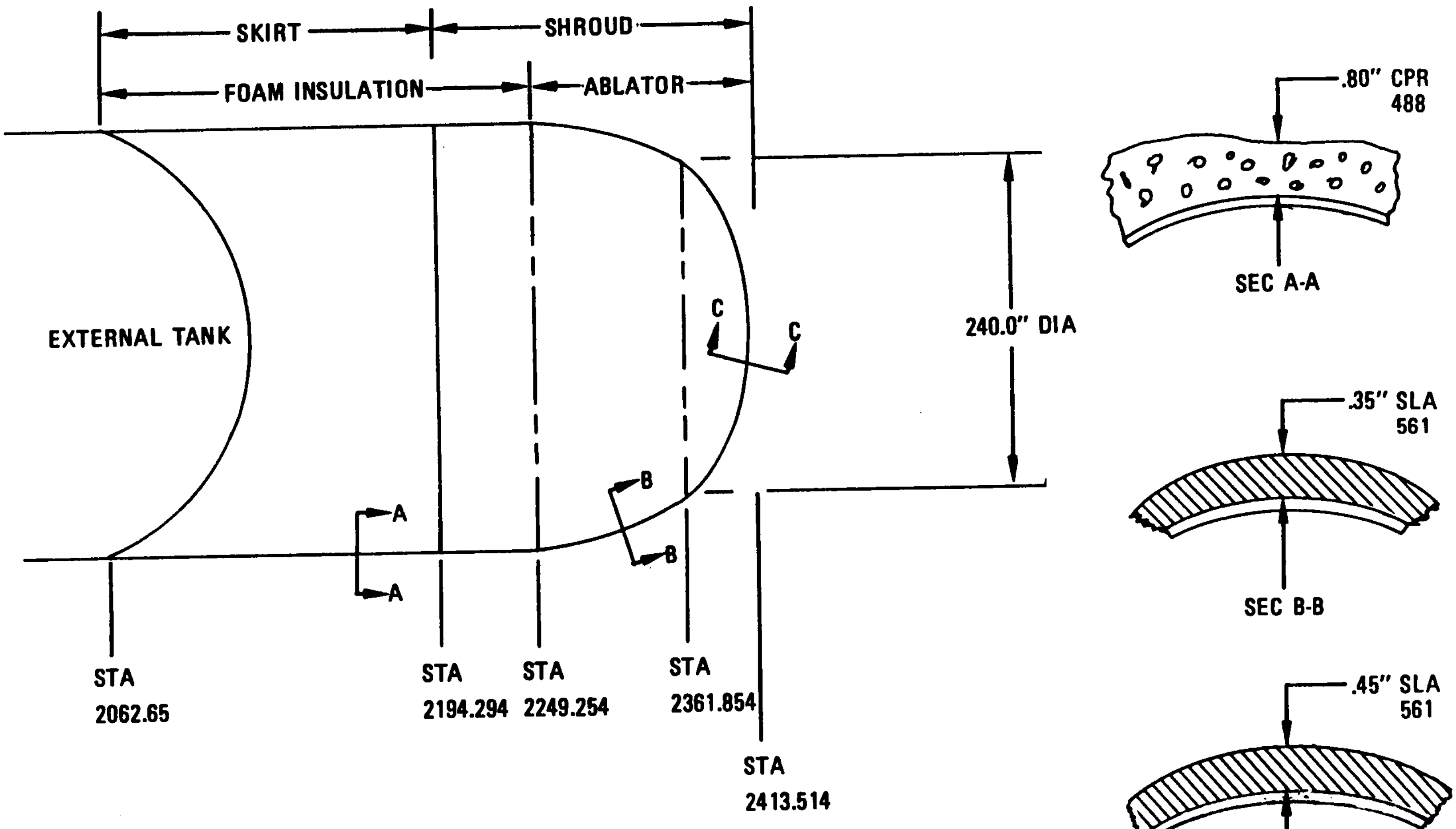
DACC THERMAL PROTECTION SYSTEM

The purpose of the TPS is to maintain the aluminum skin temperature at/below $350^{o}F$.

The skirt and cylindrical portion of the shroud have an 0.8 in. thick layer of CPR-488 SOFI. The hemispherical shroud dome is sprayed with SLA-561 ablator to a thickness of 0.35 in. over an area of 813 sq ft. The remaining dome area of 373 sq ft is sprayed to a thickness of 0.45 in.

The interface flange at X_T2062.65 is the only flange that requires a closeout for ice-frost conditions.

DACC Thermal Protection System



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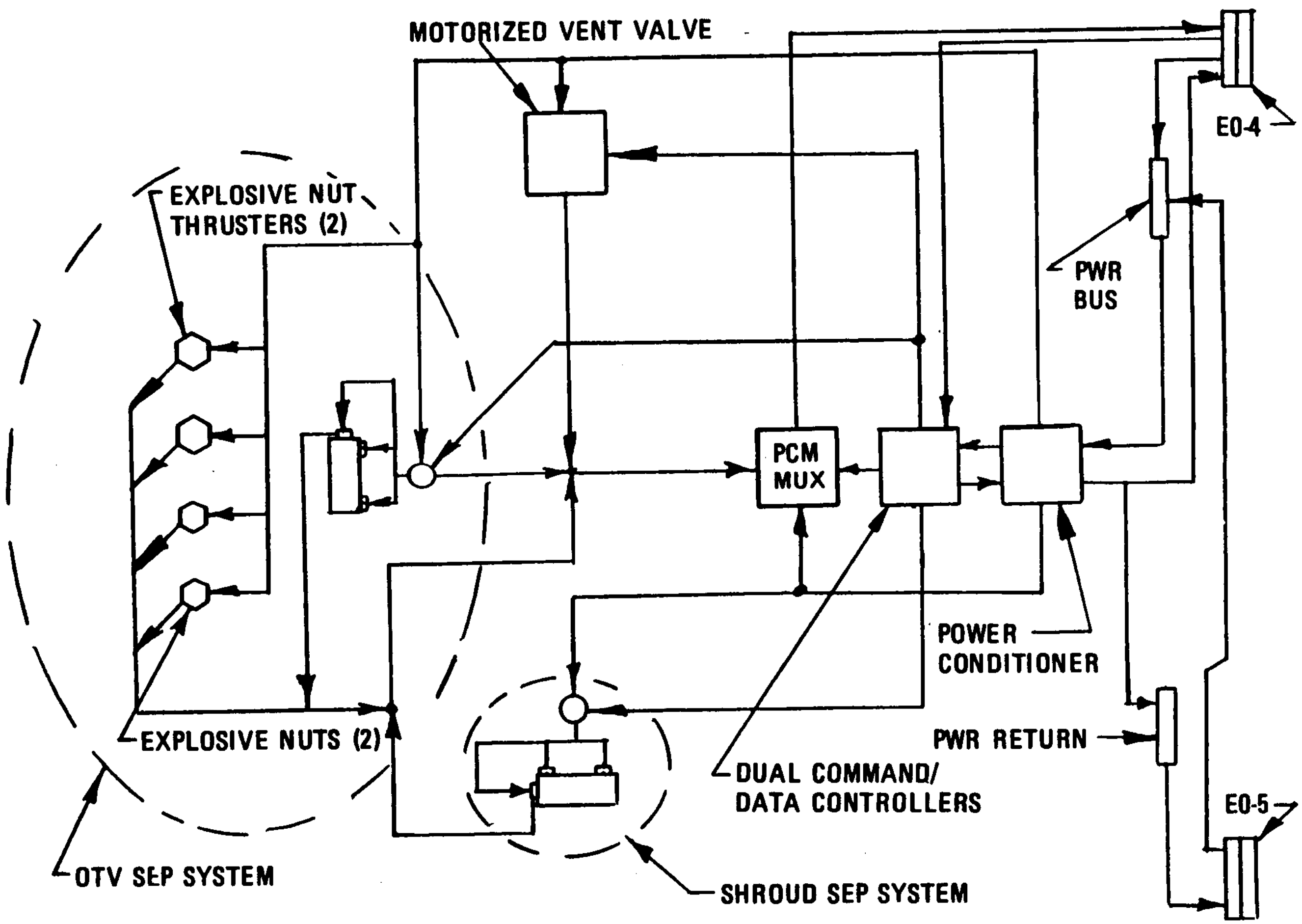
DACC AVIONICS SCHEMATIC

The DACC avionics system shares the dual command/data controllers and the PCM MUX with the cargo element. Redundant paths are provided for all critical commands and critical data. The DACC avionics system controls DACC shroud separation, the motorized vent valve position, and ignition of the OTV separation system.

DACC Avionics Schematics



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DACC WEIGHT SUMMARY

The weight summary is presented for the DACC, which is designed to carry a suborbitally released OTV. In addition to the total DACC weight and its functional breakdown, the weight is also shown for that part of the shroud which is staged during ascent.

The reported weights were established by estimating/calculating from detailed drawings, stress data, configuration layouts and subsystem descriptions. Within each functional weight breakdown, a weight allowance is estimated for inaccuracies in weight resulting from lack of detail in current design data.

The assembly attach hardware is that which is needed to mate the skirt to the ET, and the shroud to the PSS.

The growth figure is the predicted weight allowance for design and weight changes due to design deficiencies and manufacturing variations.

DACC Weight Summary

DESCRIPTION	WEIGHT (LB)	
SKIRT		3,121
STRUCTURE	2,616	
THERMAL PROTECTION	185	
AVIONICS/ELECTRICAL	155	
PROPULSION/MECHANICAL	138	
ORDNANCE	27	
SHROUD		2,015
STRUCTURE	1,065	
THERMAL PROTECTION	860	
PROPULSION/MECHANICAL	12	
ORDNANCE	78	
ASSEMBLY ATTACH HARDWARE		20
GROWTH		516
TOTAL ACC WEIGHT		5,672
ACC JETTISONED WEIGHT		1,536
ACC RETAINED WEIGHT		4,136

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DEDICATED ACC

Manufacturing Approach

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Manufacturing Approach

- PERFORM A PRODUCTION ENGINEERING ASSESSMENT OF THE DEDICATED ACC STRUCTURES & SYSTEMS INSTALLATIONS TO ESTABLISH:
  - GROUND RULES
  - MAKE/BUY RECOMMENDATIONS
  - MANUFACTURING OPERATIONS SEQUENCE FLOW
  - TOOLING, EQUIPMENT & FACILITIES REQUIREMENTS
  - TOOLING CONCEPTS
  - NON-RECURRING COSTS
  - RECURRING COSTS
  - FACILITIES ASSESSMENT

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Ground Rules and Assumptions

- PRODUCTION STUDY LIMITED TO THE DEDICATED ACC
- ET SCAR IS NOT ADDRESSED (PREVIOUSLY STUDIED)
- PLAN ASSUMES ET PROGRAM TO BE PROTECTED TO 24 ET'S/YR
- PRODUCTION PLAN ASSUMES (6) ACC'S PER YEAR CAPABILITY
- ACC WILL BE BUILT AT MAF
  - SKIRT WILL BE ATTACHED TO ET
  - HEMISPHERICAL DOME/BARREL SHROUD ASSY WILL BE SHIPPED LOOSE ON BARGE
- ASSUMED TOOLING IDENTIFIED IN RATE TOOLING COMPLETION PROPOSAL WILL BE AVAILABLE
- ASSUMED FACILITIES IDENTIFIED IN THE FIVE YEAR CONSTRUCTION OF FACILITIES PLAN (NOV 1982) WILL BE AVAILABLE

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DEDICATED ACC
Manufacturing Operations Sequence Flow

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SEQUENCE FLOW – SKIRT

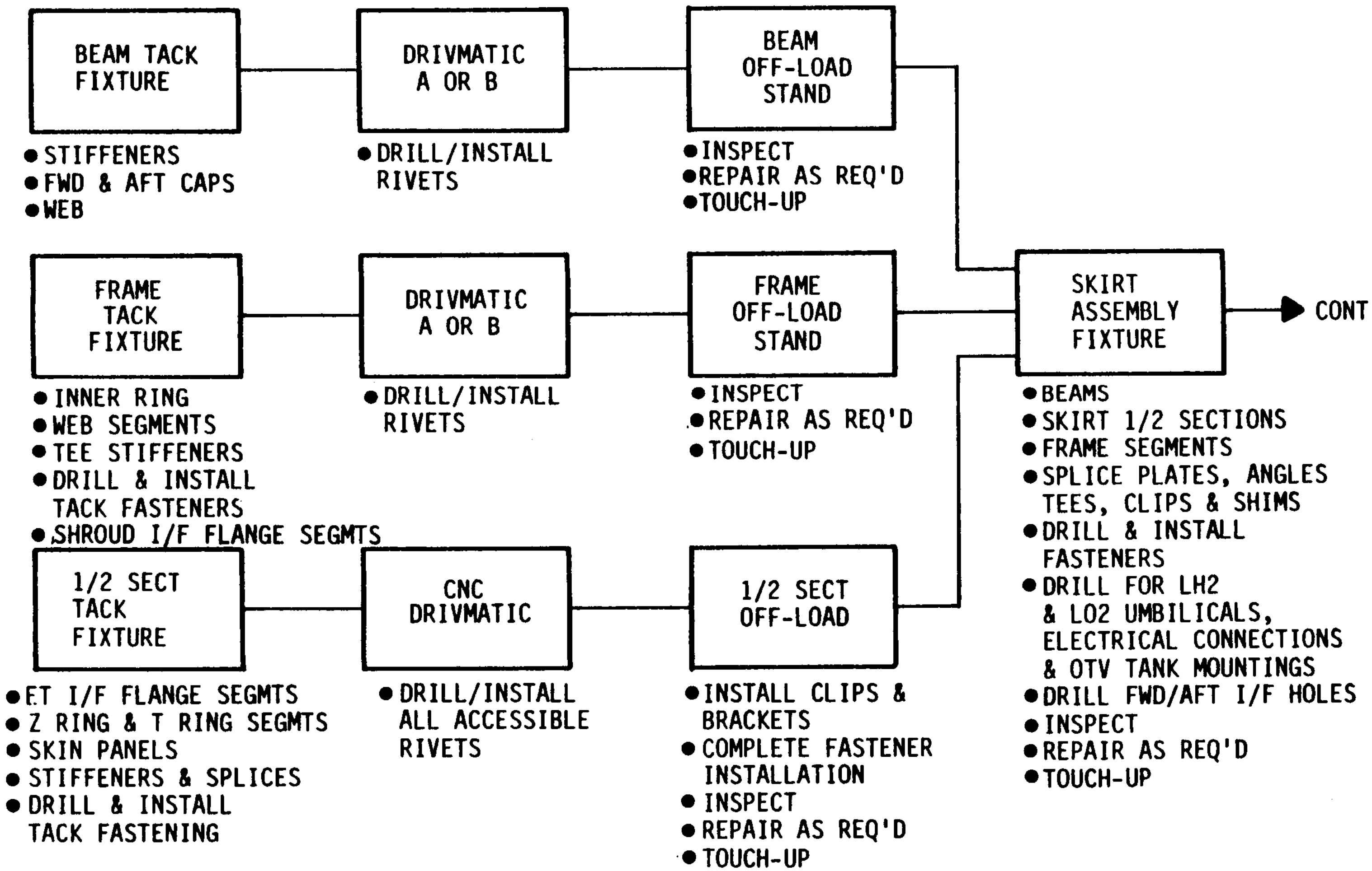
The skirt structural assembly starts with the assembly of the payload support beam and structural ring frame subassemblies which utilize existing drivmatic riveters.

The skirt skin panels, ET Interface flange, 'Z' and 'T' ring segments, skin stiffeners and splices are subassembled into half-sections and riveted on a CNC Drivmatic Riveter.

Beam subassemblies are precisely located and assembled in the Skirt Assembly Fixture; then the frame segments and half sections are loaded and secured.

The skirt assembly is then completed by splicing the half-sections and frames and securing the frames to the half sections; finally the beam assembly is secured to the frames to skirt skins.

Sequence Flow-Skirt



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SEQUENCE FLOW - SKIRT (CONT)

All systems shall be installed to the skirt and tested prior to moving to the new ACC SOFI Spray Booth. After TPS application the skirt will be attached to the ET LH_2 tank in Cell B.

ET and Orbiter interfacing system installations and TPS closeouts will be accomplished during normal ET Final Assembly in Building 103, Test and Checkout will be in Building 420.

SEQUENCE FLOW - SHROUD

The shroud construction commences with the assembly of the hemispherical dome gore panels and butt splice straps which will be located and fastened in a bench Tack Fixture prior to locating to a dedicated Riveting Fixture of a Gantry Robot.

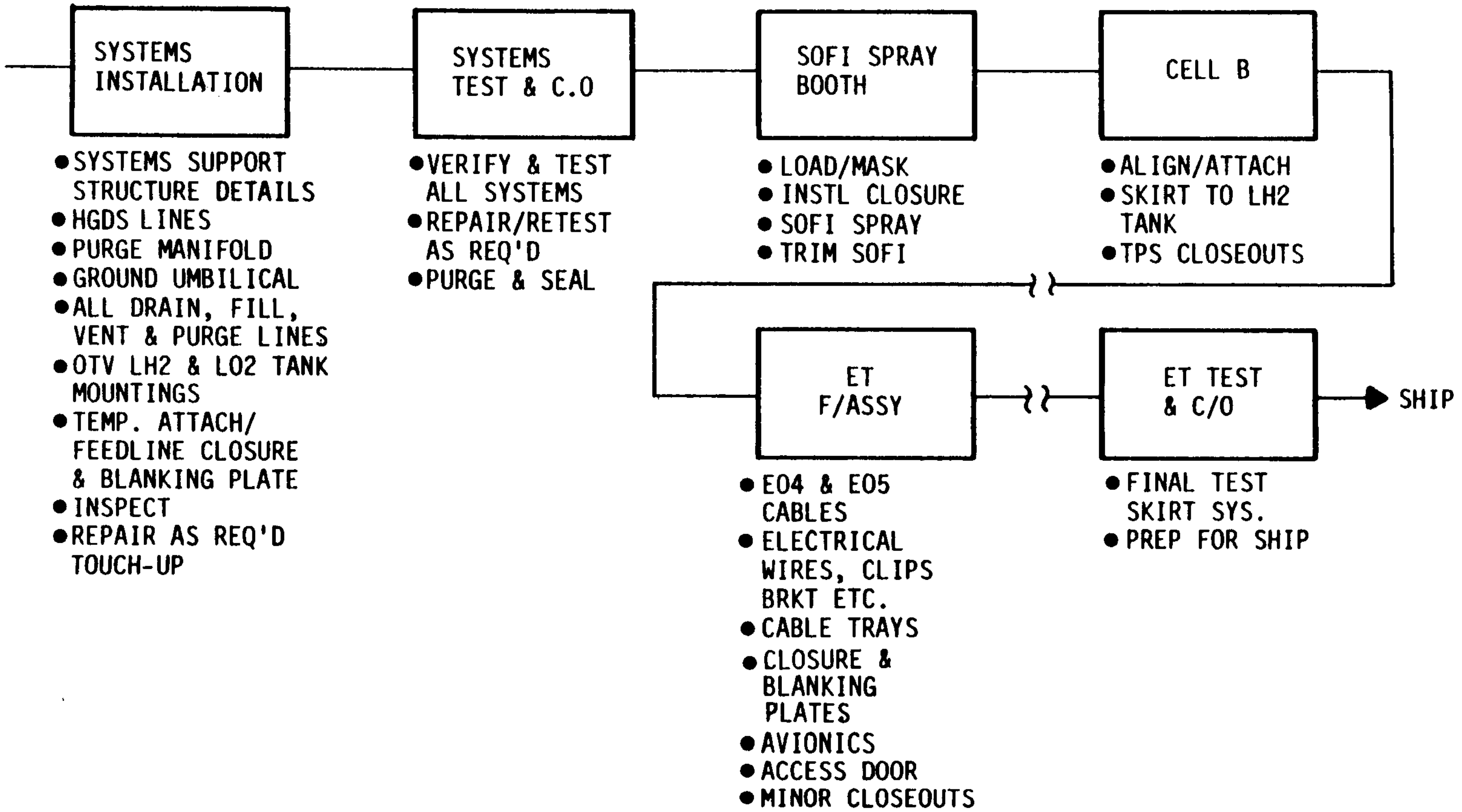
The gore panel assemblies will be located in the Shroud Structure Tack Fixture together with the dome cap, barrel panels, interface chord and separation joint details.

After tack fastening the assembly will be moved to the CNC Drivmatic Riveter which will complete the fastener installation to the barrel/dome splice, barrel panel splice and the interface chord splice.

On completion of the automatic fastener installation the shroud will be relocated to the Shroud Assembly Fixture for installation of the separation joint fasteners and the vent valve.

Finally the skirt interface hole pattern will be drilled from the support/drill plate.

