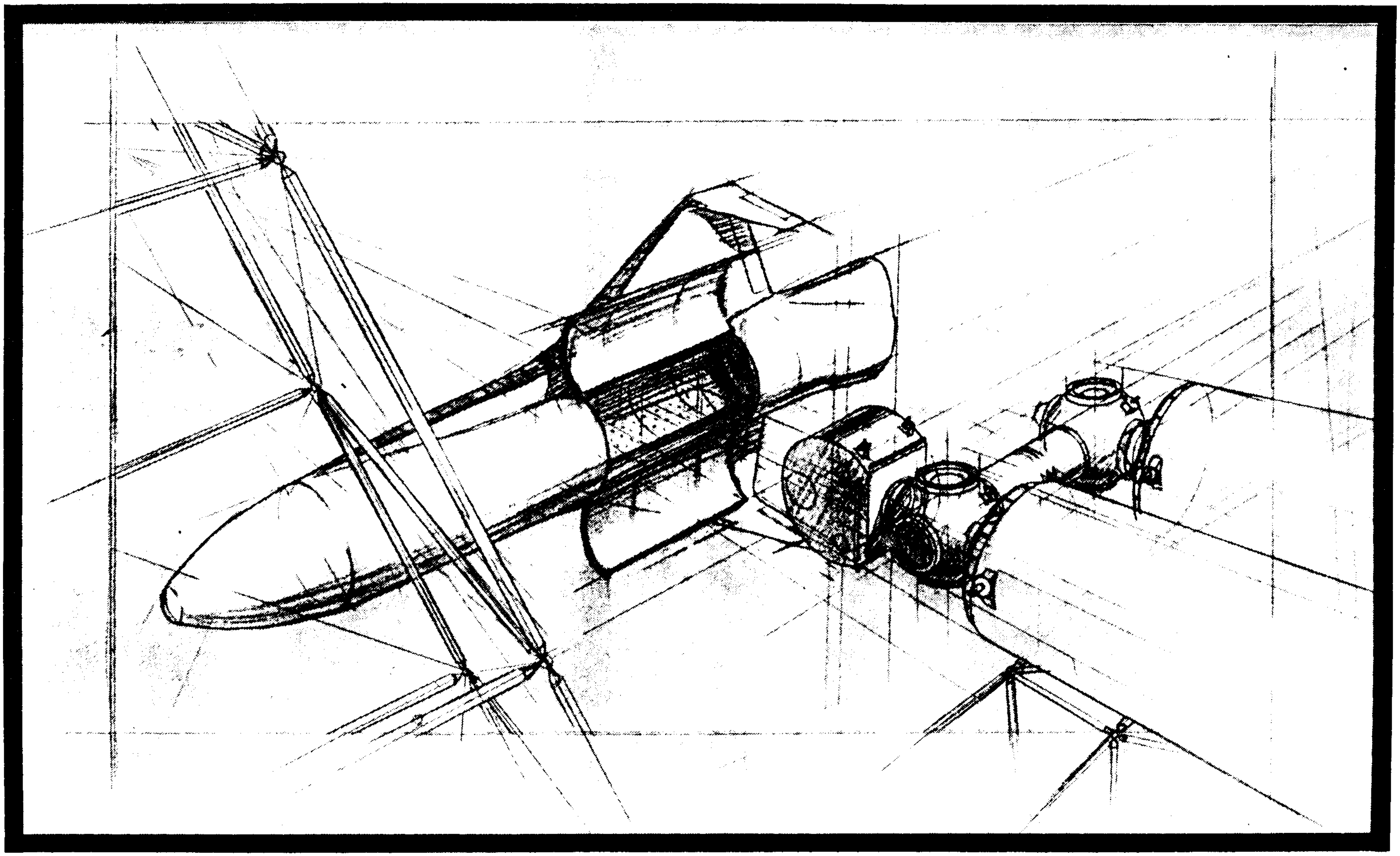
PROPOSED CONCEPT FOR A SPACEPLANE



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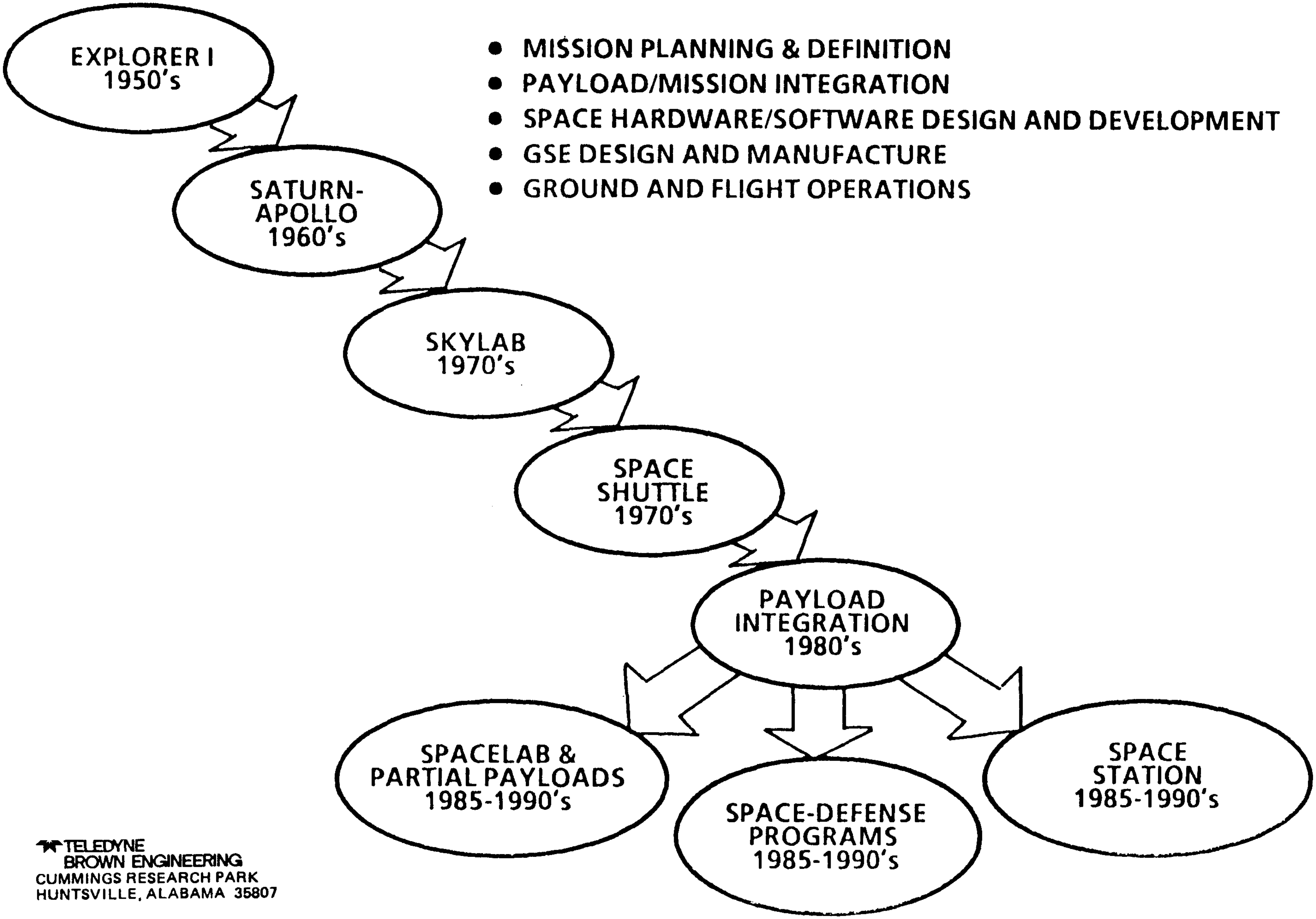
TBE SPACE PROGRAMS ACTIVITIES

- MISSION PLANNING & DEFINITION
- PAYLOAD/MISSION INTEGRATION
- SPACE HARDWARE/SOFTWARE DESIGN AND DEVELOPMENT
- GSE DESIGN AND MANUFACTURE
- GROUND AND FLIGHT OPERATIONS



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OVERVIEW OF TBE SPACE DIVISION CAPABILITIES

GENERAL:

- LONG HISTORY OF ENGINEERING SUPPORT TO MSFC
- EXPERIMENT CARRIERS PROVIDED TO GSFC

CURRENT ACTIVITIES:

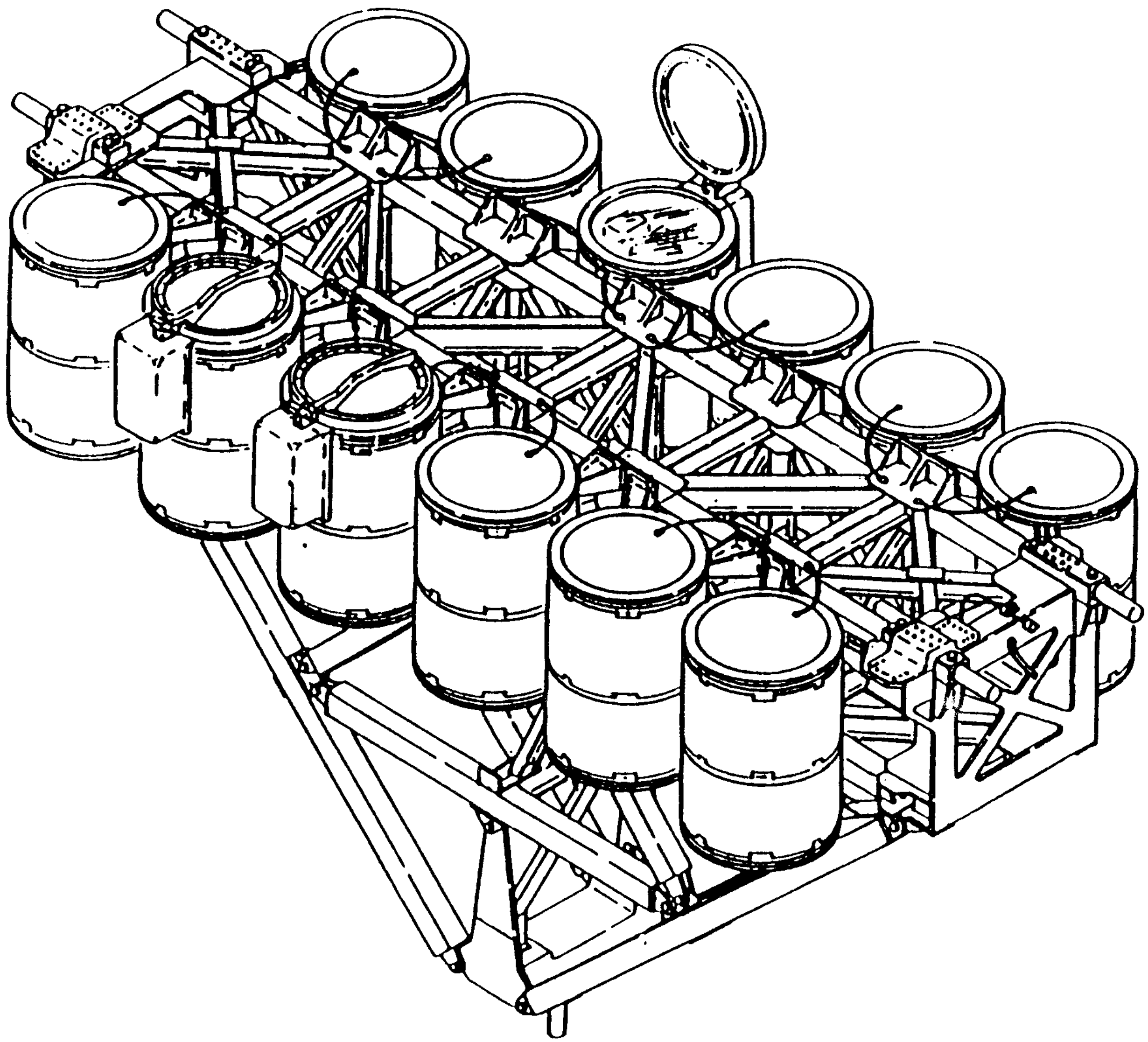
- SPACELAB PAYLOAD MISSION INTEGRATION CONTRACTOR (PMIC)
  - ANALYTICAL INTEGRATION
  - PHYSICAL INTEGRATION
  - MISSION OPERATIONS (POCC)
  - MPE/CARRIER HARDWARE DESIGN & DEVELOPMENT

