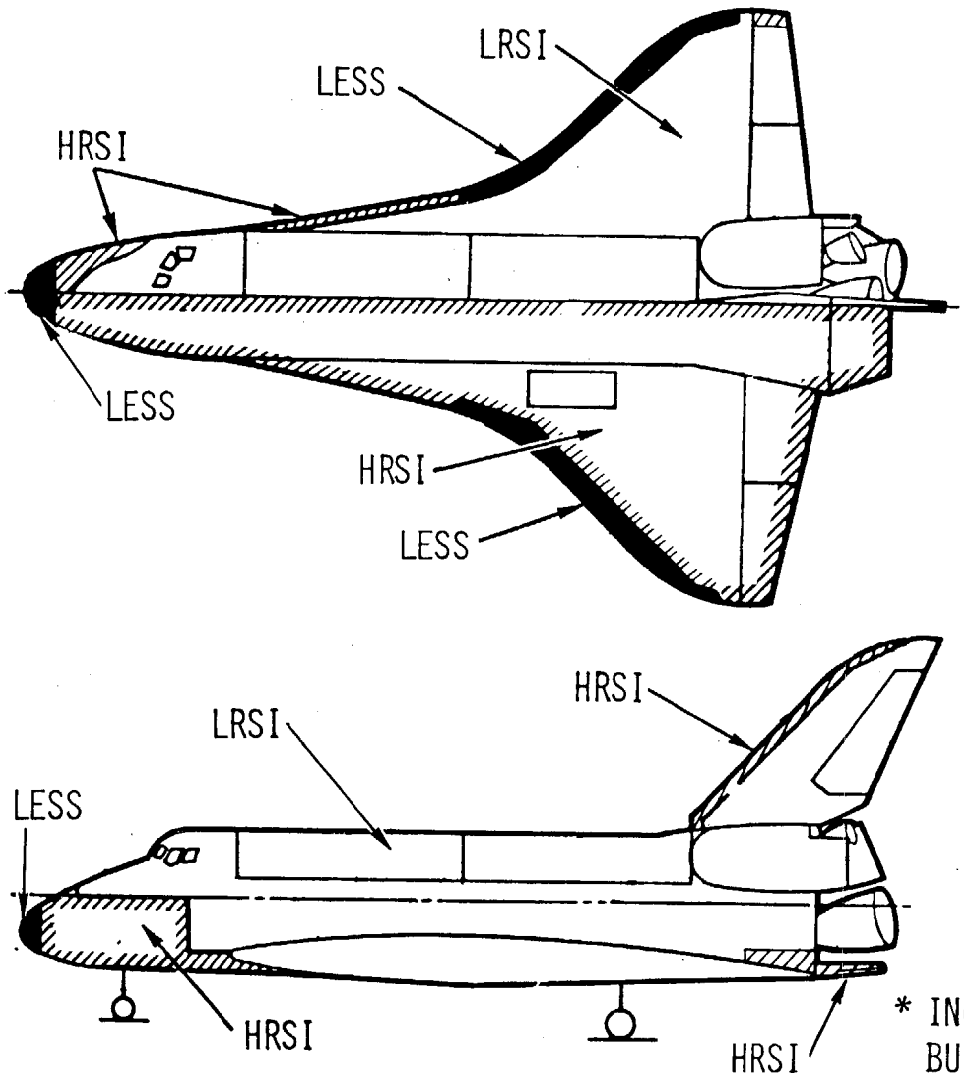
THERMAL PROTECTION SYSTEM DESCRIPTION



140 C CONFIGURATION
TRAJECTORY NOM NO. 14414.1 (UNFAIRED)

TPS	AREA	WT (LB)
LRSI	6,317	2,966
HRSI	5,134	7,951
RCC	409	3,023
TOTAL	11,860	15,984 *

LRSI - COATED SILICA

HRSI - COATED SILICA

RCC - REINFORCED CARBON-CARBON

SIP - NOMEX "E" FELT

* INCLUDES 2044-LB THERMAL SEALS, BULK INS,

Figure 6

LRSI AND HRSI JOINT

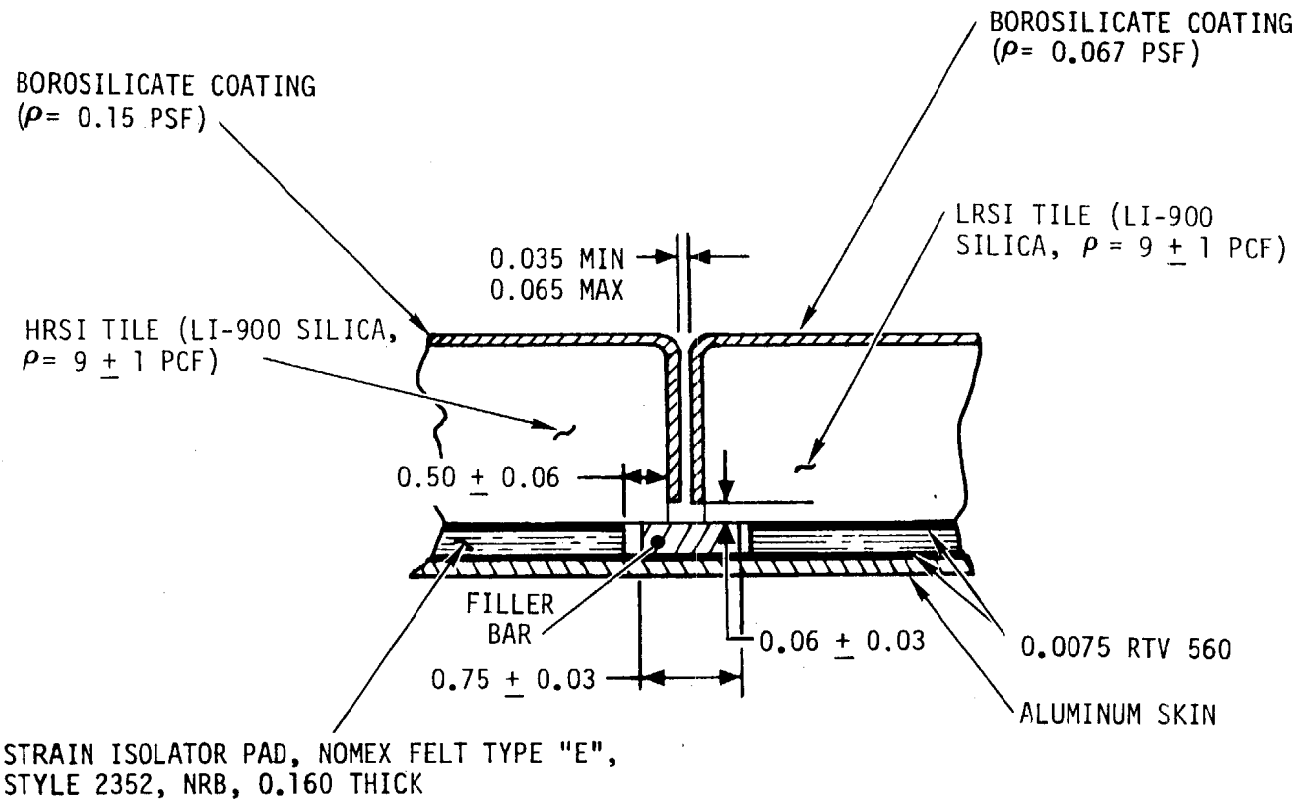


Figure 7

LEADING EDGE STRUCTURAL SUBSYSTEM

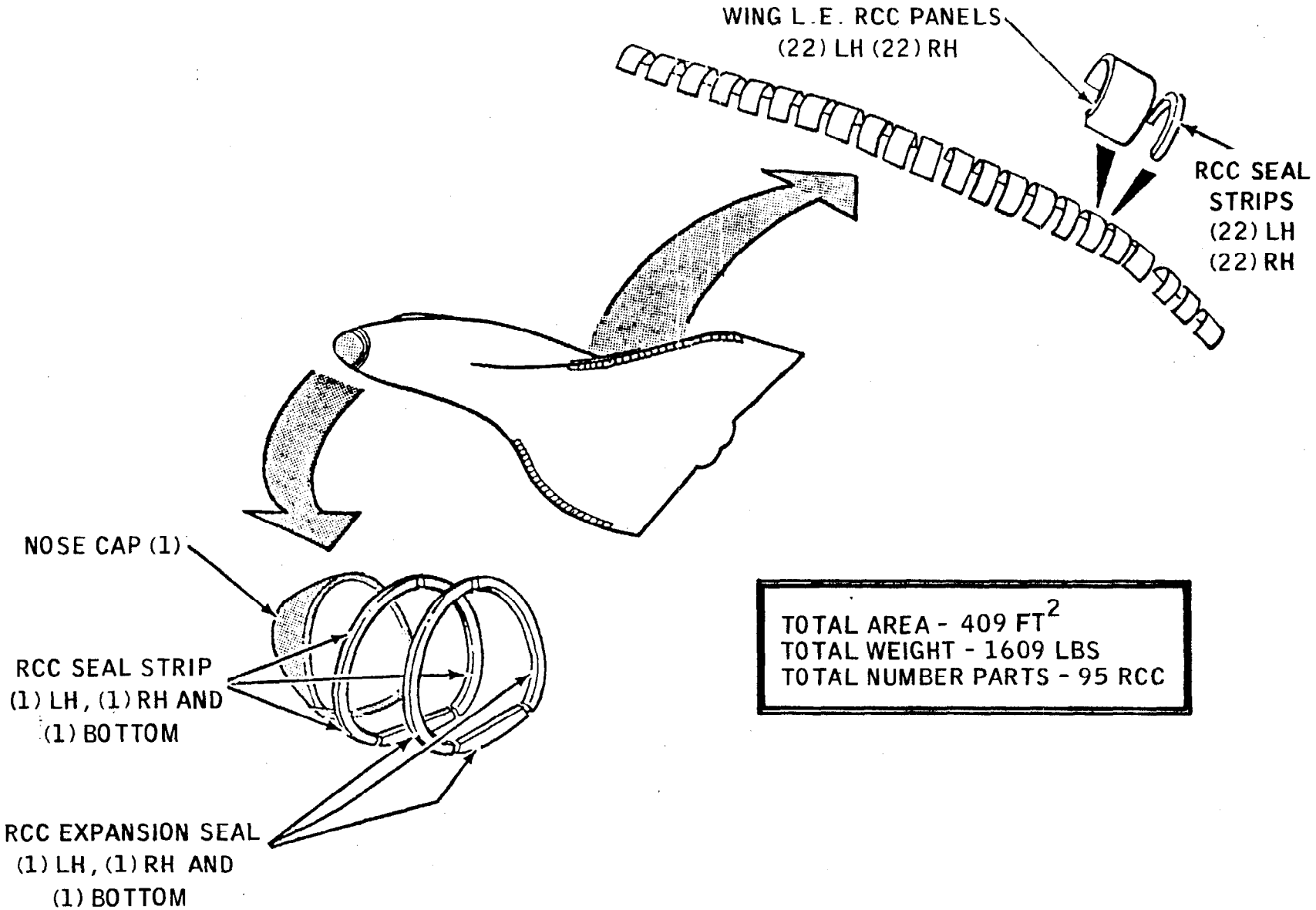


Figure 8

VERTICAL TAIL
SPACE SHUTTLE ORBITER

INCONEL SANDWICH DESIGN

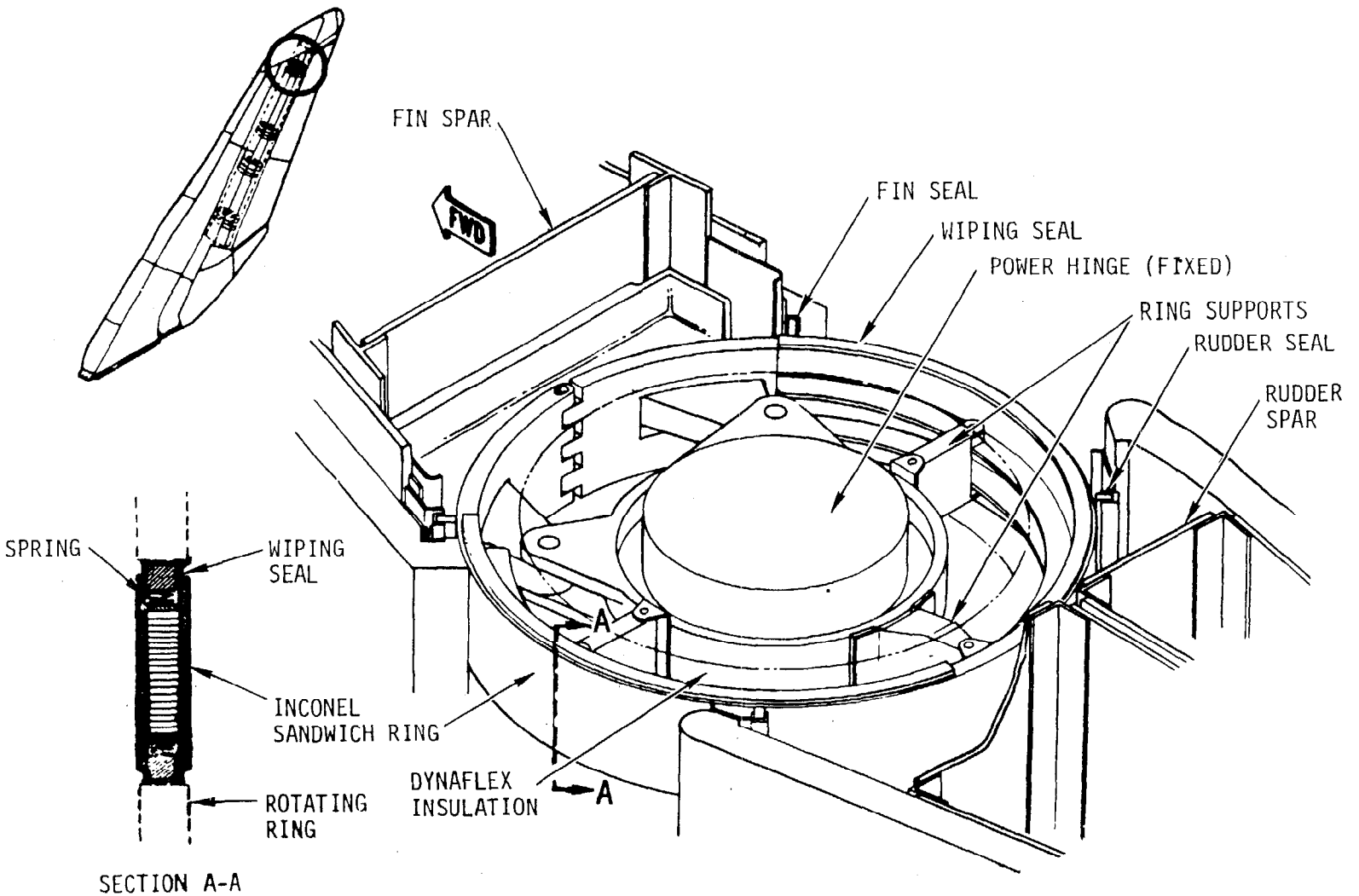
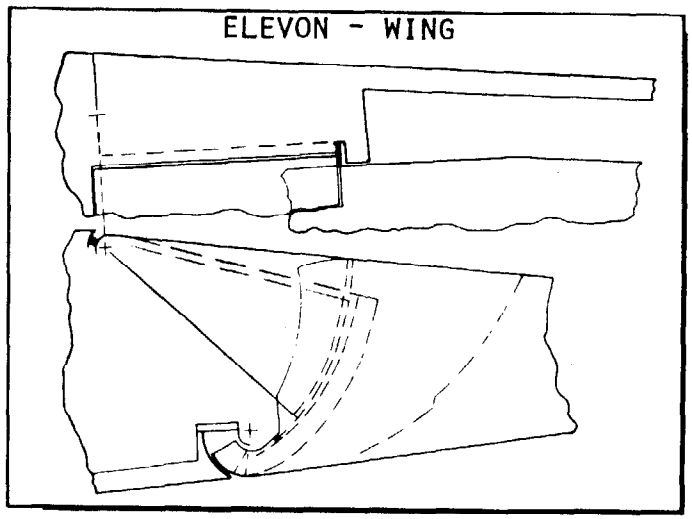
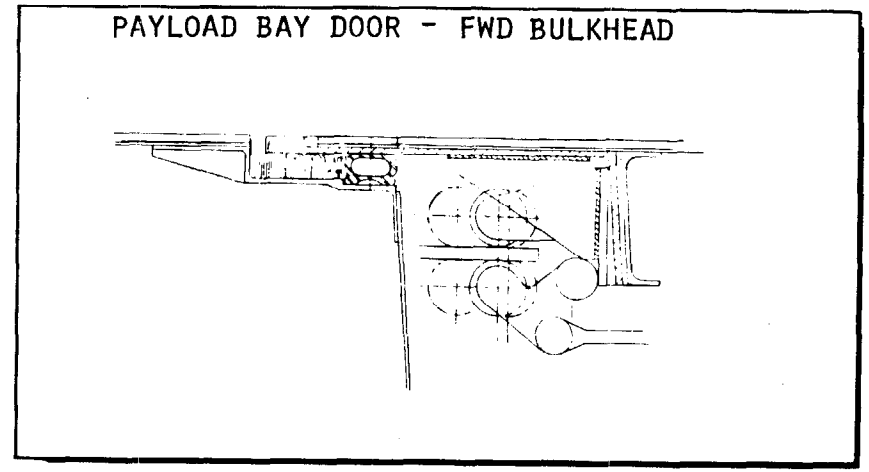
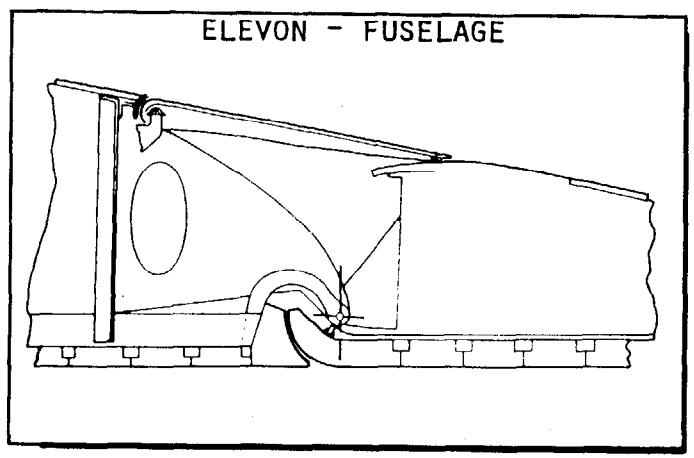


Figure 9

THERMAL SEAL CONCEPTS







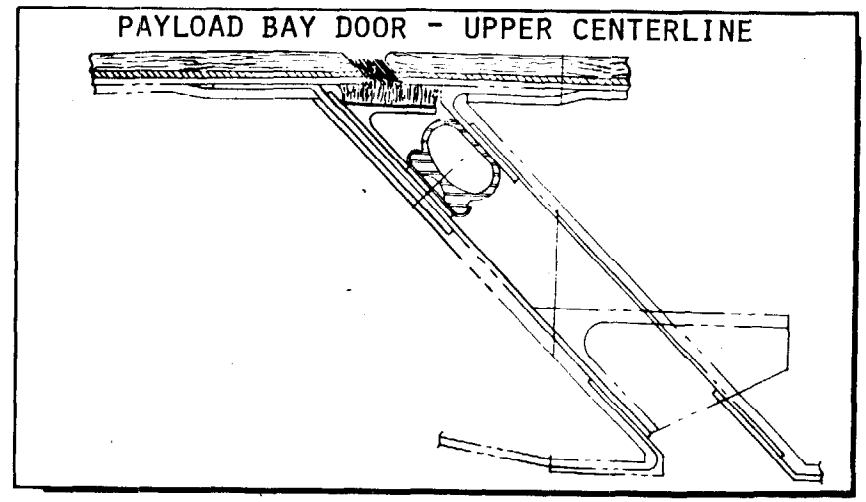
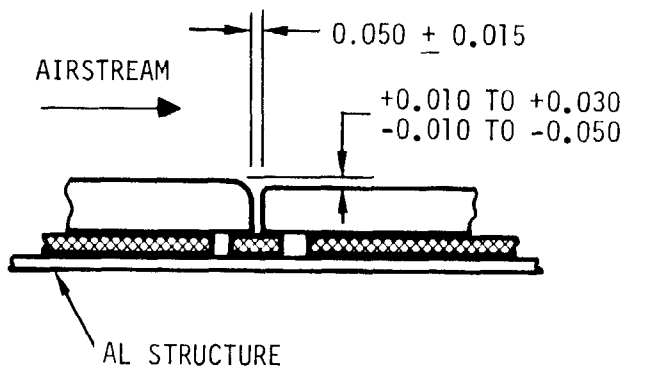


Figure 10

TPS GEOMETRY TOLERANCE

TILE ORIENTATION & SIZE

- MAX ANGLE BETWEEN LOCAL FLOW & TILE GAPS (NO TILE GAP PARALLEL TO FLOW)
- TILE PLANFORM SIZE - SET BY STRESS REQMTS



TILE INSTALN TOLERANCES INCREASE TOWARD TAIL & TOP OF ORBITER

WING LOWER SURFACE TILE GAP ORIENTATION

Figure 11

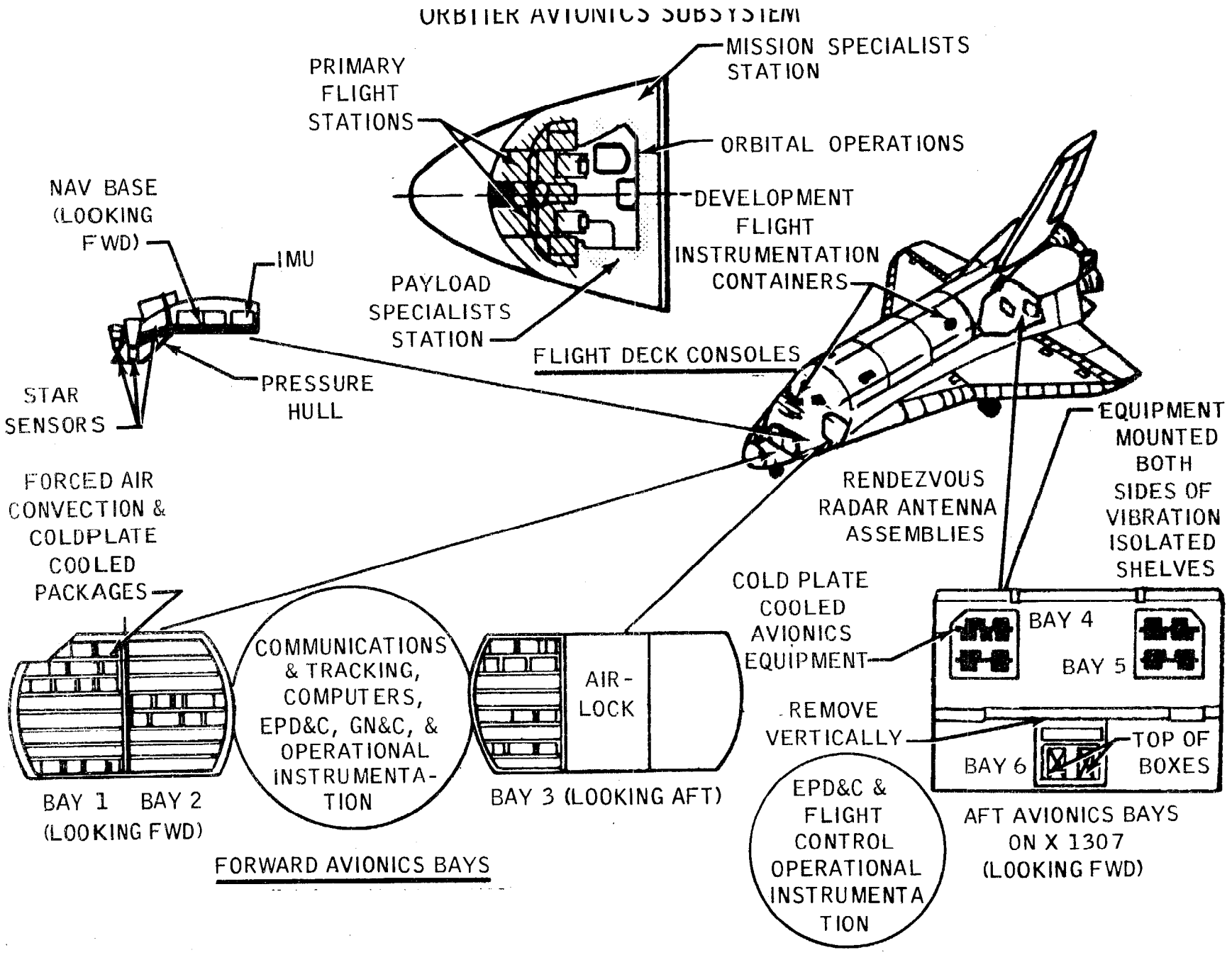
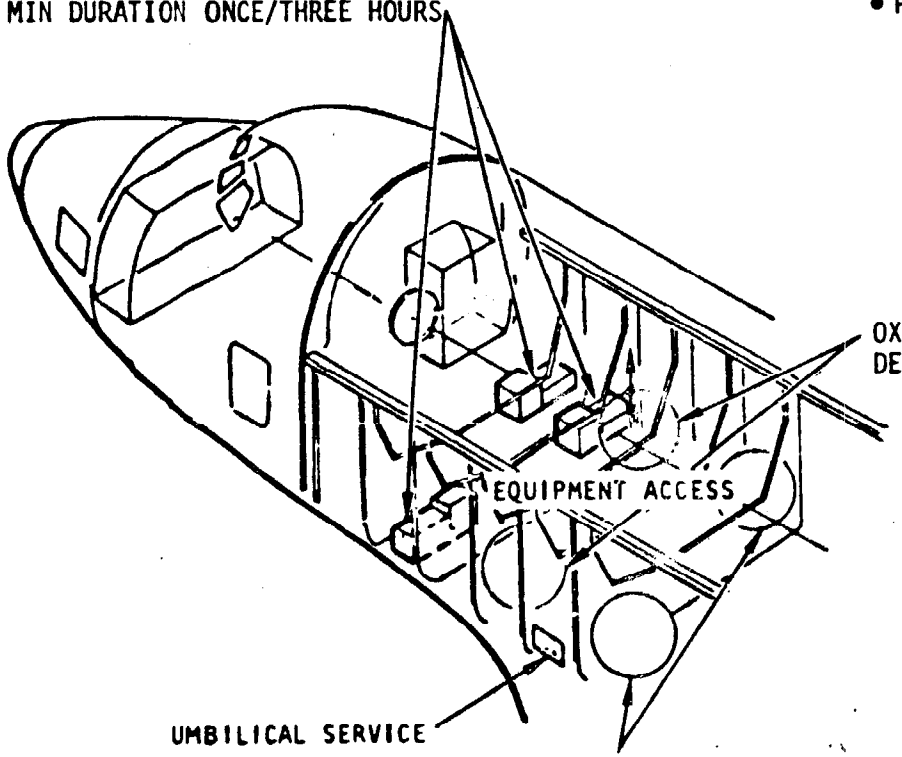