Sequence Flow–Skirt (Cont)



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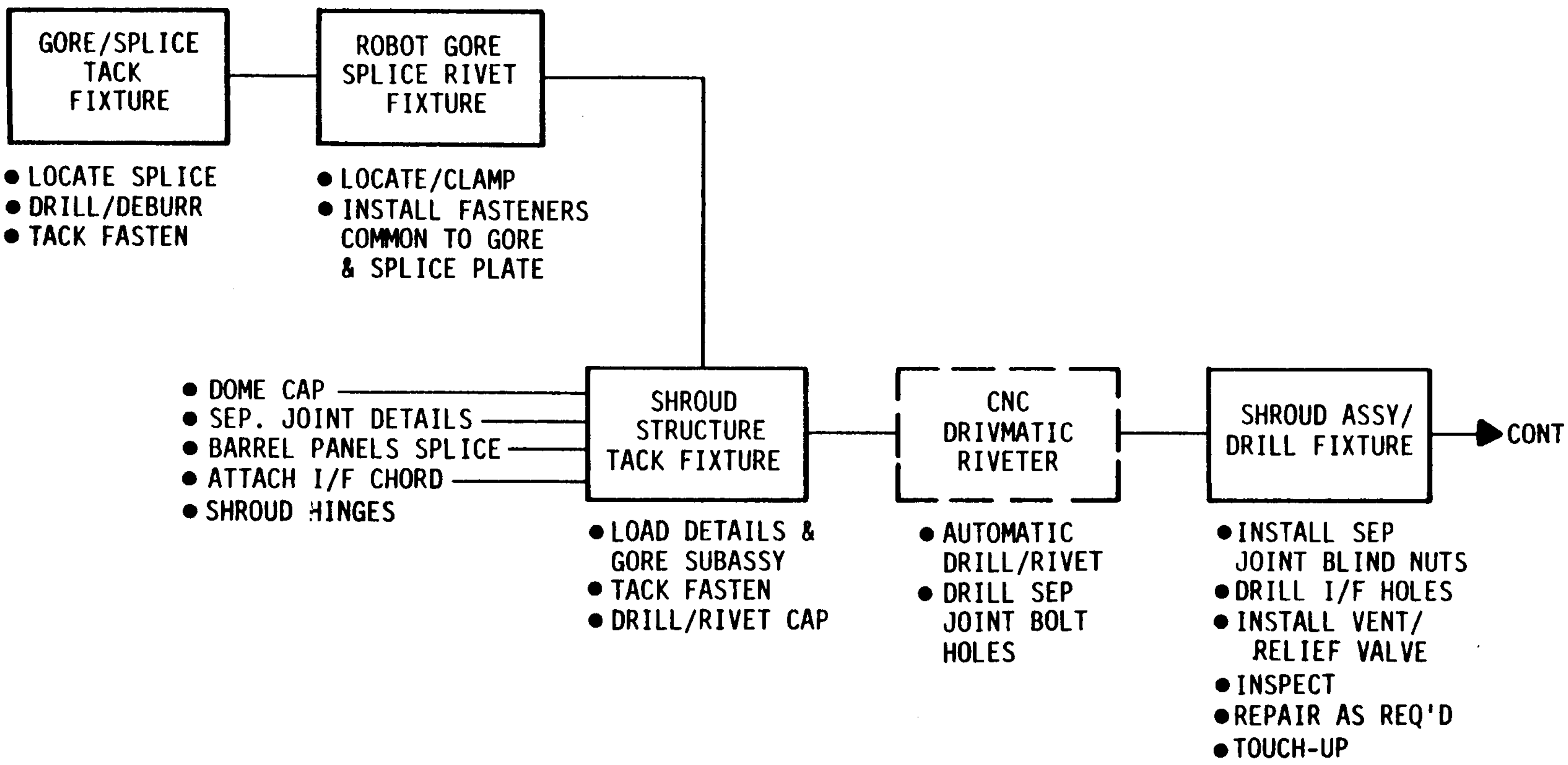
Sequence Flow–Shroud



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SEQUENCE FLOW – SHROUD (CONT)

The shroud will be sprayed with SLA in existing Cell N, utilizing a new rotational fixture.

SOFI application will be made in the SOFI Spray Booth which accommodates both shroud and skirt.

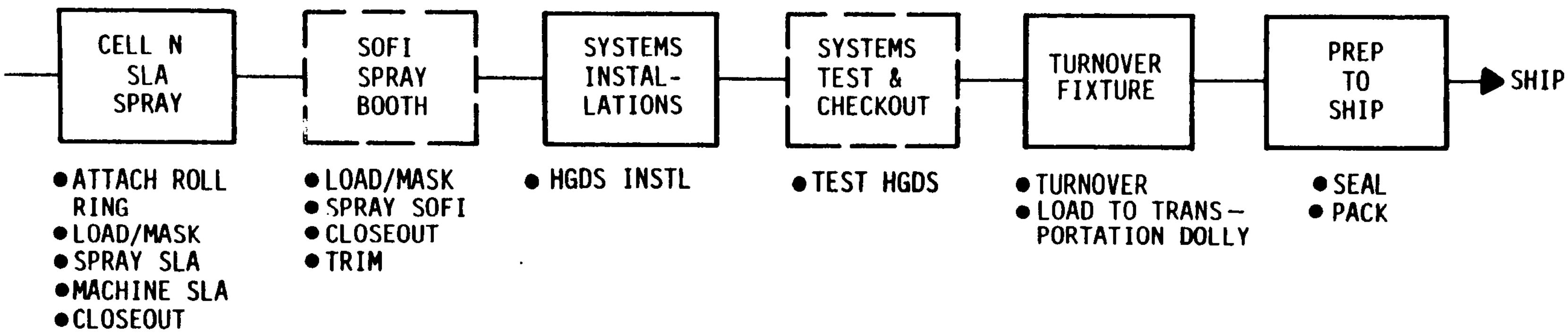
The Hazardous Gas Detection System (HGDS), is installed in the System Installation Fixture.

Test and checkout is performed in the common Skirt/Shroud Test and Checkout Fixture.

A new Turnover Fixture Basket is provided to facilitate location of the shroud to the transportation dolly in the flight-direction-up attitude.

After mounting to the transportation dolly the shroud will be sealed and packed for shipment.

Sequence Flow–Shroud (Cont)



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DEDICATED ACC
Facilities Assessment

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Ground Rules

- Work within 60-36 manufacturing layout constraints
- Maintain 20 ET/year production capability and protect 24 ET/year flexibility
- Base facilities requirements on dedicated ACC manufacturing primary data
- All ROM costs to be in FY84 C of F dollars and are derived from previous similar construction and equipment estimates
- Facilities ROM construction of facilities (C of F) estimates cover nonrecurring efforts for manufacturing area preparation, including relocations, crane, foundation and TPS spray booth installations, and utility extensions

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ANALYSIS OF MANUFACTURING REQUIREMENTS (SKIRT AND SHROUD)

The area designated for ACC build will be facilitized for 12 major new tools and 18 work stations.

Selection of the area is consistent with the manufacturing layout approach of grouping like tooling and maximizing the use of common tooling and labor skills. ACC production flow interfaces with existing frame segment Drivmatics.

The project includes construction of nine pile supported foundations, additional overhead crane installation, a TPS spray booth and the expansion of a traffic aisle.

Analysis of Manufacturing Requirements

- BASED ON PRELIMINARY MANUFACTURING REQUIREMENTS DATA (12-84)

TOOL/AREA FUNCTION	AREA (SQ FT)		SPECIAL REQUIREMENTS		
	BLDG 103	OTHER	FOUNDATION	CRANE	OTHER
• SKIRT					
· ½ SECTION TACK FIX.	1600		X	5-TON	
· CNC DRIVMATIC RIVETER	2400		X	5-TON	
· ½ SECTION OFFLOAD	800		–	5-TON	
· STRUCTURAL ASSY FIX.	1600		X	5-TON	
· SOFI SPRAY BOOTH	1600		X	5-TON	
· SYSTEM INSTALL FIX.	1600		X	5-TON	
· SYSTEM TEST & C/O	1600		X	5-TON	
· BEAM TACK FIX. (4 EA)	1200		–	1-TON	
· BEAM OFFLOAD STANDS	1200		–	1-TON	
· FRAME TACK FIX. (2 EA)	1200		–	1-TON	
· FRAME OFFLOAD STANDS	500		–	1-TON	
· DOLLY/SLINGS/MISC STAGING	8700		–	–	
· MINOR MODS TO: BLDG 420 (A&B); BLDG 103 FA	–		–	–	
SUBTOTAL SKIRT	24,000				

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Analysis of Manufacturing Requirements

- BASED ON PRELIMINARY MANUFACTURING REQUIREMENTS DATA (10/84)

TOOL/AREA FUNCTION	AREA (SQ FT)		SPECIAL REQUIREMENTS		
	BLDG 103	OTHER	FOUNDATION	CRANE	OTHER
• SHROUD					
· MASTER MODEL	800		–	1-TON	
· GORE SPLICE TACK FIX.	800		–	1-TON	
· ROBOT GORE SPLICE RIVET	800		X	1-TON	EQUIP. PURCHASE GANTRY ROBOT
· SHROUD STRUCT TACK FIX.	2,400		X	5-TON	
· SHROUD ASSY/DRILL FIX.	2,400		X	5-TON	
· SYSTEMS INSTALL.	1,600		–	5-TON	
· SHROUD TURNOVER FIX.	1,600		–	5-TON	
· PREP TO SHIP	1,600		–	5-TON	
· MASTER DRILL TEMP	900		–	–	
· DOLLY/HANDLING EQ,ETC	4,800		–	–	
SUBTOTAL SHROUD	17,700				
SUBTOTAL SKIRT	24,000				
· PROD. CONTROL (20%)	8,340				
· AISLES/MISC (10%)	5,004				
GRAND TOTAL	55,044		(9) PILE SUPPORTED		

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IMPLEMENTATION PLAN

The accentuated areas on this chart represent approximately 55,000 square feet of manufacturing floor space allocated for ACC manufacturing. The area offers a 32 ft crane height, 35 ft wide access aisles and proximity to existing and planned production tooling.

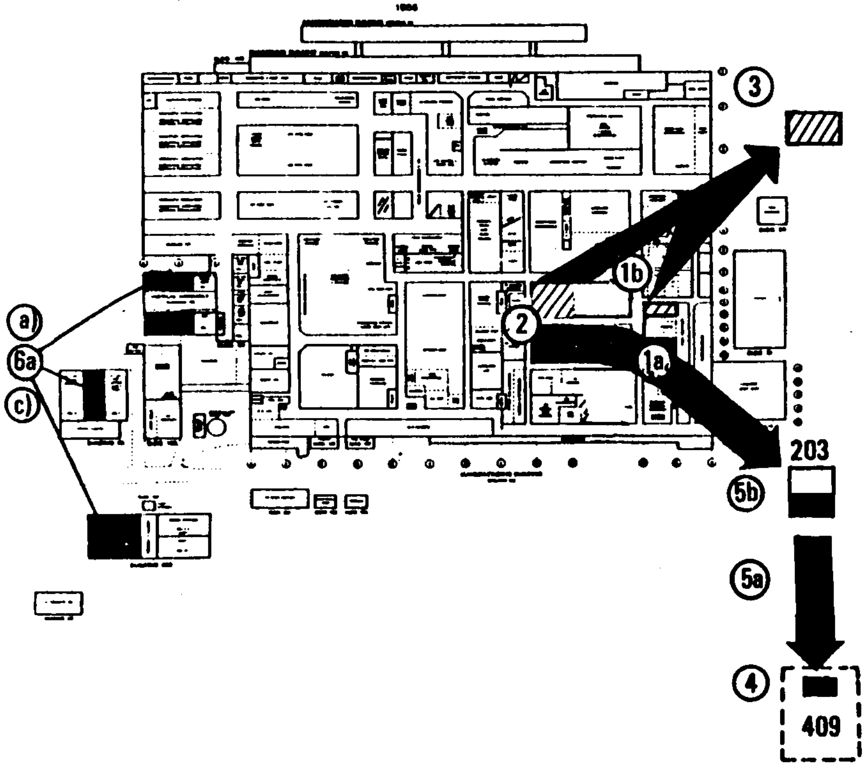
Space is made available for ACC manufacturing by the displacement of existing operations being affected by Facilities Self Sufficiency (FSS) operations.

Facilities support operations and external tank manufacturing support entities can be relocated to alternate locations in the main manufacturing sphere or to outlying buildings to accommodate ACC related operations in Building 103.

Implementation Plan

- PRELIMINARY FACILITIES REQUIREMENTS

MARTIN MARIETTA MANUFACTURING BLOCK AREA LAYOUT



BLDG 103

(1) PROVIDE APPROX 55,000 SQ FT

a) RELOCATE MASTER MODEL (H11) TOTAL FAB (N/11) MATERIAL STORES (Q11) TO BLDG 203 (4)

b) RELOCATE HEAVY EQUIP MAINT (N/8;Q/8) NEW FACILITY (3)

(2) INSTALL a) APPROX 50,000 SQ FT OF OVERHEAD CRANES TO INCLUDE TRUSS MODS

b) - UTILITIES TO (19) TOOLING POSITIONS

c) - (9) TOOLING FOUNDATIONS

NEW CONTRUCTION

(3) 27,000 SQ FT PREFAB STRUCTURE FOR SOME RELOCATED ACTIVITIES FROM BLDG 103 (1G)

(4) 20,000 SQ FT COVERED SLAB IN SALVAGE YARD FOR RELOCATED EQUIP. FROM BLDG 203

BLDG 203

(5) CLEAR APPROX 32,000 SQ FT

a) RELOCATE EQUIP. TO SALVAGE YARD AREA BLDG 409 (4)

b) RELOCATE ACTIVITIES FROM BLDG 103 (1a)

MINOR ELECTRICAL/MECHANICAL MODS

(6) a) CELL 'A' & 'B' BLDG 110

b) CELL 'N' BLDG 131

c) POSITIONS 1 & 2 BLDG 420

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Agenda

- Introduction
- Requirements
- Payload Integration
- Design (General Purpose)
- Design (Dedicated OTV)
- ⇨ Mission Analyses
- Planning
- Costs

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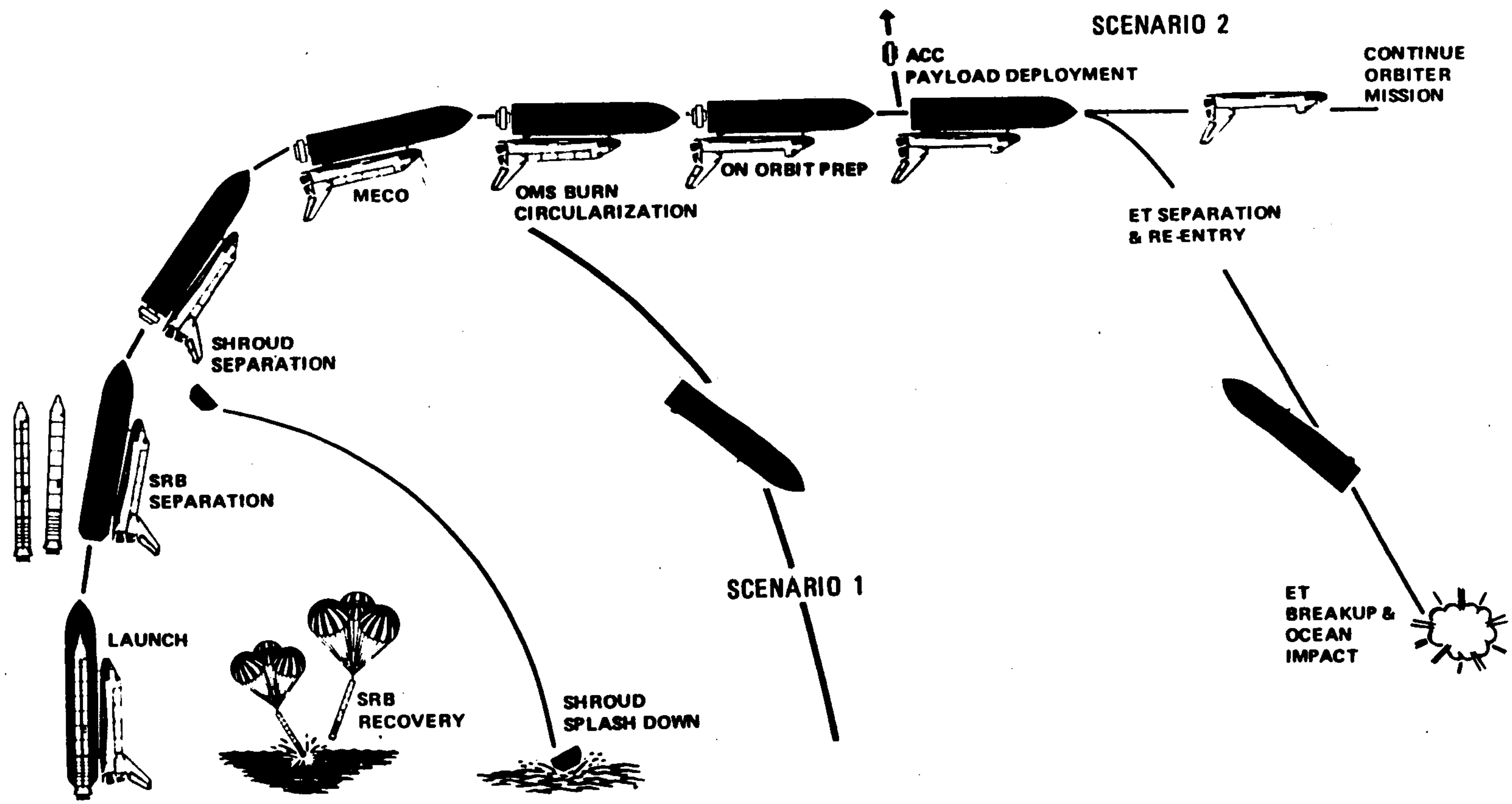
ACC MISSION SCENARIOS

After the Space Shuttle is launched, the SRBs are expended and jettisoned. Shortly thereafter, the ACC shroud is jettisoned to reduce the payload weight penalty.

In Scenario #1, after MECO, the OTV is ejected from the DACC followed by separation of the orbiter from the ET/DACC (prior to OMS #1 firing). The OTV free flies to the designated park orbit and rendezvous with the orbiter.

In Scenario #2, after MECO, the ET/GPACC continues into orbit with the orbiter. The payloads are individually ejected from the GPACC. Payloads normally initiate autonomous operations after achieving a safe separation distance from the orbiter. After all ACC payloads are deployed, the orbiter separates from the ET/GPACC and, at the proper time, the GPACC SRMs burn to deorbit the ET/GPACC for ocean impact. The orbiter continues its planned mission in the same manner as current orbiter missions.

ACC Mission Scenarios



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STS/DACC SEQUENCED MASS PROPERTIES (SCENARIO 1)

The sequenced mass properties data for a DACC mission is shown in the facing chart. The mission is a payload delivery mission launched due east into a 120 nm circular orbit. The purpose of this mission is to place a payload(s) in orbit for mating with an OTV. The OTV is suborbitally released from the DACC shortly after Shuttle MECO.

Included in the data is the DACC payload (55K ground based cryogenic OTV) which weights 61,309 lb. Also included is 13,617 lb of cargo in the orbiter cargo bay: 11,429 lb of this cargo is deployable payload; the remainder is ASE.

The cg locations are given in the STS coordinate system and the inertia data is about the cg location shown for each flight event.

STS/DACC Sequenced Mass Properties (Scenario 1)

DESCRIPTION	WEIGHT (LB)	CENTER OF GRAVITY (INCHES) X	Y	Z	MOMENT OF INERTIA (SLUG-FT^2 x 10^3) I_X	I_Y	I_Z	PRODUCT OF INERTIA (SLUG-FT^2 x 10^3) P_{XY}	P_{XZ}	P_{YZ}
LIFT-OFF	4,483,845	1417.6	0.2	416.1	50,909	369,927	408,391	-124	6,620	1
PRE-SRB STAGING	1,849,966	1250.4	0.5	439.1	9,950	152,617	152,933	- 89	9,228	-3
POST-SRB STAGING	1,544,657	1132.4	0.6	446.6	5,365	103,595	99,853	- 65	11,014	-5
PRE-ACC SHROUD STAGING	1,286,362	1204.5	0.7	455.9	5,220	90,797	87,201	- 80	9,894	-7
POST-ACC SHROUD STAGING	1,284,826	1203.2	0.7	456.0	5,212	90,398	86,803	- 80	9,912	-7
MECO	357,450	1829.1	0.9	597.0	3,088	20,422	18,951	- 70	526	-9

NOTE:
(1) CENTER OF GRAVITY = STS COORDINATE SYSTEM
(2) DEDICATED ACC SHROUD STAGED AT 200 SEC
(3) STS VEHICLE IS PERFORMANCE ENHANCED

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STS/GPACC SEQUENCED MASS PROPERTIES (SCENARIO 2)

The sequenced mass properties data for a GPACC mission are shown in the facing chart. The mission is a payload delivery/sortie mission launched due east into a 160 nm circular orbit. The purposes of this mission are the placement of payload in orbit from both the ACC and the orbiter bay, and sortie return from orbit.

The sequenced mass properties were computed assuming an average cargo weight in the the orbiter cargo bay of 34,586 lb, and an average ACC cargo weight of 27,569 lb.

The cg locations are given in the STS coordinate system and the inertia data is about the cg location shown for each flight event.