- PARTIAL PAYLOAD EXPERIMENT CARRIERS
  - MPESS
  - HITCHHIKER M
  - SPARTAN
  - GAS BRIDGE
  - MSL CARRIER

- SPACE STATION STUDIES
  - MMPF
  - WP-1
  - WP-3

- EXPERIMENT PAYLOAD DEFINITION STUDIES

GAS BRIDGE PAYLOAD



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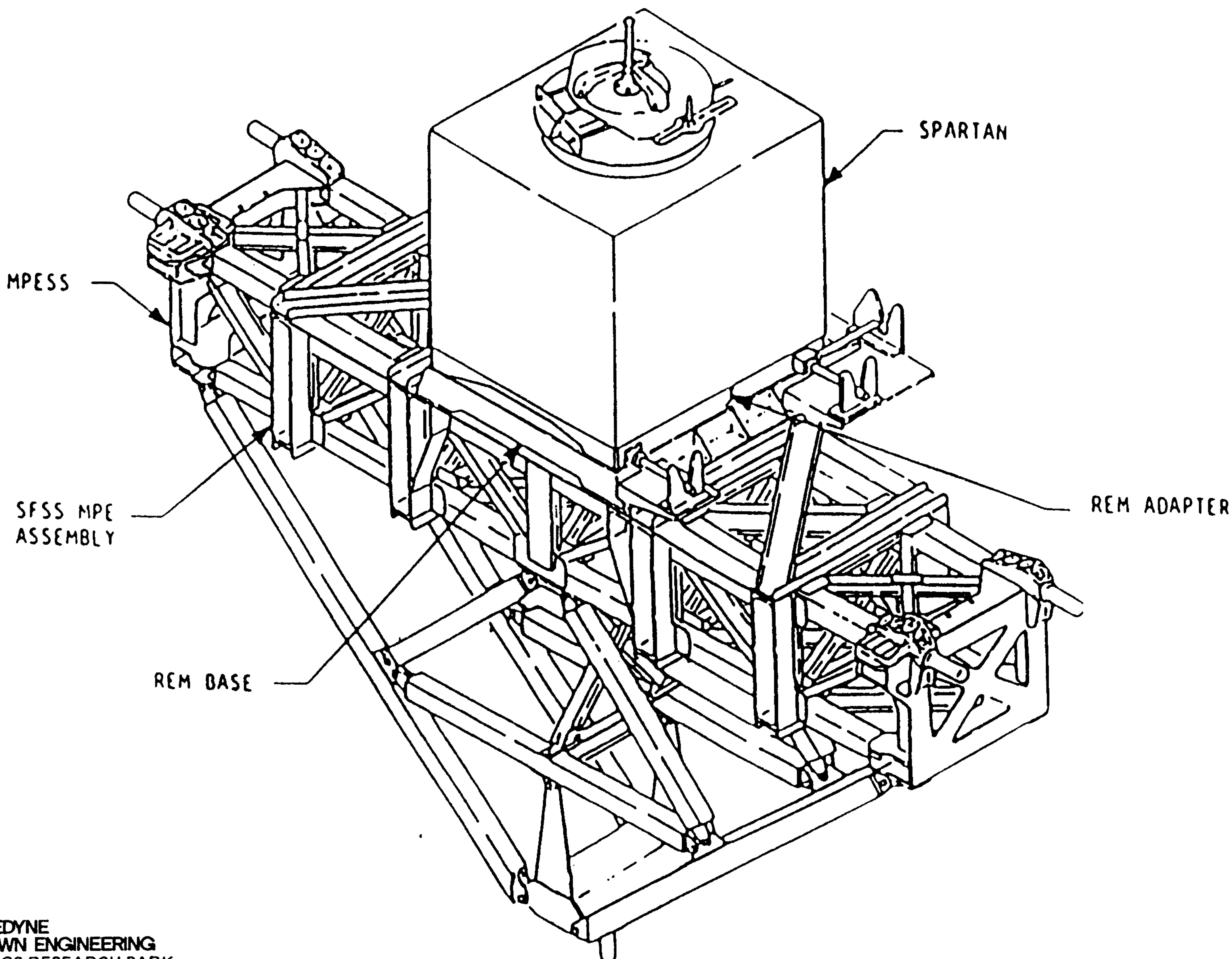
SPARTAN FLIGHT SUPPORT SYSTEM