ORBITER AVIONICS SUBSYSTEM
MISSION SPECIALISTS STATION
PRIMARY FLIGHT STATIONS
ORBITAL OPERATIONS
DEVELOPMENT FLIGHT INSTRUMENTATION CONTAINERS
NAV BASE (LOOKING FWD)
IMU
PAYLOAD SPECIALISTS STATION
FLIGHT DECK CONSOLES
PRESSURE HULL
STAR SENSORS
EQUIPMENT MOUNTED BOTH SIDES OF VIBRATION ISOLATED SHELVES
FORCED AIR CONVECTION & COLDPLATE COOLED PACKAGES
RENDEZVOUS RADAR ANTENNA ASSEMBLIES
COLD PLATE COOLED AVIONICS EQUIPMENT
BAY 4
BAY 5
REMOVE VERTICALLY
TOP OF BOXES
BAY 6
COMMUNICATIONS & TRACKING, COMPUTERS, EPD&C, GN&C, & OPERATIONAL INSTRUMENTATION
AIR-LOCK
BAY 1 BAY 2 (LOOKING FWD)
BAY 3 (LOOKING AFT)
EPD&C & FLIGHT CONTROL OPERATIONAL INSTRUMENTATION
AFT AVIONICS BAYS ON X 1307 (LOOKING FWD)
FORWARD AVIONICS BAYS

Figure 12

ORBITER ELECTRICAL POWER SUBSYSTEM

FUEL CELL POWER PLANT (FCP) - 3
2-KW MINIMUM 7-KW CONTINUOUS, 12-KW PEAK/FCP
15 MIN DURATION ONCE/THREE HOURS

- POWER REACTANT STORAGE/DISTRIBUTION SUBSYSTEM
- POWER GENERATION SUBSYSTEM



OXYGEN
DEWARS - 2, 12.3 FT^3 CAPACITY, 1050 PSIA MAX PRESSURE

HYDROGEN DEWARS - 2
23.5 FT^3
CAPACITY, 335
PSIA MAX PRESSURE

FCP SUBSYSTEM

- 14-KW CONTINUOUS/24-KW PEAK
- 27.5 TO 32.5 VDC

REACTANT STORAGE

- 1530-KWH MISSION ENERGY
- 264-KWH ABORT/SURVIVAL ENERGY
- 112 LB O_2 FOR ECLSS
- 92 LB H_2/TANK
- 781 LB O_2/TANK

} TOTAL LOADED QUANTITY

Figure 13

TUBING

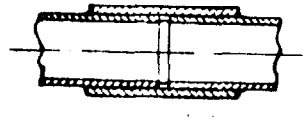
- TUBING

MATERIAL	21-6-9 (MB0160-035)
QUANTITY	1570 FEET
SIZES O. D.	1/4", 3/8", 1/2", AND 5/8"
WALL SIZE	.016

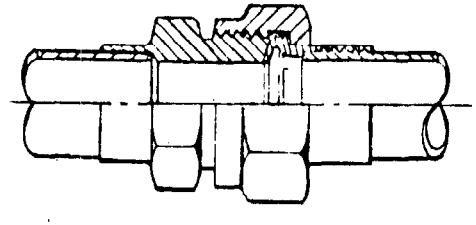
- JOINING METHODS

PERMANENT	SEPARABLE FITTINGS	
BRAZE	DYNATUBE	USED ON FC40 COOLANT, H_2O, O_2, & H_2

INDUCTION BRAZE
(TUBE END TO FITTING)



BRAZE
ROCKWELL
INTERNATIONAL
APOLLO



DYNATUBE-RESISTOFLEX

Figure 14

ELECTRICAL POWER SYSTEM
INSULATION

- LINE INSULATION

  1. TUBING RUNS WILL BE INSULATED

     USING POLYURETHANE FOAM 1/2" THICK, ON PRSD ONLY

  2. LINE HEATERS WILL REQUIRE WRAP WITH ALUMINIZED

     KAPTON TAPE, SPECIFICATION (TBD), ON PGS ONLY

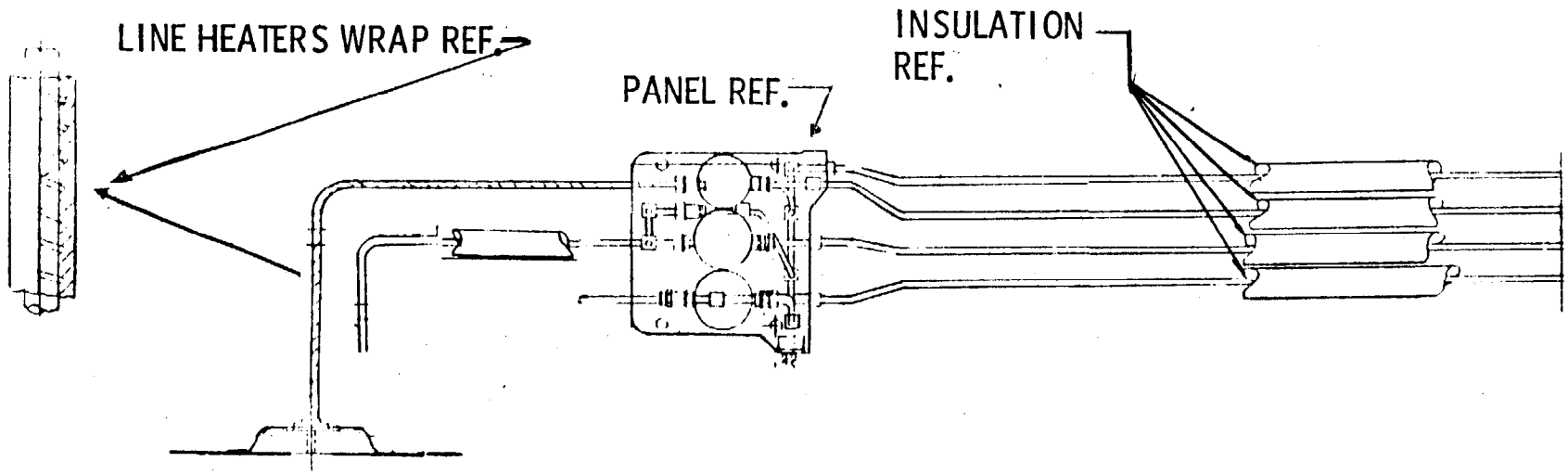


Figure 15

AERO SURFACE CONTROLS

- PDR REVIEW INCLUDED:
  - LAYOUTS
  - ENVELOPE DRAWINGS
  - ICD'S
  - PROCUREMENT SPECIFICATIONS
  - DESIGN REQUIREMENTS
  - INSTALLATION/RIGGING
  - GSE
  - VERIFICATION PLANS
  - SCHEDULES