STS/GPACC Sequenced Mass Properties (Scenario 2)

DESCRIPTION	WEIGHT	CENTER OF GRAVITY			MOMENT OF INERTIA			PRODUCT OF INERTIA		
		X	Y	Z	I_X	I_Y	I_Z	P_{XY}	P_{XZ}	P_{YZ}
	(LB)	(INCHES)			(SLUG-SQ FT^2 x 10^3)			(SLUG-FT^2 x 10^3)		
LIFT-OFF	4,482,141	1415.4	0.2	415.3	50,711	367,096	405,931	-120	6,465	- 1
PRE-SRB STAGING	1,854,160	1243.2	0.5	437.0	9,789	149,467	150,118	- 83	9,014	- 5
POST-SRB STAGING	1,548,851	1124.1	0.6	444.1	5,216	99,788	96,368	- 59	10,721	- 6
PRE-ACC SHROUD STAGING	1,446,986	1150.7	0.7	447.2	5,170	94,922	91,548	- 64	10,329	- 7
POST-ACC SHROUD STAGING	1,440,898	1145.7	0.7	447.4	5,139	93,033	89,661	- 64	10,403	- 7
MECO	351,194	1795.7	1.2	590.4	3,089	18,813	17,490	- 80	1,127	-14

NOTE:
(1) CENTER OF GRAVITY = STS COORDINATE SYSTEM
(2) GENERAL PURPOSE ACC SHROUD STAGED AT 160 SEC
(3) STS VEHICLE IS PERFORMANCE ENHANCED

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STS/GPACC Performance

GROUND RULES AND ASSUMPTIONS

- PERFORMANCE DETERMINED TO 160 NM CIRCULAR ORBIT
- MISSION ASSUMED: 4 MEN/7 DAYS
- $Q\alpha$ = -3000 PSF-DEG
- MAXIMUM DISPERSED Q IS 819 PSF
- SSME ISP = 452.35 SEC AT 100% THRUST
- INJECTION INTO 57 X 160 NM ORBIT TARGETED
- GPACC SHROUD SEPARATION 36 SEC AFTER SRB STAGING (6,088 LB)
- ETR FEBRUARY LAUNCH (28.5 INCLINATION)
- 109% MAXIMUM SSME POWER LEVEL
- SRBs : 61-84 HPMs, 60° PMBT, FWCs
- AVERAGE ORBITER BAY WEIGHT TO ORBIT = 34,586 LB*
- AVERAGE ORBITER BAY WEIGHT FROM ORBIT = 22,277 LB*

*DETERMINED FROM MSFC NOMINAL MISSION MODEL, REVISION 7 (PS01)

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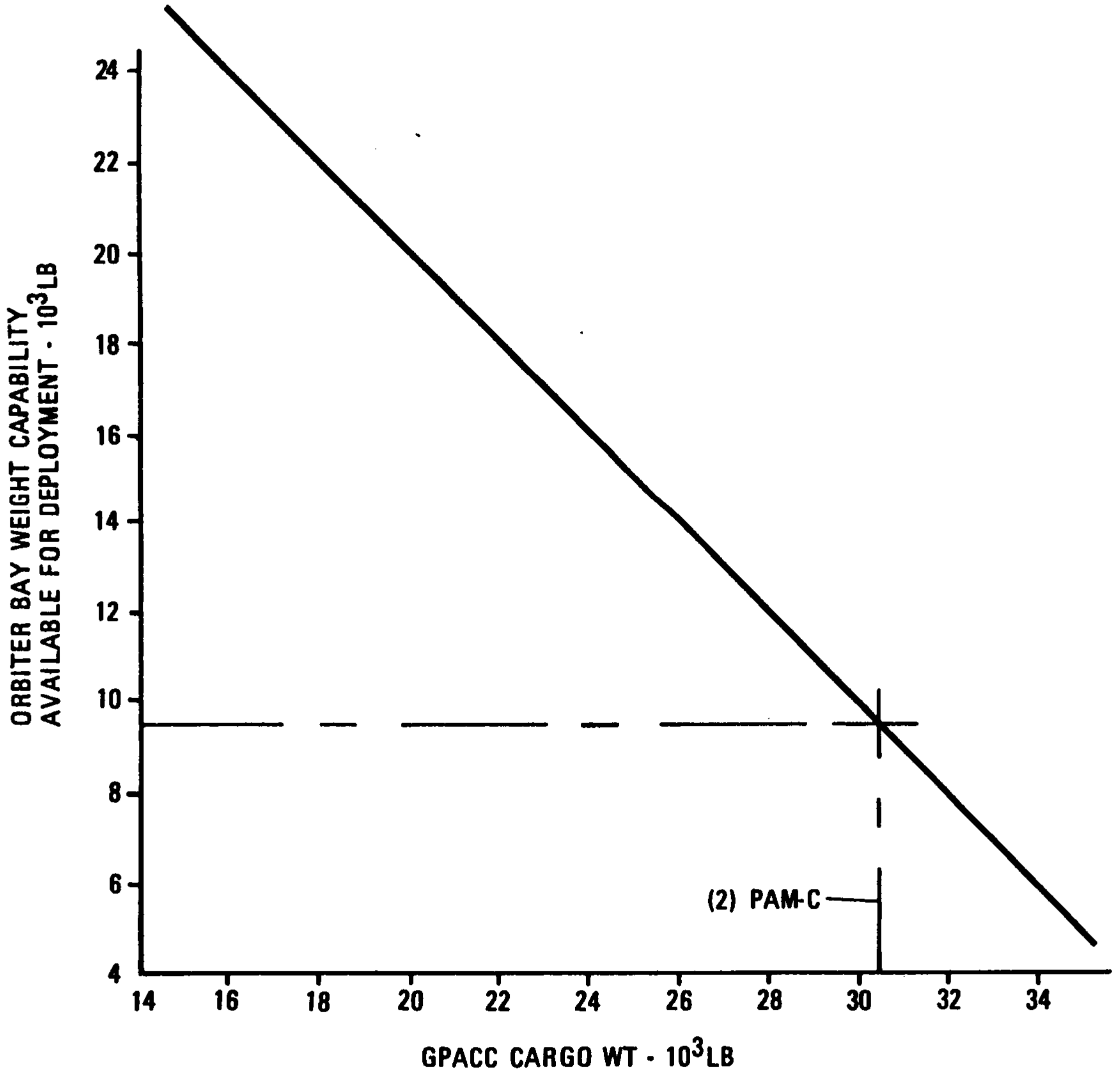
STS/GPACC PERFORMANCE

The STS/GPACC mission flies to a 57 nm X 160 nm direct injection MECO and carries the ET/GPACC to orbit.

The orbiter bay weight capability available for deployment is a function of the GPACC cargo weight. If two PAM-C cargos weighing 30,490 lb are carried/deployed from the GPACC, then the weight capability available for deployment from the orbiter bay is 9,388 lb.

Typical STS/GPACC performance is shown for a four man/seven day mission returning a 22,277 lb sortie payload from a 160 nm orbit.

STS/GPACC Performance



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STS/DACC Performance

GROUND RULES AND ASSUMPTIONS

- o OTV STAGED SUBORBITALLY (MECO + 400 SEC)
- o ORBITER PERFORMANCE DETERMINED TO 120 NM CIRCULAR ORBIT
- o MISSION ASSUMED: 4 MEN/3 DAY
- o $Q\alpha$ = -3000 PSF-DEG
- o MAXIMUM DISPERSED Q IS 819 PSF
- o SSME ISP = 452.35 SEC AT 100% THRUST
- o NOMINAL STS 4 X 86 NM ORBIT TARGETED
- o DACC SHROUD SEPARATION 76 SEC AFTER SRB STAGING (1536 LB)
- o ETR FEBRUARY LAUNCH (28.5 INCLINATION)
- o 109% MAXIMUM SSME POWER LEVEL
- o SRBs: 61-84 HPMs, 60^{o} PMBT, FWCs
- o ASSUMED ORBITER P/L BAY ASE = 2188 LB

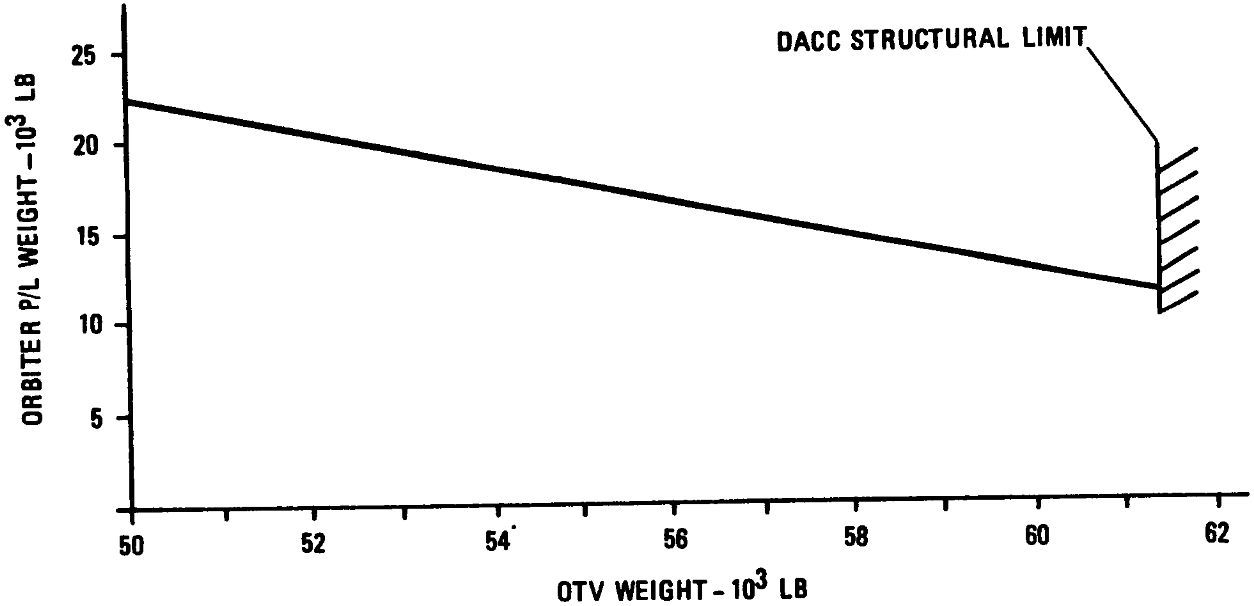
STS/DACC PERFORMANCE

The STS/DACC mission flies to a 4 nm X 86 nm standard STS MECO carrying an OTV which is suborbitally released.

The payload lift capability deployed from the orbiter bay is a function of the OTV weight ejected suborbitally. For a fully loaded OTV weighing 61,309 lb, the payload lift capability deployed from the orbiter bay is 11,429 lb.

Typical STS/DACC performance is shown for a four man/three day mission returning 2,188 lb of orbiter bay ASE from a 120 nm park orbit.

STS/DACC Performance



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STS/ACC FLIGHT CONTROL – ASCENT

The addition of an ACC to the SSV produces an additional negative pitching moment. The positive pitching moment needed to fly an orbiter zero lift angle of attack can be achieved by using a combination of control effectors, e.g., SRB gimbal deflection, SSME gimbal deflection and/or elevon deflection.

STS/ACC Flight Control - Ascent

MACH NUMBER	ANGLE OF ATTACK FOR ORBITER ZERO LIFT	CM* FOR ORBITER/ ET/SRB	CM FOR ORBITER/ ET ACC/SRB	DIFFERENCE
0.60	1.083	-0.1257	-0.1557	-0.0300
0.90	1.145	-0.1682	-0.1911	-0.0229
1.05	0.783	-0.1193	-0.1833	-0.0640
1.50	0.347	-0.0987	-0.1324	-0.0337
2.50	1.472	-0.0185	-0.0185	0.0

*CM - PITCHING MOMENT COEFFICIENT

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STS/ACC FLIGHT CONTROL – OMS MANEUVER

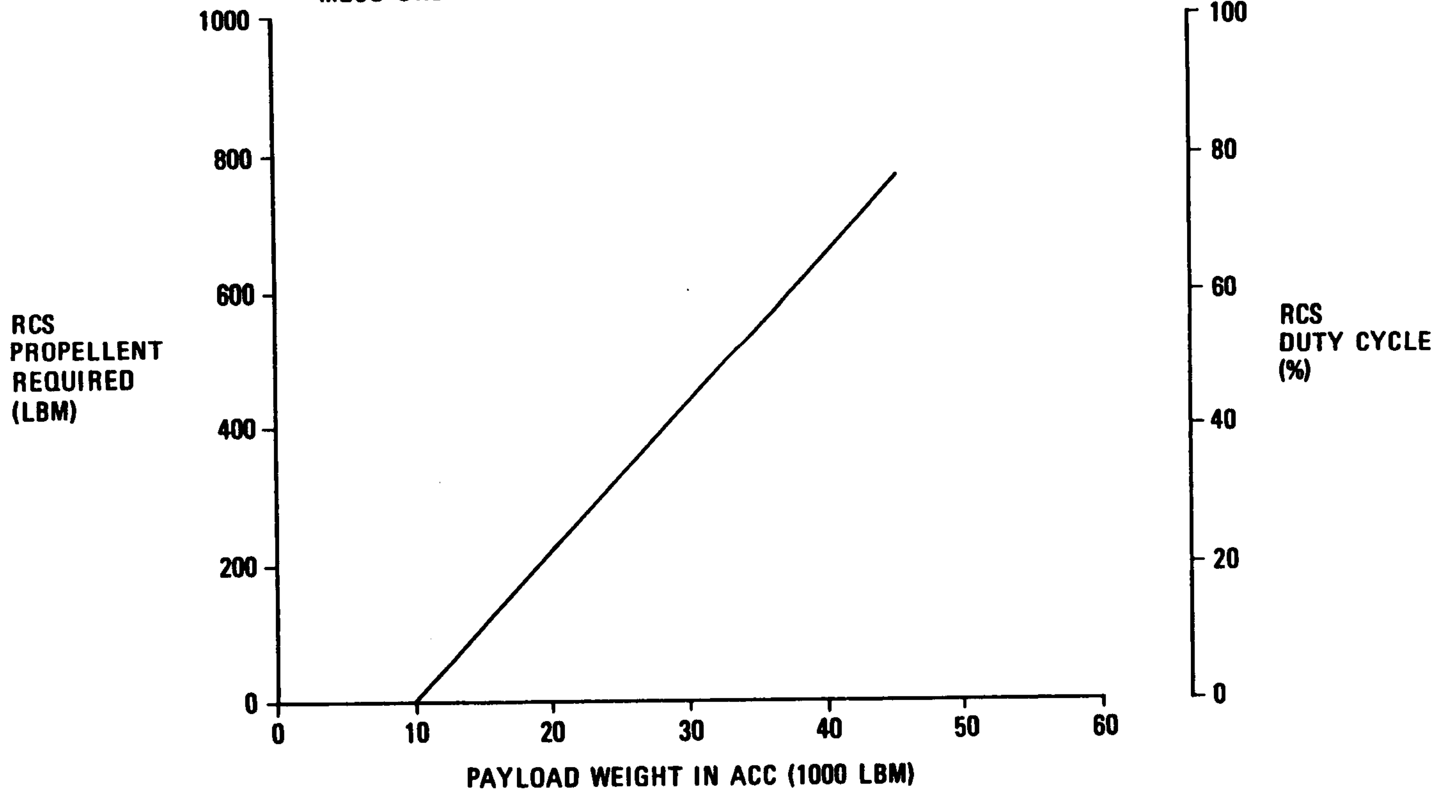
On the STS/ACC flights where the ET is taken to orbit, the OMS engine thrust vector may not pass through the STS cg. As a result, the orbiter RCS is used to maintain STS control during OMS firings.

The RCS propellant required to maintain control is a function of the ACC cargo weight (shown opposite).

STS/ACC Flight Control - OMS Maneuver

UTILIZES RCS TO CONTROL STS/ACC

TOTAL PAYLOAD WT - 65,000 LB
MECO WT - 353,000 LB
MECO ORBIT - 57 NM X 160 NM



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Mission Analysis

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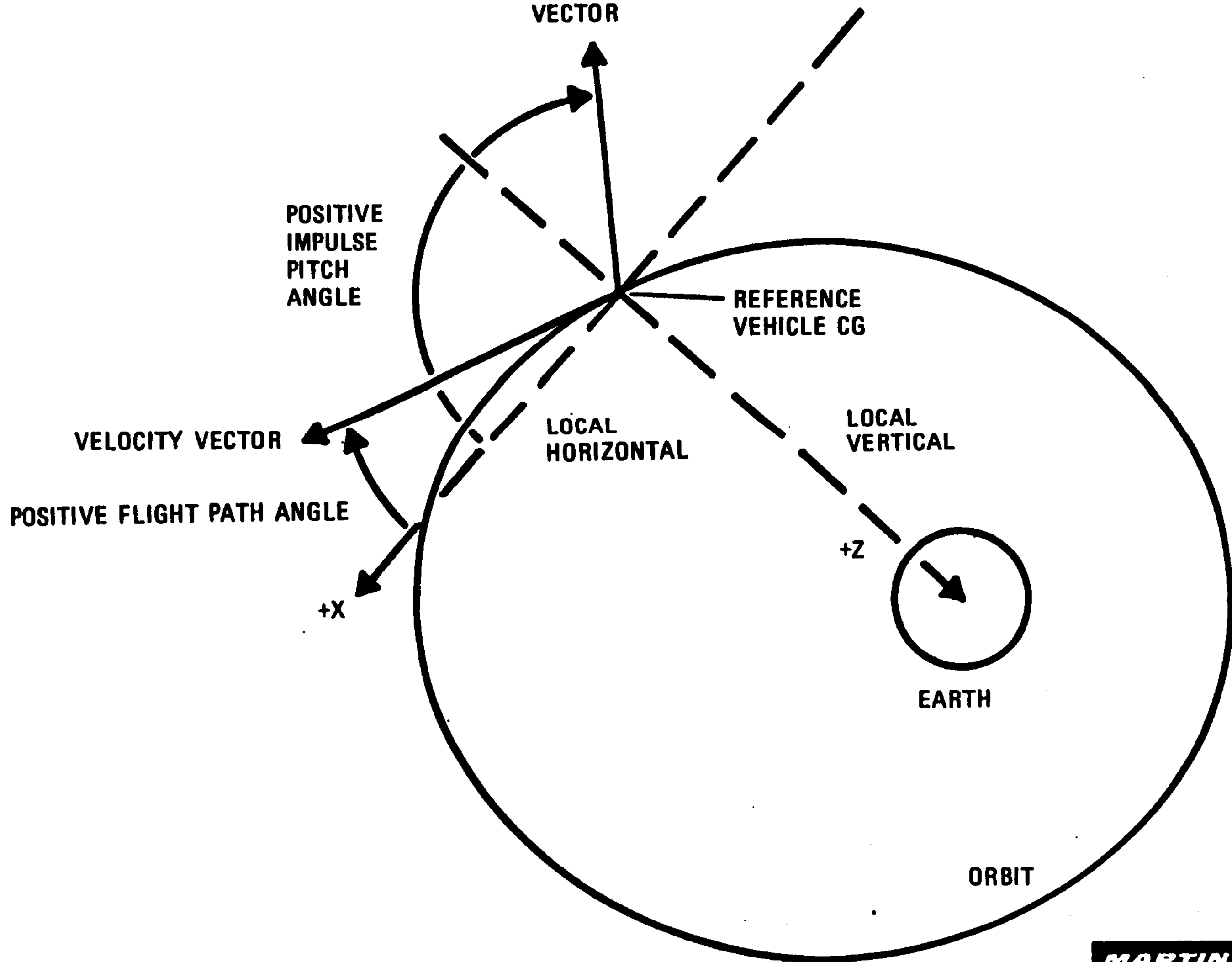
MISSION ANALYSIS COORDINATE SYSTEM

The local vertical (LV) is defined as the line from the orbiting vehicle CG to the earth's center. The local horizontal (LH) is defined as the line in the orbit plane through the orbiting vehicle CG perpendicular to the LV. With this system, positive Z is along the LV toward the earth's center. The positive X direction is defined by the projection of the velocity vector (VV) onto the LH. A third axis is normal to the orbit plane in right hand relationship. The flight path angle (gamma) is defined as the angle between the velocity vector and the +X axis, with the positive sense as shown. This coordinate system is used by NASA for orbital mechanics and is commonly known as the LVLH coordinate system.

Mission Analysis Coordinate System



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Multiple ACC Payloads
(PAM-C)

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MISSION TIMELINES: MULTIPLE ACC PAM-C PAYLOADS

The mission events and times for a STS/GPACC mission carrying two (2) PAM-C cargos in the GPACC are detailed in the following charts.

Mission Timelines: Multiple ACC PAM-C Payloads

EVENT START (DAY:HOUR:MINUTE) (MISSION ELAPSED TIME)	DURATION (MINUTES)	EVENT	REMARKS
00:00:00		LAUNCH	
00:00:02.2		SRB SEPARATION	
00:00:02.6		ACC SHROUD SEPARATION	
00:00:08		MECO	
00:00:52		OMS CIRCULARIZATION BURN	ORBIT CIRCULARIZED AT 160 NM
00:00:54.7	2 HOURS	POST-INSERTION ACTIVITIES	COMPLETE BY 00:03:00 PLBD OPEN
00:03:00	15	PREP FOR ET VENTING	
00:03:15	40	ET VENTING	
00:03:55	35	IMU ACTIVITIES	FINAL: -ZLV
00:04:30	30	AFT STATION C/O	
00:05:00	1 HOUR	MEAL	LUNCH
00:06:00	20	CAMERA SETUP	
00:06:20	1 HOUR	PREDEPLOYMENT C/O	PAYLOAD IN ACC
00:07:00		ACC PAM-C POWER ON	SELF TEST
00:07:30		ATTITUDE MNVR	PAYLOAD POINTING
00:07:48	12	INITIATE MECHANICAL DEPLOYMENT SEQUENCE	ACC PAM-C
00:07:50	10	INITIATE SPINUP	ACC PAM-C

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Mission Timelines: Multiple ACC PAM-C Payloads (cont)

EVENT START (DAY:HOUR:MINUTE) (MISSION ELAPSED TIME)	DURATION (MINUTES)	EVENT	REMARKS
00:07:57	3	INITIATE TERMINAL SEQUENCE	ACC PAM-C
00:07:59	1	ARM PAM-C	
00:08:00		DEPLOYMENT	EJECTION
00:08:10		OMS SEPARATION BURN	ORBITER NEW ORBIT: 160 X 167 NM
00:08:35		MNVR	WINDOW PROTECTION
00:08:45		PAM-C IGNITION	DEACTIVATE CAMERA
00:09:20	35	IMU ACTIVITIES	FINAL: -ZLV
00:09:55	1 HOUR	MEAL	SUPPER
00:10:55	45	PRESLEEP	
00:11:40	8 HOURS	SLEEP	
00:19:40	45	POSTSLEEP	FLIGHT DAY 2
00:20:25	15	TPR MSG REVIEW	TELEPRINTER MESSAGE
00:20:40	35	IMU ACTIVITIES	
00:21:15	1 HOUR	MEAL	BREAKFAST
00:22:15	1 HOUR	BURN PREP	
00:23:15		OMS BURN	RECIRCULARIZED AT 160 NM
00:23:50	20	CAMERA SETUP	

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Mission Timelines: Multiple ACC PAM-C Payloads (cont)

EVENT START (DAY:HOUR:MINUTE) (MISSION ELAPSED TIME)	DURATION (MINUTES)	EVENT	REMARKS
01:00:10	30	PREDEPLOYMENT C/O	PAYLOAD IN ACC
01:00:20		ACC PAM-C POWER ON	SELF TEST
01:00:40	10	ATTITUDE MNVR	PAYLOAD POINTING
01:01:08	12	INITIATE MECHANICAL DEPLOYMENT SEQUENCE	ACC PAM-C
01:01:10	10	INITIATE SPINUP	ACC PAM-C
01:01:17	3	INITIATE TERMINAL SEQUENCE	ACC PAM-C
01:01:19	1	ARM PAM-C	
01:01:20		DEPLOYMENT	EJECTION
01:01:30		OMS SEPARATION BURN	ORBITER NEW ORBIT: 160 X 167 NM
01:01:50		MNVR	WINDOW PROTECTION
01:02:05		PAM-D IGNITION	DEACTIVATE CAMERA
01:02:30	35	IMU ACTIVITIES	FINA: -ZLV
01:03:05	1 HOUR	MEAL	LUNCH
01:04:05	2 HOURS, 25 MIN.	AVAILABLE TIME	
01:06:30	1 HOUR	SEPARATION + BURN PREP	ET/ORBITER SEPARATION PREPARATION