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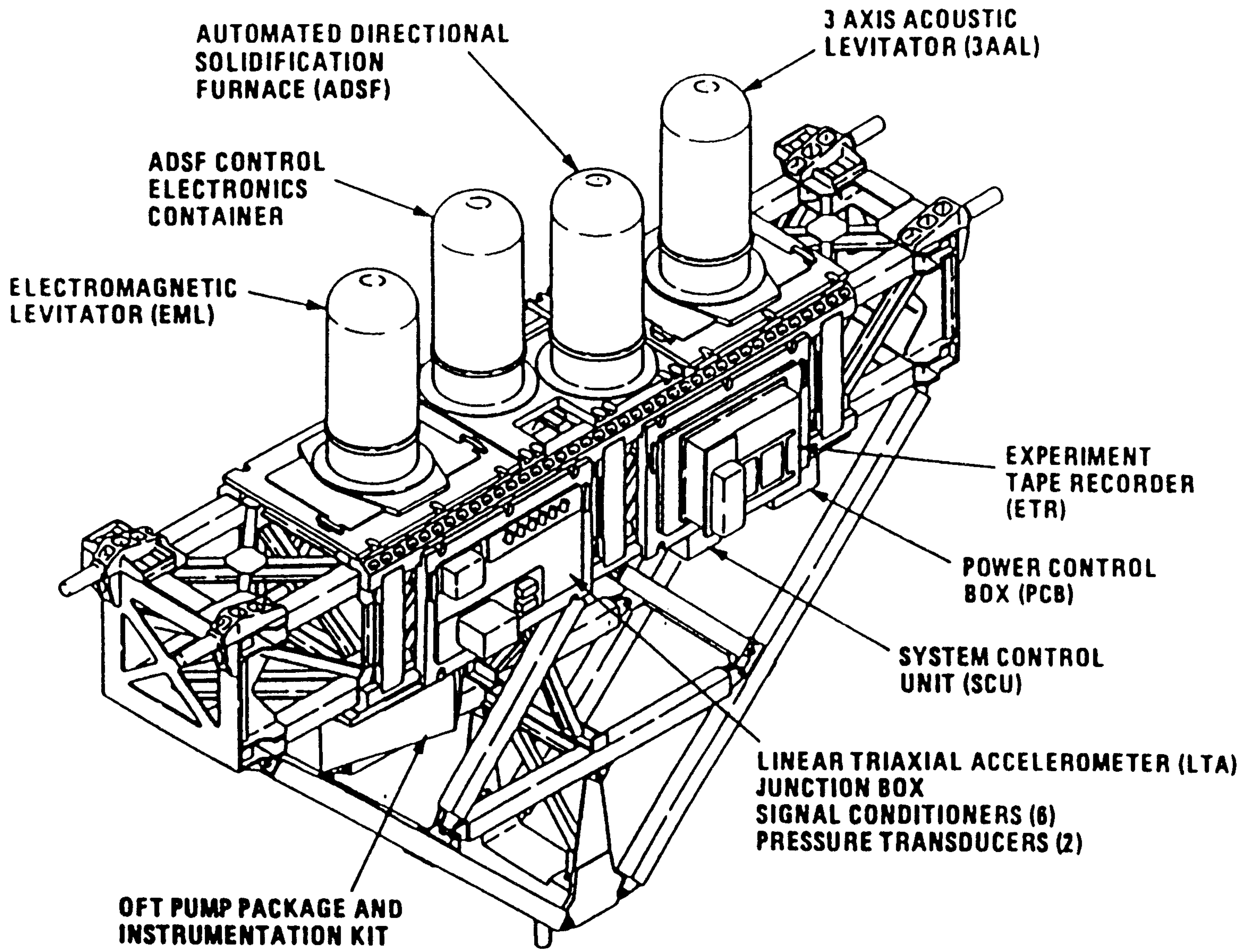
MSL-2 PAYLOAD CONFIGURATION