- TYPICAL ALL OPERATIONAL VEHICLES

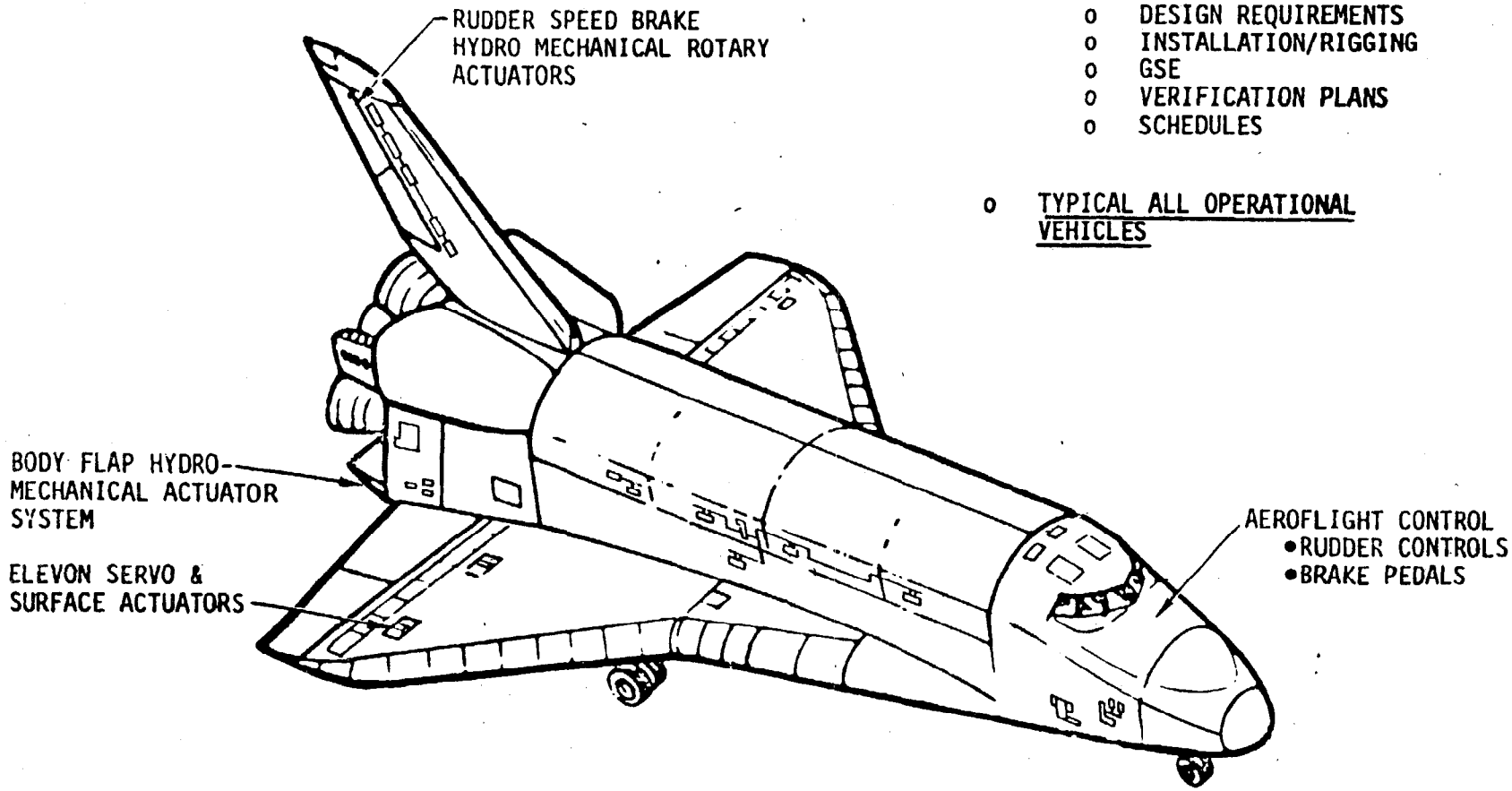


Figure 16

ORBITER-ET SEPARATION SUBSYSTEM

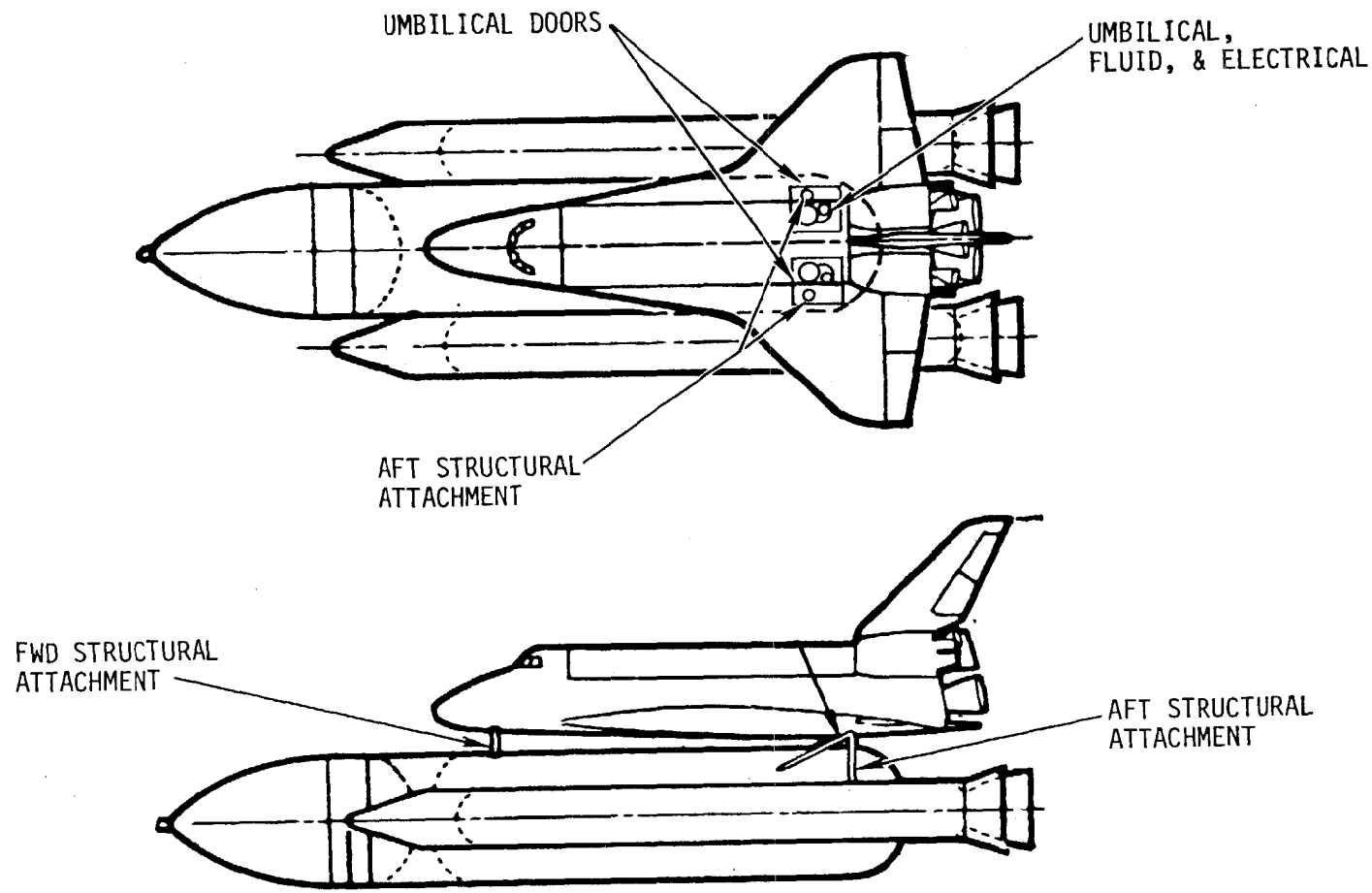


Figure 17

ORBITER/ET AFT SEPARATION

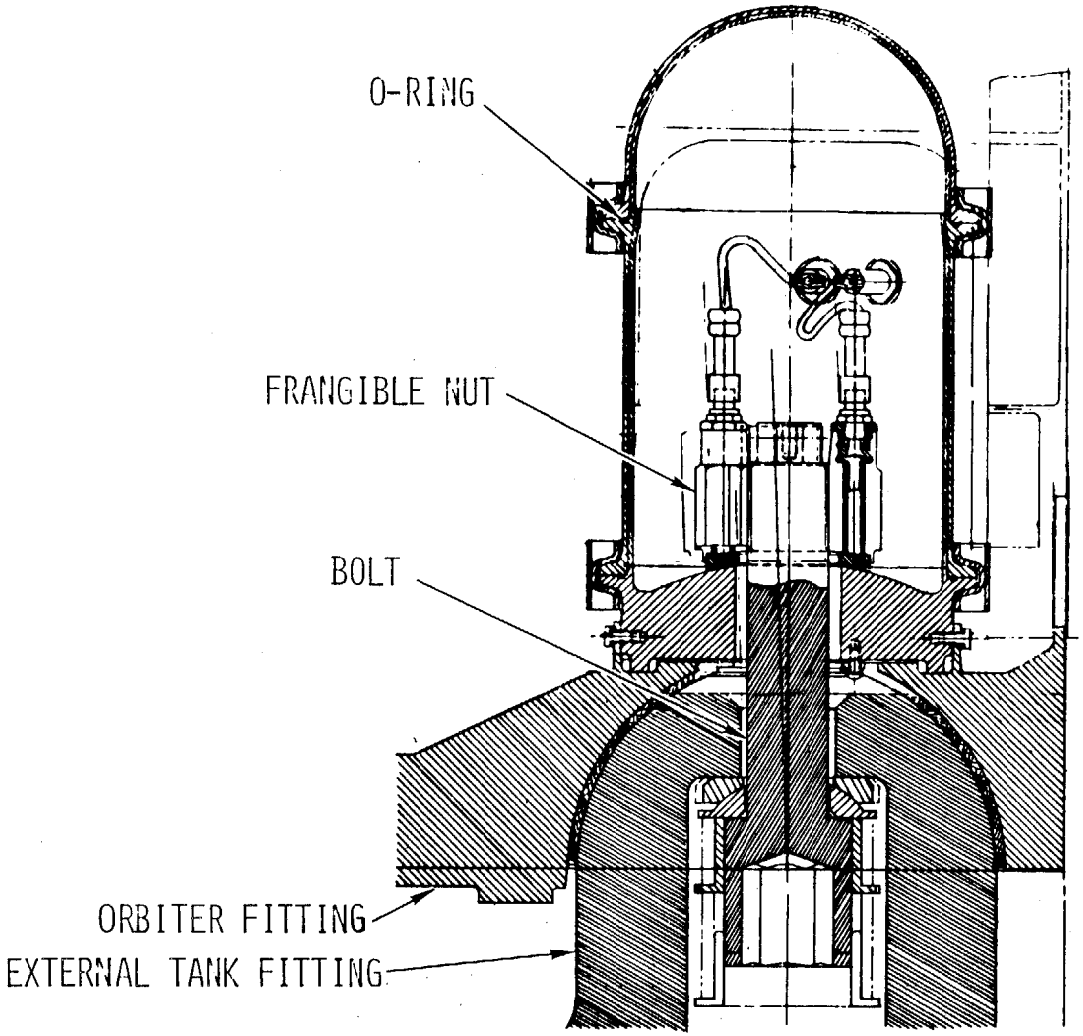


Figure 18

CONTROLLER ORGANIZATION AND REDUNDANCY

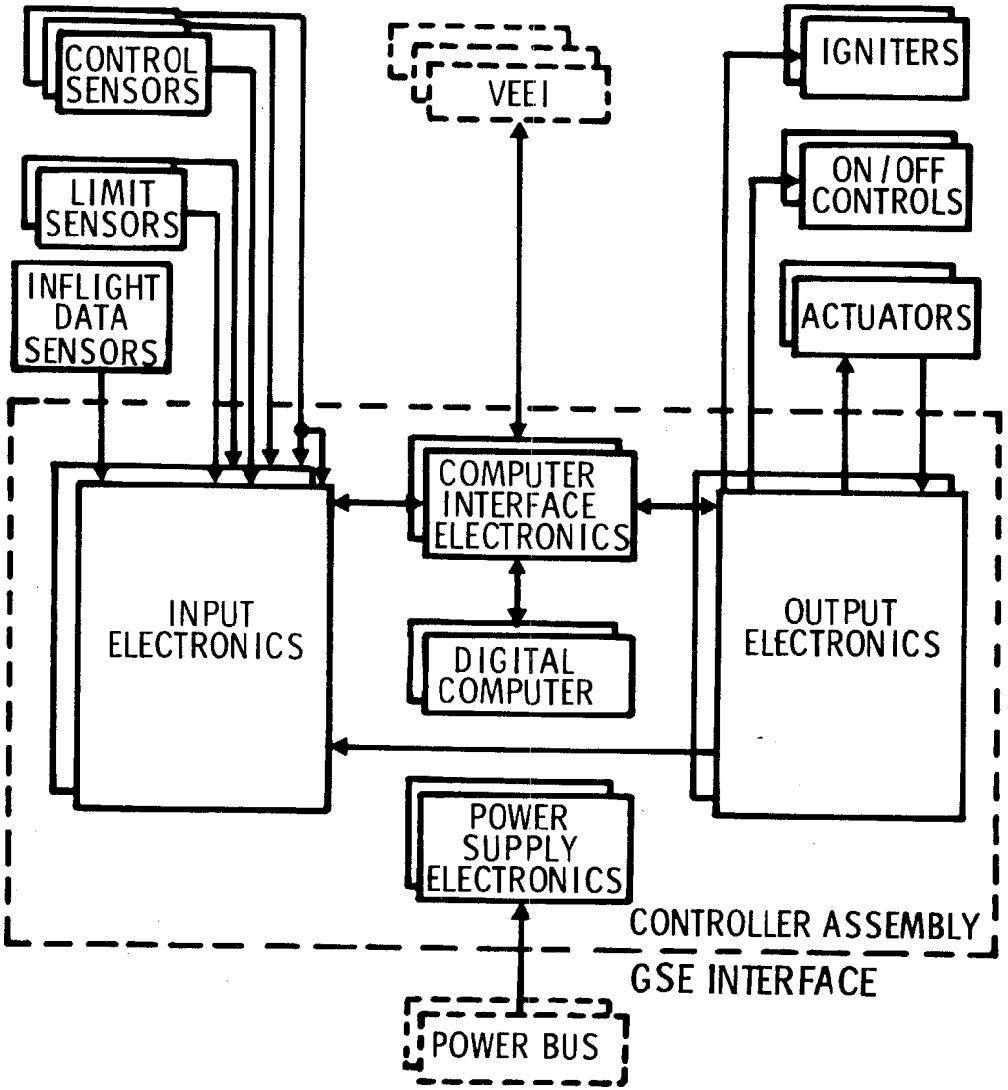


Figure 19

CONTROLLER ELECTRONICS ARRANGEMENT

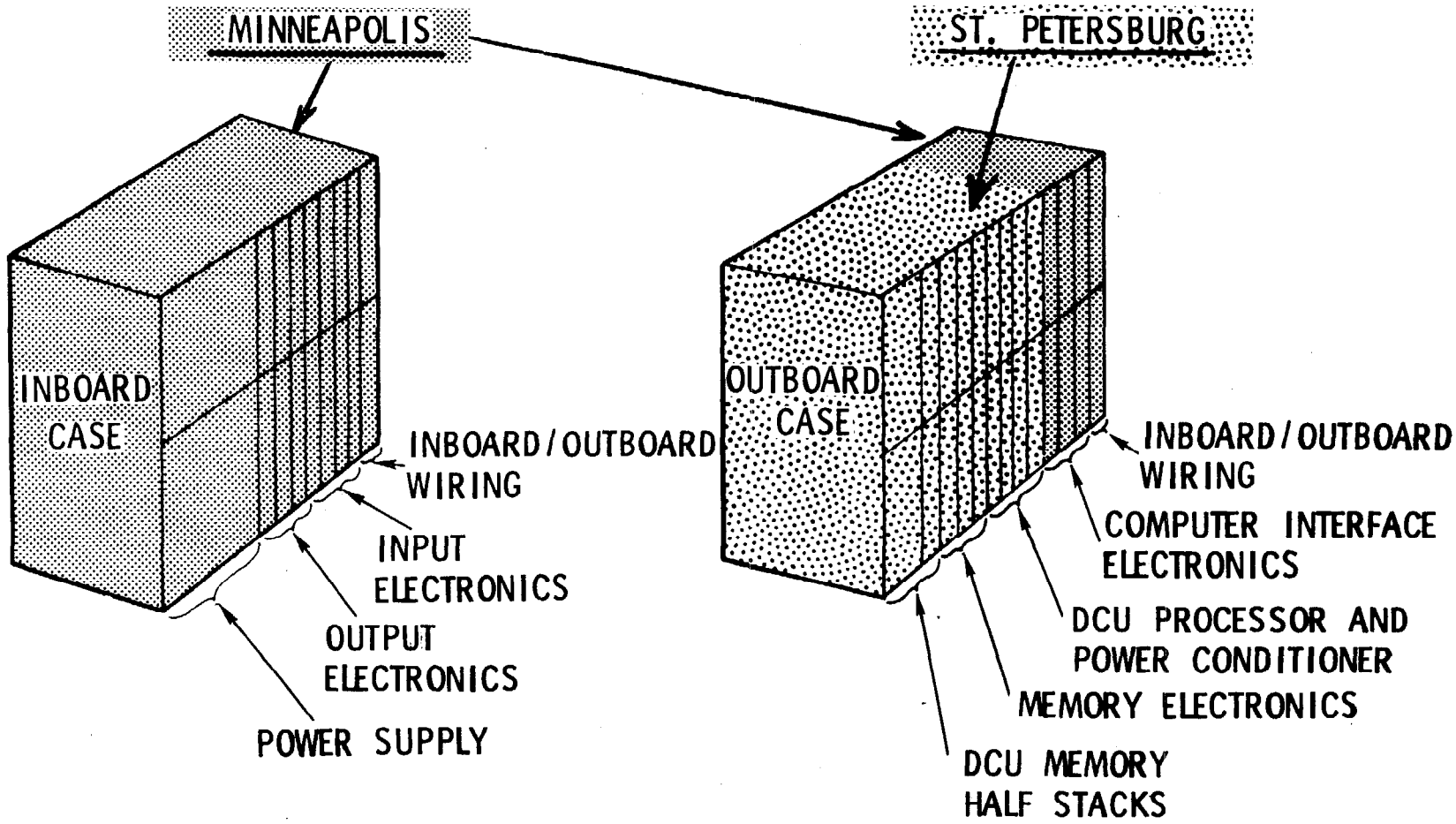


Figure 20

SSME HEAT EXCHANGER DETAILS

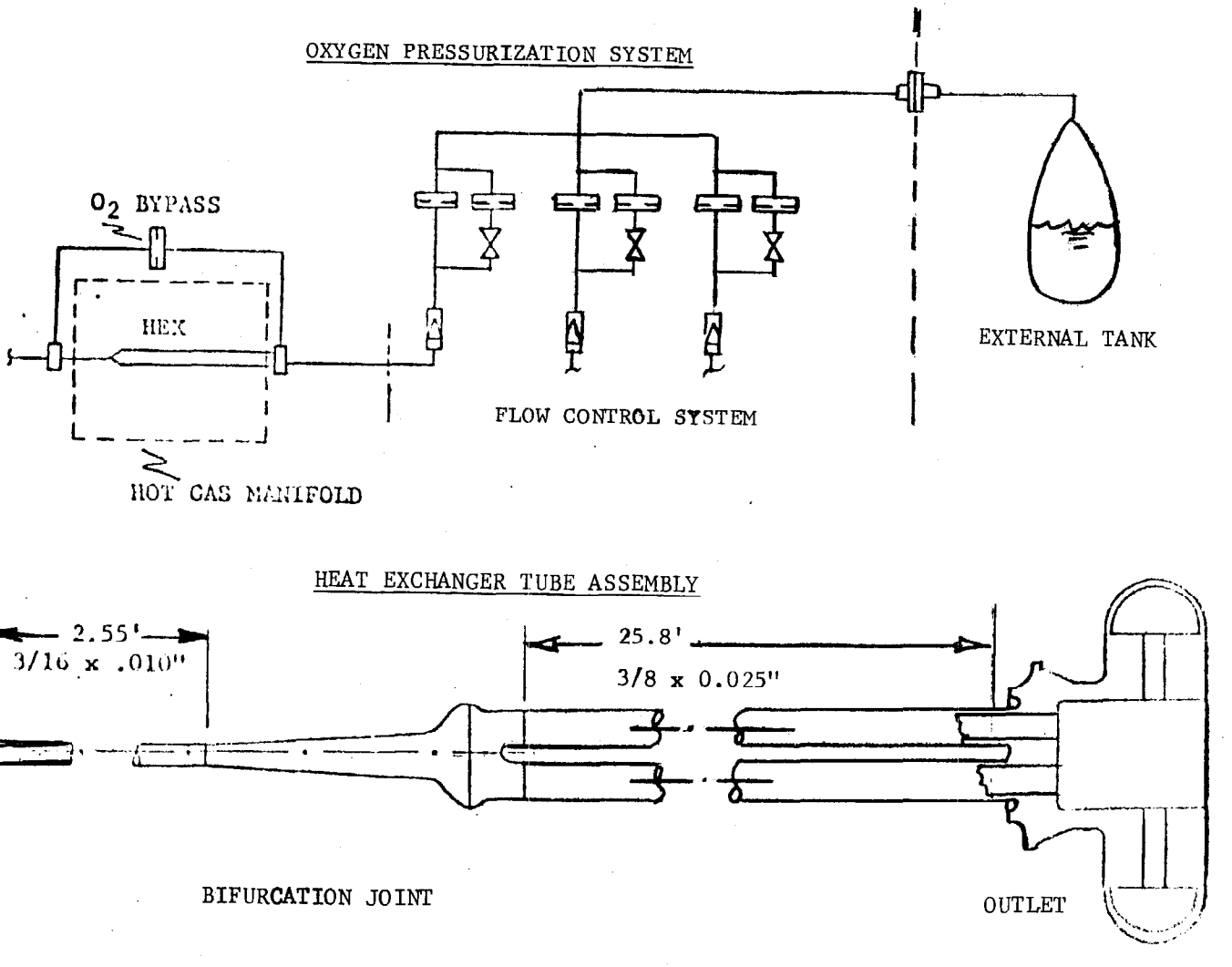


Figure 21

COMPARISON OF SATURN AND SHUTTLE STABILITY LOOPS

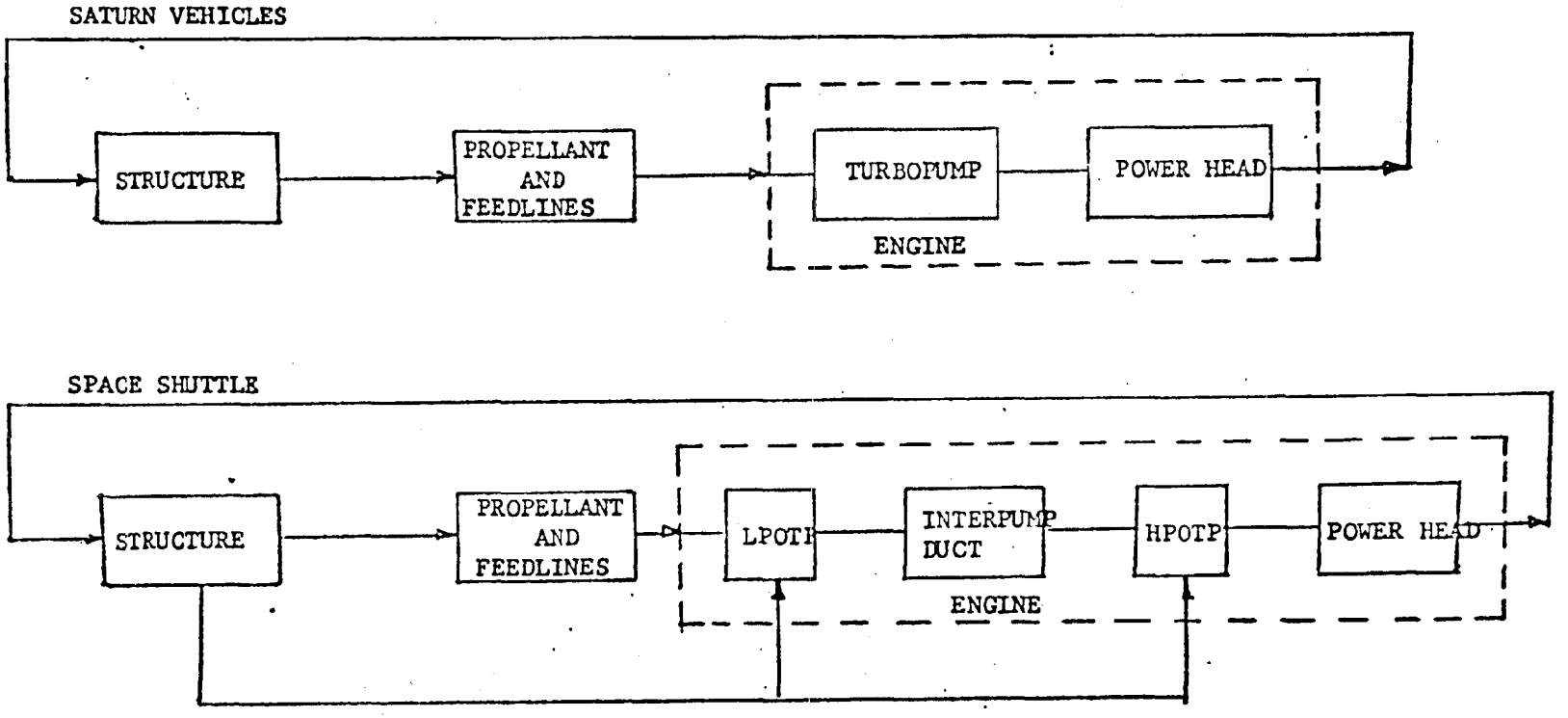


Figure 22

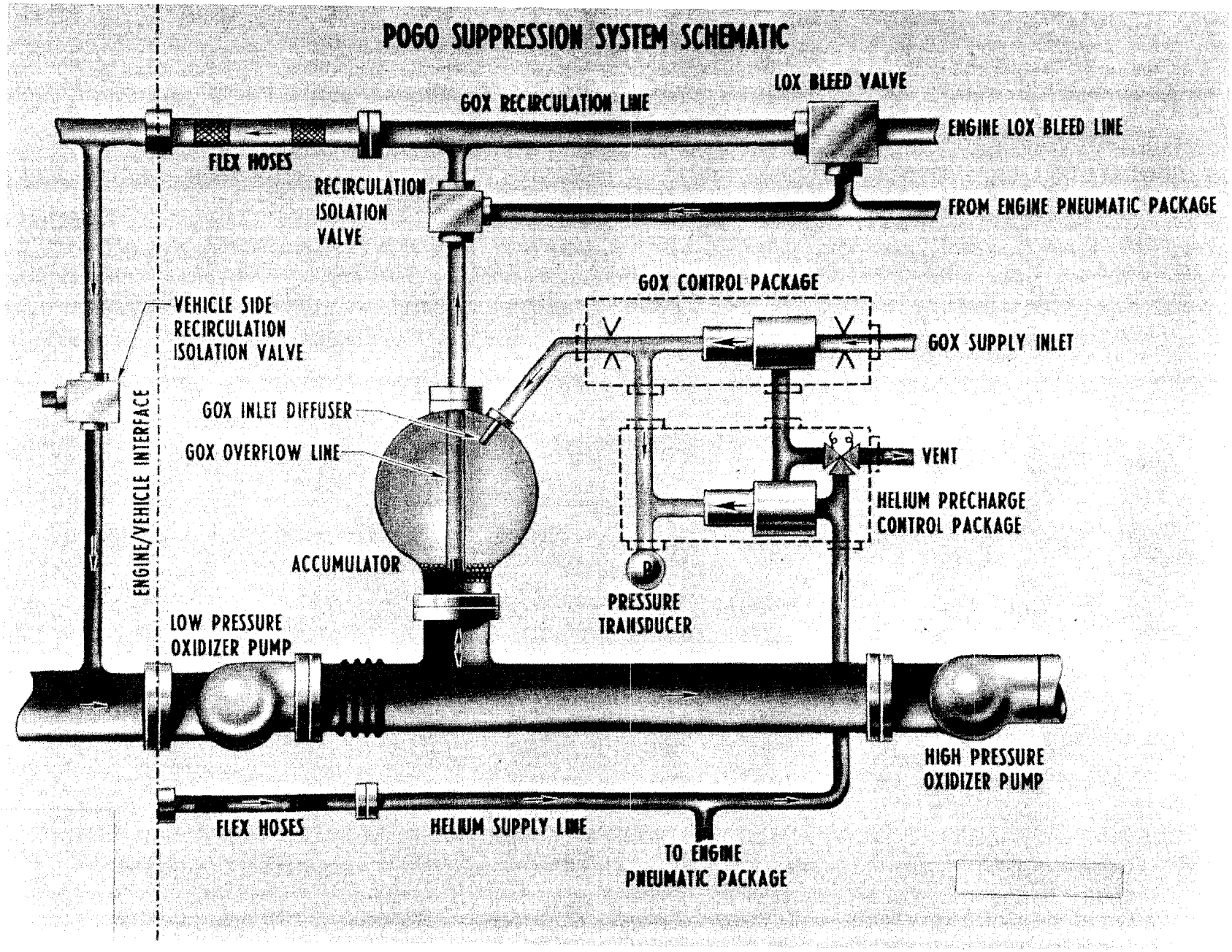

POGO SUPPRESSION SYSTEM SCHEMATIC
LOX BLEED VALVE
GOX RECIRCULATION LINE
ENGINE LOX BLEED LINE
FLEX HOSES
RECIRCULATION ISOLATION VALVE
FROM ENGINE PNEUMATIC PACKAGE
GOX CONTROL PACKAGE
VEHICLE SIDE RECIRCULATION ISOLATION VALVE
GOX SUPPLY INLET
GOX INLET DIFFUSER
GOX OVERFLOW LINE
VENT
HELIUM PRECHARGE CONTROL PACKAGE
ENGINE/VEHICLE INTERFACE
ACCUMULATOR
PRESSURE TRANSDUCER
LOW PRESSURE OXIDIZER PUMP
HIGH PRESSURE OXIDIZER PUMP
FLEX HOSES
HELIUM SUPPLY LINE
TO ENGINE PNEUMATIC PACKAGE

Figure 23

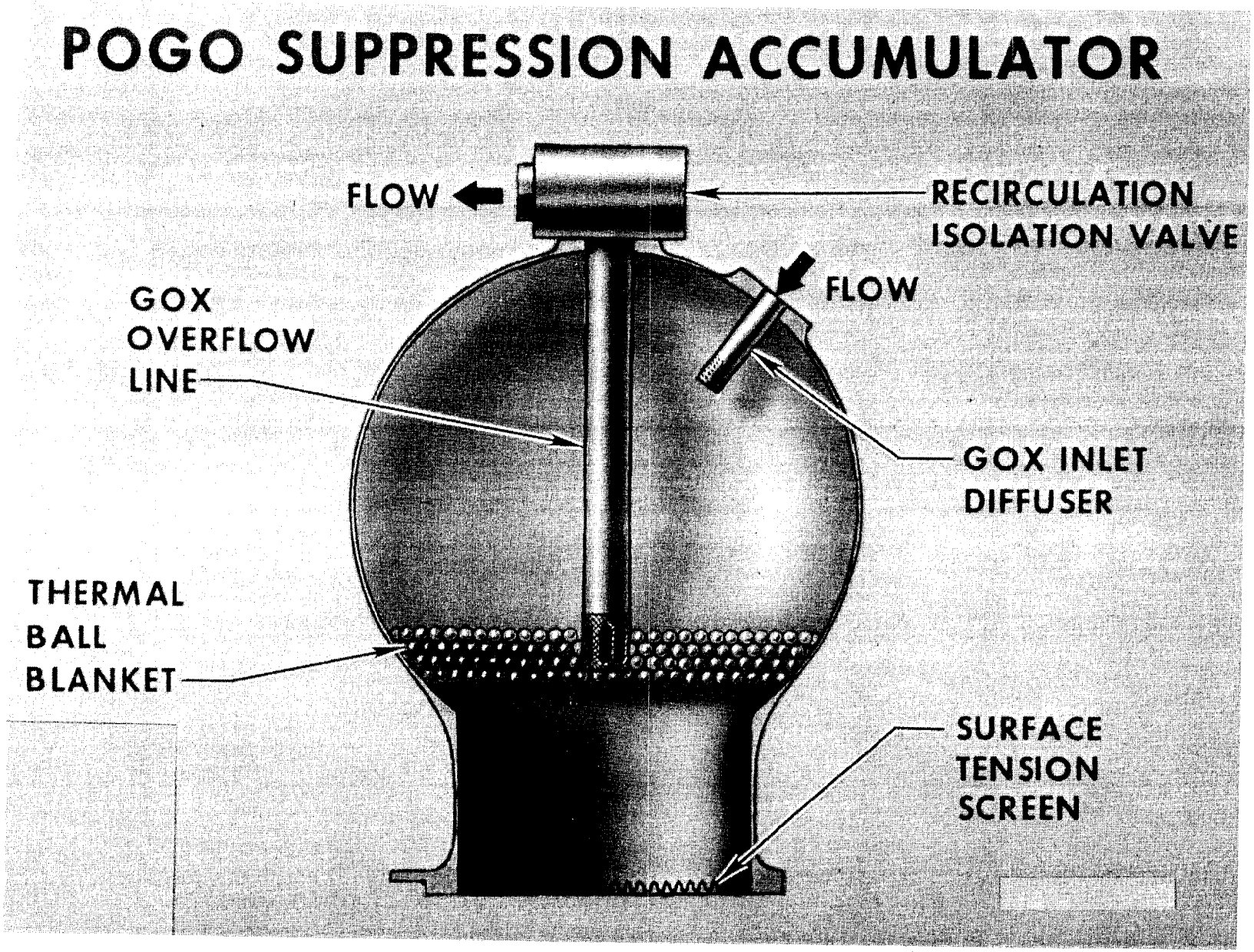
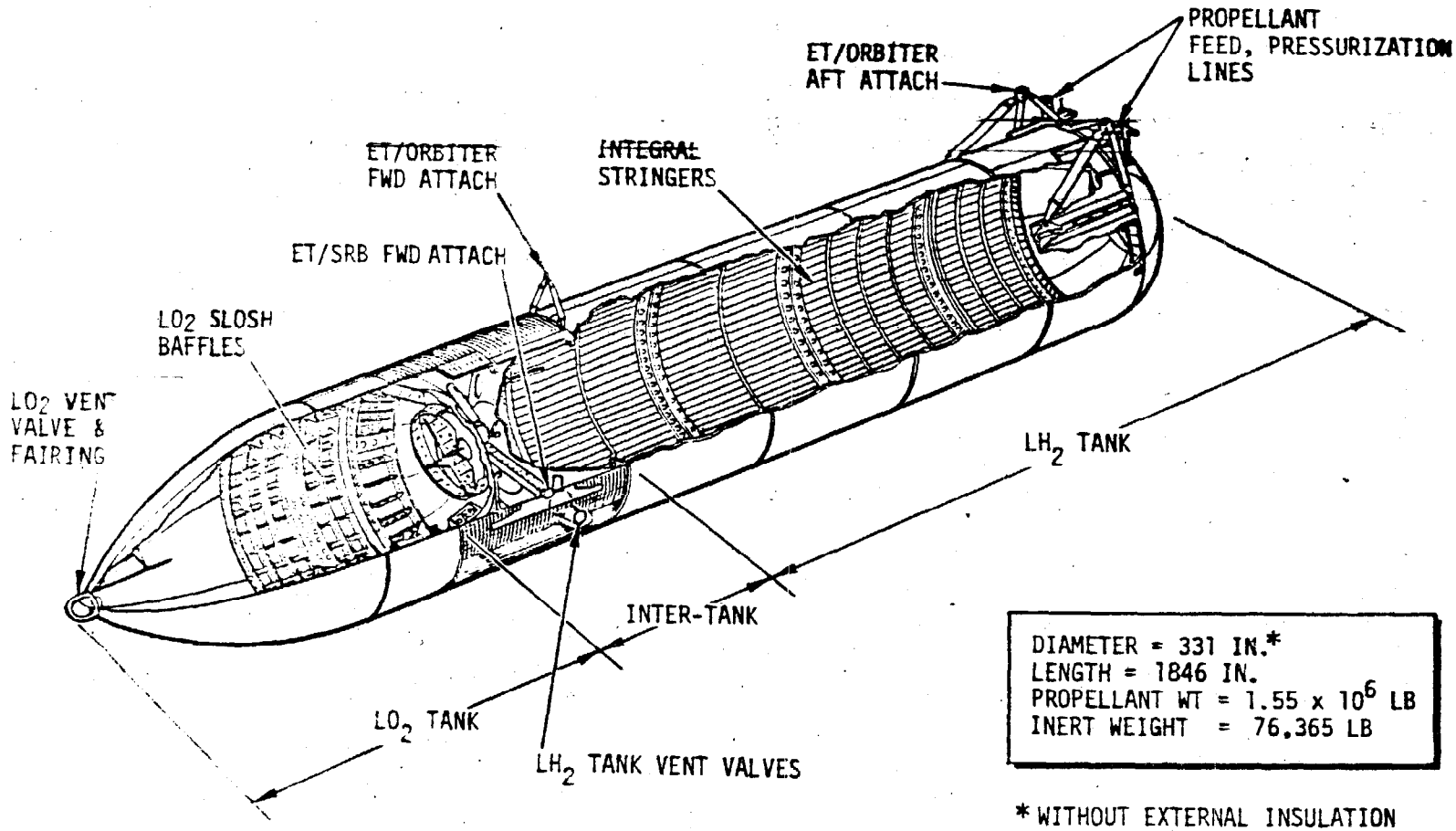

POGO SUPPRESSION ACCUMULATOR
FLOW
RECIRCULATION ISOLATION VALVE
FLOW
GOX OVERFLOW LINE
GOX INLET DIFFUSER
THERMAL BALL BLANKET
SURFACE TENSION SCREEN

Figure 24

EXTERNAL TANK

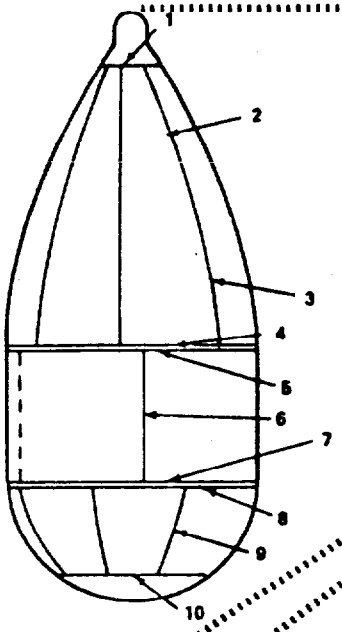


DIAMETER = 331 IN.*
LENGTH = 1846 IN.
PROPELLANT WT = 1.55×10^6 LB
INERT WEIGHT = 76,365 LB

* WITHOUT EXTERNAL INSULATION

Figure 25

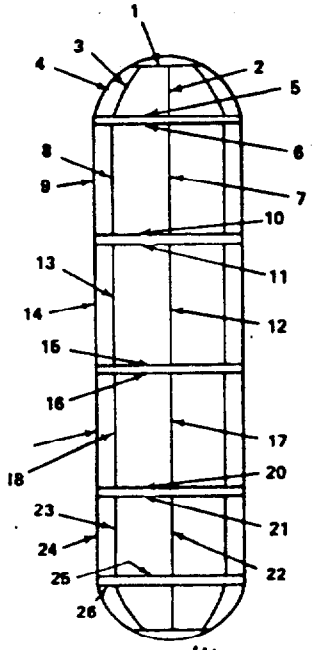
LO_2 TANK ANALYSIS



CRITICAL DEFECTS

WELD	THICKNESS, in.	STRESS DIRECTION	STRESS, ksi	CRITICAL CRACK DEPTH, in.	FAILURE MODE
1	0.120	Parallel Transverse	5.3 2.7	12.4 20.4	Leak
2	0.120-.212	Parallel Transverse	2.7/11.6 5.3/23.2	47.0-2.6 5.39-0.279	Leak
3	0.212-0.42	Parallel Transverse	11.6/9.1 23.2/18.2	2.6-4.2 0.279-0.458	Leak
4	0.236	Parallel Transverse	32.1 13.5	0.34 0.83	Leak
5	0.400	Parallel Transverse	27.3 7.6	0.47 2.6	Leak
6	0.452-0.479	Parallel Transverse	7.0/6.6 5.2	7.5-8.2 0.25	Fracture
7	0.386	Parallel Transverse	30.2 8.3	0.39 2.2	Leak
8	0.280	Parallel Transverse	4.9 22.0	14.5 0.312	Leak
9	0.198-0.261	Parallel Transverse	31.2/28.5 6.9/22.1	0.36-0.43 3.18-0.31	Leak
10	0.37	Parallel Transverse	15.5 20	1.42 0.38	Leak

LH_2 TANK ANALYSIS



1	0.175	Transverse Parallel	23.85 18.5	0.266 1.04	Leak
2	0.175-0.150	Transverse Parallel	18.5 23.85	0.444 0.612	Leak
3	0.175-0.150	Transverse Parallel	18.5 23.85	0.444 0.59	Leak
4	0.175-0.150	Transverse Parallel	18.5 23.85	0.444 0.612	Leak
5	0.150	Transverse Parallel	23.1 5.1	0.284 13.30	Leak
6	0.324	Transverse Parallel	21.4 10.7	0.33 3.02	Leak
7	0.324	Transverse Parallel	21.4 10.7	0.33 3.02	Leak
8	0.324	Transverse Parallel	21.4 10.7	0.33 3.02	Leak
9	0.324	Transverse Parallel	21.4 11.9	0.33 2.44	Leak
10	0.324	Transverse Parallel	11.9 21.4	1.06 0.76	Leak
11	0.324	Transverse Parallel	11.9 21.4	1.06 0.76	Leak
12	0.324	Transverse Parallel	21.4 10.7	0.33 3.02	Leak
13	0.324	Transverse Parallel	21.4 11.71	0.33 2.4	Leak
14	0.324	Transverse Parallel	21.4 13.83	0.33 1.85	Leak
15	0.324	Transverse Parallel	13.83 21.4	0.80 0.76	Leak
16	0.324	Transverse Parallel	13.83 21.4	0.80 0.76	Leak
17	0.324	Transverse Parallel	21.4 10.7	0.33 3.02	Leak
18	0.324	Transverse Parallel	21.4 13.14	0.33 2.03	Leak
19	0.324	Transverse Parallel	21.4 15.67	0.33 1.63	Leak
20	0.324	Transverse Parallel	15.67 21.4	0.62 0.76	Leak
21	0.324	Transverse Parallel	15.67 21.4	0.62 0.76	Leak
22	0.324	Transverse Parallel	21.4 10.7	0.33 3.02	Leak
23	0.324	Transverse Parallel	21.4 13.14	0.33 2.03	Leak
24	0.324	Transverse Parallel	21.4 15.67	0.33 1.63	Leak
25	0.324	Transverse Parallel	10.7 21.4	1.32 0.76	Leak
26	0.324	Transverse Parallel	10.7 21.4	1.32 0.76	Leak