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Mission Timelines: Multiple ACC PAM-C Payloads (concl)

EVENT START (DAY:HOUR:MINUTE) (MISSION ELAPSED TIME)	DURATION (MINUTES)	EVENT	REMARKS
01:07:30		ORBITER/ET SEPARATION	
		ORBITER POSIGRADE BURN	
		ET ATTITUDE STABILIZATION	
		ET SPINUP	
		ORBITER MNVR	WINDOW PROTECTION
01:08:15		ET RETROGRADE BURN	
01:08:40	35	IMU ACTIVITIES	FINAL: -ZLV
01:09:00		ET IMPACT	PACIFIC OCEAN
01:09:15	1 HOUR	MEAL	SUPPER
01:10:15	45	PRESLEEP	
01:11:00	8 HOURS	SLEEP	
01:19:00	45	POSTSLEEP	FLIGHT DAY 3
01:19:45	15	TPR MSG REVIEW	
01:20:00	35	IMU ACTIVITIES	FINAL: -ZLV
01:20:35	1 HOUR	MEAL	BREAKFAST
01:21:35	A/R	ORBITER CONTINUES MISSION	

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Suborbitally Released OTV

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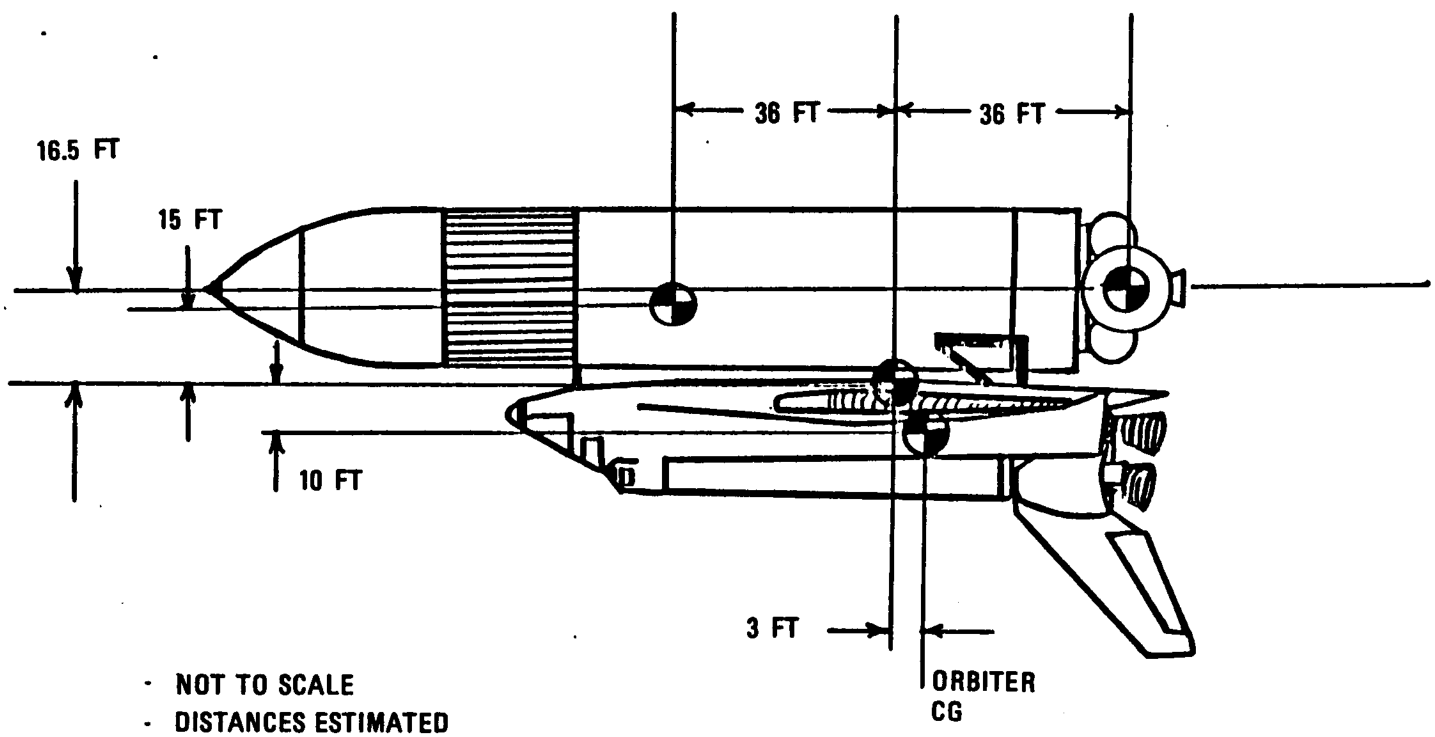
INITIAL VEHICLE CG OFFSETS

The analysis assumed all three vehicles (OTV, ET and orbiter) started with their centers of gravity (cg) coincident. The computer then tracks each cg (as a point mass) with respect to a selected reference cg (i.e., one vehicle). To analyze close-in physical clearances, these assumptions must be properly compensated for using the initial cg offsets.

Initial Vehicle CG Offsets



- NOT TO SCALE
- DISTANCES ESTIMATED

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SUBORBITAL RELEASED OTV TIMELINE

The following charts detail the mission events and times for a STS/DACC mission carrying and releasing an OTV suborbitally. The OTV then free flies to a 120 nm park orbit to rendezvous with the orbiter.

The terms "DX", "DZ" and "DS" indicate distance differences along the X (local horizontal) axis, Z (local vertical) axis, and along the shortest line between the two vehicles (slant range).

Suborbital Released OTV Timeline

Time (Sec)	Event	DV (FPS)	DV Pitch (Deg)	Relative Separation DX	DZ	DS	From	Remarks
0000	MECO	0	0	0	0	0	ET	V=25680 FPS H = 59.485 NM GAMMA = 0.65
0400	OTV SEP	2	170	0	0	0	ET	NO THRUSTING
0425	ORB SEP BURN	0	--	49	7	50	OTV	OTV IS 92° FROM ORB RCS BORESIGHT
0430	MIDPOINT	8	-100	--	--	--	--	
0435	CUTOFF	0	--	62	47	78	OTV	OTV IS 63° FROM ORB RCS BORESIGHT
0500	OTV ACS:ON	--	--	- 148	- 570	590	ORB	ORB IS 25° FROM OTV RCS BORESIGHT
0525	OTV VERT-ICAL BURN	0	--	- 204	- 768	795	ORB	ORB IS 25° FROM OTV RCS BORESIGHT
0580	MIDPOINT	6	80	--	--	--	--	

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Suborbital Released OTV Timeline (cont)

Time (Sec)	Event	Relative Separation dV (FPS)	dV Pitch (Deg)	DX	DZ	DS	From	Remarks
0635	Cutoff	0	--	- 552	-1948	2024	ORB	ORB is 26° from OTV RCS Boresight
0635	ORB Attitude Maneuver	--	--	552	1948	2024	OTV	To 0° Pitch for OMS-1
0780	ORB OMS-1	--	--	1522	3887	4175	OTV	OTV is 69° from OMS Boresight
0835	Midpoint	196	0	--	--	--	--	
0890	Cutoff	--	--	13454	4564	14207	OTV	OTV is 19° from OMS Boresight

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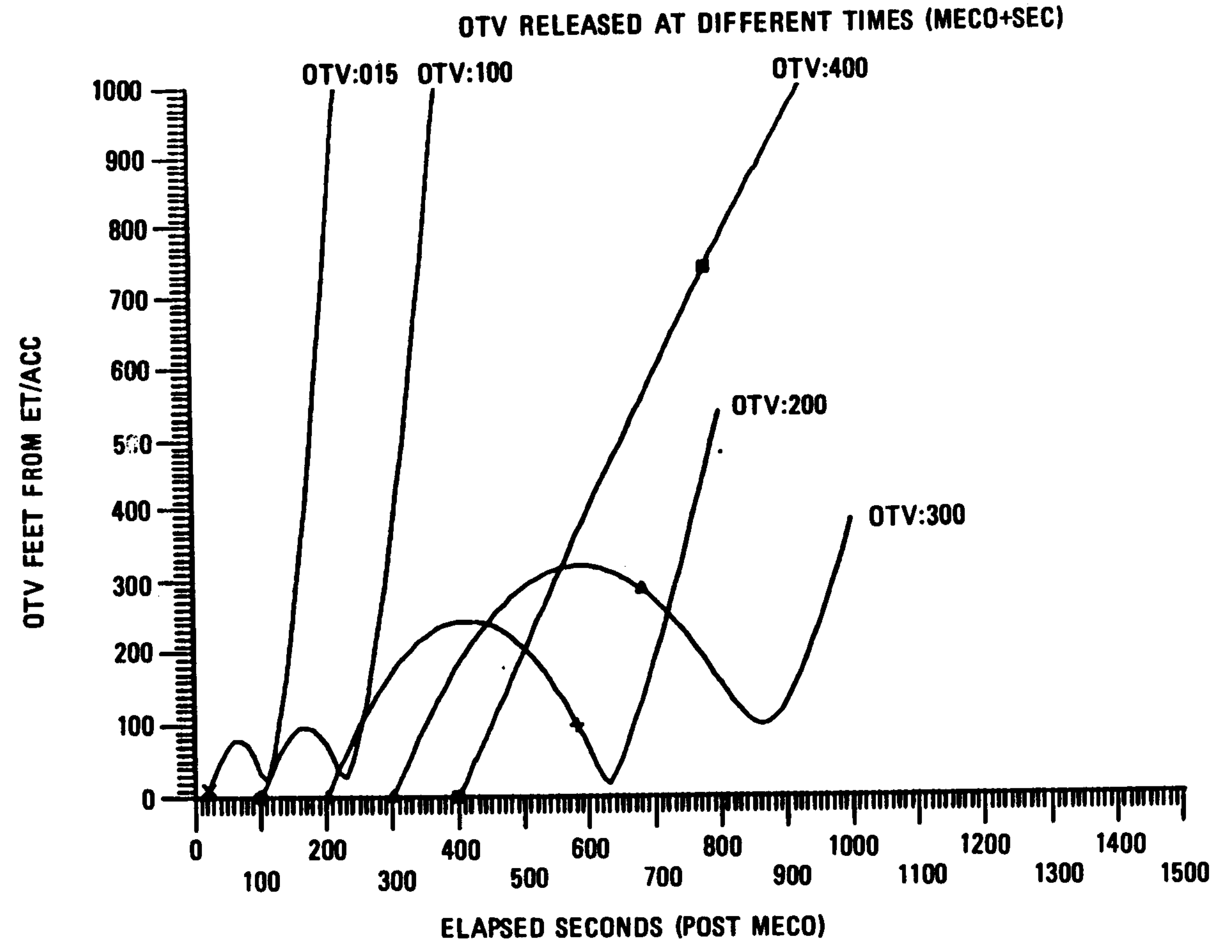
Suborbital Released OTV Timeline (Concl)

TIME (SEC)	EVENT	RELATIVE SEPARATION DV (FPS)	DV PITCH (DEG)	DX	DZ	DS	FROM	REMARKS
1000	OTV ATTITUDE MANEUVER	--	-	-35708	-29	35708	ORB	To 0^0 PITCH FOR OTV-1
1095	OTV-1 BURN	--	-	-8.8 NM	1.4NM	8.9NM	ORB	
1108	MIDPOINT	210	0	--	--	--	--	
1120	CUTOFF	--	-	--	--	--	--	
2917.5	OMS-2	--	-	-36.7NM	7.0NM	37.4NM	OTV	
2930	MIDPOINT	63	0	--	--	--	--	
2942.5	CUTOFF	--	-	--	--	--	OTV	119 X 120 NM
3797	OTV-2	--	-	33.5NM	0	33.5NM	ORB	
3800	MIDPOINT	53	0	--	--	--	--	
3803	CUTOFF	--	-	33.5NM	0	33.5NM	ORB	120 NM CIRCULAR

SUBORBITAL RELEASE FROM ACC

The time for OTV ejection from the ACC was determined from start time (OTV ejection) variation results for an identical sequence of maneuvers. Delaying the OTV ejection time reduces the differential drag effects of the vehicles. An OTV ejection time of MECO + 400 seconds was selected.

Suborbital Release from ACC



PLOT LABELS SHOW OTV SEP TIMES (POST MECO SECONDS)
DISTANCE IS TOTAL FEET FROM ORIGINAL ACC POSITION
ET DRAG IS WORST CASE: ET STABILIZED "BELLY INTO WIND"

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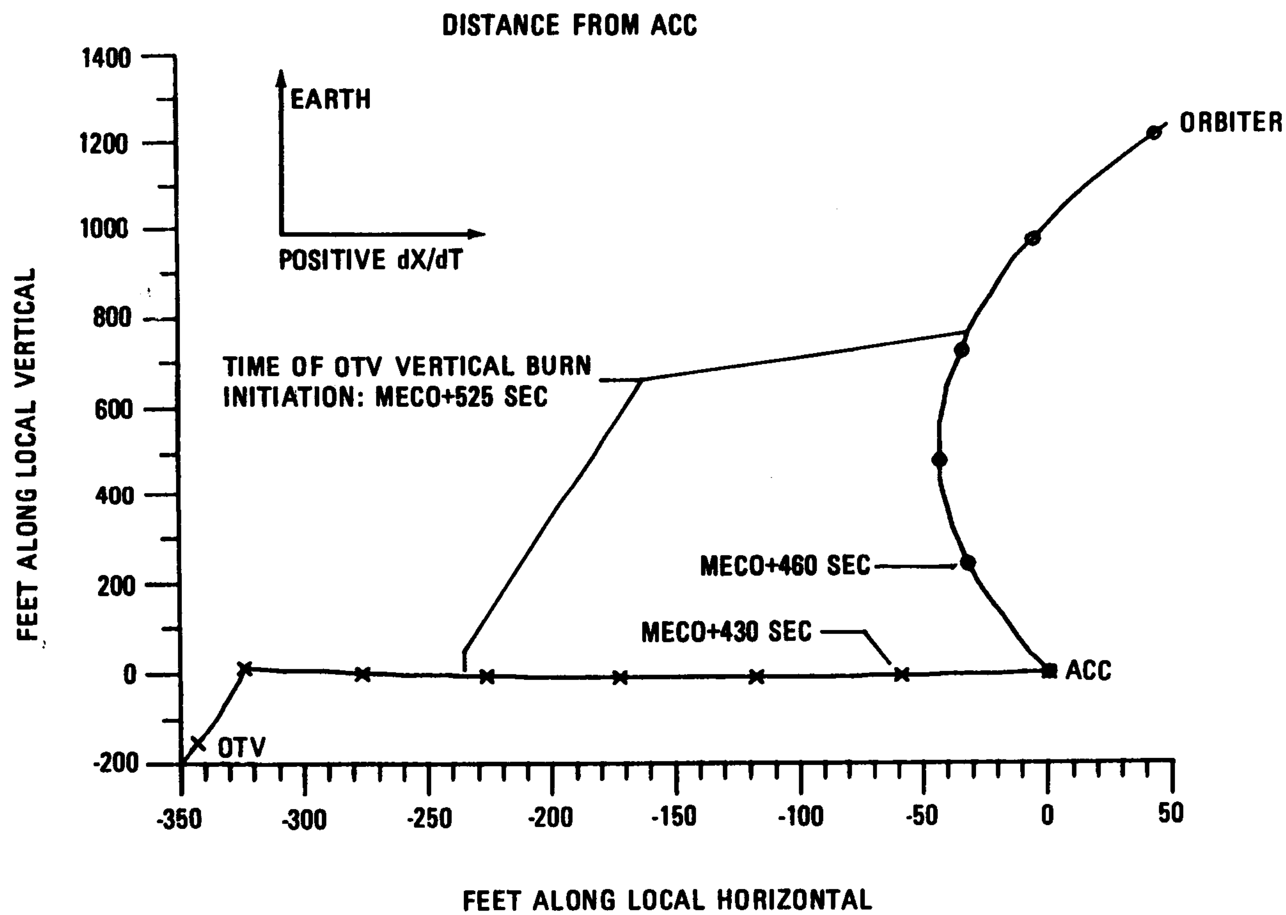
SUBORBITAL RELEASE FROM ACC

The following 3 charts show the relative positions of the Orbiter/OTV with respect to the ET/ACC for the time period MECO to OTV-1 burn (MECO + 1108 seconds). Engine burn times are considered to be instantaneous and are applied at the burn midpoint.

Suborbital Release from ACC



OTV SEP: 2 FPS, 170 DEG PITCH AT MECO + 400 SEC
ORBITER SEP: 8 FPS, -100 DEG PITCH AT MECO + 430 SEC
TIME SYMBOLS ARE 30 SEC APART

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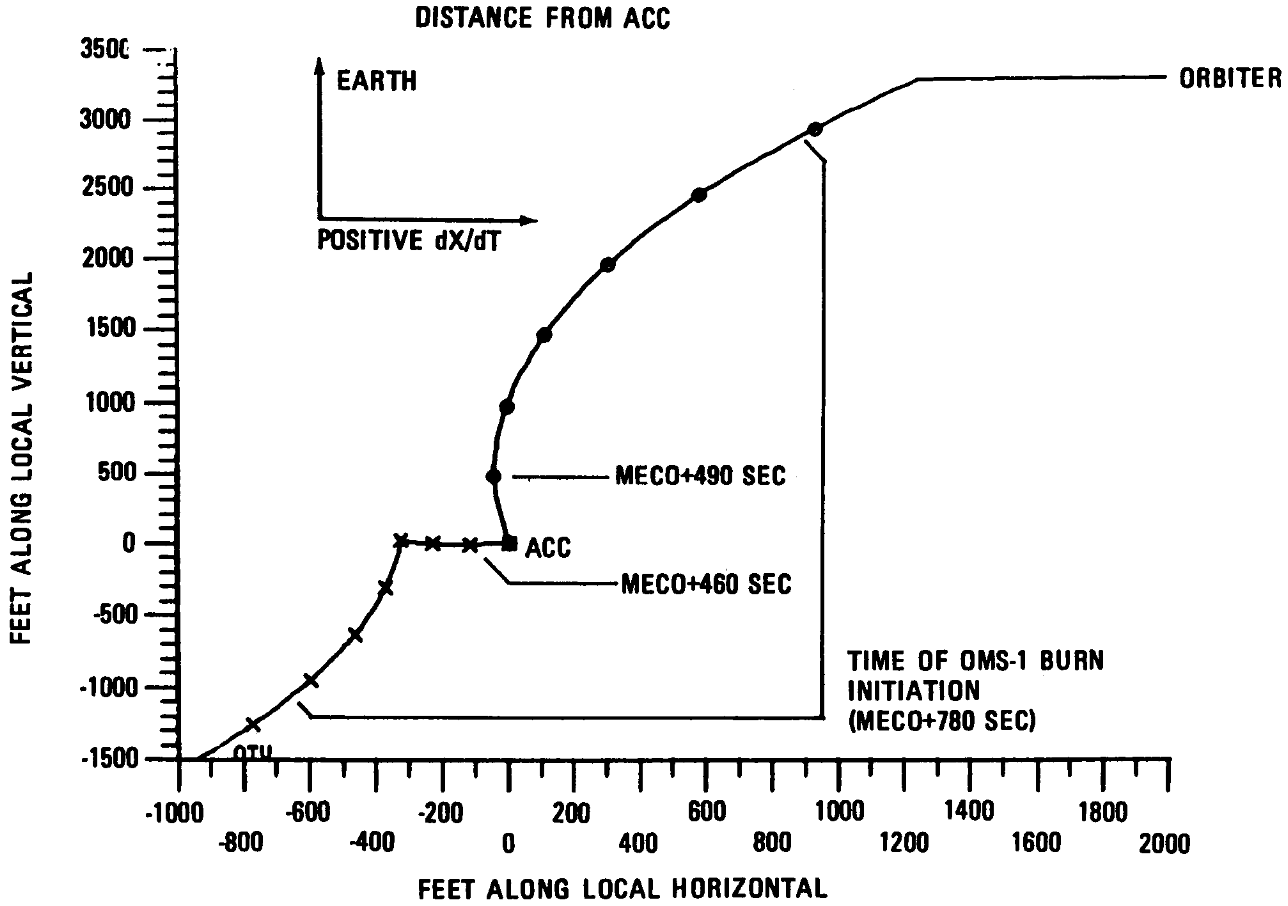
Suborbital Release from ACC



OTV SEP: 2 FPS, 170 DEG PITCH AT MECO + 400 SEC
ORBITER SEP: 8 FPS, -100 DEG PITCH AT MECO + 430 SEC
TIME SYMBOLS ARE 1 MIN APART