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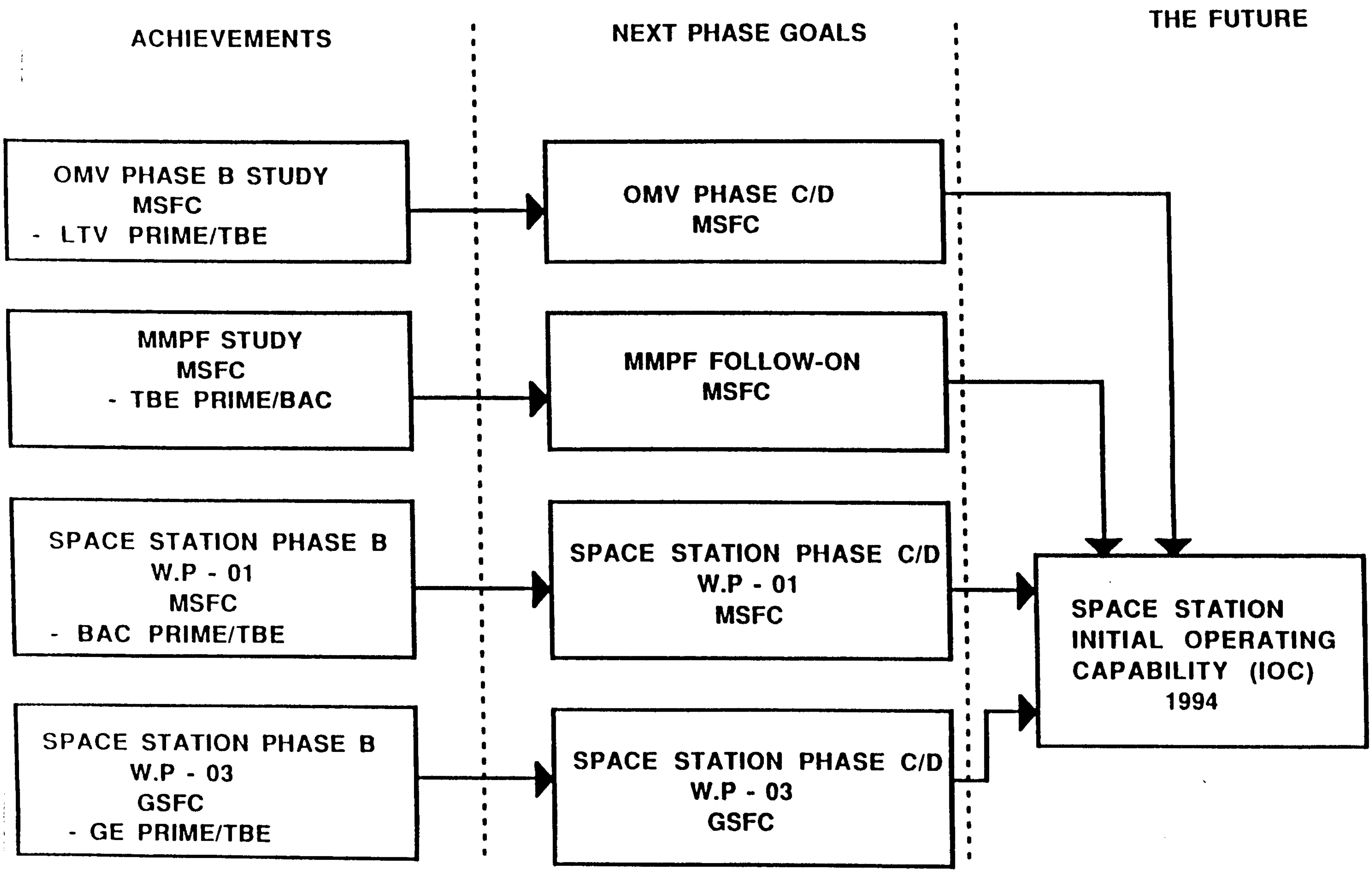
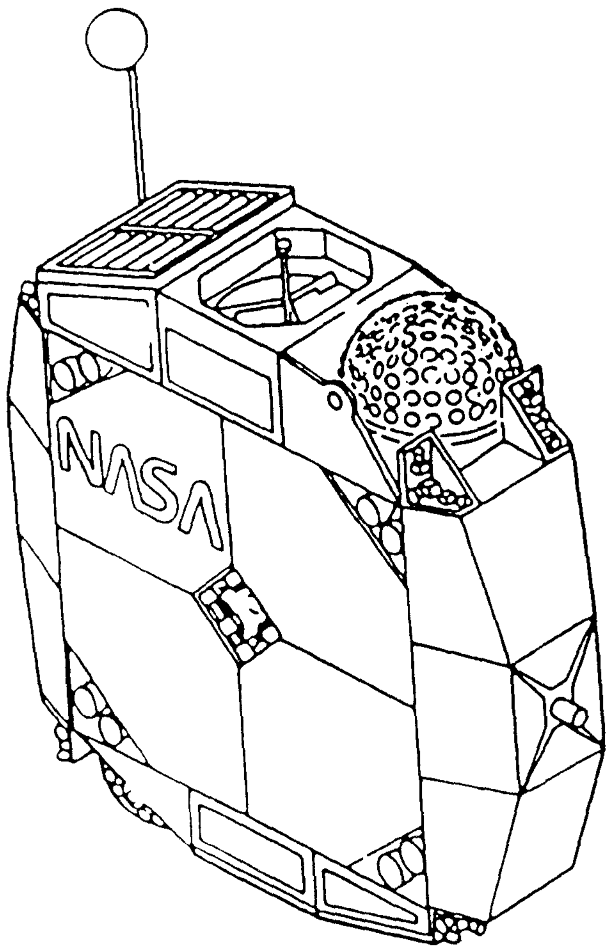
SPACE STATION -- CURRENT INVOLVEMENT AND GOALS