Figure 26

EXTERNAL TANK

TYPICAL MECHANICAL JOINT

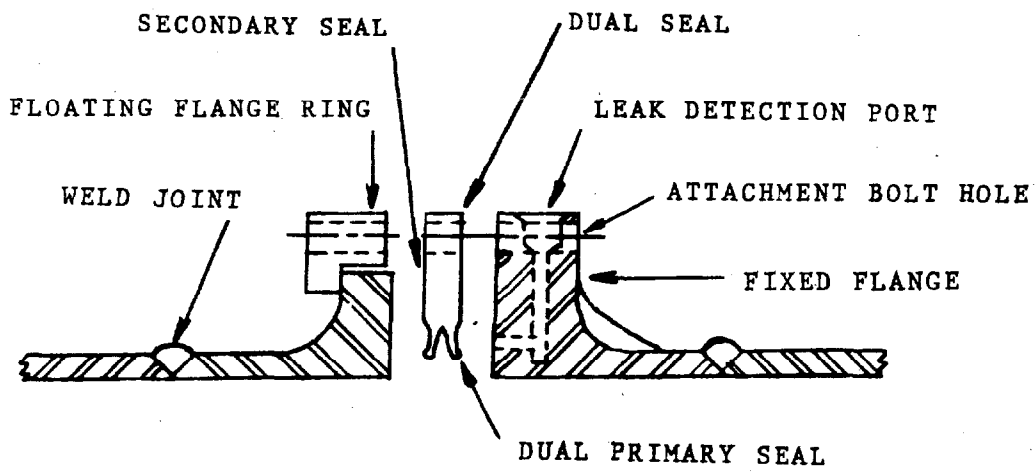


Figure 27

External Tank Propulsion/Mechanical Subsystem LO_2 Propellant Feed

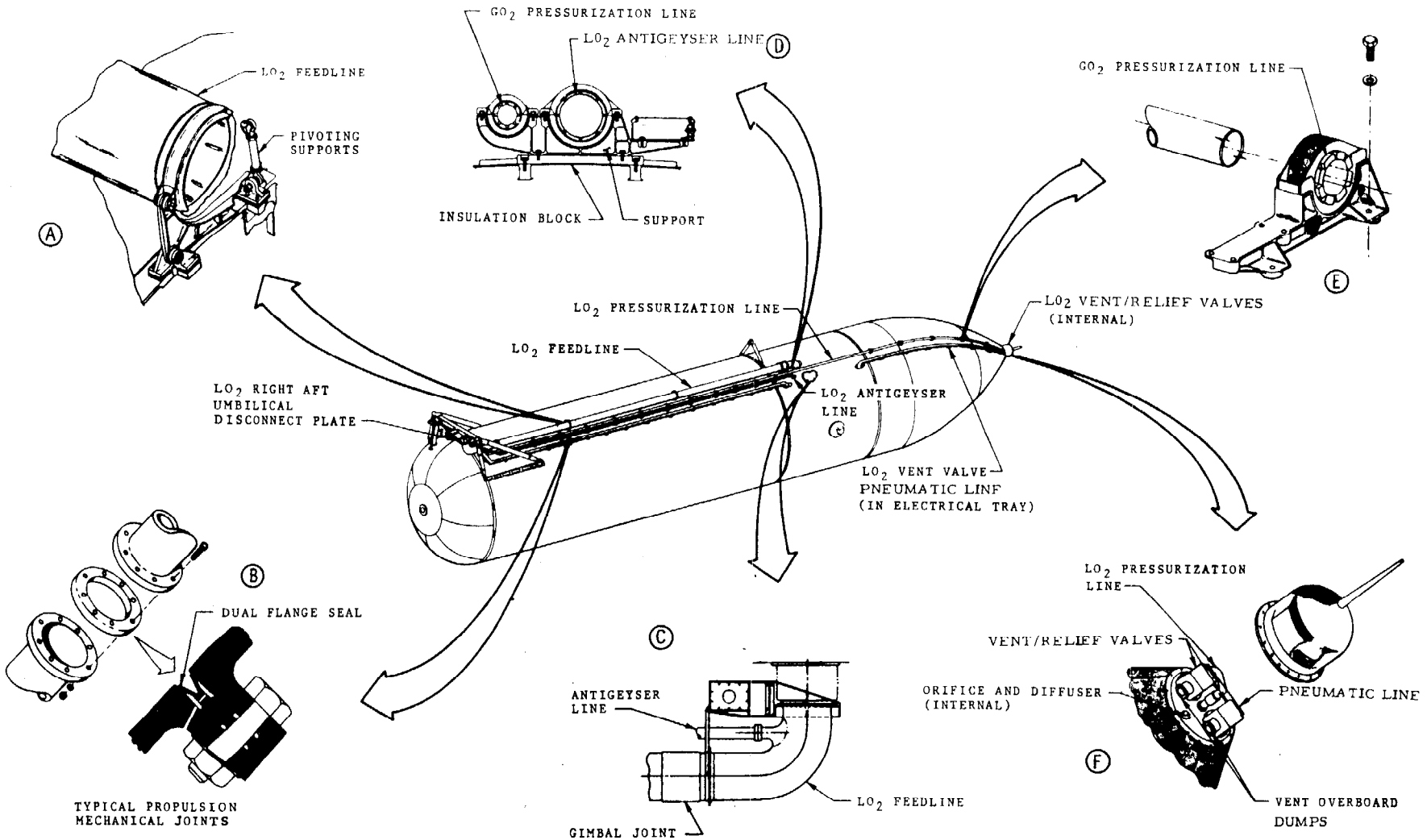


Figure 28

External Tank Propulsion/Mechanical Subsystem Separation Hardware

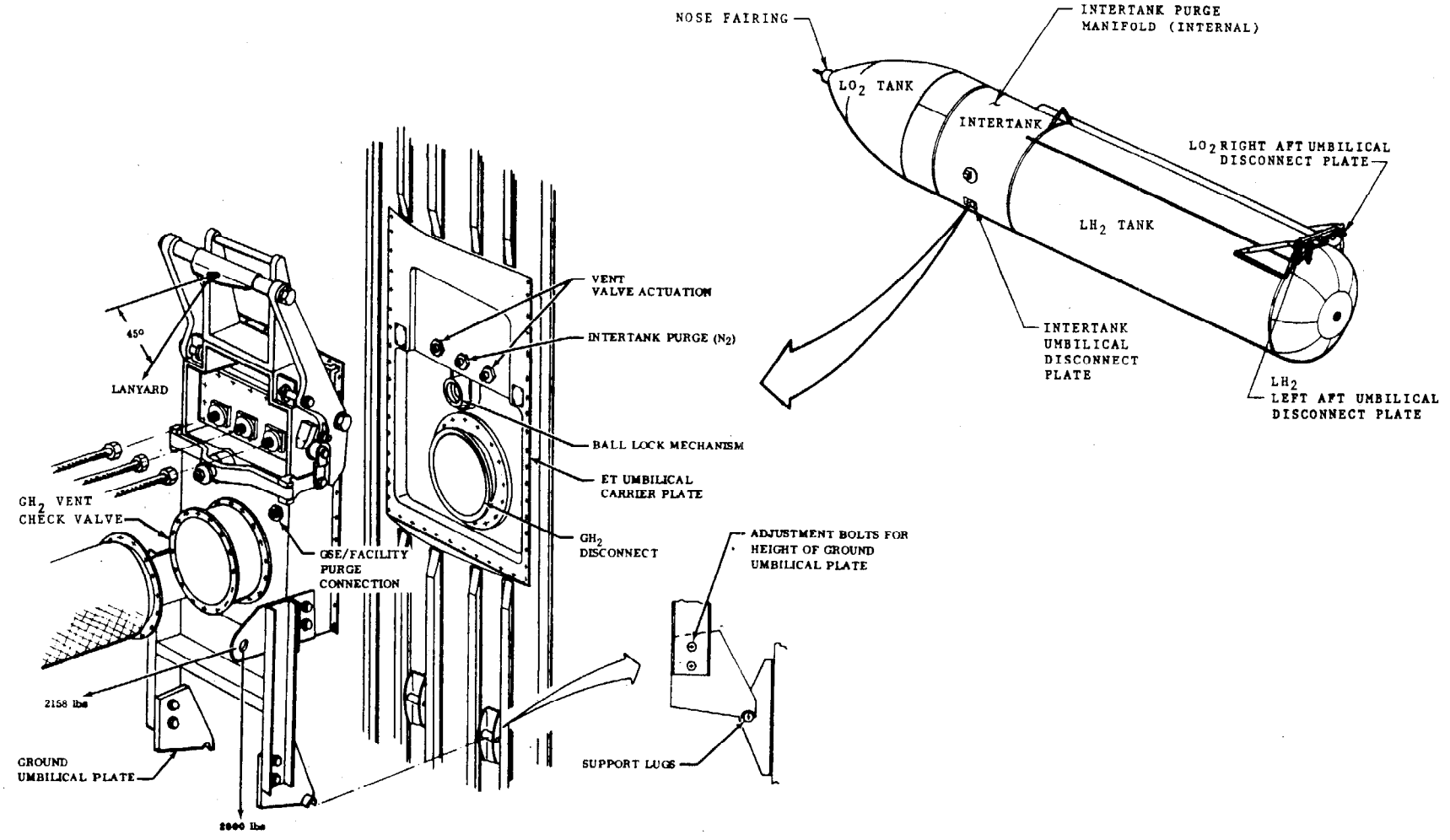


Figure 29

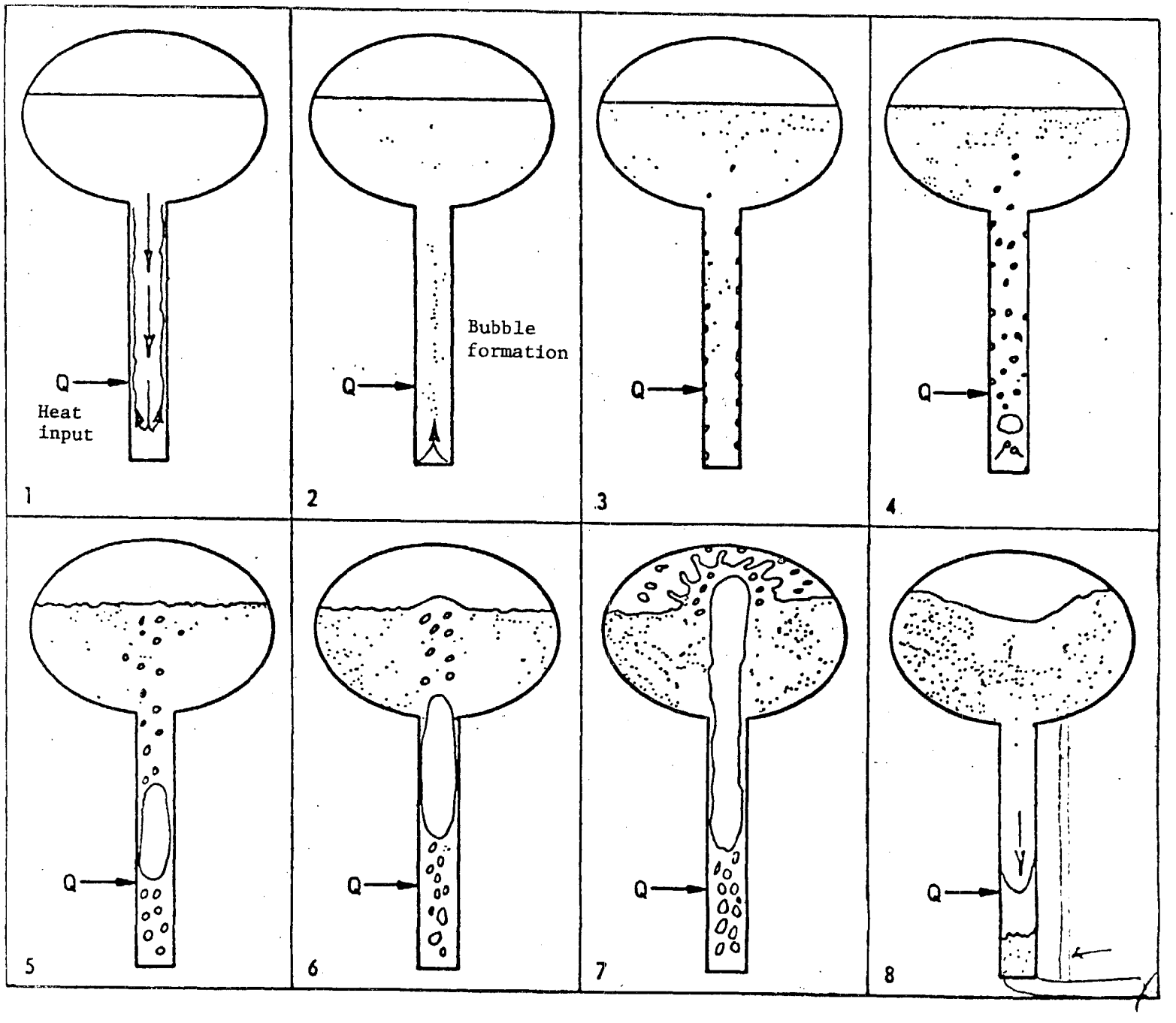
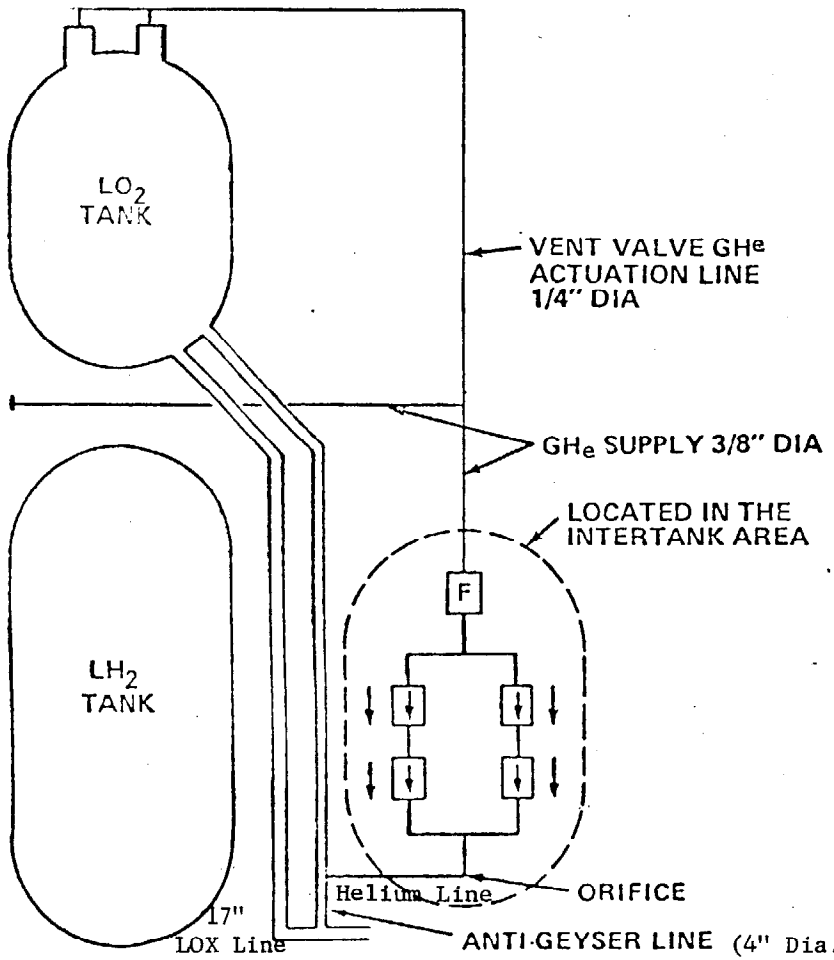


Figure 30

HELIUM INJECTION SYSTEM



DESIGN FEATURE	INITIAL DESIGN CONCEPT	CURRENT DESIGN	RATIONALE
CHECK VALVES	2–SERIES	4–SERIES/ PARALLEL	INCREASED RELIABILITY
LINE SIZE	1/4"	3/8"	MARGIN FOR GROWTH
FILTER	NONE	ONE	PROTECT CHECK VALVES
COMPONENT LOCATION	NOT DEFINED	INTERTANK	MINIMIZE EFFECT ON VENT VALVE OPERATION
WEIGHT	8 LB	25 LB	MORE COMPONENTS

Figure 31

ET ANTI-GEYSER SYSTEM TEST CONFIGURATION

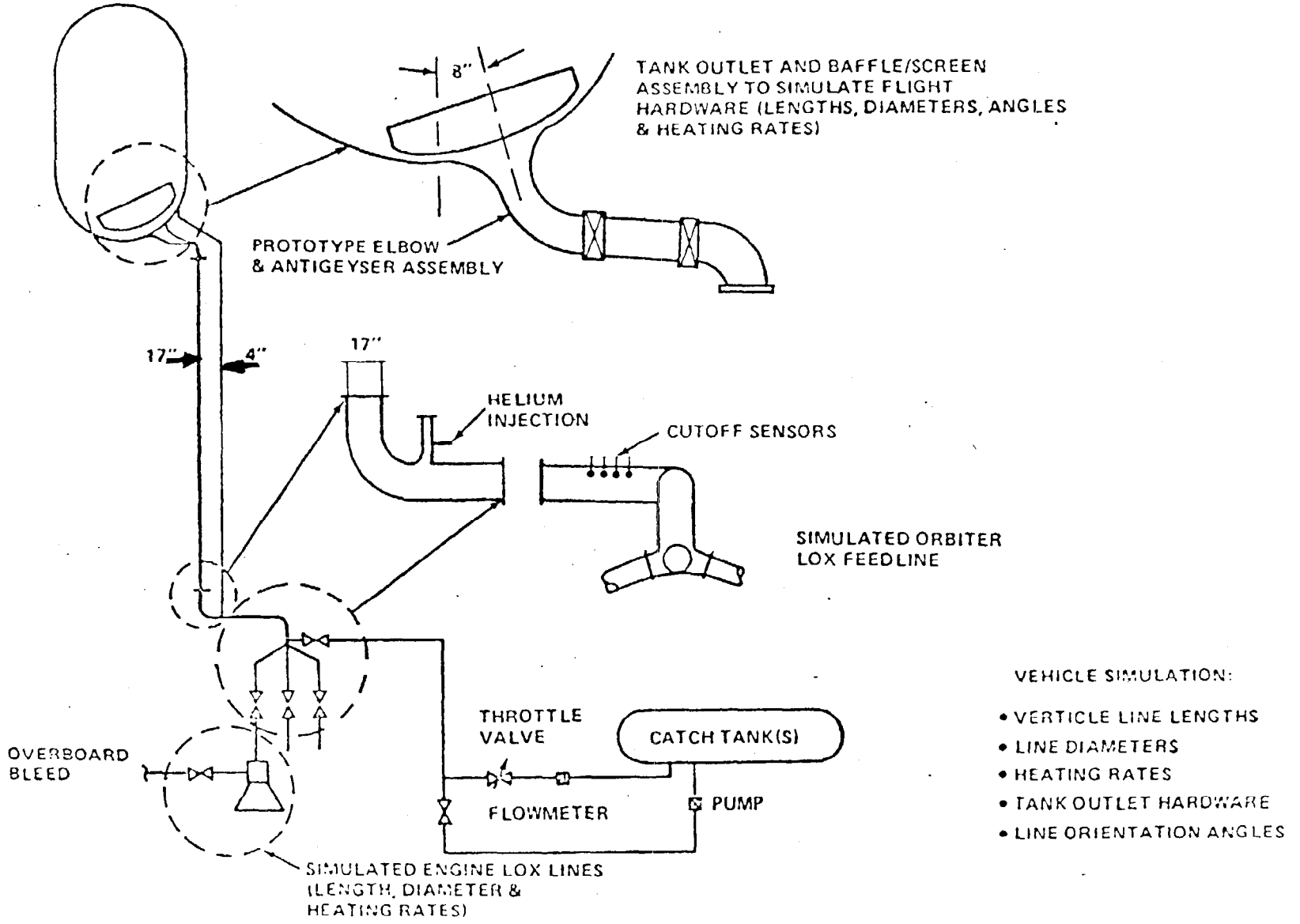


Figure 32

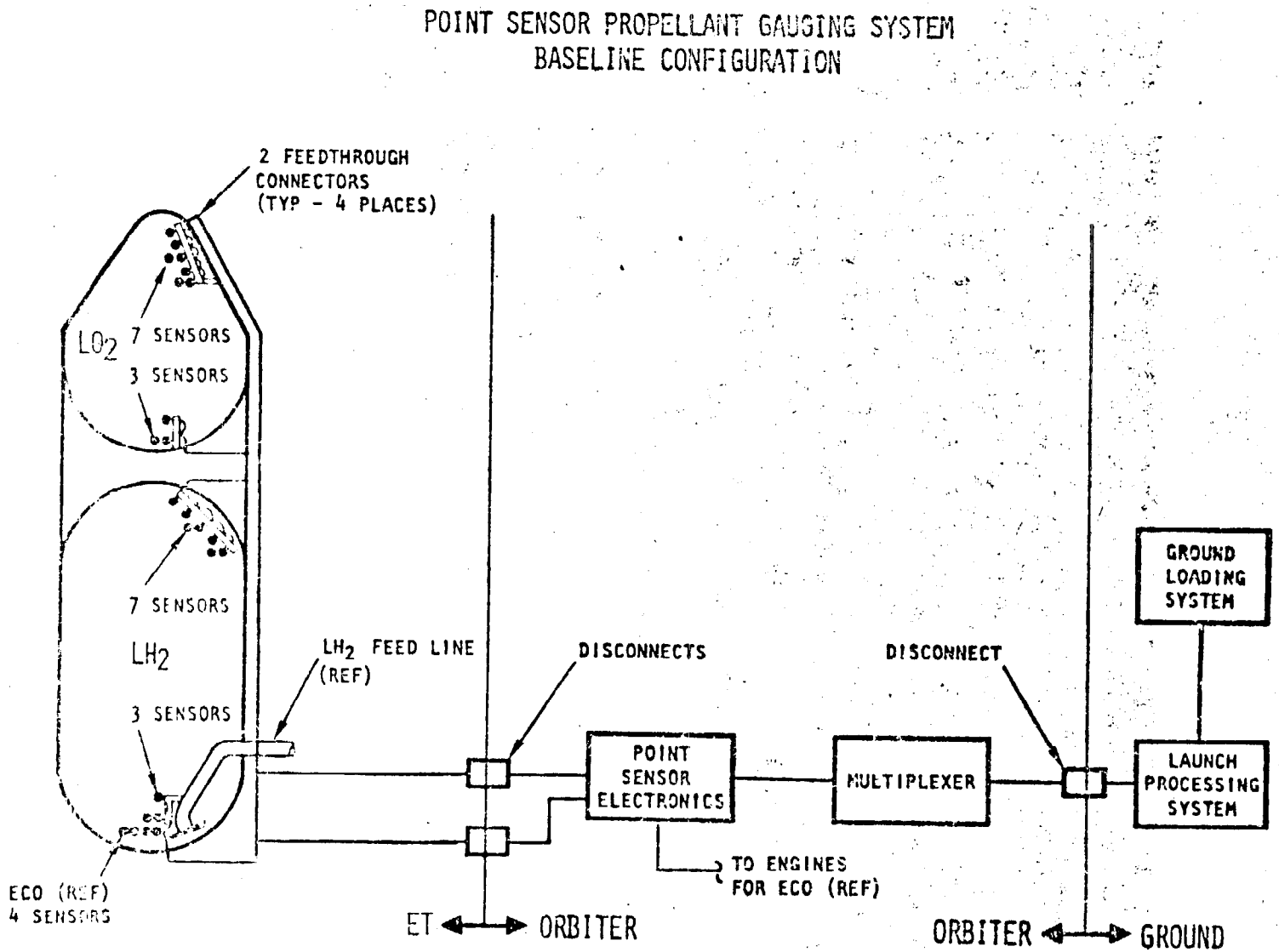

POINT SENSOR PROPELLANT GAUGING SYSTEM
BASELINE CONFIGURATION
2 FEEDTHROUGH CONNECTORS (TYP - 4 PLACES)
LO2
7 SENSORS
3 SENSORS
7 SENSORS
LH2
3 SENSORS
ECO (REF) 4 SENSORS
LH2 FEED LINE (REF)
DISCONNECTS
POINT SENSOR ELECTRONICS
TO ENGINES FOR ECO (REF)
MULTIPLEXER
DISCONNECT
GROUND LOADING SYSTEM
LAUNCH PROCESSING SYSTEM
ET
ORBITER
ORBITER
GROUND