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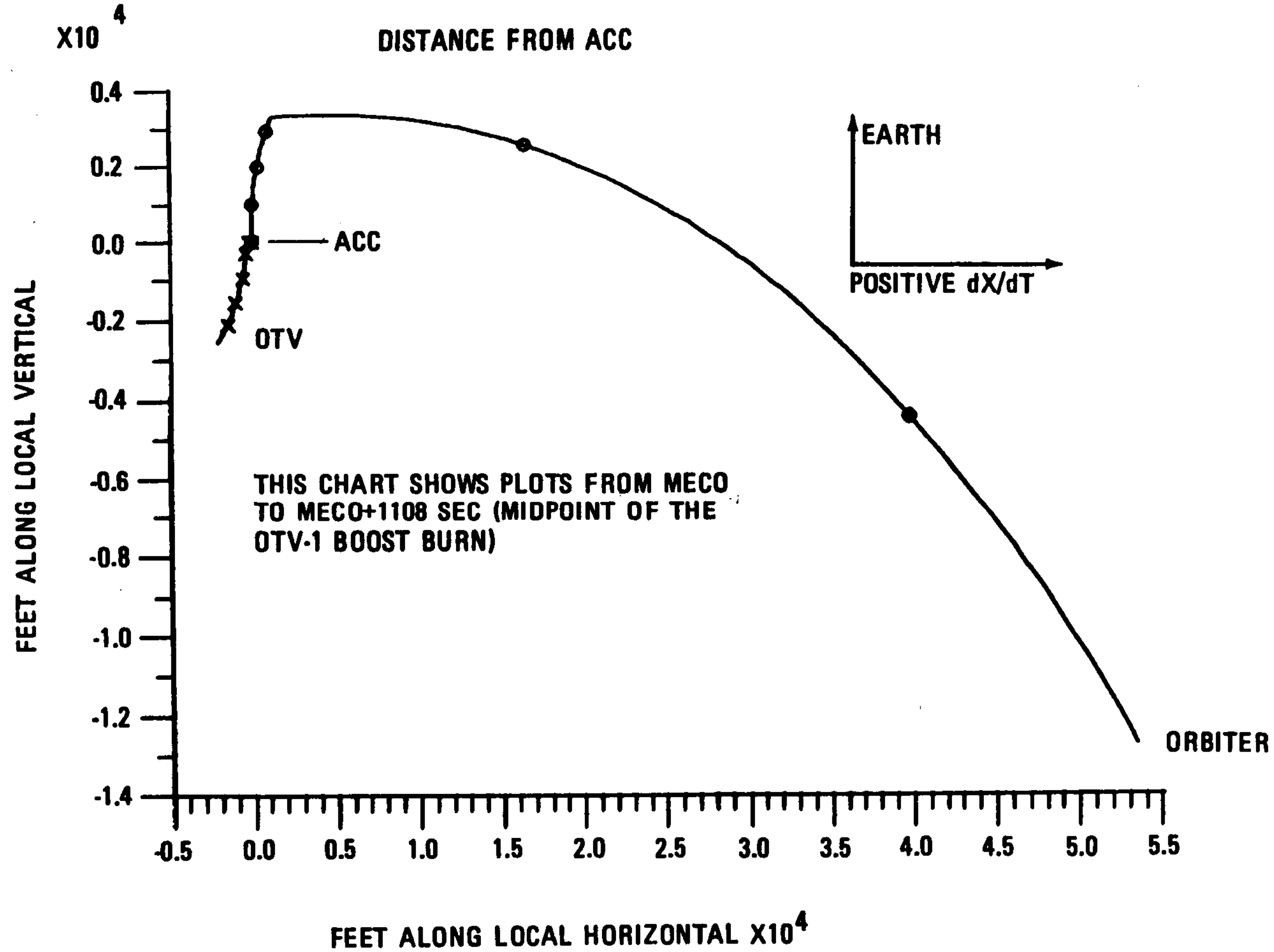
Suborbital Release from ACC



OTV SEP: 2 FPS, 170 DEG PITCH AT MECO + 400 SEC

ORBITER SEP: 8 FPS, -100 DEG PITCH AT MECO + 430 SEC

TIME SYMBOLS ARE 2 MIN APART

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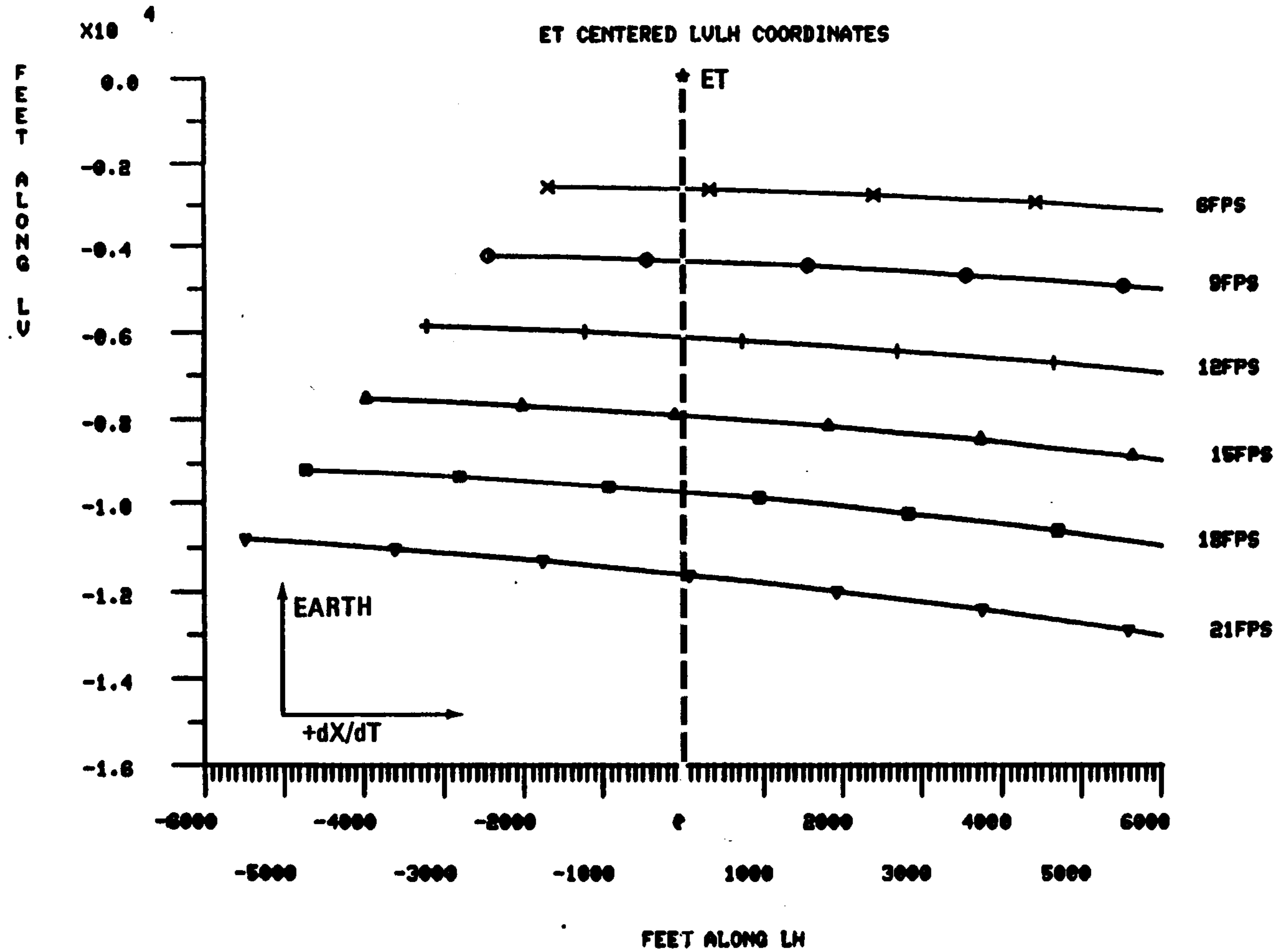
ET/OTV SEPARATION DISTANCE AT OTV FLY-OVER

This chart shows how the OTV-to-ET separation distance increases as the magnitude of the OTV vertical separation burn increases. The currently planned 6 fps maneuver produces a minimum separation clearance of 2680 ft. The maneuver occurs during the OTV-1 boost burn.

ET/OTV Separation Distance at OTV Fly-Over



OTV TRAJECTORY PLOTS SHOW RESULTS OF EARLIER OTV RCS VERT. SEPARATION BURN (MAGNITUDE SHOWN, ALL AT PITCH=080 DEGREES). TIME SYMBOLS ARE 10 SEC APARTS.

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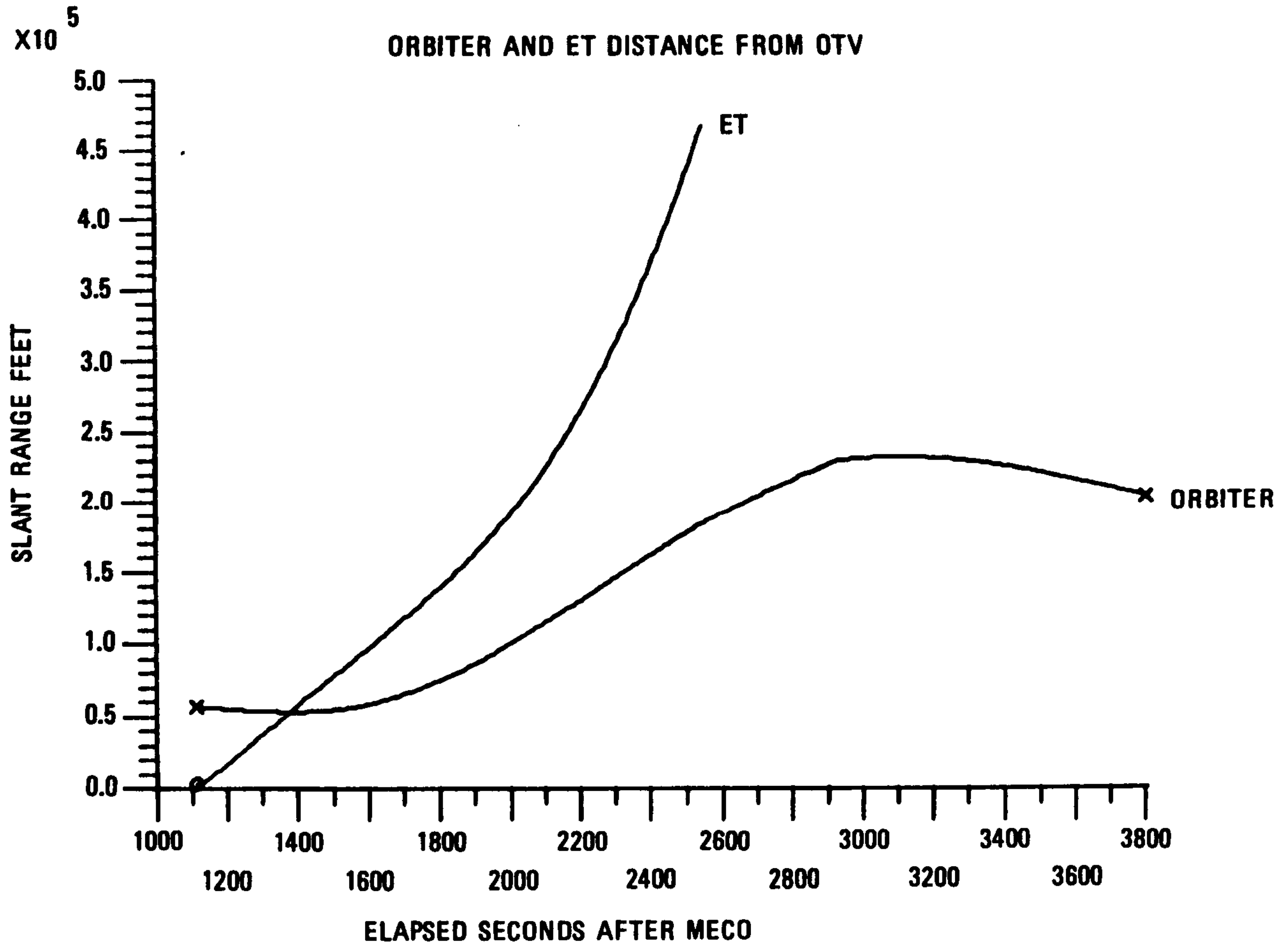
SUBORBITAL RELEASE FROM ACC

The orbiter and ET slant range distances from the OTV are shown in the facing chart. The following chart is an enlargement of the curve for only the 1100 - 1600 second time interval. It should be noted that the distance comparisons between the orbiter and ET are not valid.

Suborbital Release from ACC



OTV SEP: 2 FPS, 170 DEG PITCH AT MECO + 400 SEC
ORBITER SEP: 8 FPS, -100 DEG PITCH AT MECO + 430 SEC
DIST SHOWN BETWEEN ORBITER AND ET IS NOT VALID

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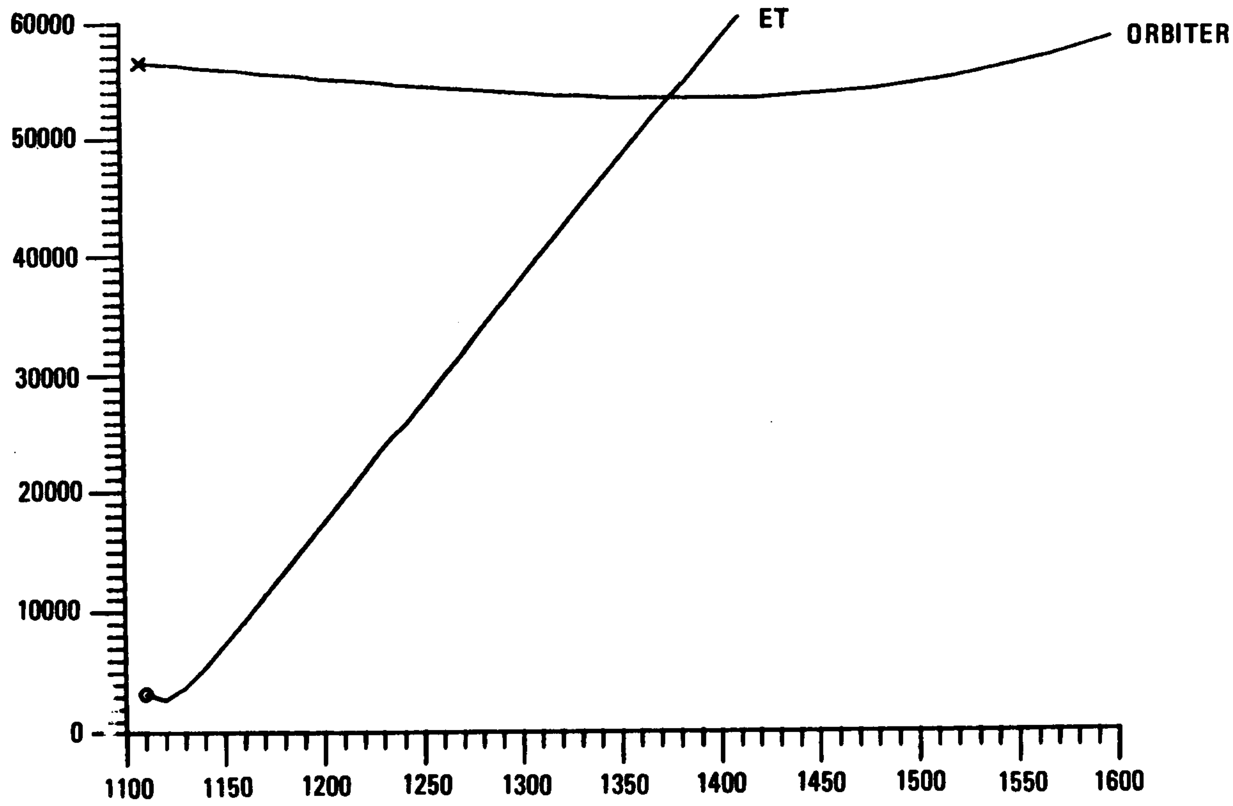
Suborbital Release from ACC

ORBITER AND ET DISTANCE FROM OTV



OTV SEP: 2 FPS, 170 DEG PITCH AT MECO + 400 SEC
ORBITER SEP: 8 FPS, -100 DEG PITCH AT MECO + 430 SEC
DIST SHOWN BETWEEN ORBITER AND ET IS NOT VALID

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ORBITER/OTV ORBITAL TRANSFER PARAMETERS

This chart shows the delta-Vs and propellant quantities required by the orbiter and OTV to fly to different destination orbits after the OTV is suborbitally released from the SSV/DACC at MECO+400 seconds. All destination orbits are circular.

Orbiter/OTV Orbital Transfer Parameters

ORBITER TRANSFER

ORBIT ALTITUDE (RM)	DELTA-V (FPS)			PROPELLANT WEIGHT (LB)		
	FIRST BURN	SECOND BURN	TOTAL	FIRST BURN	SECOND BURN	TOTAL
120	200.7	65.0	265.7	4183	1337	5520
130	220.0	81.3	301.3	4581	1668	6249
140	238.8	98.2	337.0	4967	2008	6975
150	257.2	115.2	372.4	5344	2350	7694
160	275.3	132.3	407.6	5716	2691	8407

OTV TRANSFER

ORBIT ALTITUDE (RM)	DELTA-V (FPS)			PROPELLANT WEIGHT (LB)		
	FIRST BURN	SECOND BURN	TOTAL	FIRST BURN	SECOND BURN	TOTAL
120	211.0	54.2	265.2	828	211	1039
130	228.9	72.0	300.9	898	280	1178
140	246.7	89.7	336.4	967	348	1315
150	264.5	107.3	371.8	1036	415	1451
160	282.2	124.9	407.1	1105	482	1587

NOTES: (1) OMS ENGINE/T = 12,000 LBF, ISP = 313.2 SEC
(2) OTV MAIN ENGINE/T = 15,000 LBF, ISP = 459.8 SEC

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ACC/OTV Separation

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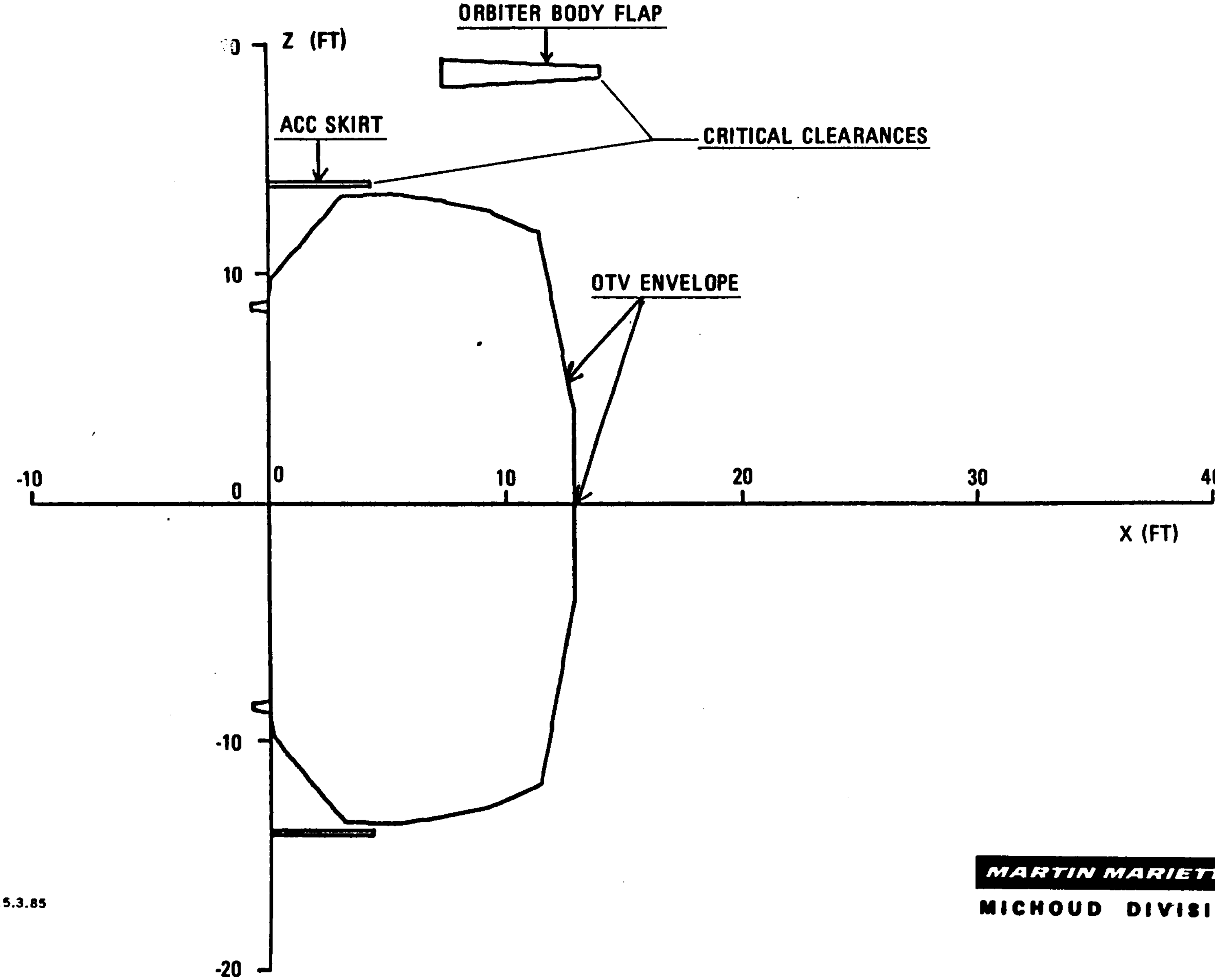
DACC/OTV SEPARATION CLEARANCES

The critical clearances associated with OTV separation from the SSV/DACC are between the DACC shroud structure and orbiter body flap. There is approximately a 3 in. radial clearance between the OTV aerobrake and retained shroud structure, and approximately 60 in. clearance with the orbiter body flap when in the null position.

DACC/OTV Separation Clearances



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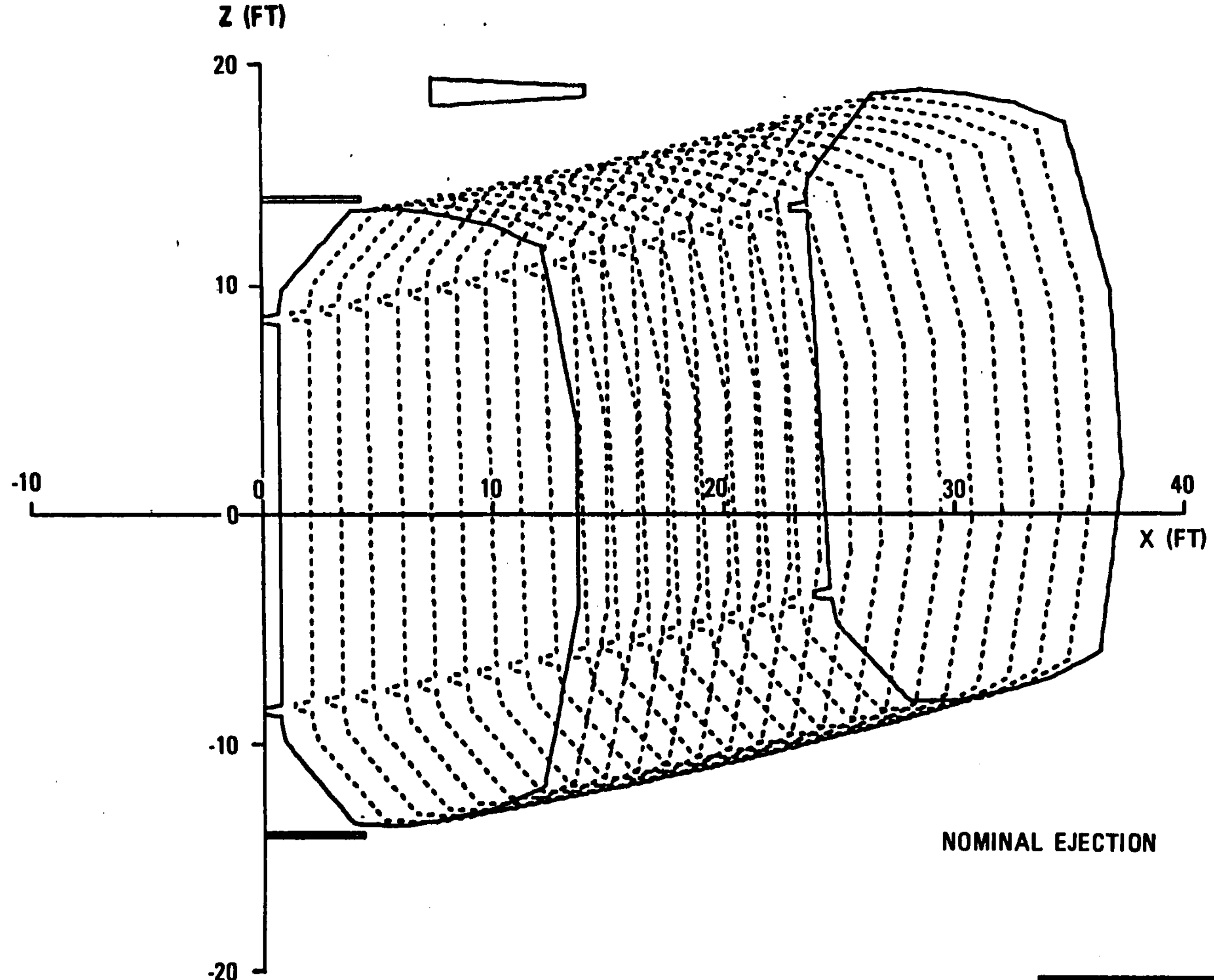
OTV SEPARATION

The OTV ejection path under normal conditions is shown. The apparent upward movement of the OTV is due to the uncorrected pitch rotation of the STS/ACC caused by the OTV ejection forces ($\Delta V = 2$ FPS). The magnitude of this STS/ACC pitch rotation is +0.29 degrees/sec. It should be noted that the OTV appears to rotate rather than the STS/ACC due to the use of a reference coordinate system fixed to the STS/ACC.

OTV Separation



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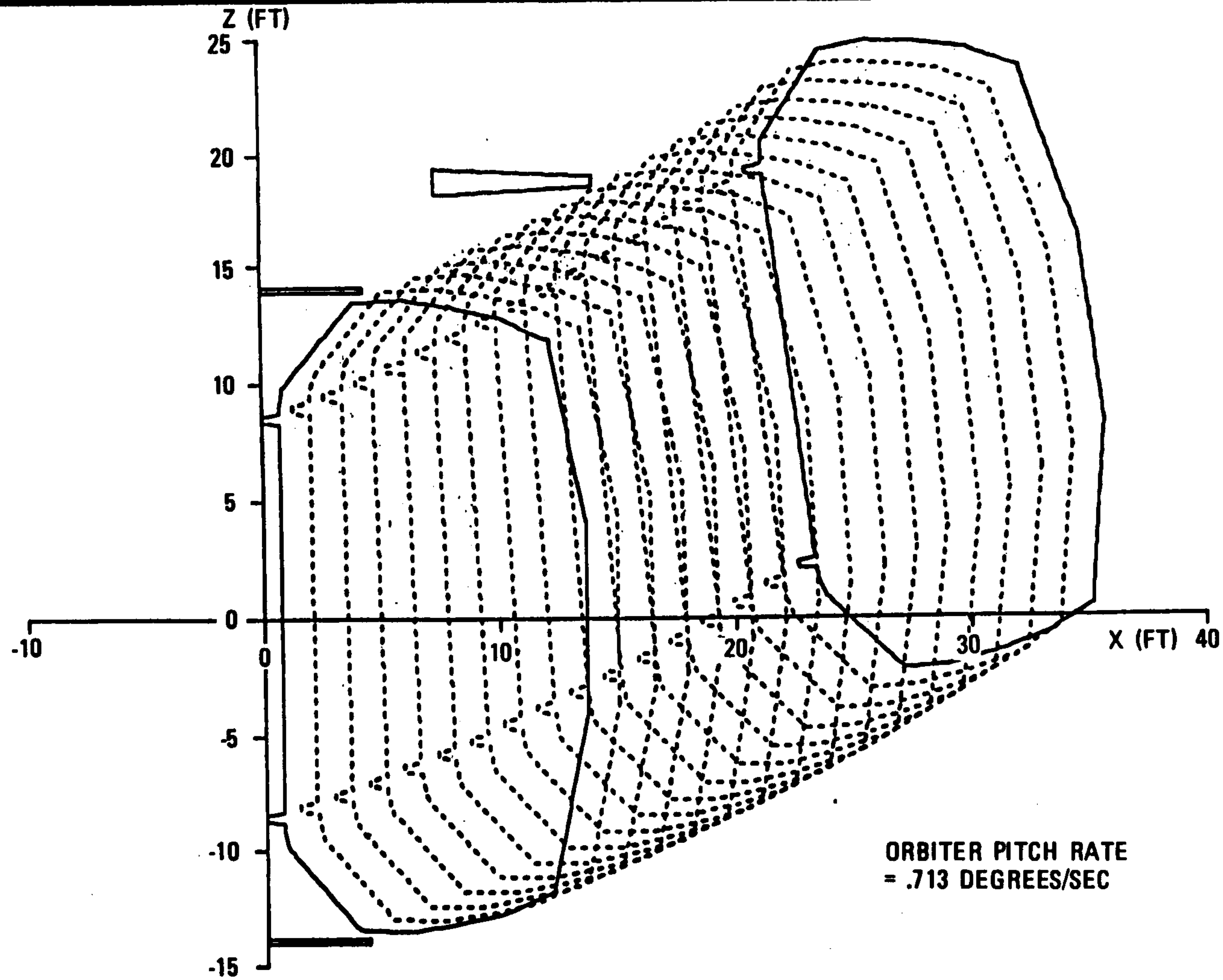
OTV SEPARATION

The maximum allowable STS/ACC pitch rate must be constrained to less than +0.713 degrees/sec to prevent OTV contact with the orbiter body flap.

OTV Separation



ORBITER PITCH RATE
= .713 DEGREES/SEC

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Orbiter/OTV Rendezvous

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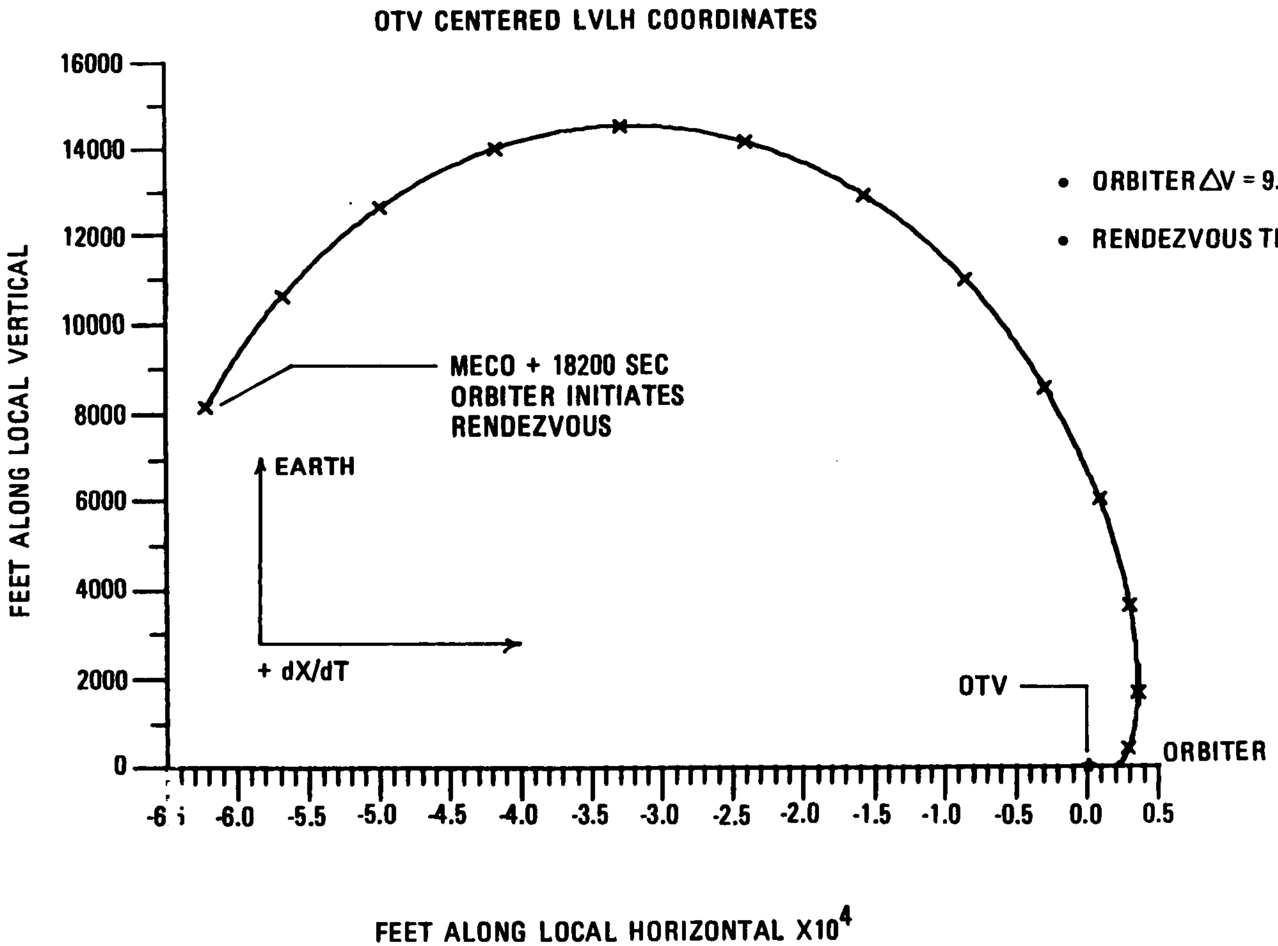
ORBITER/OTV RENDEZVOUS

Parametric analyses were performed to determine the minimum orbiter delta velocity (delta-V) required to finalize orbiter rendezvous with the OTV. The required delta-V is 9.33 fps.

The graph on the opposite page presents the orbiter position with respect to the OTV during the rendezvous operations. The total time for this rendezvous sequence is approximately 64 minutes.

Orbiter/OTV Rendezvous



- ORBITER ΔV = 9.33 FPS
- RENDEZVOUS TIME = 63.75 MIN

AT MECO+18200 SEC, ORBITER INITIATES RENDEZVOUS
AT MECO+22025 SEC, ORBITER EXECUTES STATIONKEEPING MNVR
TIME SYMBOLS ARE 5 MIN APART

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OTV Carried to 120 NM Park Orbit

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MISSION TIMELINES: OTV CARRIED IN ACC

The following charts detail the mission events and times for a STS/DACC mission that carries an OTV in the DACC to a 120 nm park orbit.

Mission Timelines: OTV carried in ACC

EVENT START (DAY:HOUR:MINUTES) (MISSION ELAPSED TIME)	DURATION (MINUTES)	EVENT	REMARKS
00:00:00		LAUNCH	
00:00:02.2		SRB SEPARATION	
00:00:03.3		ACC SHROUD SEPARATION	
00:00:08		MECO	
00:00:52		OMS CIRCULARIZATION BURN	ORBIT CIRCULARIZED AT 120 NM
00:01:00	120	POST INSERTION ACTIVITIES	COMPLETE BY 00:03:00 PLBD OPEN
00:03:00	15	PREP FOR ET VENTING	
00:03:15	40	ET VENTING	
00:03:55	35	IMU ACTIVITIES	FINAL: -ZLV
00:04:30	30	AFT STATION C/O	P/L & OTV GRD C/O
00:05:00	55	MEAL	LUNCH
00:06:00	15	ACTIVATE RMS	OTV SEPARATION C/O
00:06:15	15	ORBITER REORIENTED	
00:06:35	60	OTV SEP & MNVR & SAFE	
00:07:40	15	OTV GRAPPLE	
00:07:55	10	ERECT PAYLOAD	MOUNTED ON TILT TABLE
00:08:05	25	PAYLOAD/OTV MATE	
00:08:30	44	INTERFACE C/O & NAV UPDATE	
00:09:14	10	PAYLOAD DEPLOY	
00:09:24		ORBITER SEPARATION MNVR	

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Mission Timelines: OTV Carried in ACC (concl)

EVENT START (DAY:HOUR:MINUTE) (MISSION ELAPSED TIME)	DURATION (MINUTES)	EVENT	REMARKS
00:09:58		PAYLOAD LAUNCH	
00:10:00	60	MEAL	SUPPER
00:11:00	45	PRESLEEP	
00:11:45	8 HOURS	SLEEP	
00:19:45	45	POSTSLEEP	FLIGHT DAY 2
00:20:30	15	TPR MSG REVIEW	
00:20:45	35	IMU ACTIVITIES	
00:21:20	60	MEAL	BREAKFAST
00:22:20	A/R	ORBITER CONTINUES MISSION	

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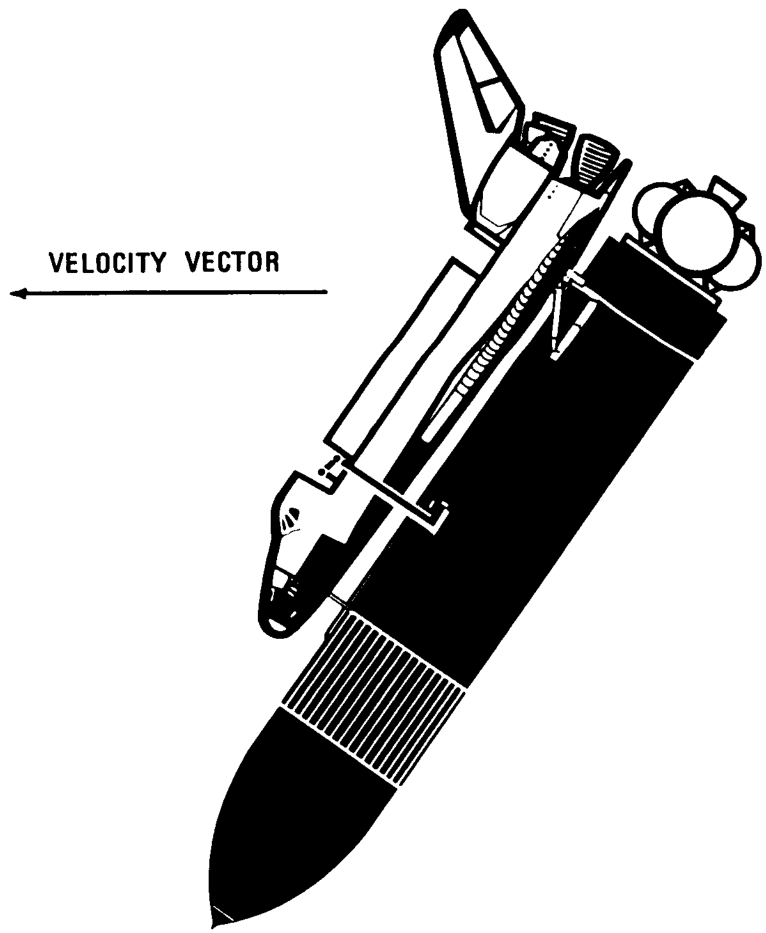
PREPS FOR OTV EJECTION: OPERATIONS TIMELINE

Event Start (Hr/Min.) Mission Elapsed Time	Duration	Event/Crew	
		Commander and Pilot	Mission-P/L Specialist
06:00	15 min.		Activate RMS Final OTV separation checks
06:15	15 min.	Orbiter reorients for OTV ejection	
06:25	10 min.		Position RMS

OTV in ACC - Preparations for OTV Ejection



1. ORBITER ORIENTS TO PROPER ATTITUDE FOR OTV EJECTION
2. RMS ORIENTED TO MONITOR OTV EJECTION (PORT SIDE)

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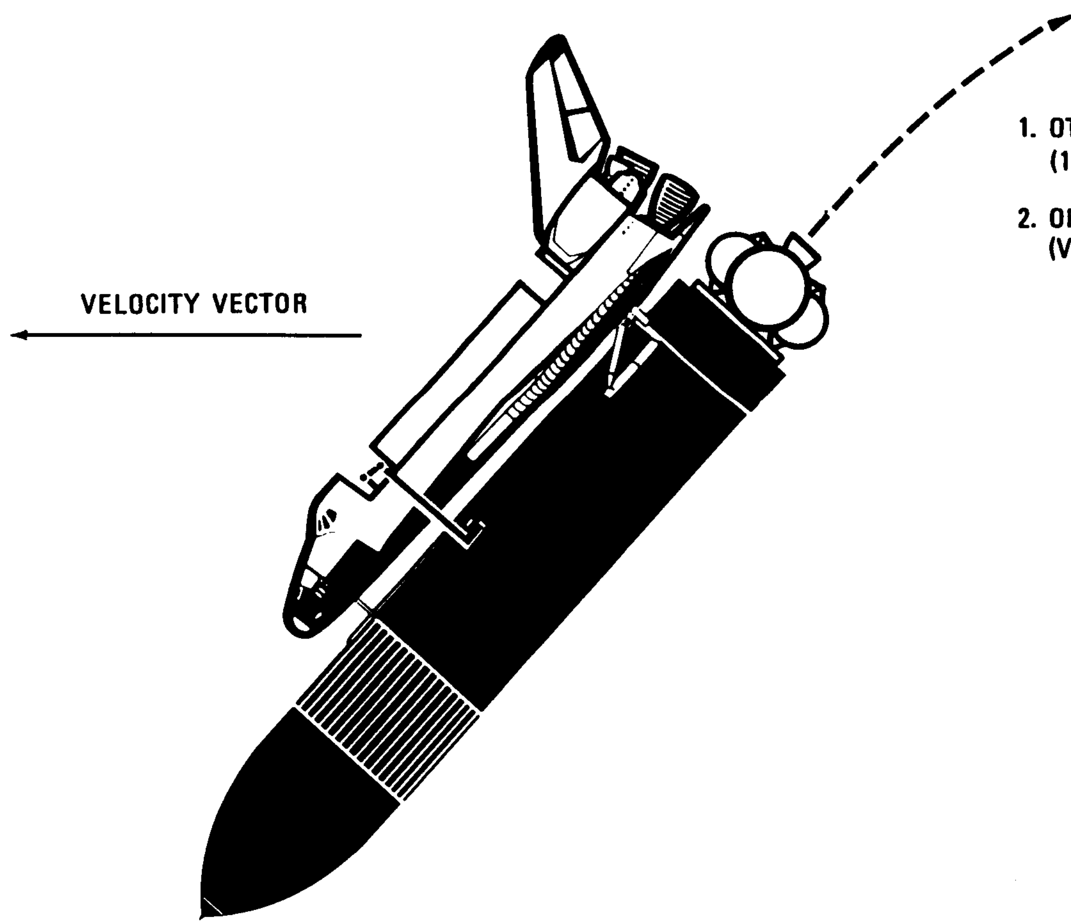
OTV EJECTION: OPERATIONS TIMELINE

Event Start (Hr/Min.)		Event/Crew	
Mission Elapsed Time	Duration	Commander and Pilot	Mission-P/L Specialist
06:35			OTV ejected

OTV in ACC - OTV Ejection



1. OTV IS EJECTED FROM ORBITER (150^{0} FROM VELOCITY VECTOR)
2. ORBITER WAITS FOR SEPARATION (VERIFIED BY RMS CAMERA)

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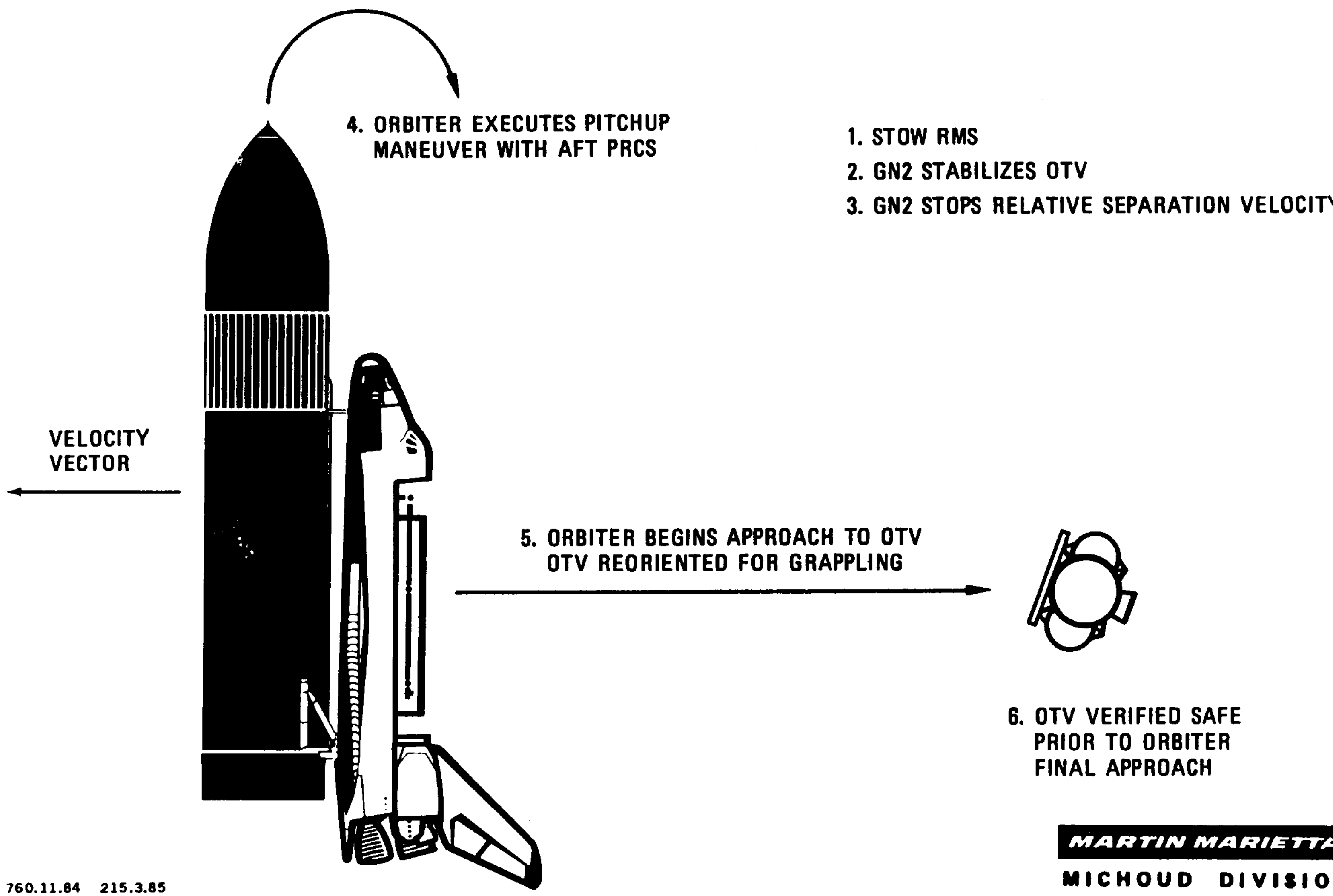
OTV RETRIEVAL: OPERATIONS TIMELINE