Figure 33

ET/SRB ATTACH CONFIGURATION

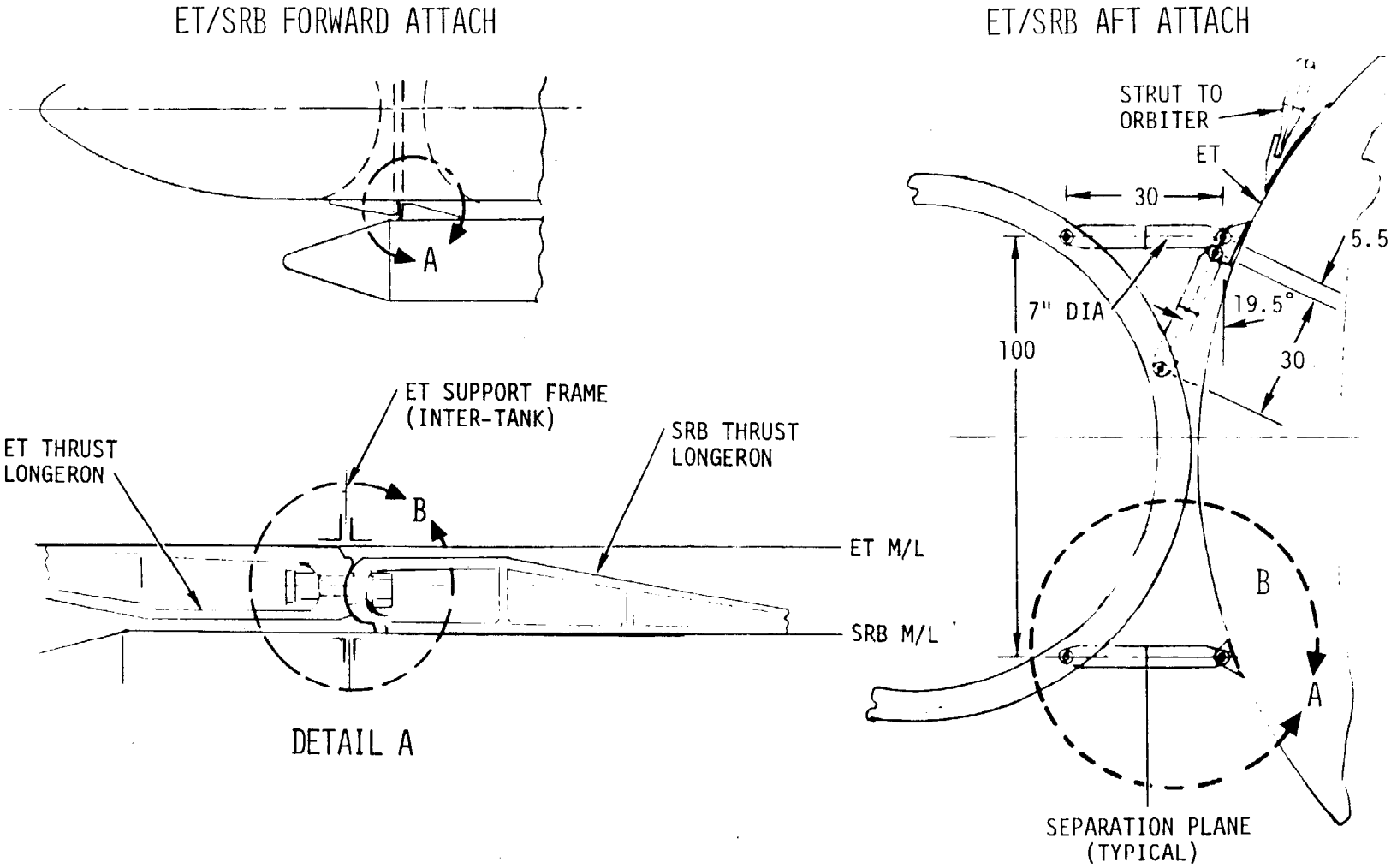


Figure 34

ET/ORBITER FWD STRUCTURAL ATTACH

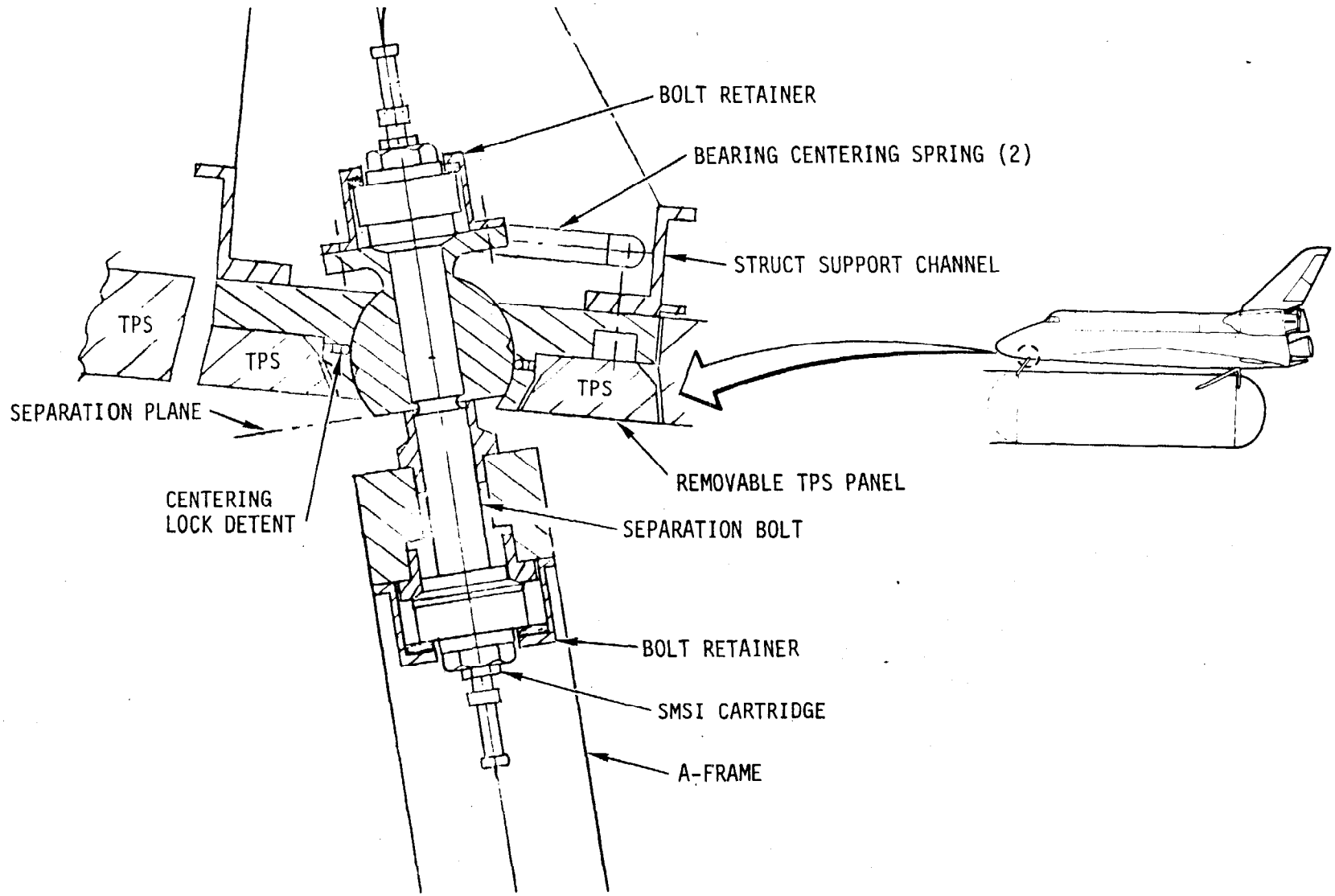


Figure 35

ET/ORBITER AFT INTERFACE STRUCTURE

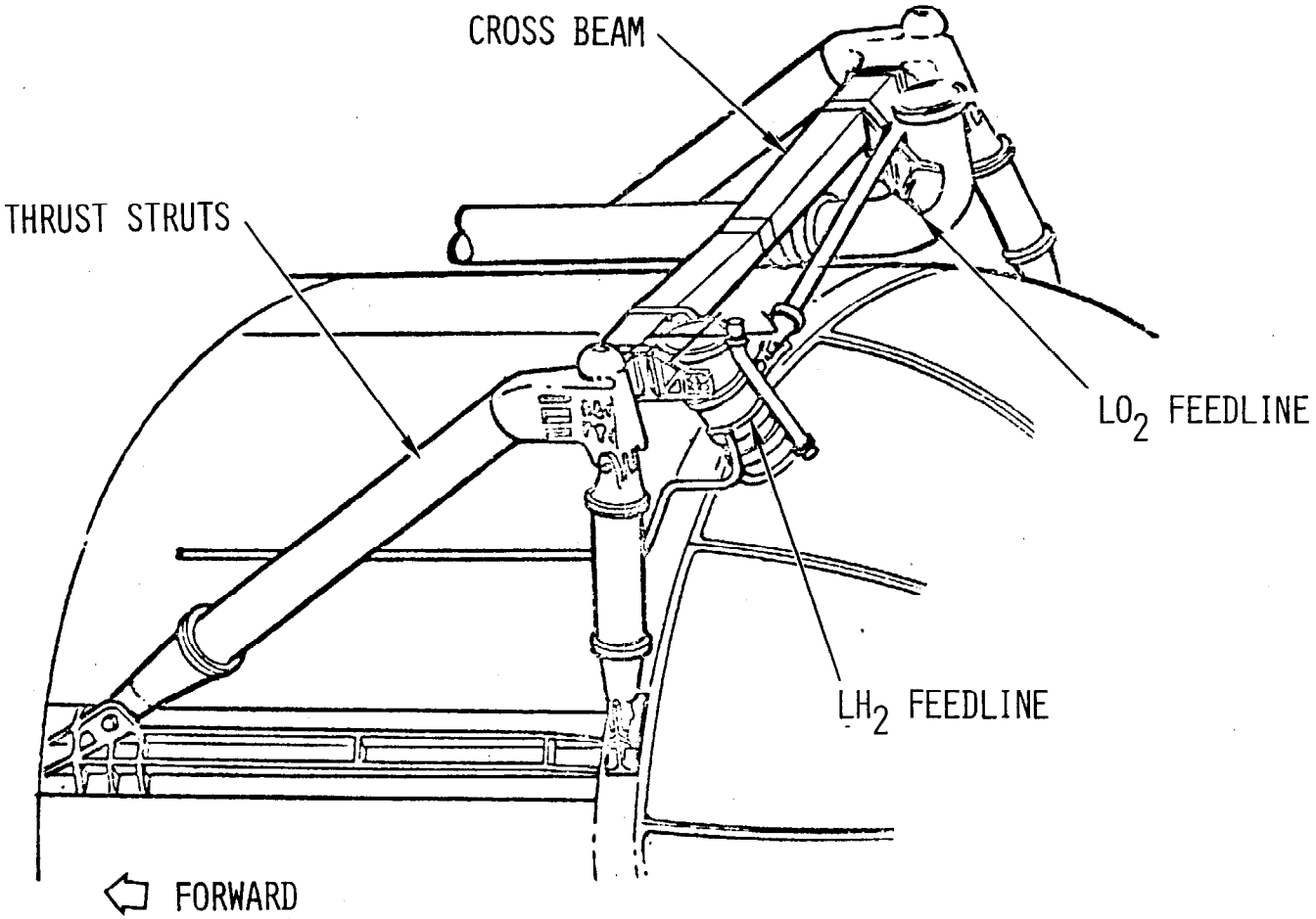


Figure 36

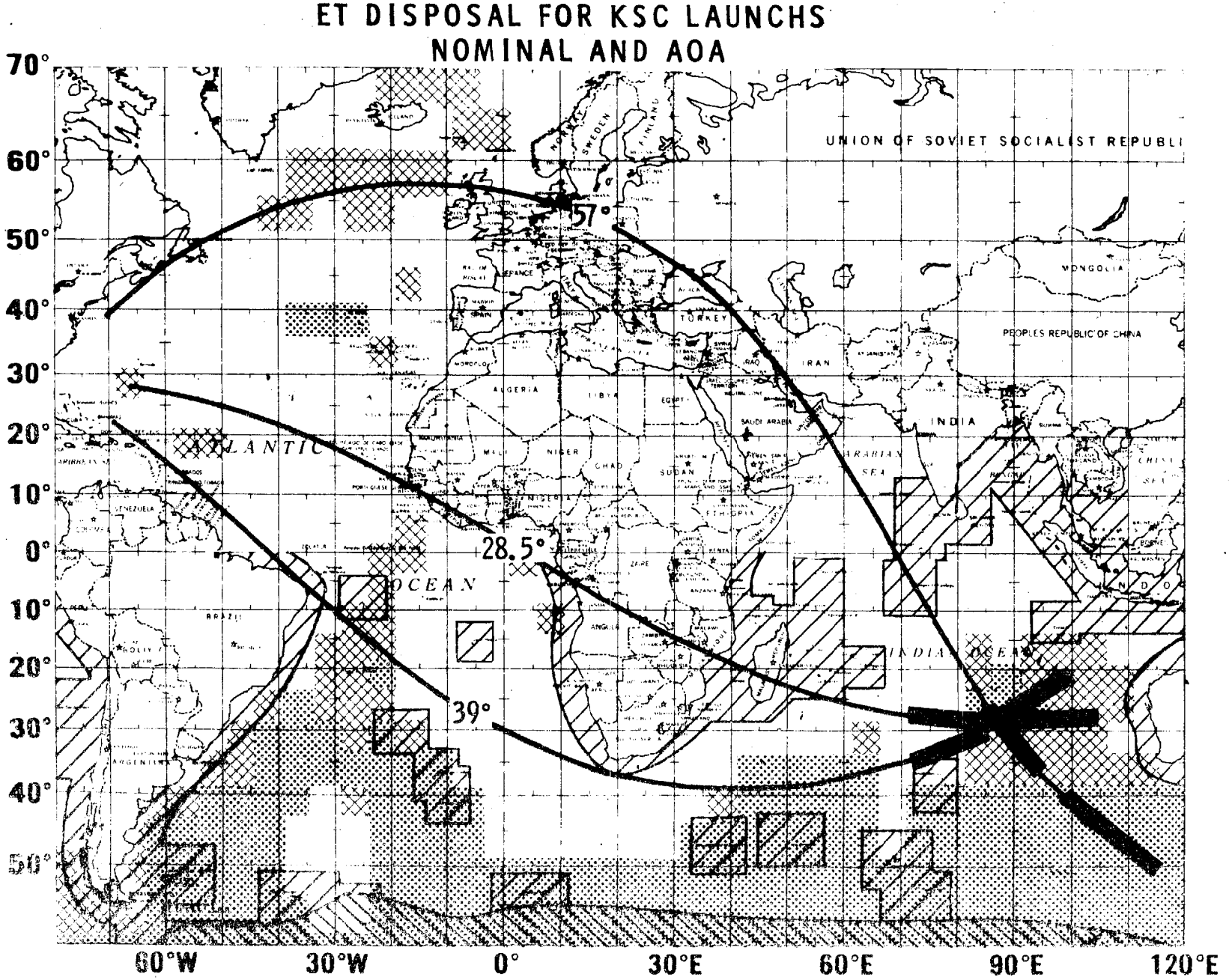

ET DISPOSAL FOR KSC LAUNCHS
NOMINAL AND AOA
57°
28.5°
39°
UNION OF SOVIET SOCIALIST REPUBLI
MONGOLIA
PEOPLES REPUBLIC OF CHINA
INDIA
ATLANTIC
OCEAN
70°
60°
50°
40°
30°
20°
10°
0°
10°
20°
30°
40°
50°
60°W
30°W
0°
30°E
60°E
90°E
120°E

Figure 37

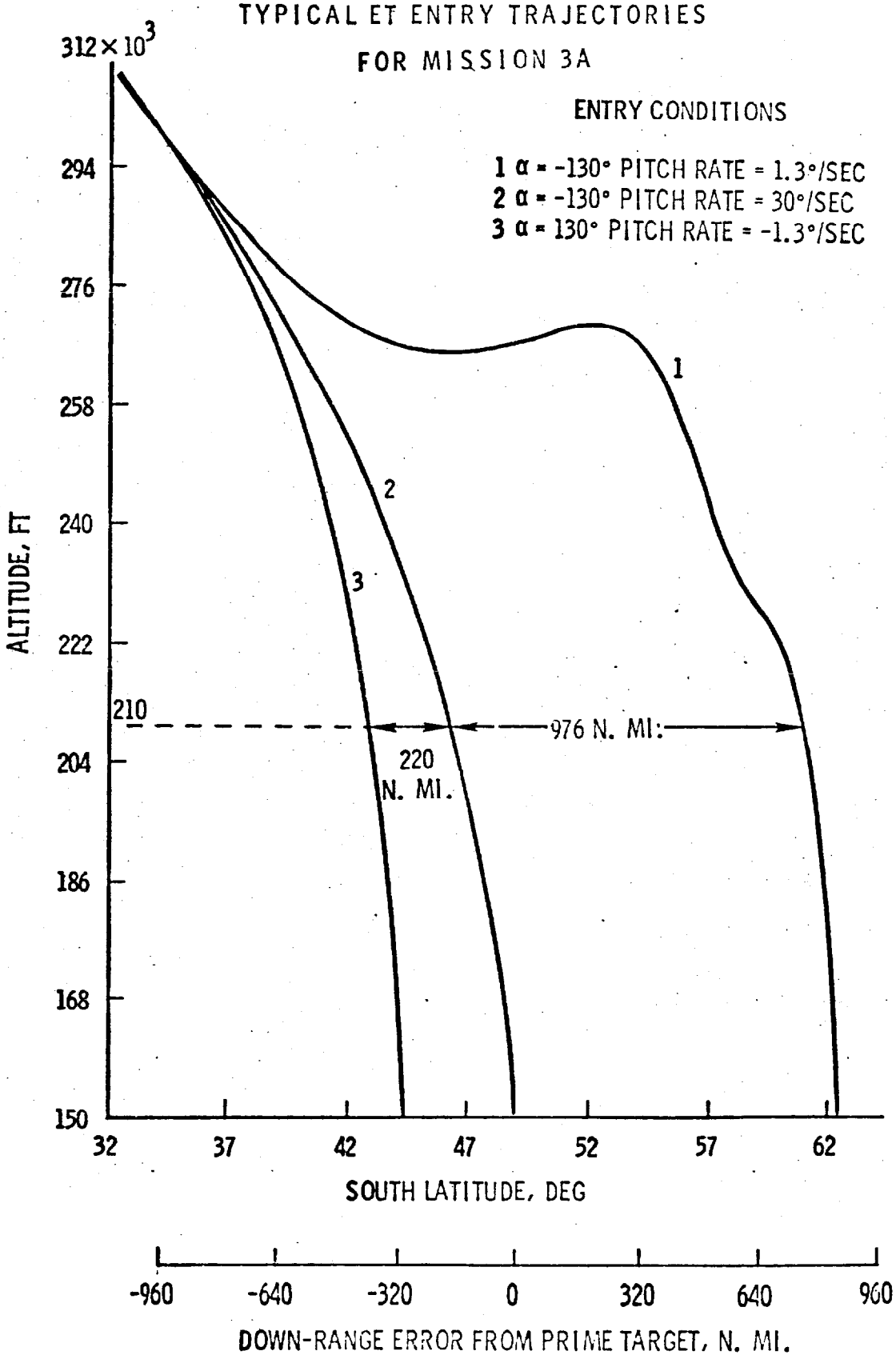

TYPICAL ET ENTRY TRAJECTORIES
FOR MISSION 3A
ENTRY CONDITIONS
1 α = -130° PITCH RATE = 1.3°/SEC
2 α = -130° PITCH RATE = 30°/SEC
3 α = 130° PITCH RATE = -1.3°/SEC
312 × 10^3
294
276
258
240
222
210
204
186
168
150
ALTITUDE, FT
1
2
3
976 N. MI.
220
N. MI.
32
37
42
47
52
57
62
SOUTH LATITUDE, DEG
-960
-640
-320
0
320
640
960
DOWN-RANGE ERROR FROM PRIME TARGET, N. MI.

Figure 38

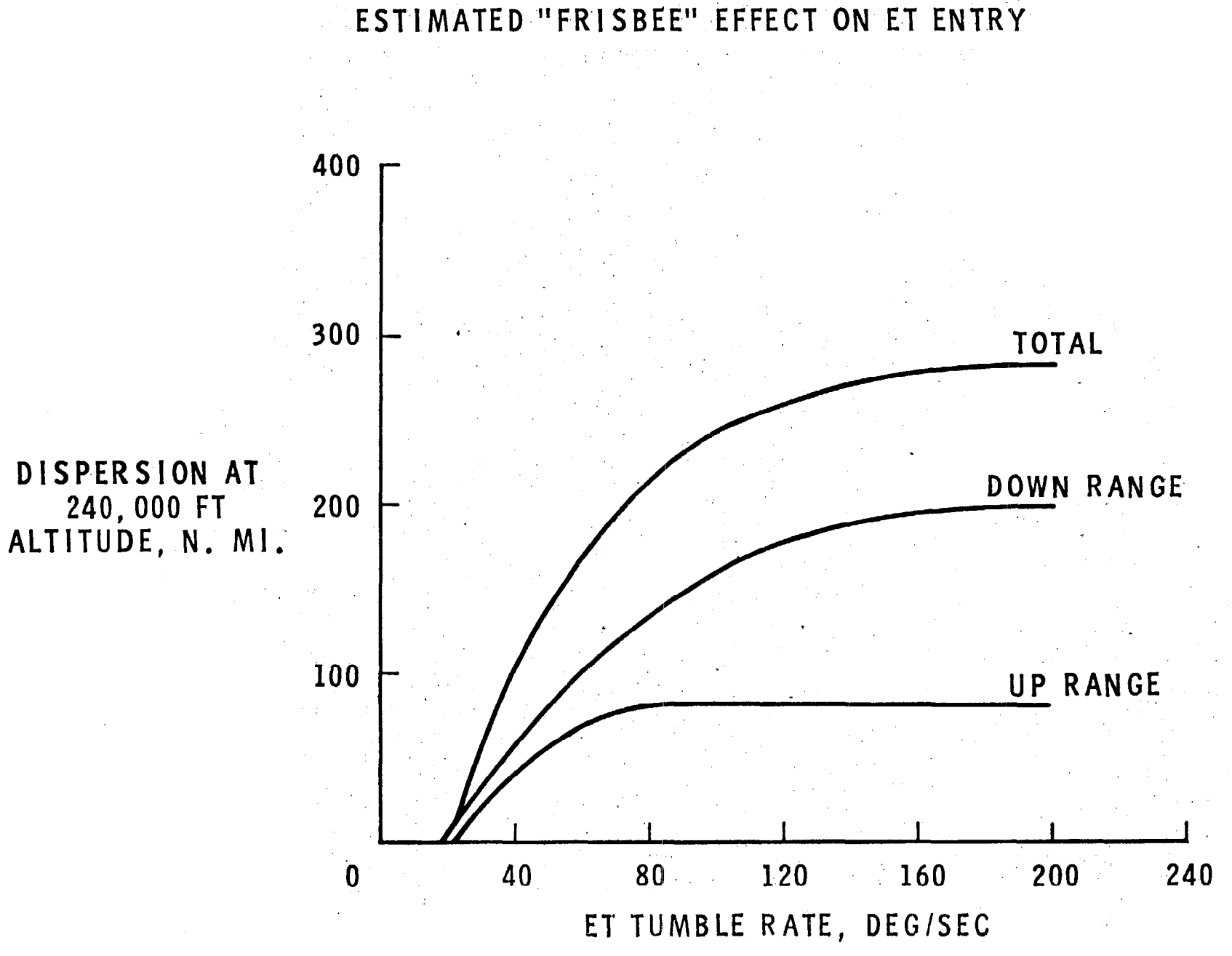

ESTIMATED "FRISBEE" EFFECT ON ET ENTRY
DISPERSION AT
240,000 FT
ALTITUDE, N. MI.
400
300
200
100
0
TOTAL
DOWN RANGE
UP RANGE
40
80
120
160
200
240
ET TUMBLE RATE, DEG/SEC

Figure 39

SOLID ROCKET BOOSTER

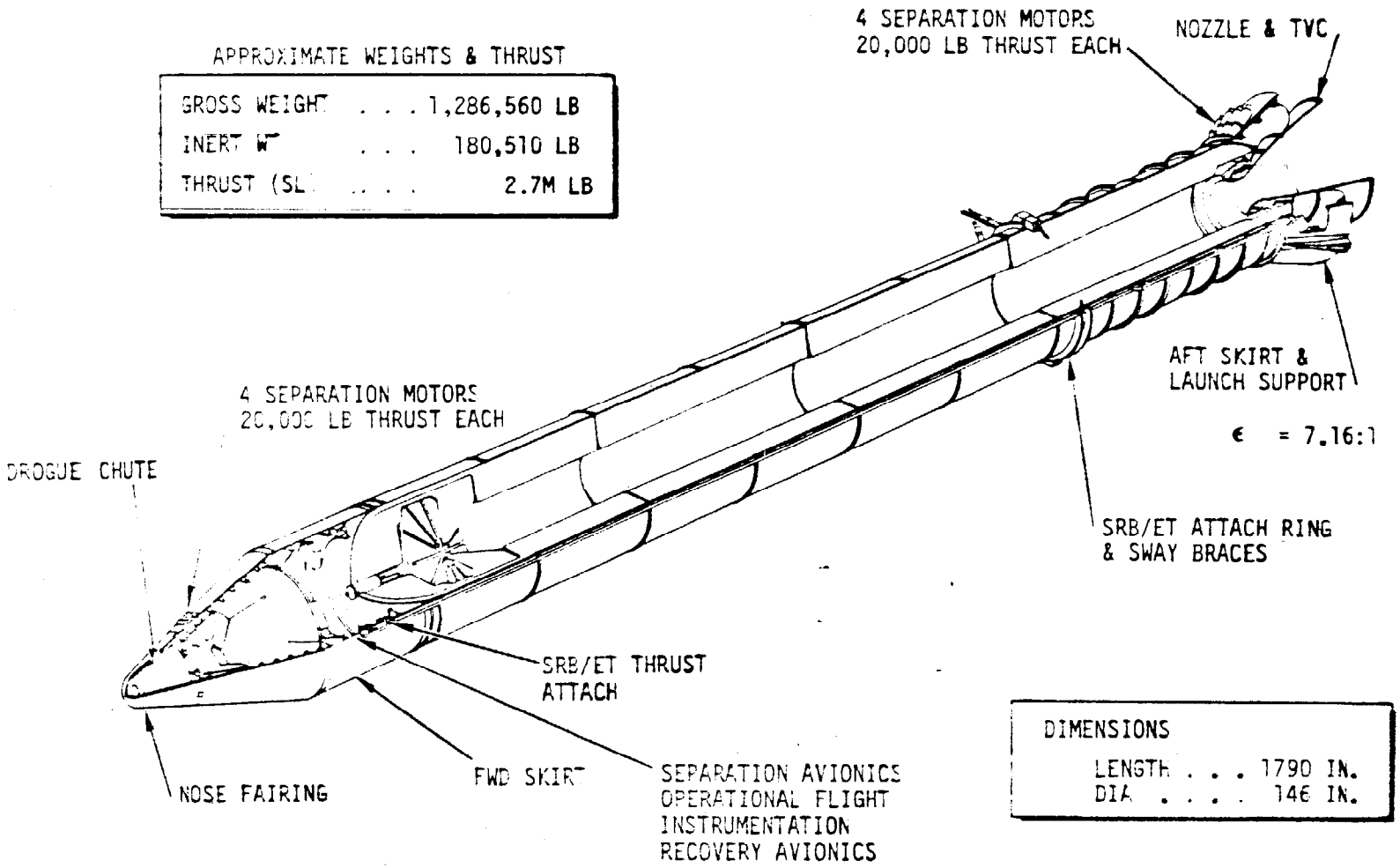


Figure 40

Case Design Configuration

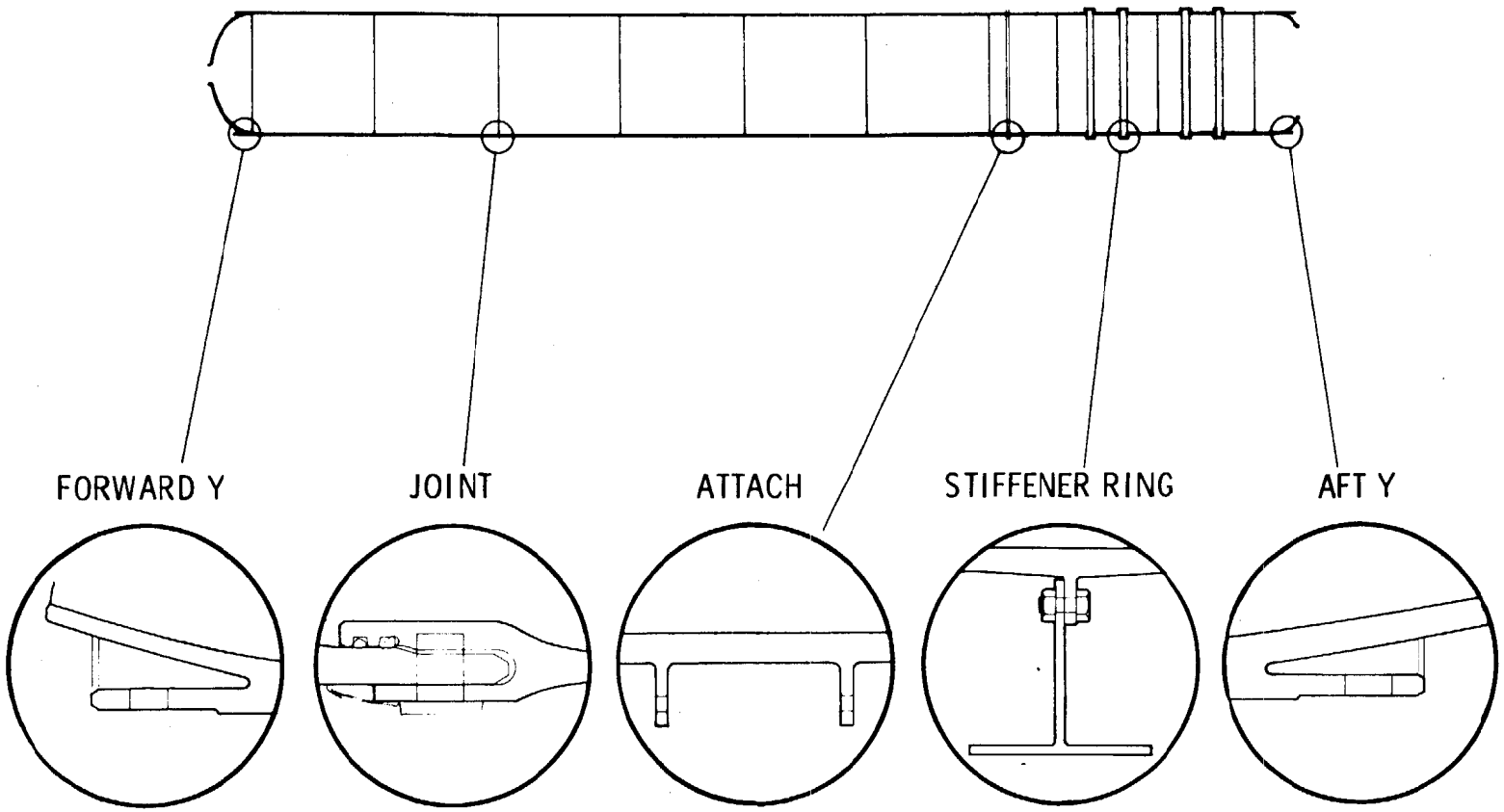


Figure 41

REPRODUCIBILITY LIMITS

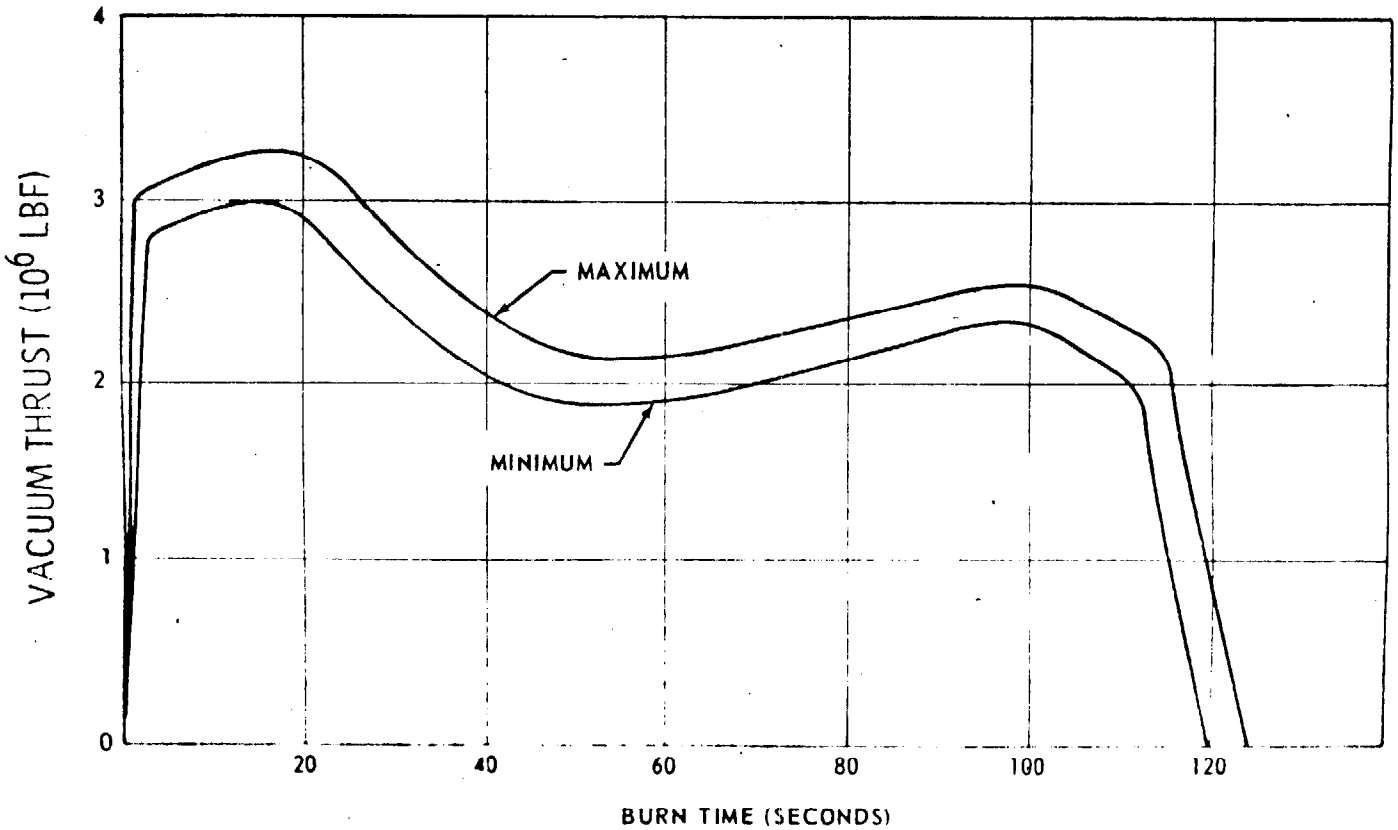


Figure 42

SRB/ET SEPARATION SYSTEM

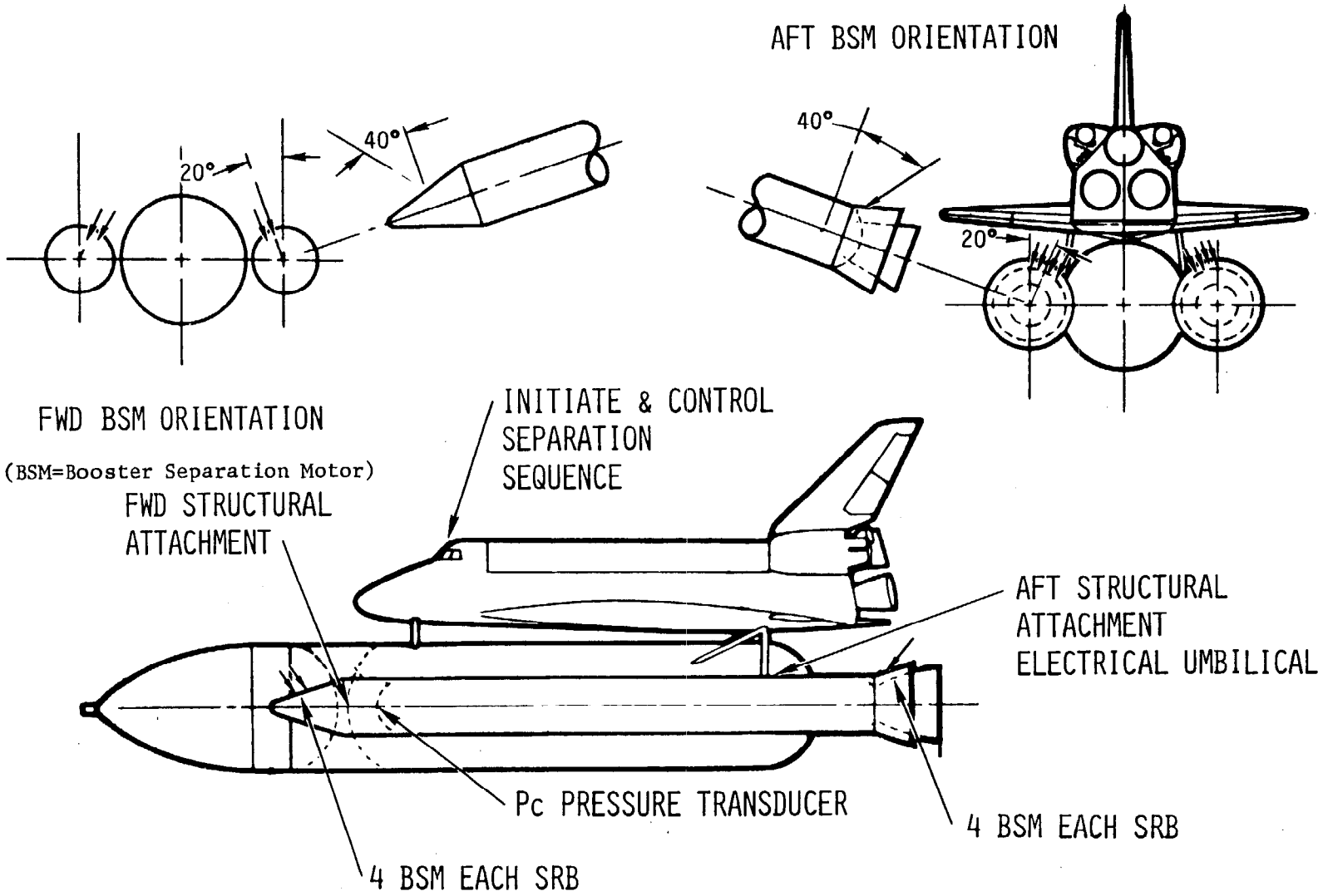
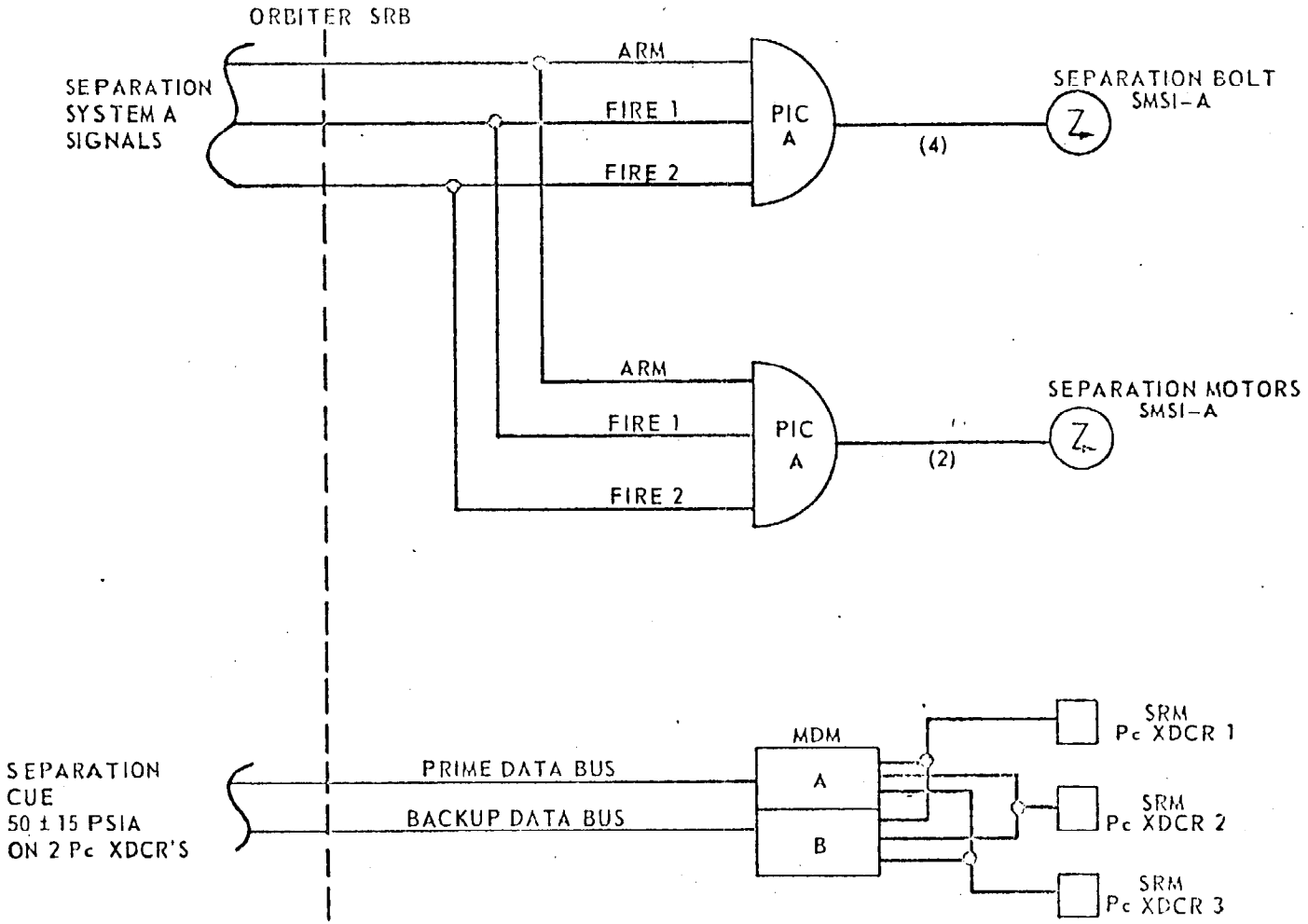


Figure 43



PIC - PYROTECHNIC INITIATOR CONTROLLER
MDM - MULTIPLEXER - DEMULTIPLEXER
SMSI - STANDARD MANNED SPACEFLIGHT INITIATOR
Pc - CHAMBER PRESSURE
XDCR - TRANSDUCER

Figure 44

SRB PDR
RECOVERY SUBSYSTEM

NOMINAL TRAJECTORY

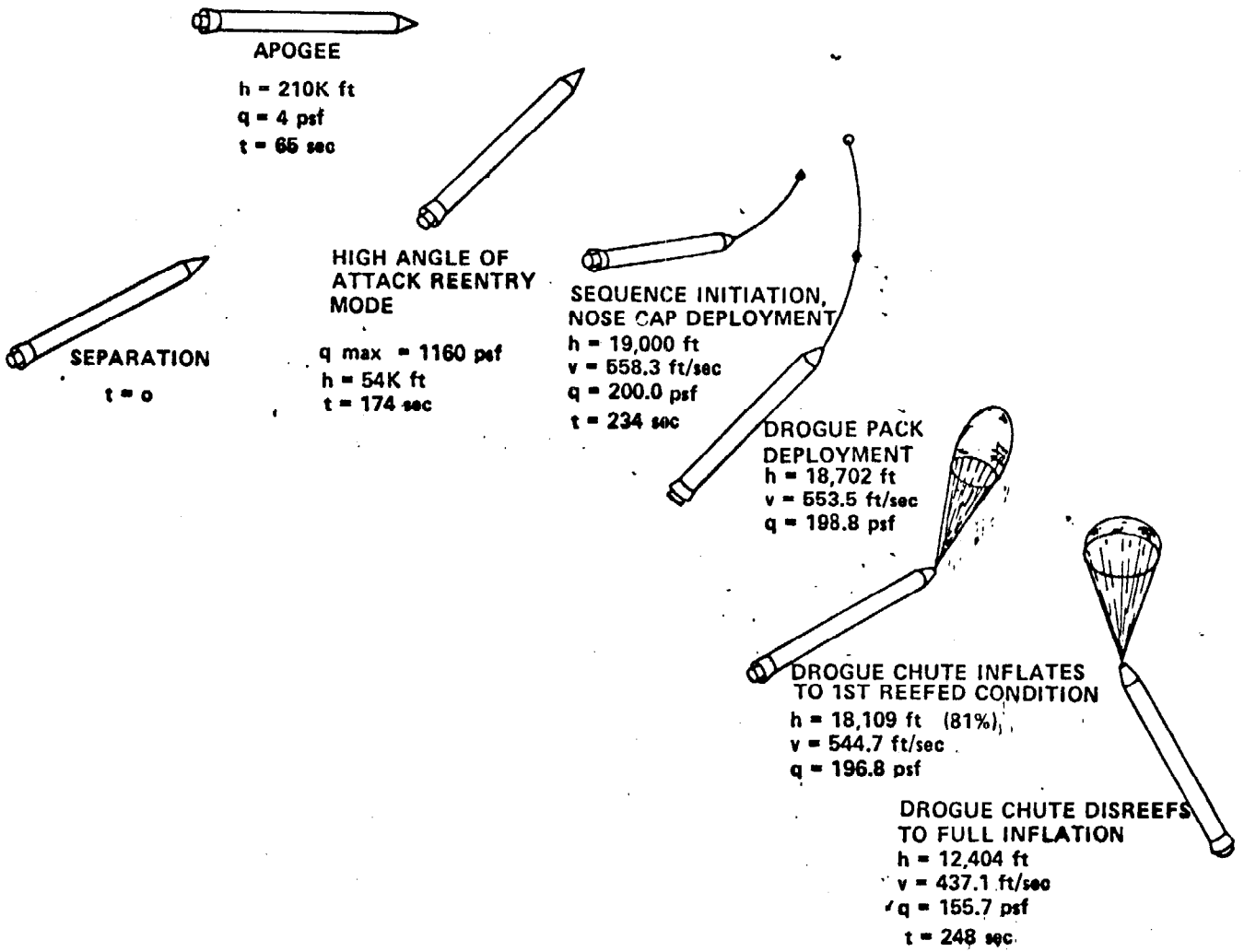


Figure 45

SRB PDR
RECOVERY SUBSYSTEM

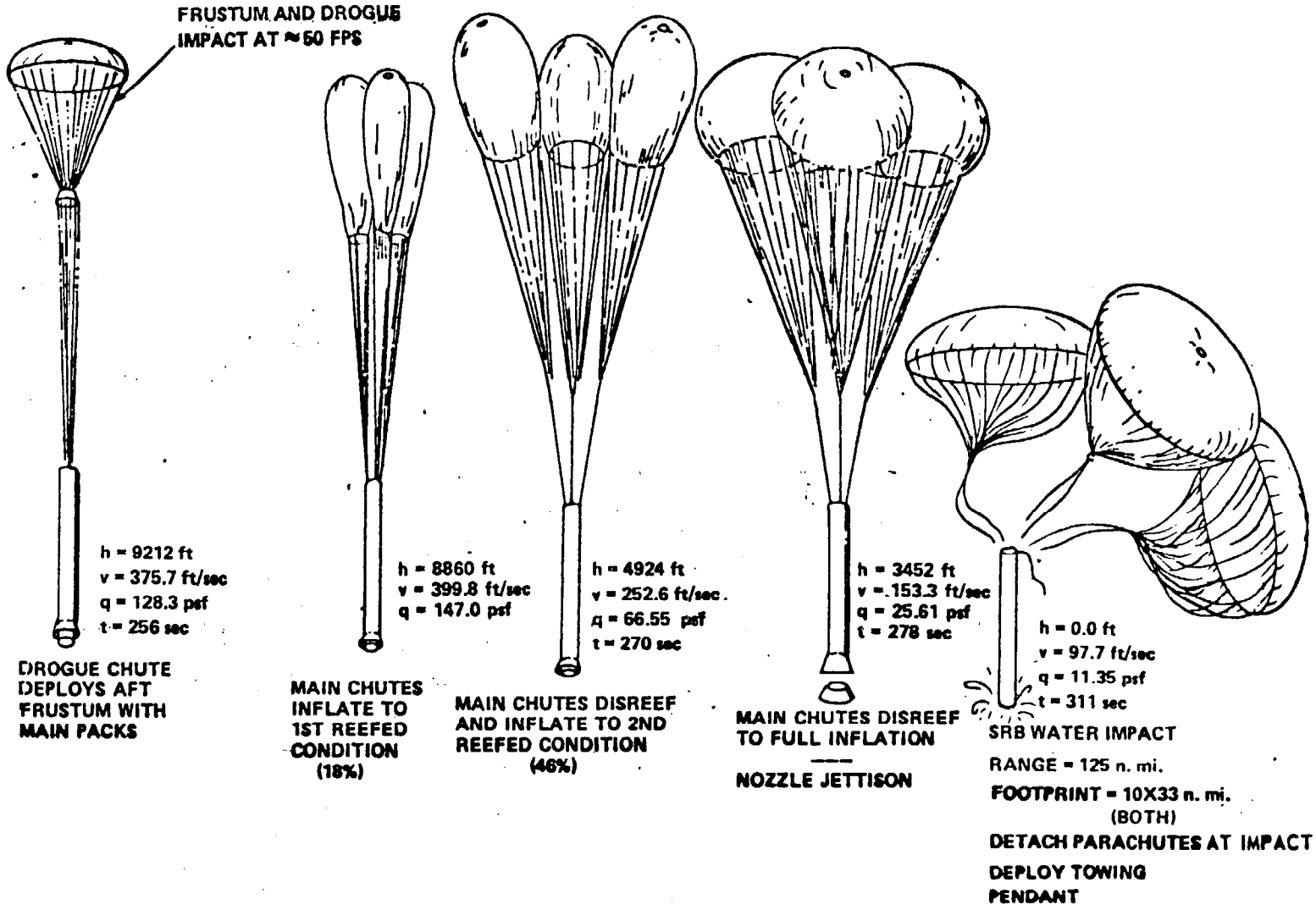


Figure 45 (Concluded)

RECOVERY SYSTEM PACKAGING IN THE NOSE CONE

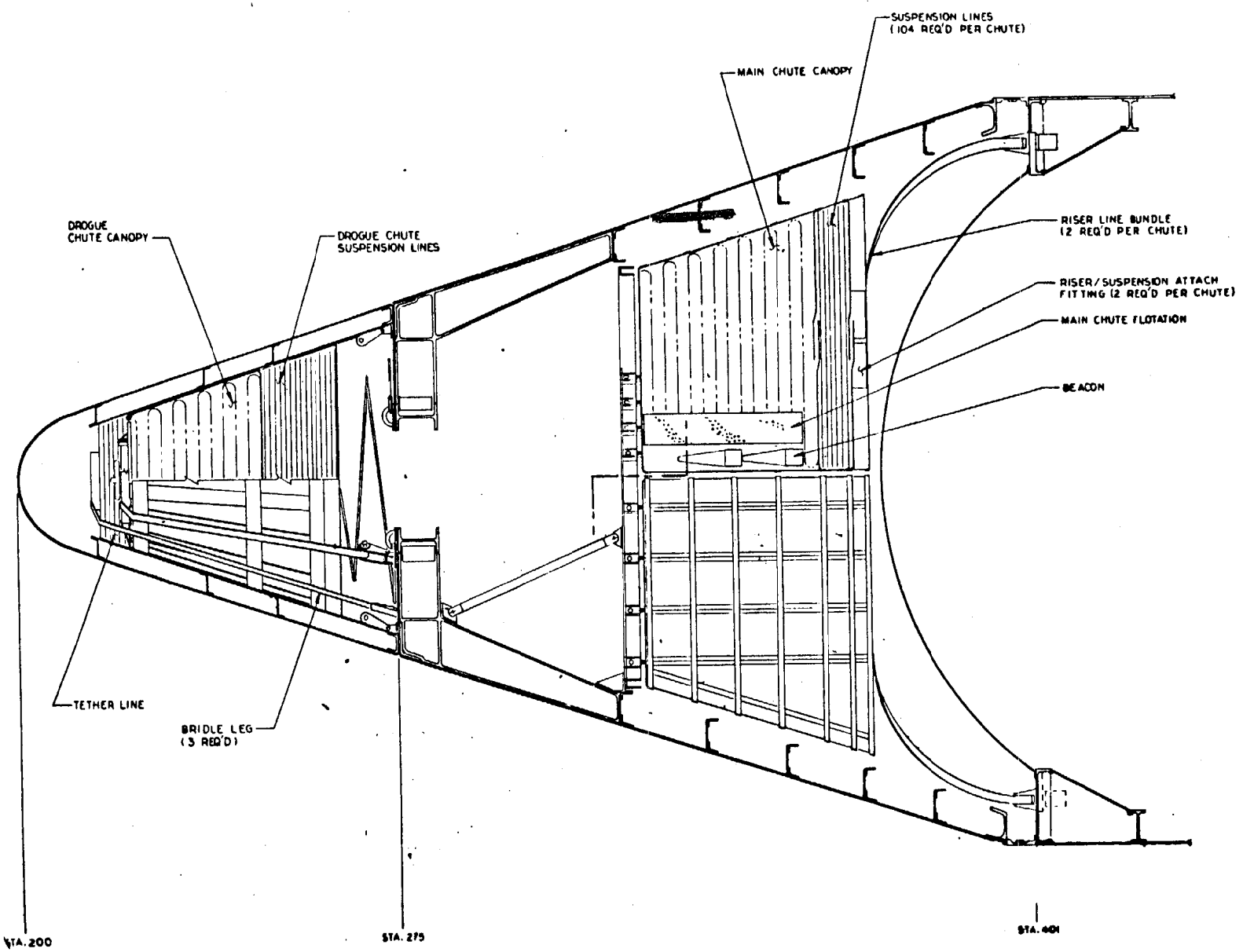


Figure 46

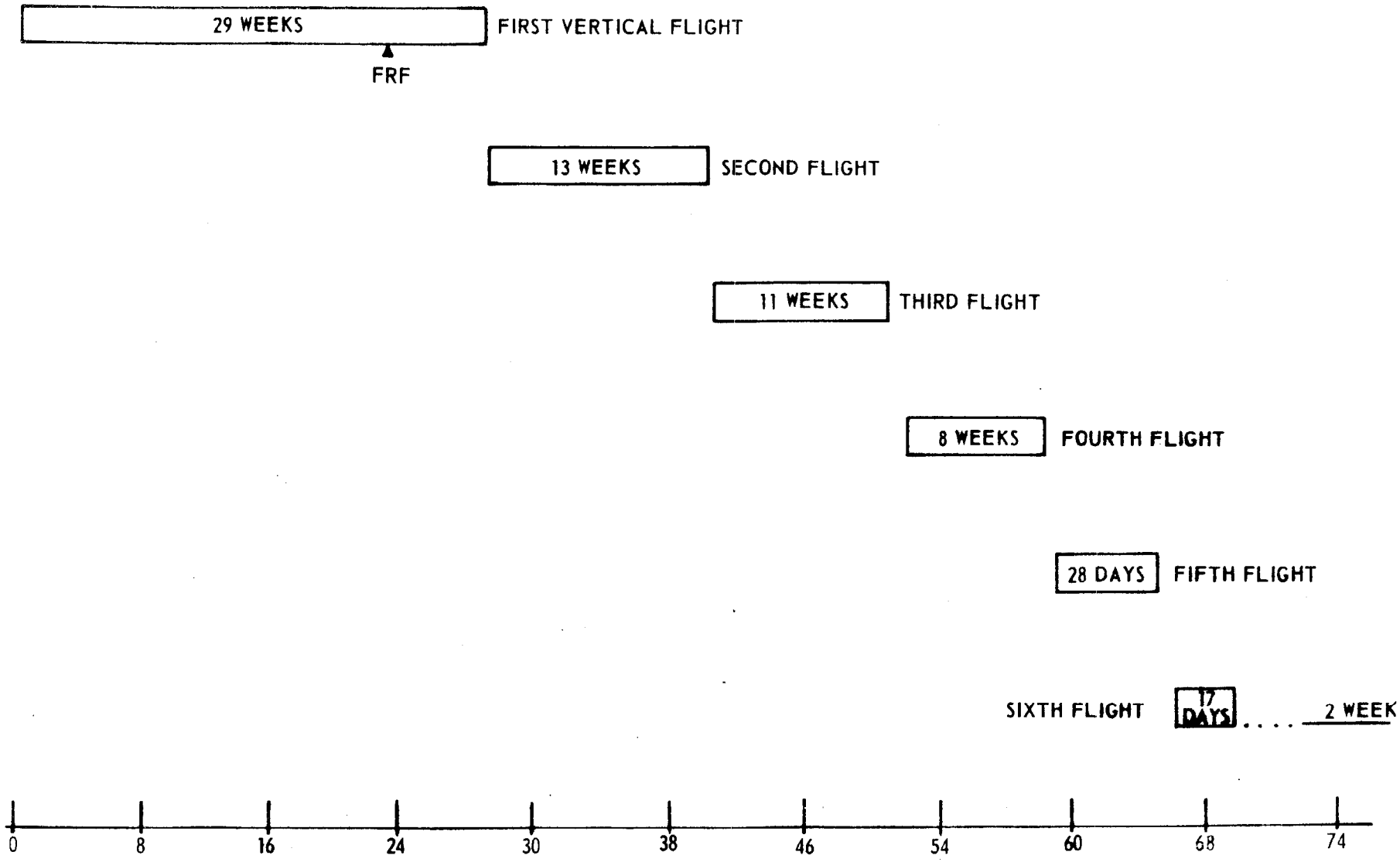

29 WEEKS
FIRST VERTICAL FLIGHT
FRF
13 WEEKS
SECOND FLIGHT
11 WEEKS
THIRD FLIGHT
8 WEEKS
FOURTH FLIGHT
28 DAYS
FIFTH FLIGHT
SIXTH FLIGHT
17 DAYS
2 WEEK
0
8
16
24
30
38
46
54
60
68
74