Event Start (Hr/Min.)		Event/Crew	
Mission Elapsed Time	Duration	Commander and Pilot	Mission-P/L Specialist
06:38	10 min.		Stow RMS
06:38.3	3 min.		Stabilize OTV (ground command)
06:41.4			OTV delta-V (2 fps) (ground command)
06:50	10 min.	Orbiter pitchup maneuver	
07:00	40 min.	Orbiter approaches OTV	OTV reoriented to convenient attitude for grappling
07:35			OTV verified safe
07:40	15 min.		OTV grapple

OTV in ACC - OTV Retrieval



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DACC on Pad Access
(Contingency Mode)

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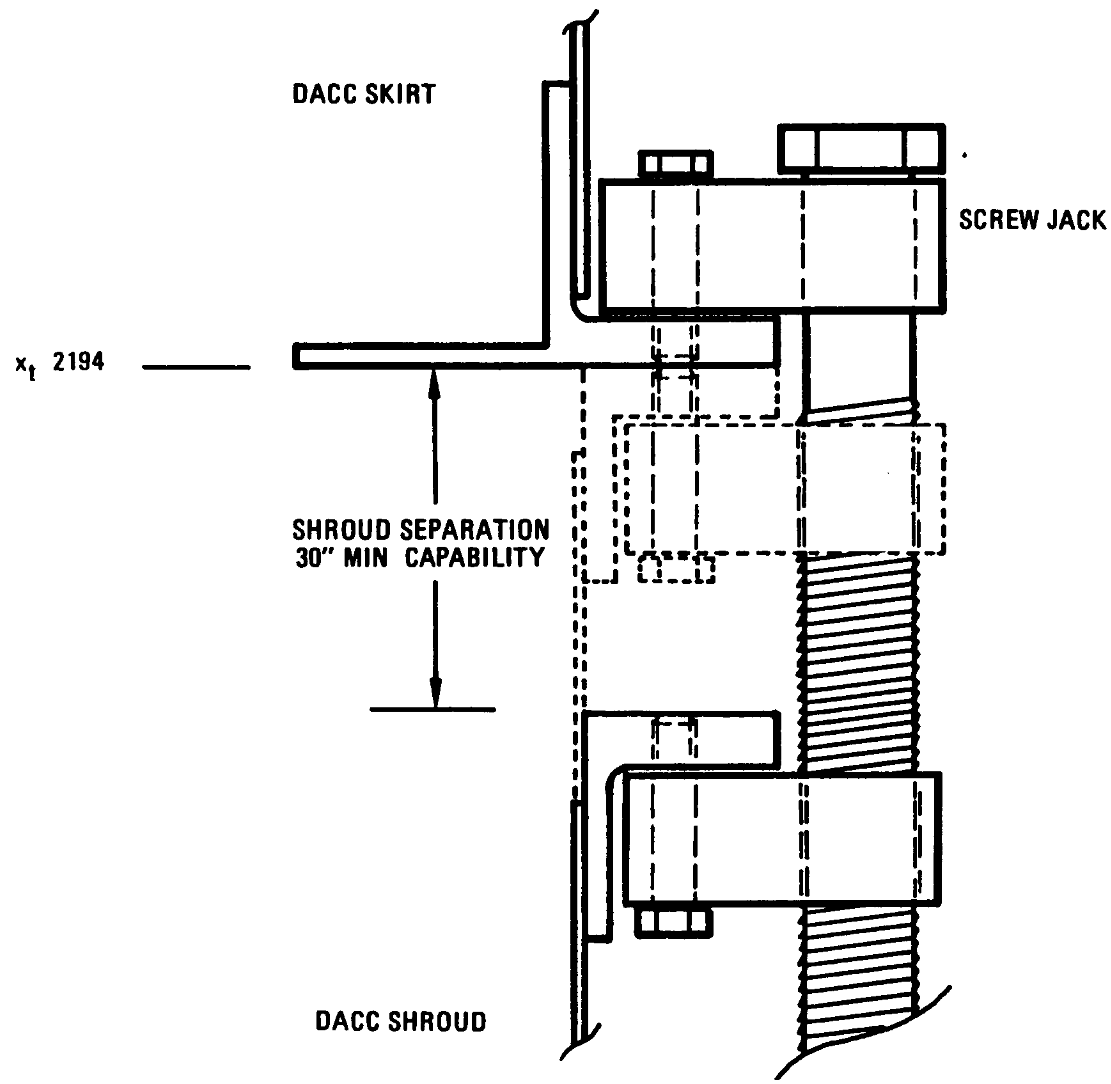
SHROUD LOWERING CONCEPT

For contingency access to the OTV, a partial DACC shroud removal concept will be used to lower the shroud approximately 30 in. This concept uses either manually driven or motorized screwjacks that are installed at four locations around the DACC X_T2194 field joint.

Shroud Lowering Concept



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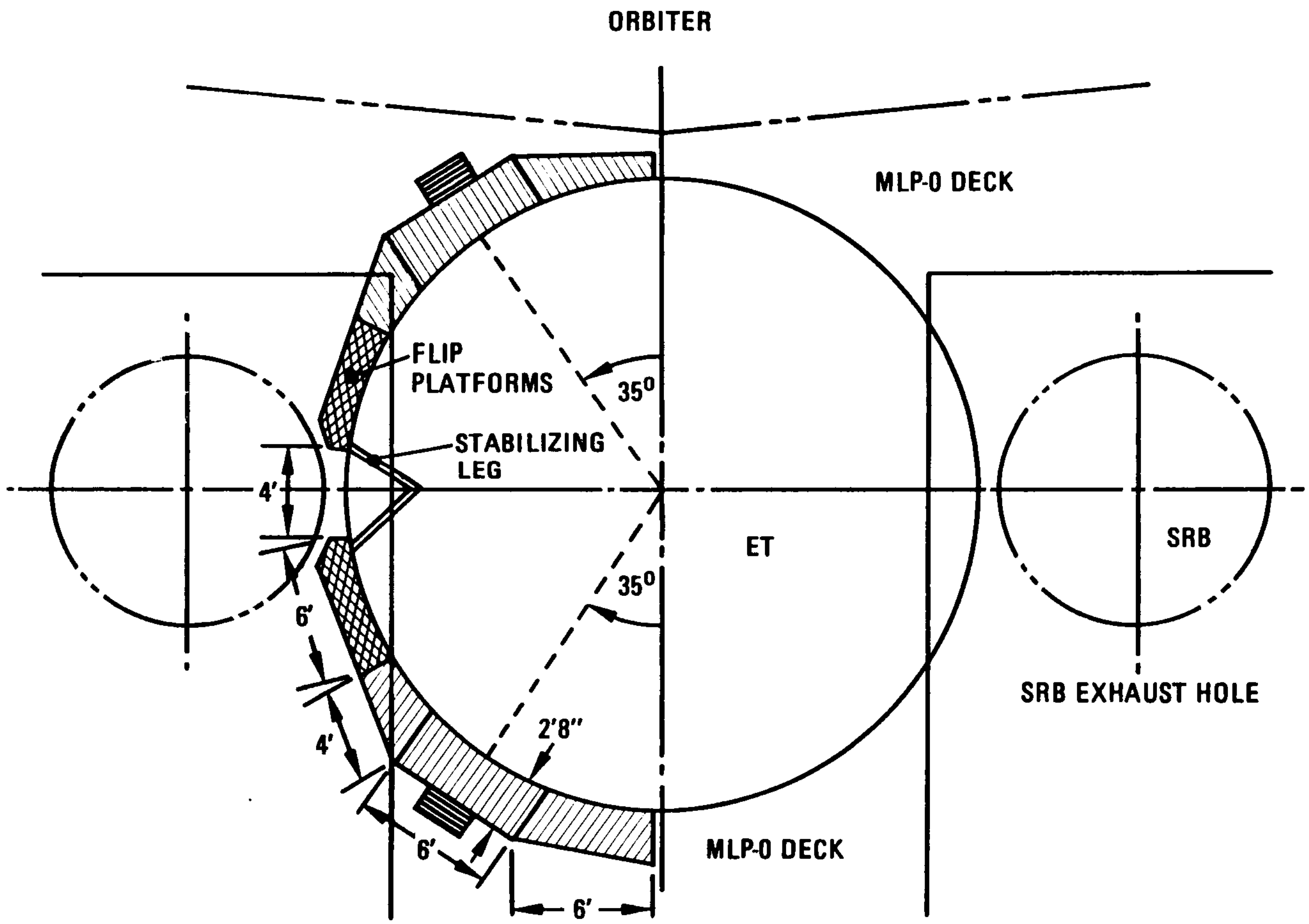
KSC OPERATIONS

ACCESS PLATFORM CONFIGURATION FOR PARTIAL DACC SHROUD REMOVAL

For contingency OTV pad access requiring partial shroud removal, a 360° access platform configuration is required to remove the DACC skirt/shroud I/F flange bolts.

Access Platform Configuration for Partial DACC Shroud Removal



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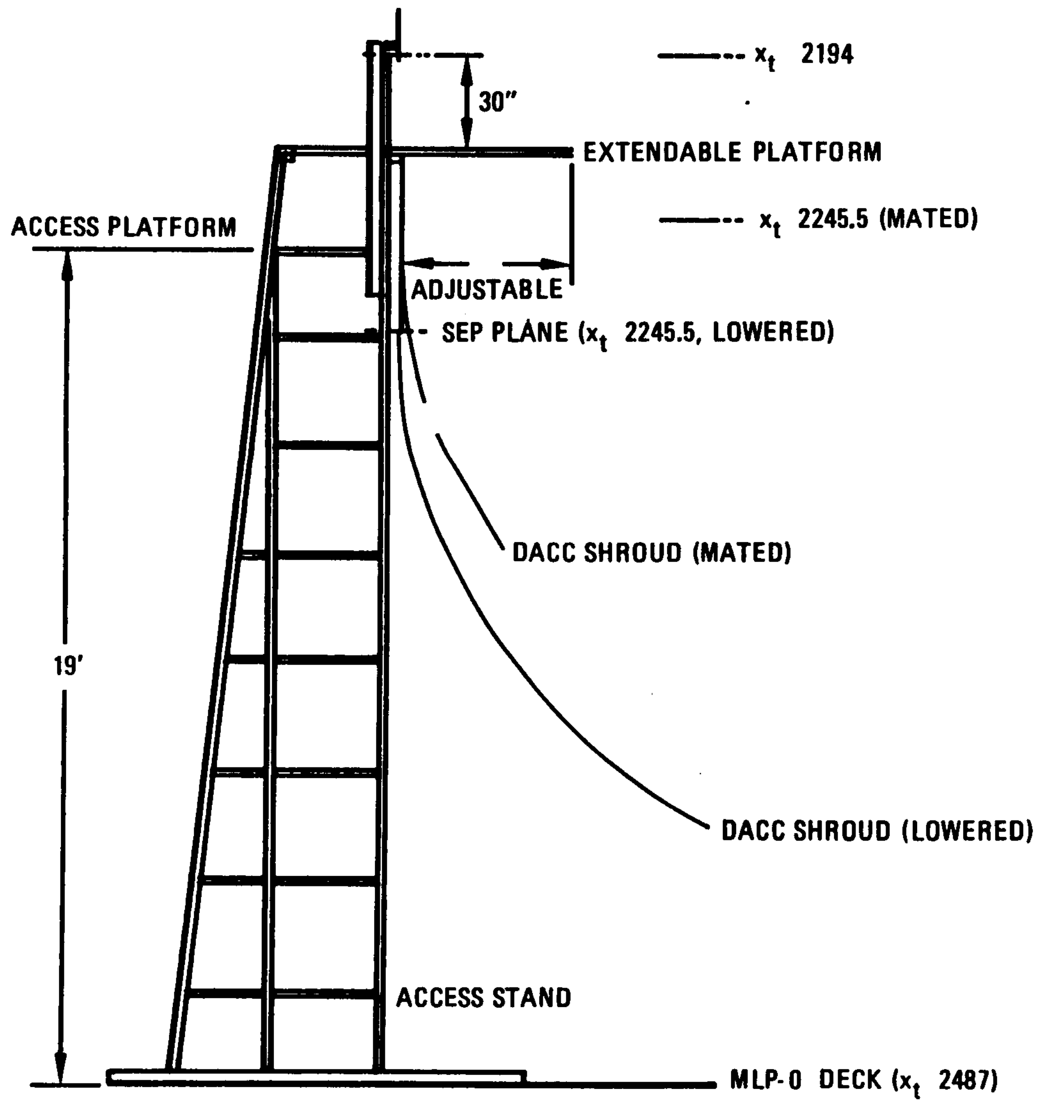
INTERNAL ACCESS CONCEPT

Access to the OTV LRUs is via a "diving board" platform attached to the external platform at one end. The opposite end is attached to either the DACC PS beam or the OTV rack structure.

Internal Access Concept



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KSC OPERATIONS

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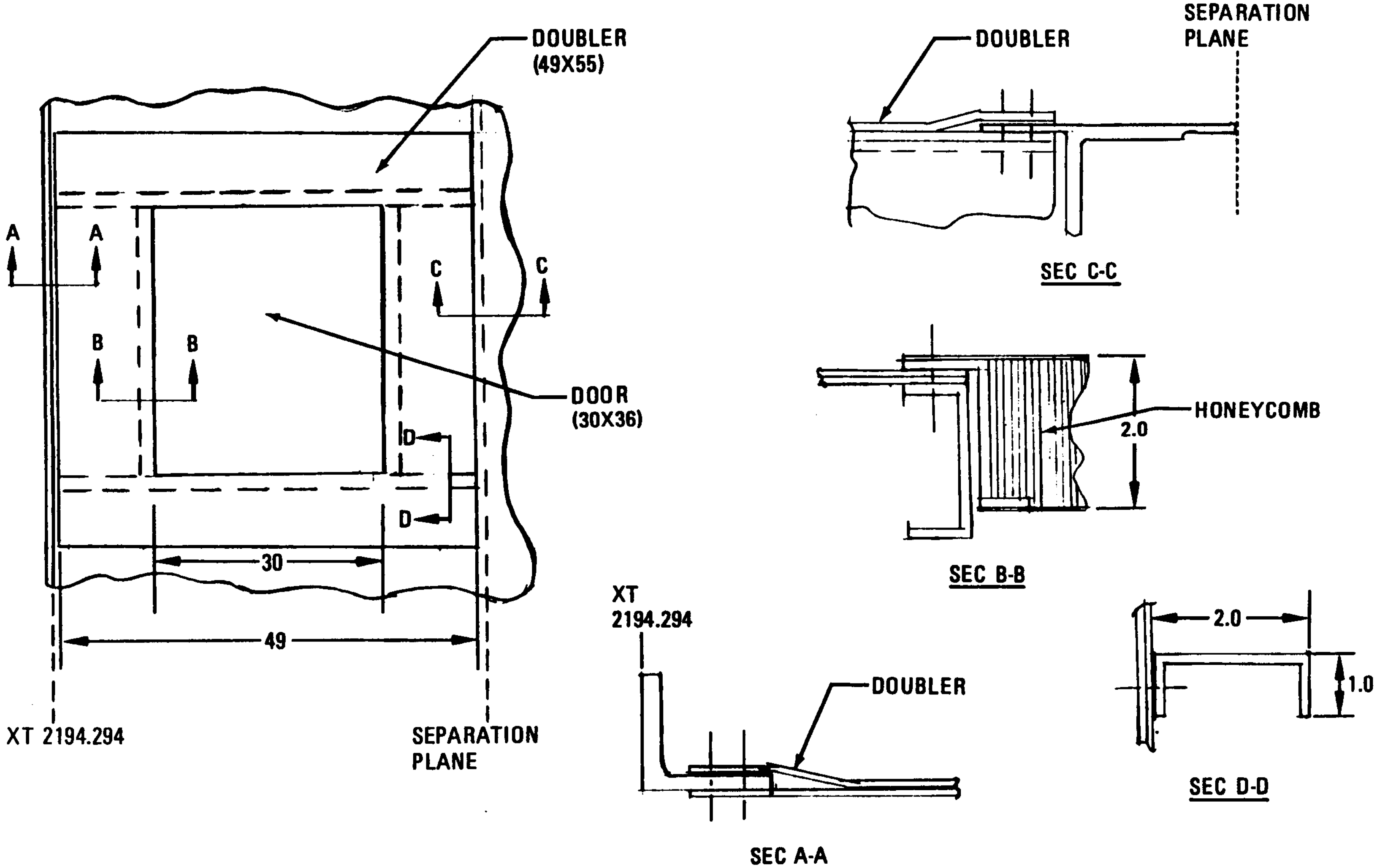
215.3.85
276.5.85

SHROUD ACCESS DOOR DESIGN

A 2 in. thick honeycomb door design was used for the trade study. This design has a backup shroud structure consisting of a skin doubler around the 30 in. X 36 in. opening and channel beams. This structure reacts the shroud loads resulting from internal pressure.

Shroud Access Door Design



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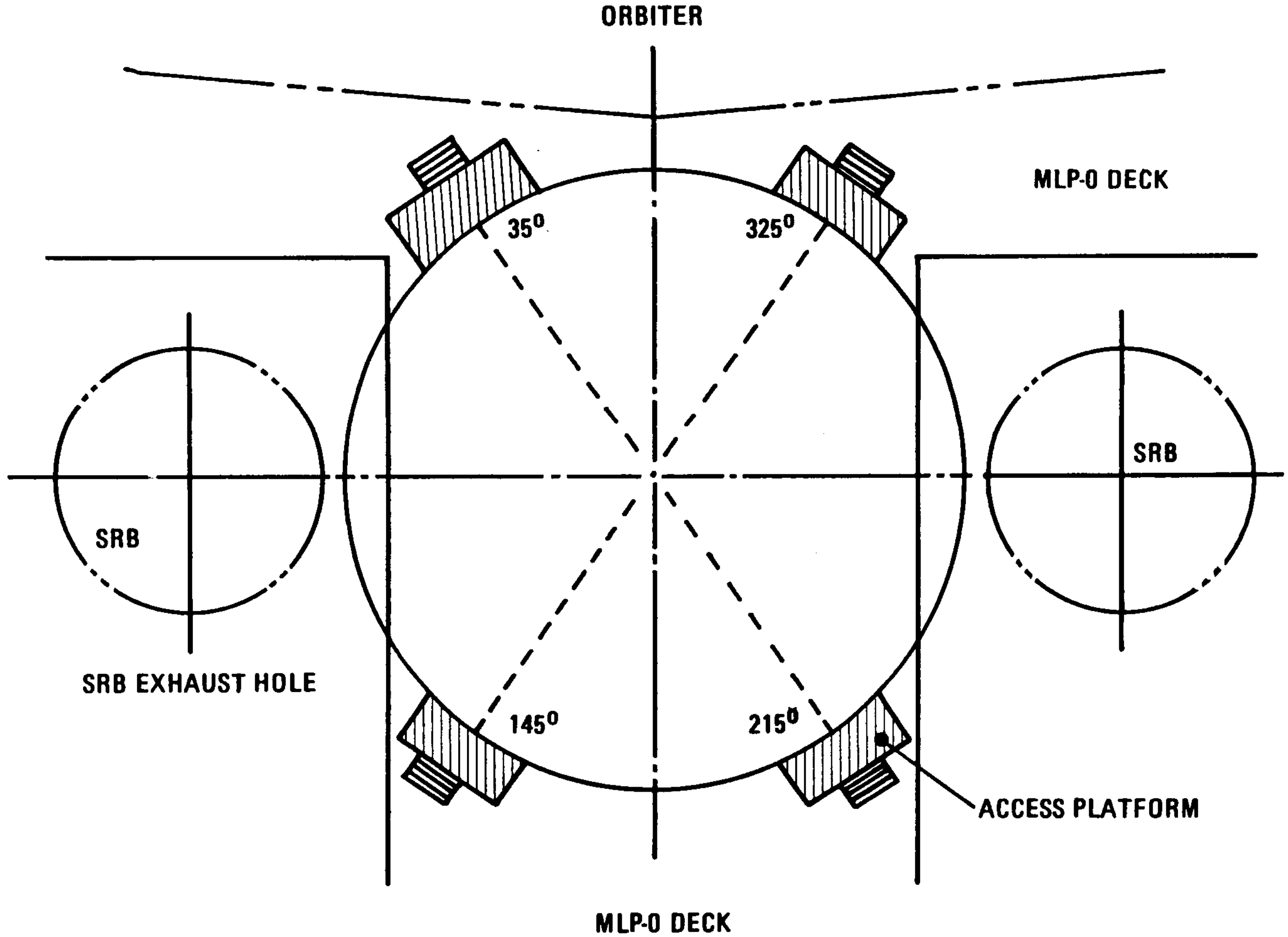
ACCESS PLATFORM LOCATIONS FOR ACCESS DOOR CONCEPT

This chart shows the access platform locations on the MLP "O" Deck that allow ingress/egress of the DACC shroud access doors.