Figure 47

SAFETY ANALYSIS PROCESS

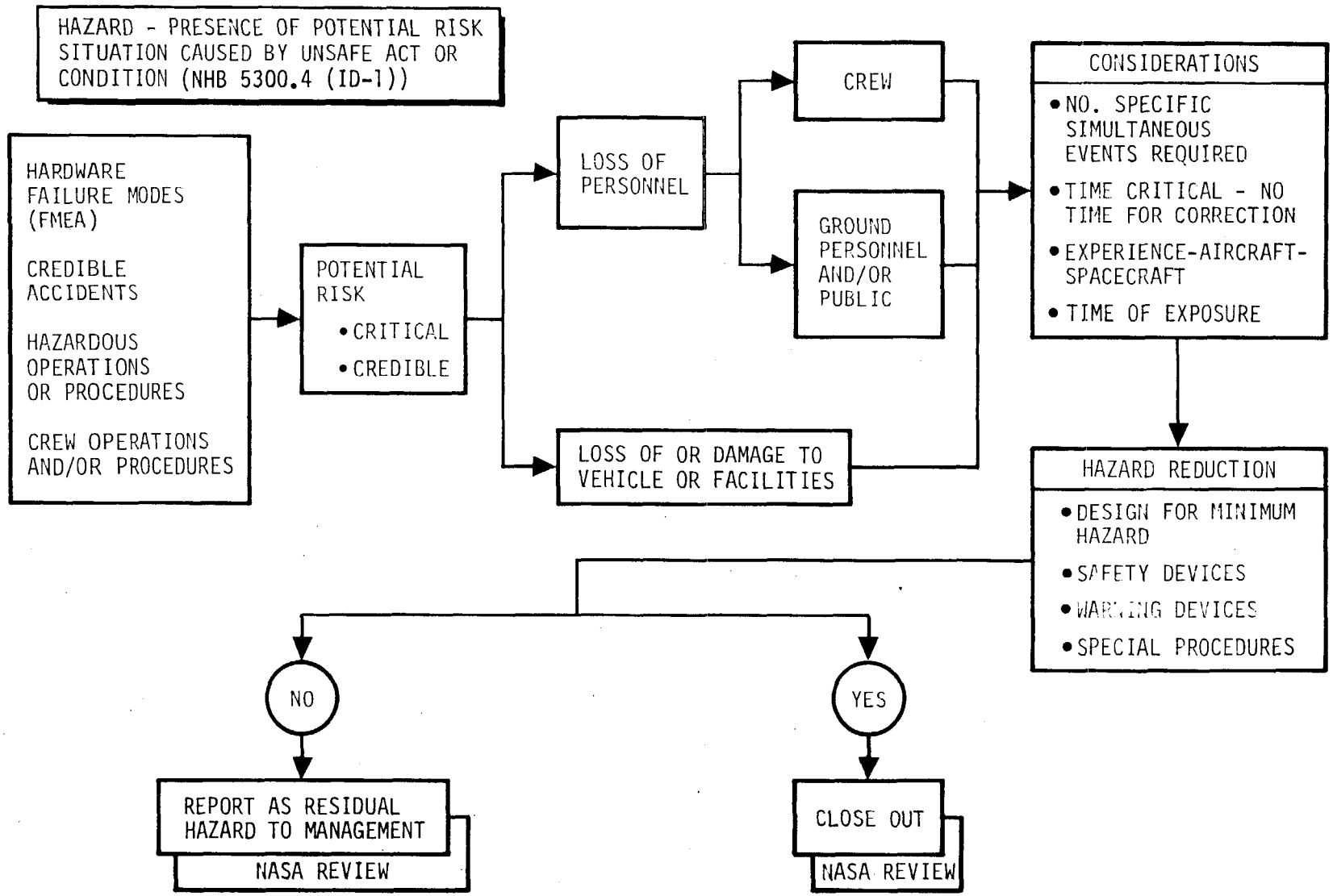
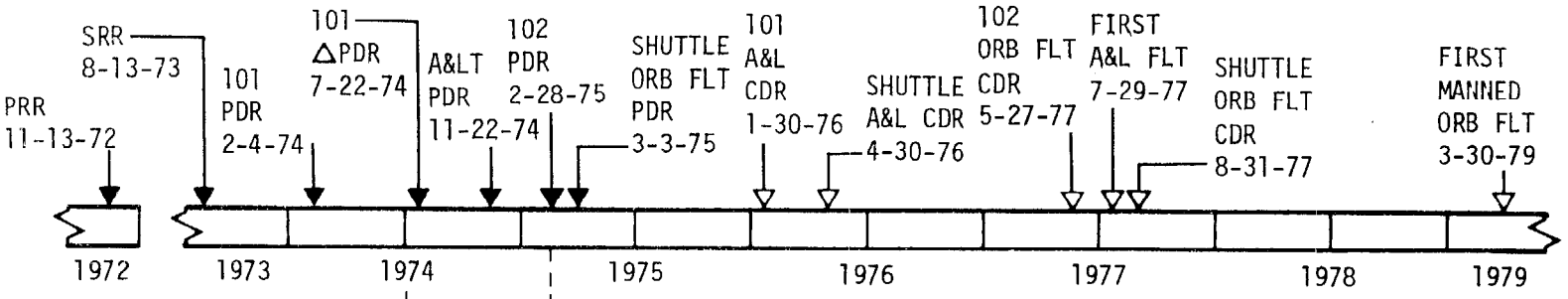


Figure 48

SHUTTLE AND ORBITER
RELIABILITY AND SAFETY ACTIVITIES



REQUIREMENTS DEFINED
- ABORT
- RESCUE
- FLUID VENTING
- FIRE/TOXICITY
- SEPARATION
- REDUNDANCY
- CERTIFICATION

FMEAs	SUBSYSTEMS -	18	20	FINAL ORB FMEA	MISSION RULES INPUTS
	COMPONENTS -	850	947		
	MODES -	1047	3773		
HAZARDS	SUBSYSTEMS -	18	20	UPDATE	CONTINGENCY PLAN & PROCEDURES
	ORBITER HA'S/SAR	120	200		
	TOP-DOWN SAFETY ANALYSIS		150		
INTERFACE ANALYSES	747/ORB		SSME/ORB ET/ORB SRB/ET	PREL	UPDATE — SITE & C/O OPERATIONS SUPPORT
SHUTTLE SAFETY ANALYSIS REPORT	▲			UPDATE	

Figure 49

GROUND HAZARDOUS GAS DETECTION SYSTEM SUMMARY

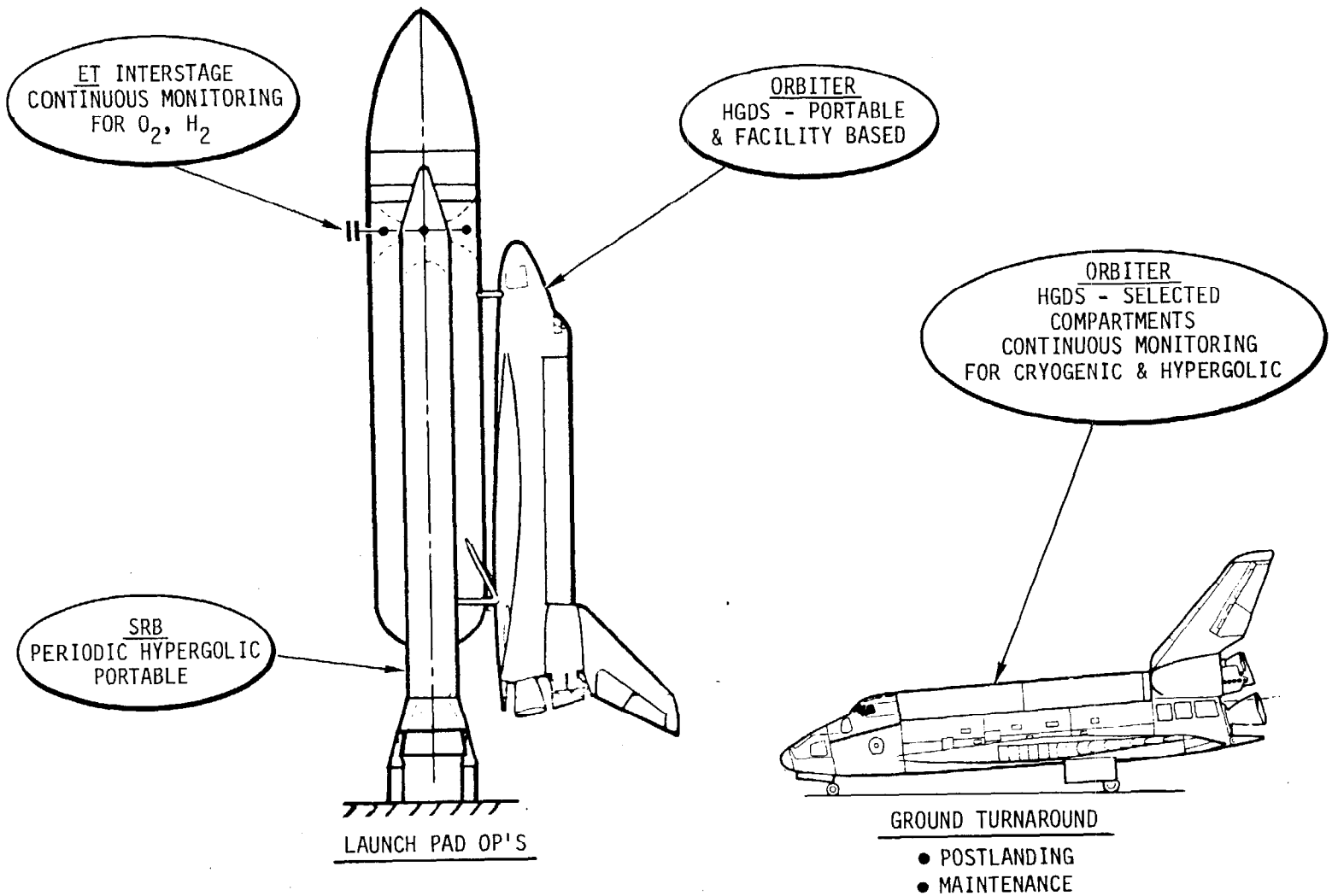


Figure 50

LANDING/DECELERATION
NOSE GEAR INSTALLATION

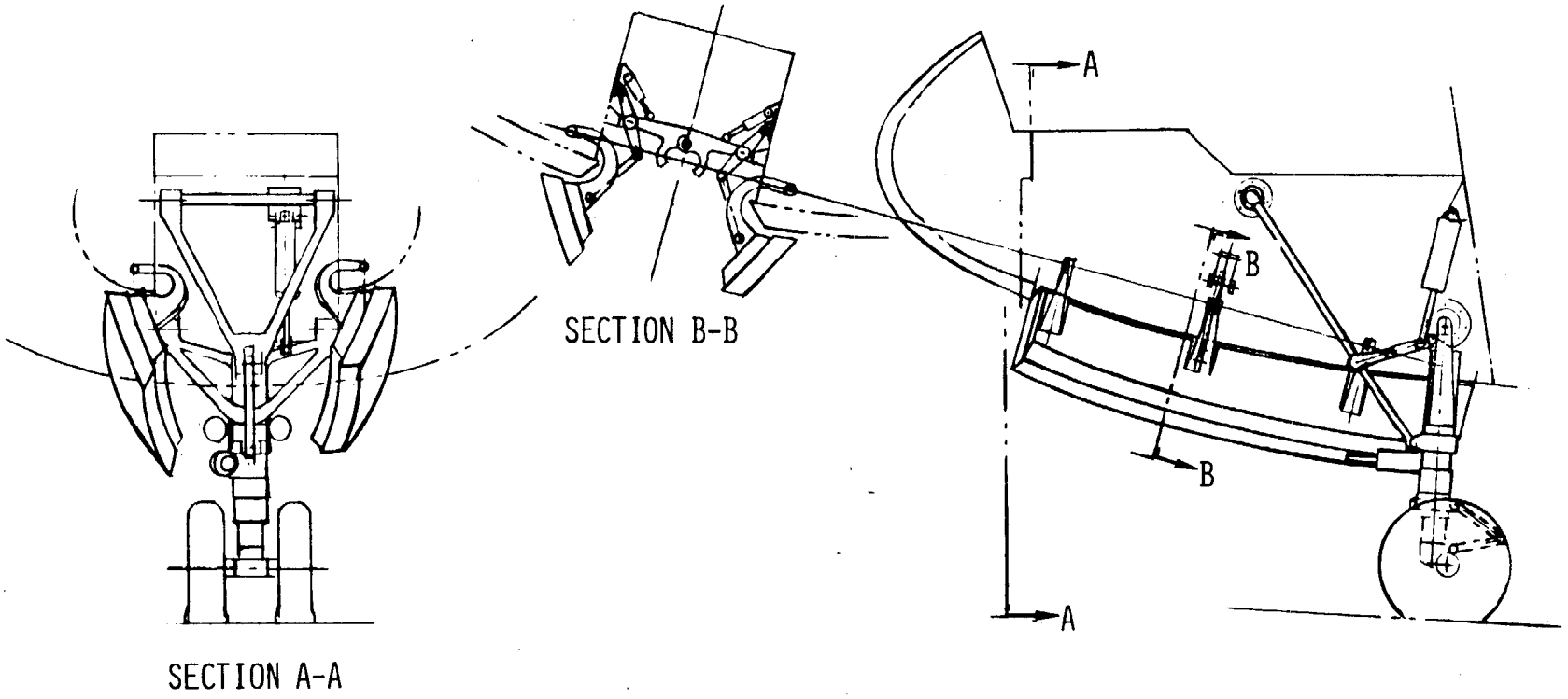


Figure 51

LANDING/DECELERATION
MAIN GEAR

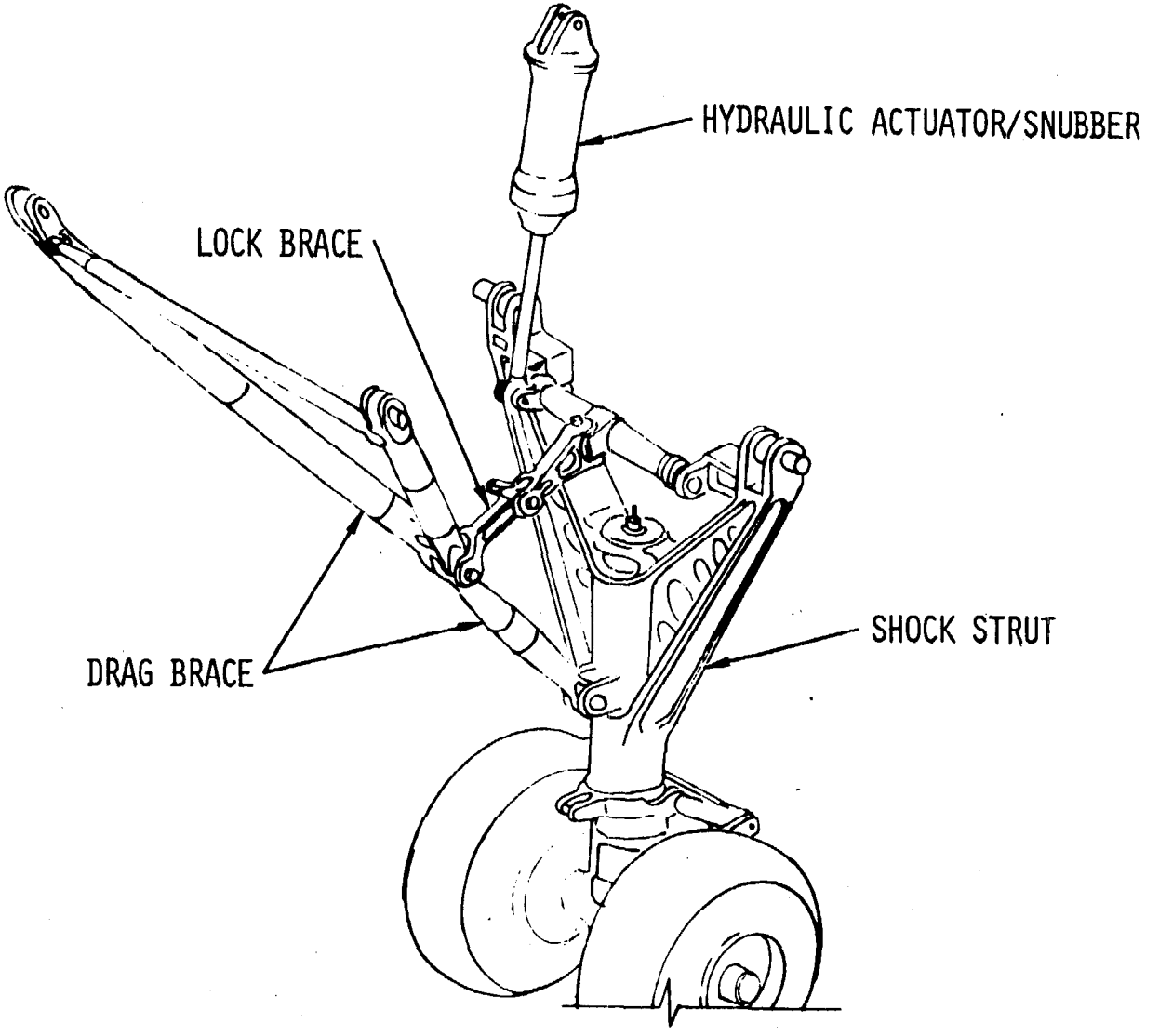


Figure 52

BASELINE SYSTEM

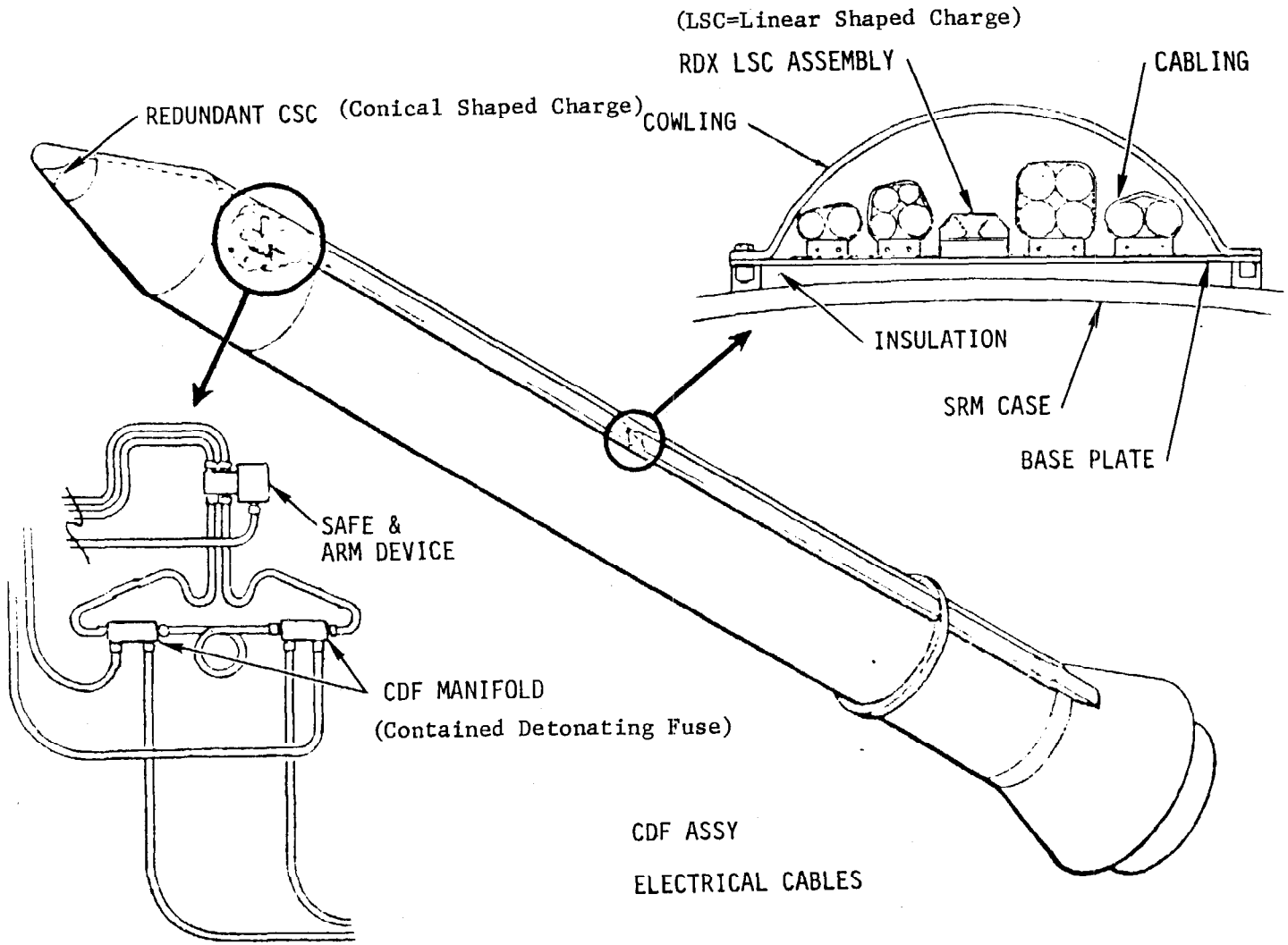


Figure 53

RANGE SAFETY
BASELINE SYSTEM

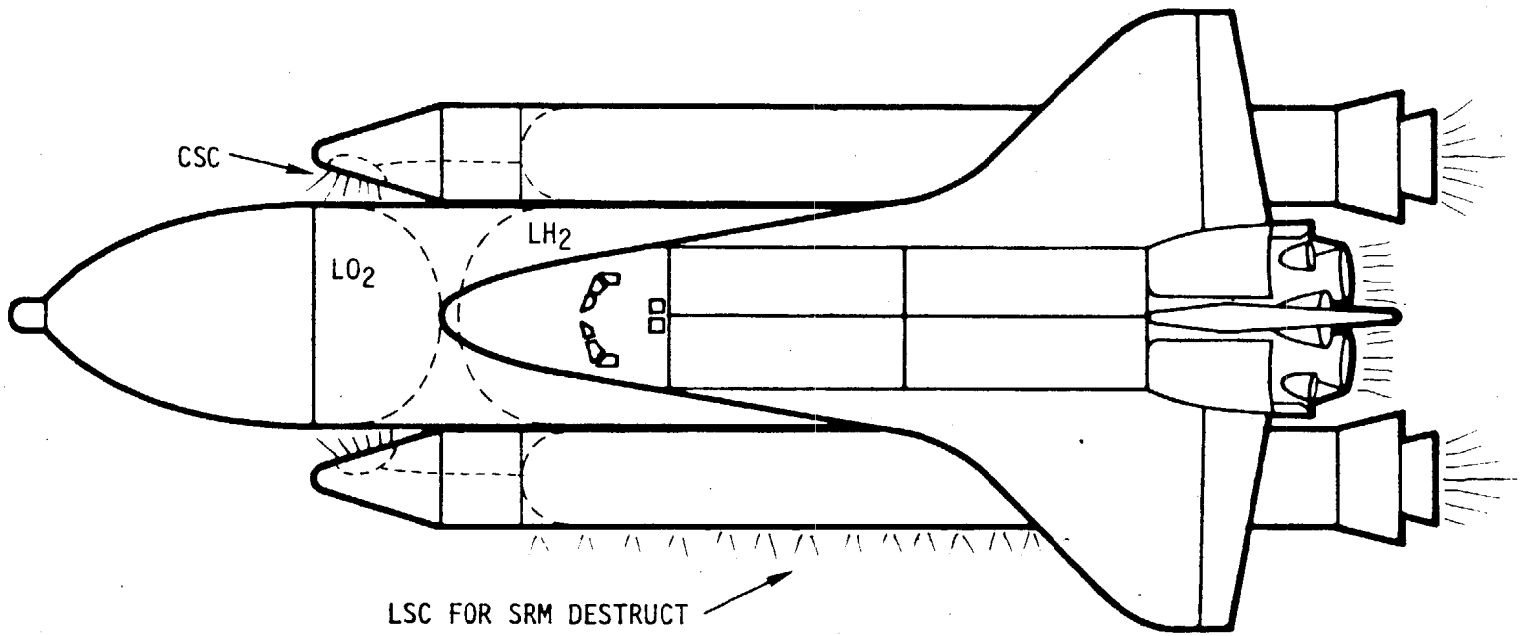


Figure 54

MAJOR GROUND TEST PROGRAMS

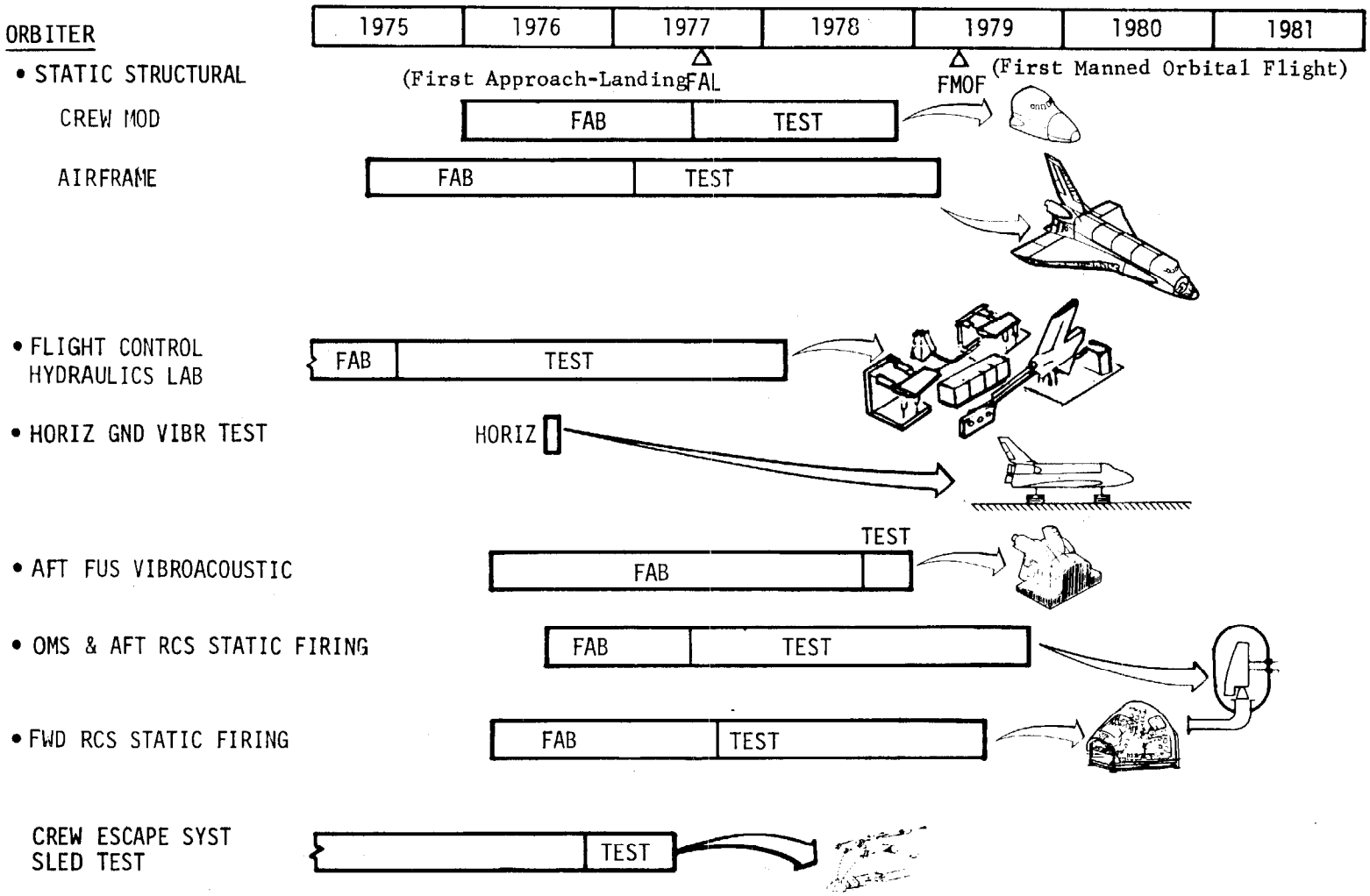


Figure 55

MAJOR GROUND TEST PROGRAMS (CONT)

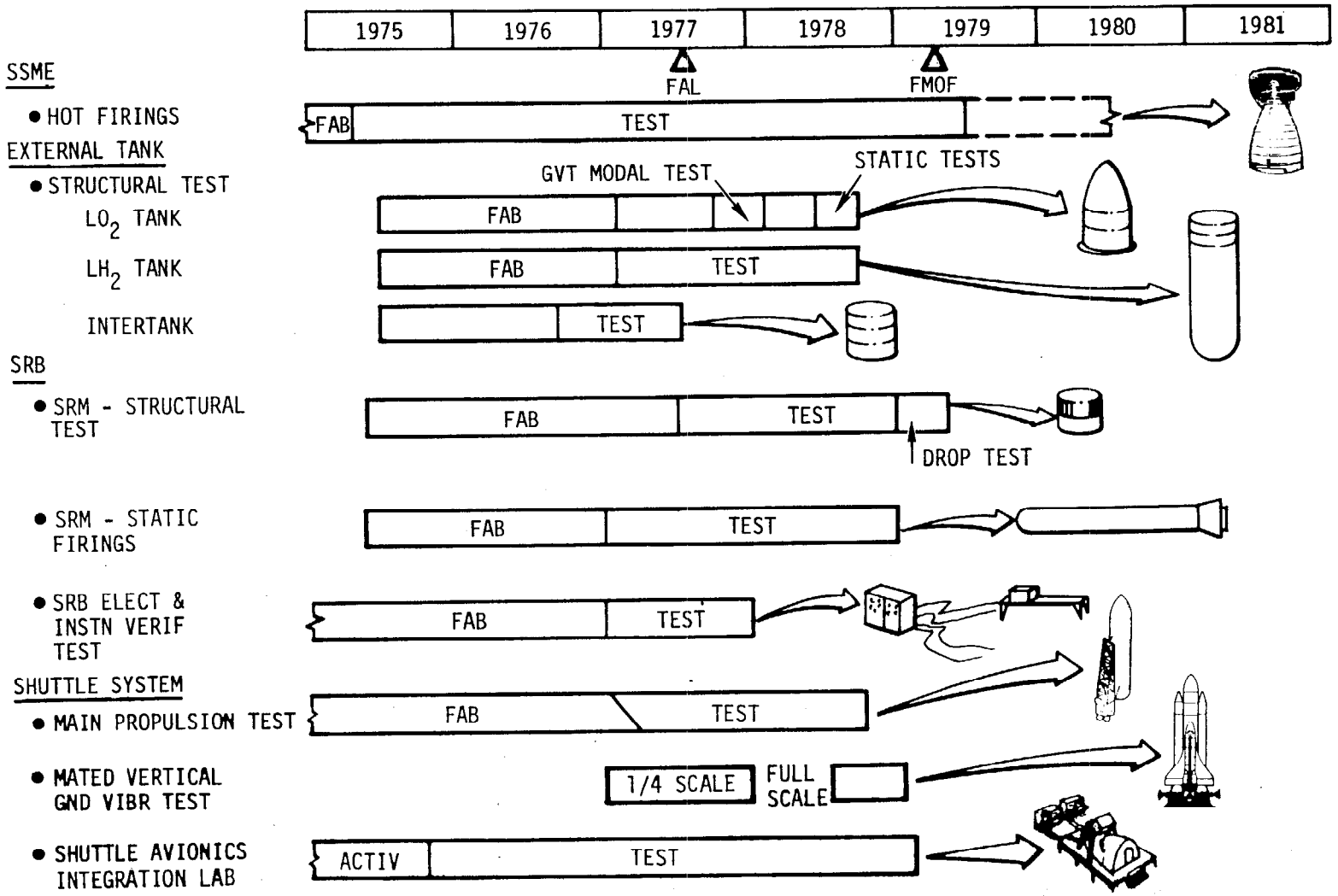


Figure 55 (Concluded)

SPACE SHUTTLE AVIONICS SYSTEMS

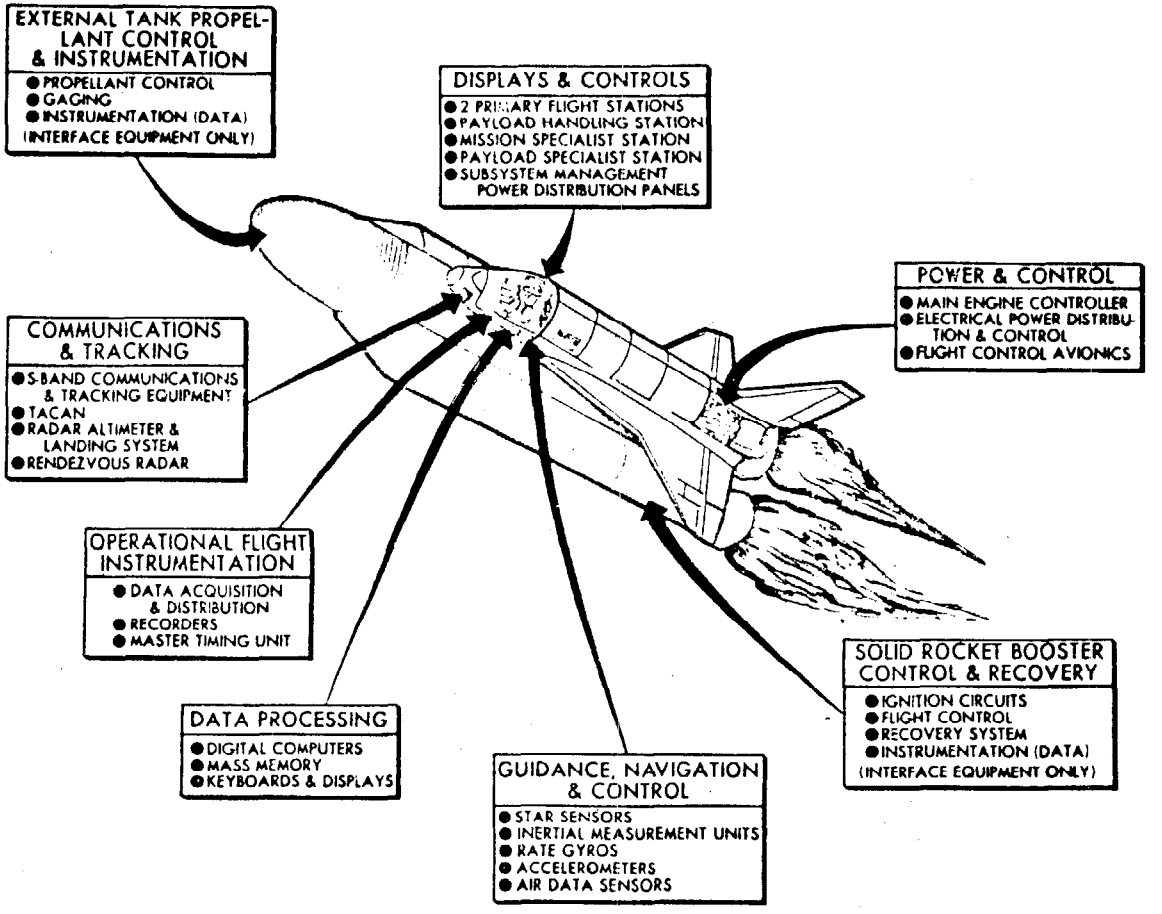


Figure 56

SRB/ET SEPARATION SYSTEM VERIFICATION LOGIC

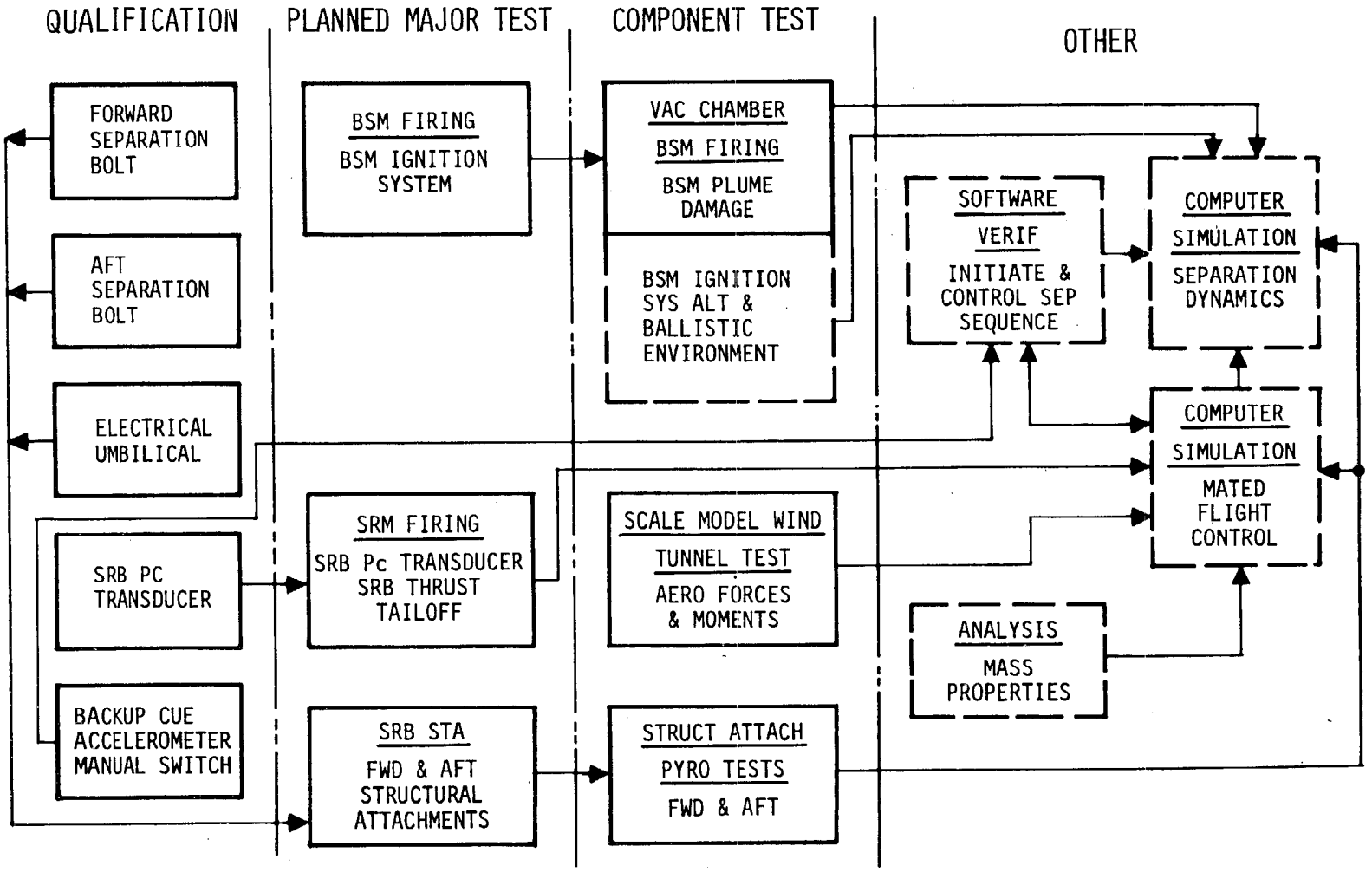


Figure 57

SPACE SHUTTLE MAIN PROPULSION SYSTEM
(SCHEMATIC)

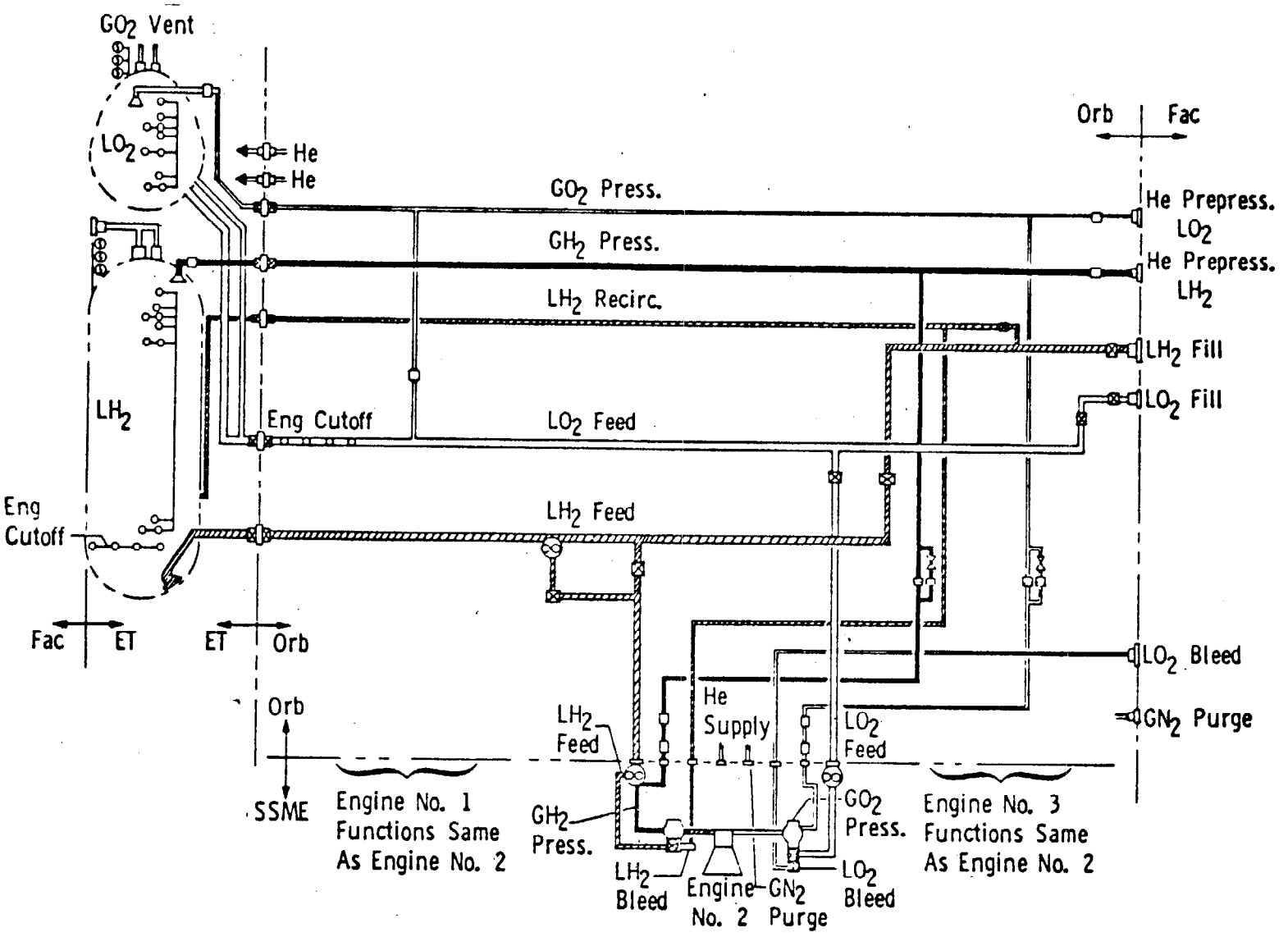


Figure 58

POGO SUPPRESSOR SYSTEM

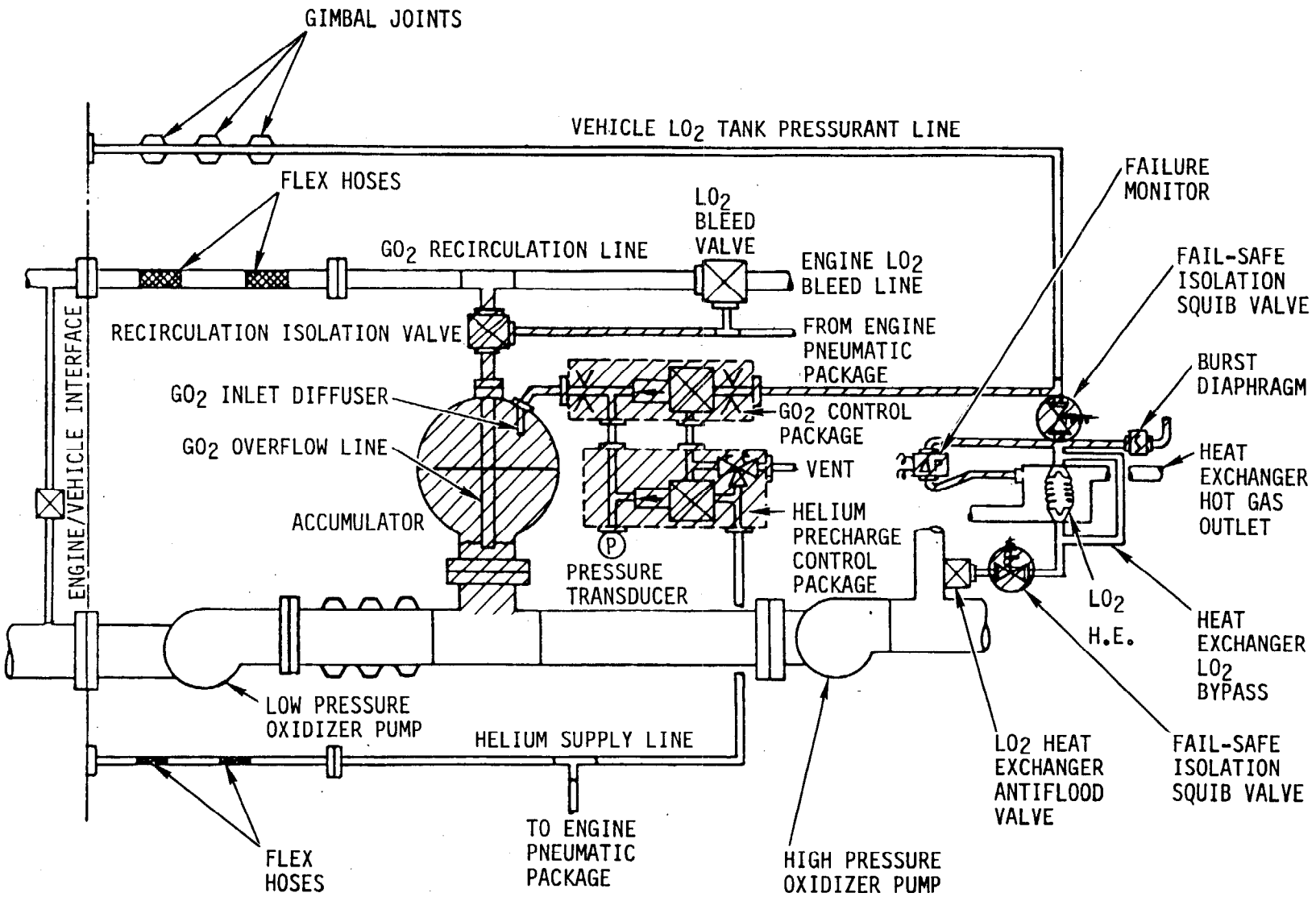


Figure 59

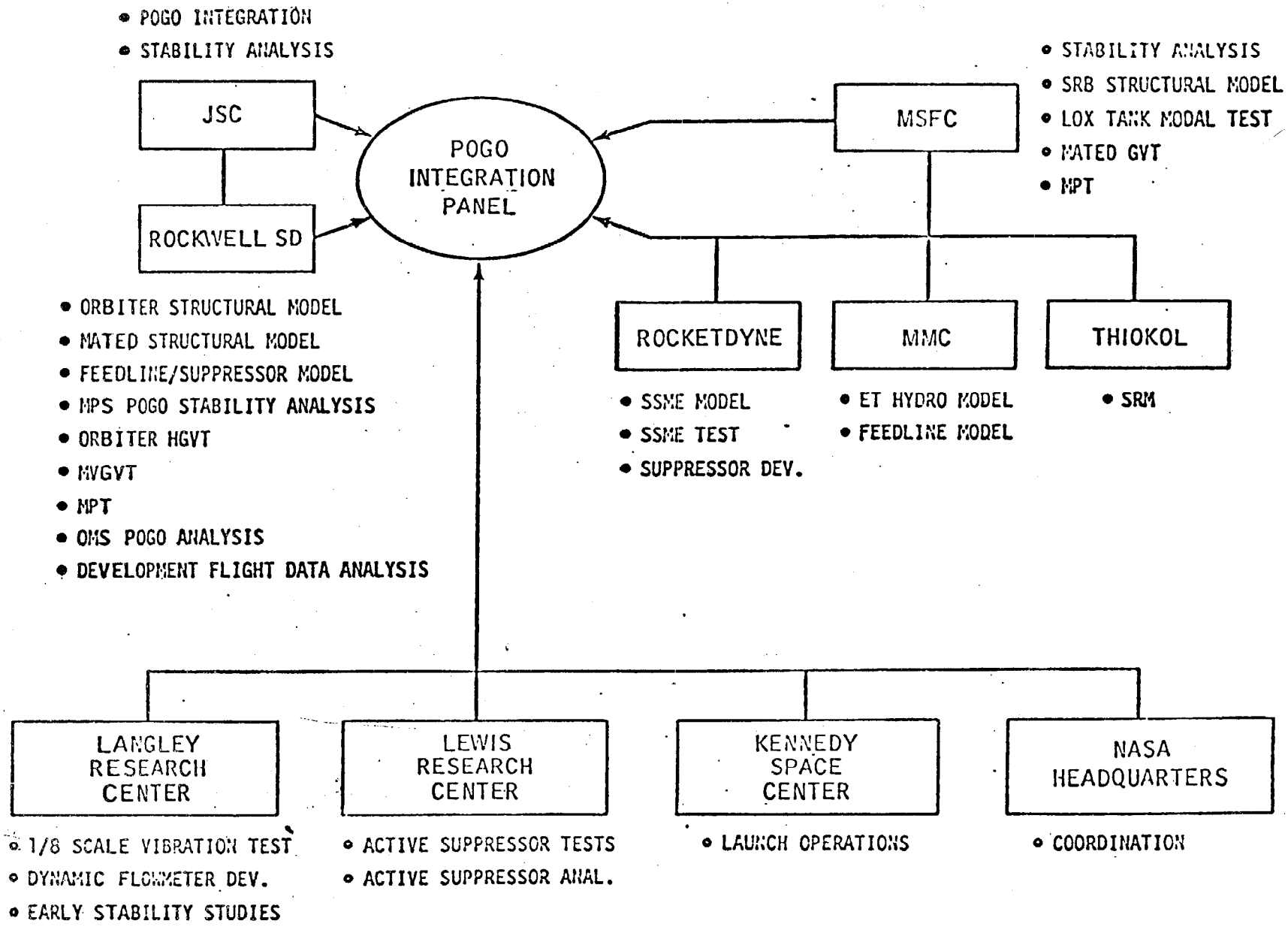

• POGO INTEGRATION
• STABILITY ANALYSIS
JSC
ROCKWELL SD
POGO INTEGRATION PANEL
MSFC
• STABILITY ANALYSIS
• SRB STRUCTURAL MODEL
• LOX TANK MODAL TEST
• MATED GVT
• MPT
• ORBITER STRUCTURAL MODEL
• MATED STRUCTURAL MODEL
• FEEDLINE/SUPPRESSOR MODEL
• MPS POGO STABILITY ANALYSIS
• ORBITER HGVT
• MVGVT
• MPT
• OMS POGO ANALYSIS
• DEVELOPMENT FLIGHT DATA ANALYSIS
ROCKETDYNE
• SSME MODEL
• SSME TEST
• SUPPRESSOR DEV.
MMC
• ET HYDRO MODEL
• FEEDLINE MODEL
THIOKOL
• SRM
LANGLEY RESEARCH CENTER
• 1/8 SCALE VIBRATION TEST
• DYNAMIC FLOWMETER DEV.
• EARLY STABILITY STUDIES
LEWIS RESEARCH CENTER
• ACTIVE SUPPRESSOR TESTS
• ACTIVE SUPPRESSOR ANAL.
KENNEDY SPACE CENTER
• LAUNCH OPERATIONS
NASA HEADQUARTERS
• COORDINATION

Figure 60