Access Platform Locations for Access Door Concept



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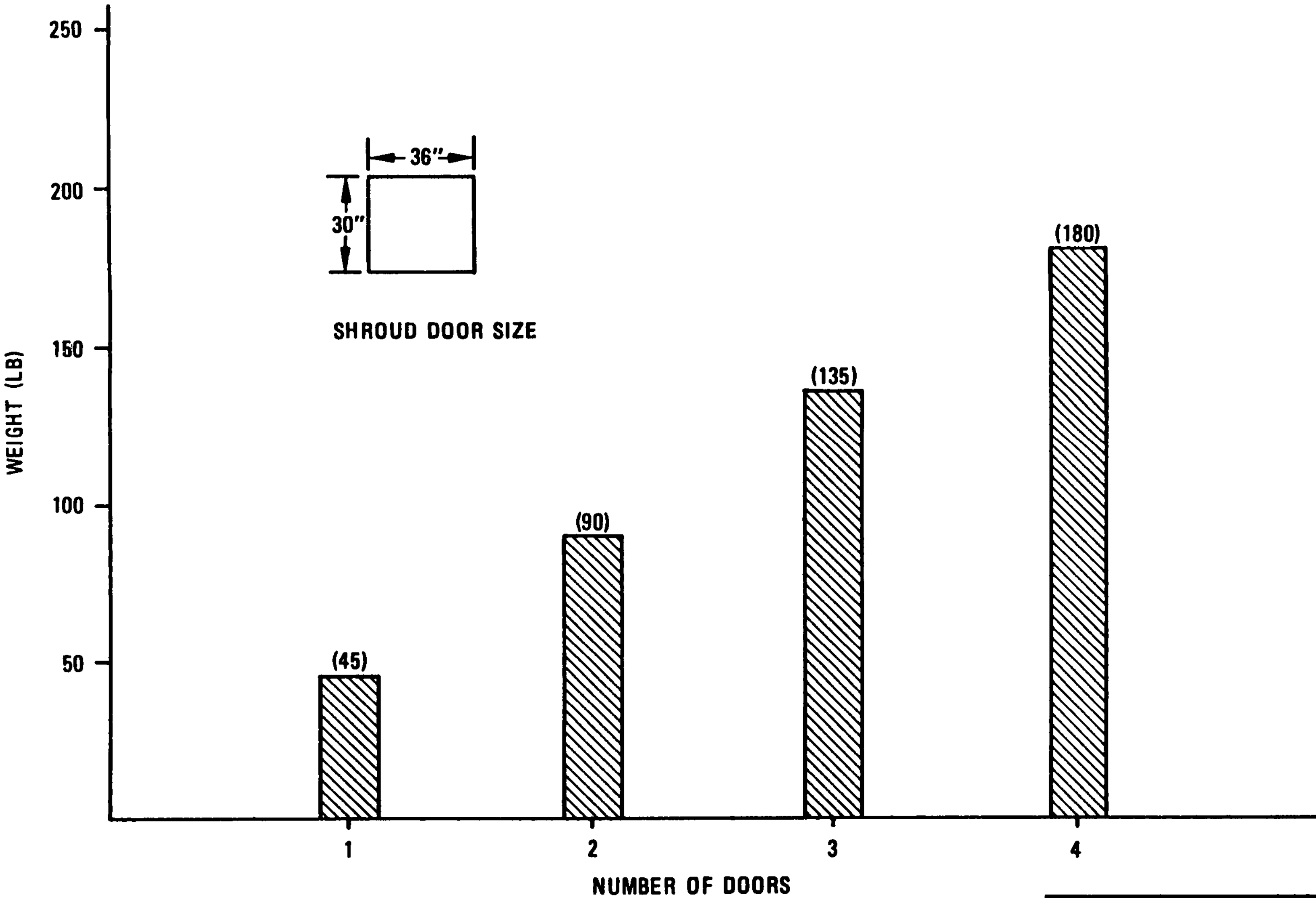
ACCESS DOOR WEIGHT PENALTY

Trade study results indicate that each access penetration in the shroud structure adds an additional 45 lb to the total shroud weight.

Access Door Weight Penalty



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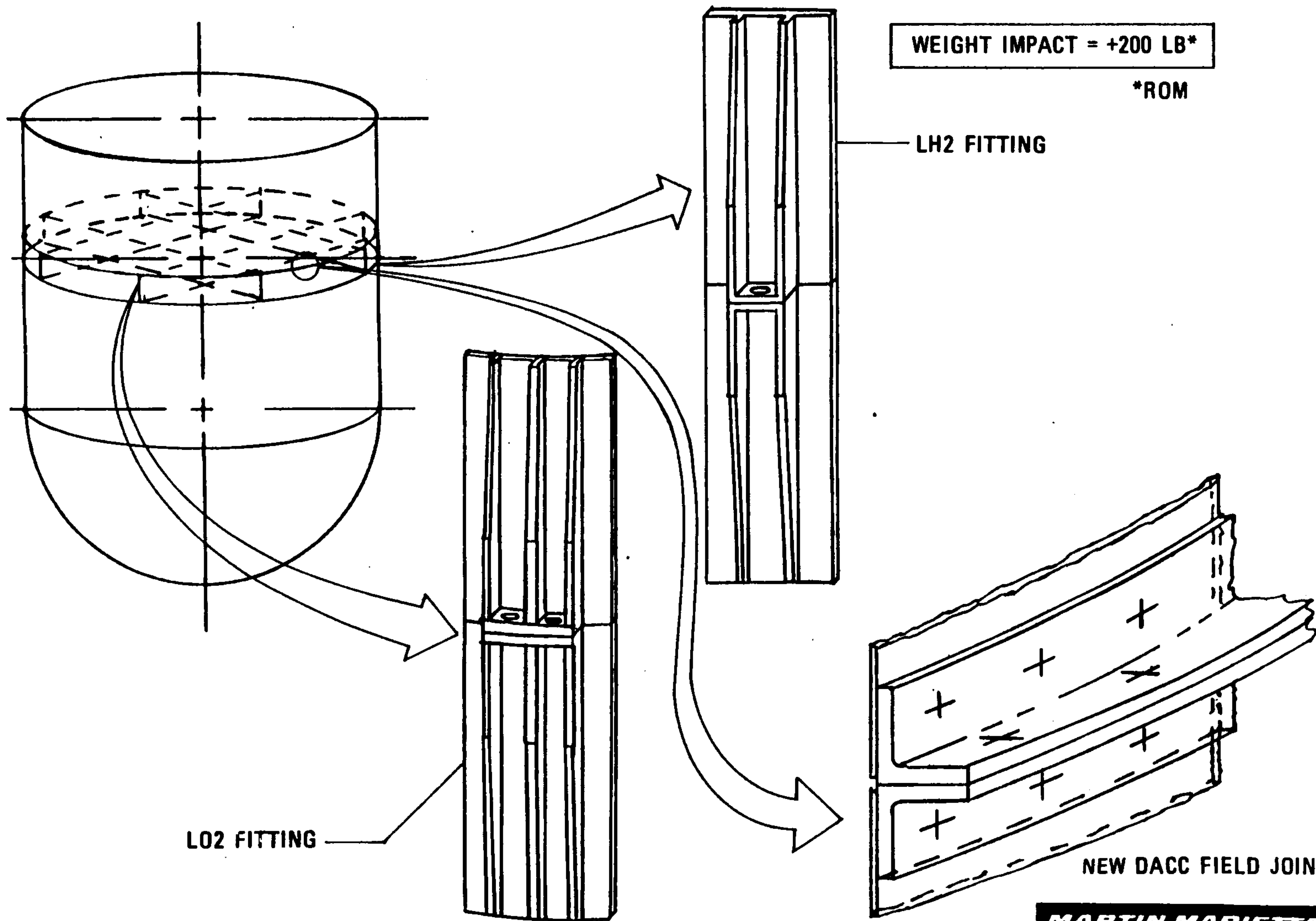
SKIRT/OTV SUPPORT BEAM STRUCTURAL JOINT

This chart shows the DACC structural modifications required to provide an additional field joint to accommodate OTV removal for major contingency operations without a STS destack. The ROM weight penalty for this modification is 200 lb.

Skirt/OTV Support Beam Structural Joint



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Agenda

Introduction

Requirements

Payload Integration

Design (General Purpose)

Design (Dedicated OTV)

Mission Analyses

⇨ Planning

Costs

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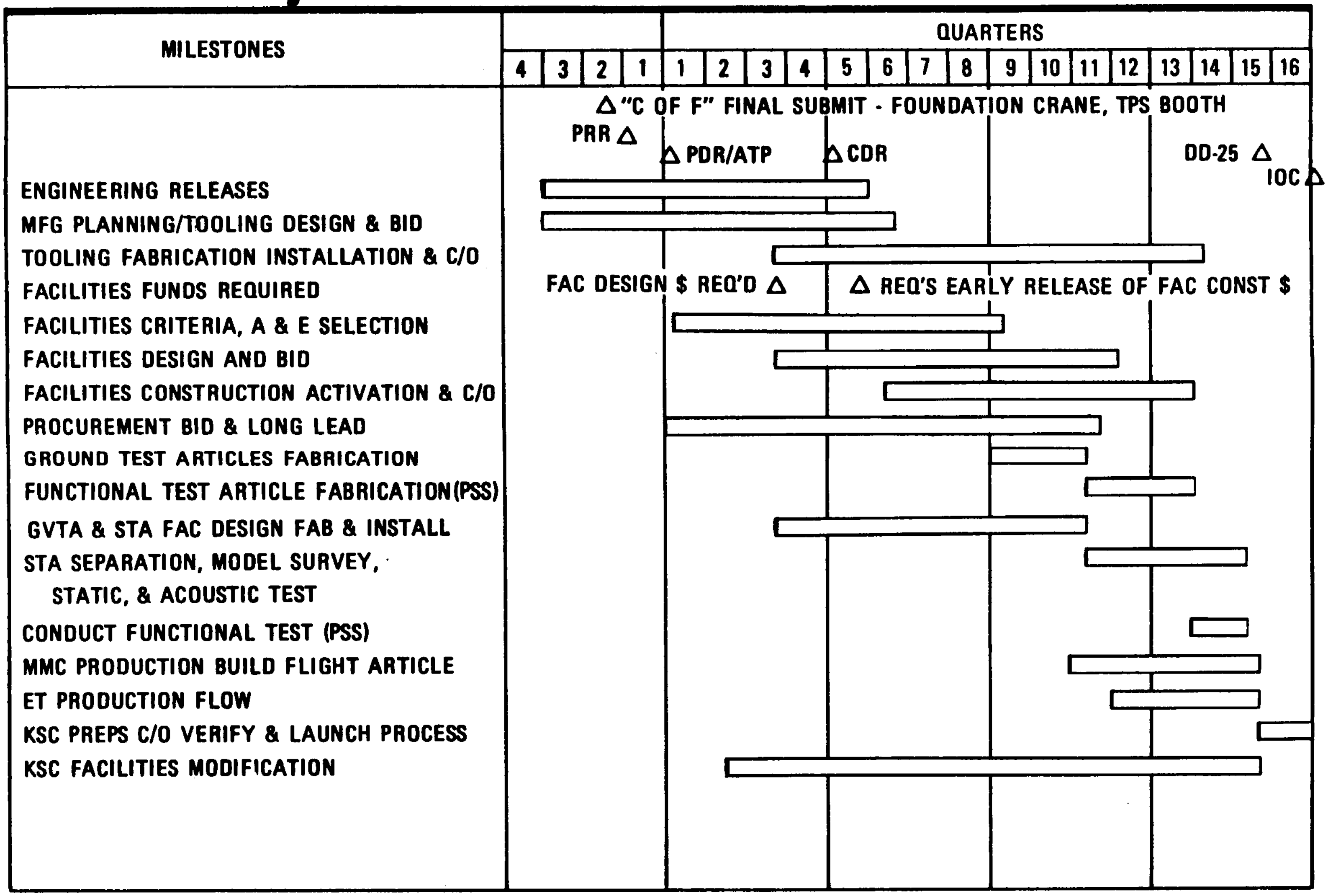
GPACC PROJECT PLAN SCHEDULE

The schedule shows the planning required to support the GPACC programmatic goal of 48 months from Authority to Proceed (ATP) to Initial Operational Capability (IOC).

GPACC Project Plan Schedule



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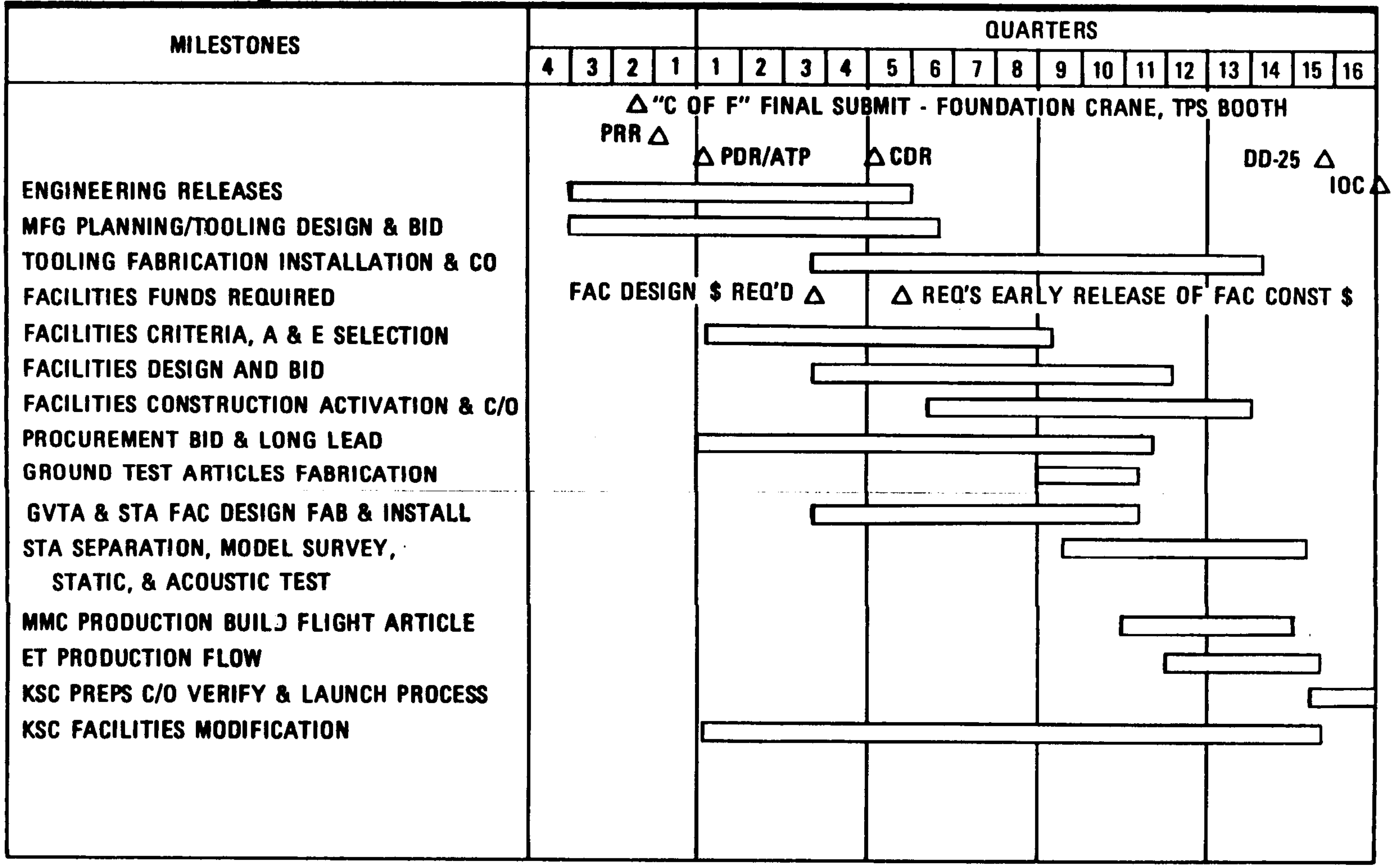
DACC PROJECT PLAN SCHEDULE

The schedule shows the planning required to support the DACC programmatic goal of 48 months from ATP to IOC.

DACC Project Plan Schedule



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Agenda

Introduction

Requirements

Payload Integration

Design (General Purpose)

Design (Dedicated OTV)

Mission Analyses

Planning

⇨ Costs

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GPACC Program Costs

<u>GPACC GROUNDRULES AND ASSUMPTIONS</u>

- CONS ANT 1984 DOLLARS (EXCLUDING FEE AND CONTINGENCY)
- GPACC IOC DATE: 1989
- MISSION MANIFEST BASED ON NASA REV. 7 NOMINAL MISSION MODEL FOR NON DOD PAYLOAD (OPERATIONAL TIME FRAME 1989 - 2000: 87 STS/ACC MISSIONS)
- BASELINE GPACC 101 CONFIGURATION
- GPACC FLIGHT TEST IS CONDUCTED IN CONJUNCTION WITH A SCHEDULED STS FLIGHT

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GPACC PROGRAM COSTS

This chart presents a summary of program costs associated with the GPACC. Nonrecurring costs appear on the left side of the cart and recurring costs on the right.

Nonrecurring DDT&E costs total $184M, including: ACC development costs, the orbiter, ET modifications, facilities/GSE, and Level II integration costs. The ACC test hardware consists of one ground test article complete with all hardware systems and one flight test article. The flight test is conducted in conjunction with a scheduled STS mission so dedicated use of STS hardware and procedures is unnecessary. Orbiter enhancements include the addition of display panels and cabling subsystems as well as software modification. External Tank modifications consist of: additions to the 2058 frame to accommodate the ACC attach flange, changes to the aft strut cable tray, elimination of the tumble valve, and a new RSS/deorbit signal device. Facilities/GSE costs include MAF manufacturing modifications, KSC facility impacts and GSE launch processing impacts. The MAF GSE impacts are included in ACC tooling.

Operations costs for 87 GPACC flights total $484M, including ACC, recurring ET modifications and ground/flight operations. The average cost of ACC hardware over 87 flights if $4.4M. The average cost per flight (CPF), including ET modifications and operations costs, is $5.6M.

Note that our economic analysis indicates that the addition of the GPACC could result in an overall reduction of $753M in STS operations costs. The savings in operations costs resulting from eliminating 31 flights would more than offset the ACC DDT&E and operations costs.

GPACC Program Costs

C-5

NONRECURRING

AFT CARGO CARRIER		$ 96M
DESIGN/DEVELOP	24M	
SYSTEMS ENGINEERING	10M	
TOOLING	36M	
TEST HARDWARE	13M	
SYSTEMS TEST	7M	
PROGRAM MGT	6M	
ORBITER IMPACTS		13M
ET MODS		7M
FACILITIES/GSE		42M
LEVEL II		26M
		$184M

RECURRING (87 FLIGHTS)

AFT CARGO CARRIER		$386M
SHROUD	50M	
SKIRT	59M	
PROPULSION	78M	
AVIONICS/ELEC	61M	
A&CO	52M	
SE&I, PM	87M	
ET MOD		5M
LAUNCH OPS		12M
FLIGHT OPS		81M
		$484M

AVERAGE COST PER FLIGHT	$ 5.6M
ACC H/W AVERAGE UNIT COST	$ 4.4M

COST IN 1984 DOLLARS

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DACC Program Costs

DEDICATED ACC GROUNDRULES AND ASSUMPTIONS

- o CONSTANT 1984 DOLLARS (EXCLUDING FEE AND CONTINGENCY)
- o DACC IOC DATE: 1994
- o MISSION MANIFEST BASED ON OTV MISSION MODEL PROVIDED BY NASA
- o BASELINE DACC 201 CONFIGURATION
- o DACC FLIGHT TEST IS CONDUCTED IN CONJUNCTION WITH A SCHEDULED STS FLIGHT

DACC PROGRAM COSTS

This chart presents a summary of program costs associated with the DACC. Nonrecurring costs appear on the left side of the chart and recurring costs on the right.

Nonrecurring DDT&E costs total $158M, including: ACC development costs, the orbiter, ET modifications, facilities/GSE, and Level II integration costs. The ACC test hardware consists of one ground test article complete with all hardware systems and one flight test article. The flight test is conducted in conjunction with a scheduled STS mission so dedicated use of STS hardware and procedures is unnecessary. Orbiter enhancements include the addition of display panels and cabling subsystems as well as software modifications. External Tank modifications consist of additions to the 2058 frame to accommodate the ACC attach flange, and changes to the aft strut cable tray. Facilities/GSE costs include MAF manufacturing modifications, KSC impacts and GSE launch processing impacts. The MAF GSE impacts are included in ACC tooling.

Operations costs for 64 DACC flights total $138M, including ACC, recurring ET modifications and ground/flight operations costs. The average cost of ACC hardware over 64 flights is $1.9M. The average CPF, including ET modifications and operations costs, is $2.1M.

DACC Program Costs

NONRECURRING

AFT CARGO CARRIER		$ 73M
DESIGN/DEVELOP	15M	
SYSTEMS ENGINEERING	7M	
TOOLING	35M	
TEST HARDWARE	6M	
SYSTEMS TEST	5M	
PROGRAM MGT	5M	
ORBITER IMPACTS		13M
ET MODS		6M
FACILITIES/GSE		45M
LEVEL II		21M
		$158M

RECURRING (64 FLIGHTS)

AFT CARGO CARRIER		$121M
SHROUD	23M	
SKIRT	27M	
PROPULSION	2M	
AVIONICS/ELEC	24M	
A&CO	16M	
SE&I, PM	29M	
ET MOD		3M
LAUNCH OPS		7M
FLIGHT OPS		7M
		$138M

AVERAGE COST PER FLIGHT	$2.1M
ACC H/W AVERAGE UNIT COST	$1.9M

COST IN 1984 DOLLARS

296.5.85

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