ORBITAL MANEUVERING VEHICLE (OMV) PHASE B STUDY

TEAMED WITH LTV



TBE TASKS:

- GROUND CONTROL STATION
- AIRBORNE SUPPORT EQUIPMENT (ASE)
- FUELING/DEFUELING GSE
- STS INTEGRATION
- LAUNCH OPERATIONS SUPPORT PLAN

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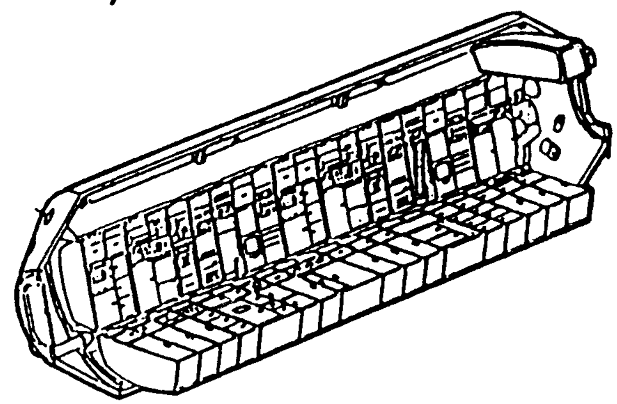
THE MICROGRAVITY AND MATERIALS PROCESSING FACILITY (MMPF) STUDY

MMPF USER REQUIREMENTS

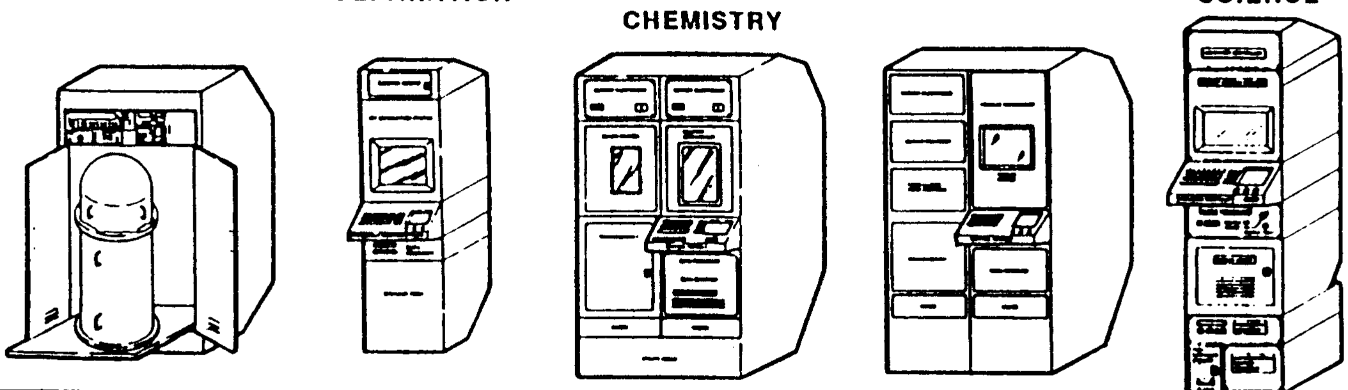
- EXPERIMENT
- EQUIPMENT/FACILITIES
- RESOURCES
- OPERATIONS
- LOGISTICS



SPACE STATION LAB MODULE (MATERIALS)

MMPF RECOMMENDATIONS - LAB ACCOMMODATIONS/PROVISIONS

DIRECTIONAL SOLIDIFICATION | ELECTROKINETIC SEPARATION | POLYMER CRYSTAL GROWTH AND CHEMISTRY | FLOAT ZONE CRYSTAL GROWTH | COMBUSTION SCIENCE



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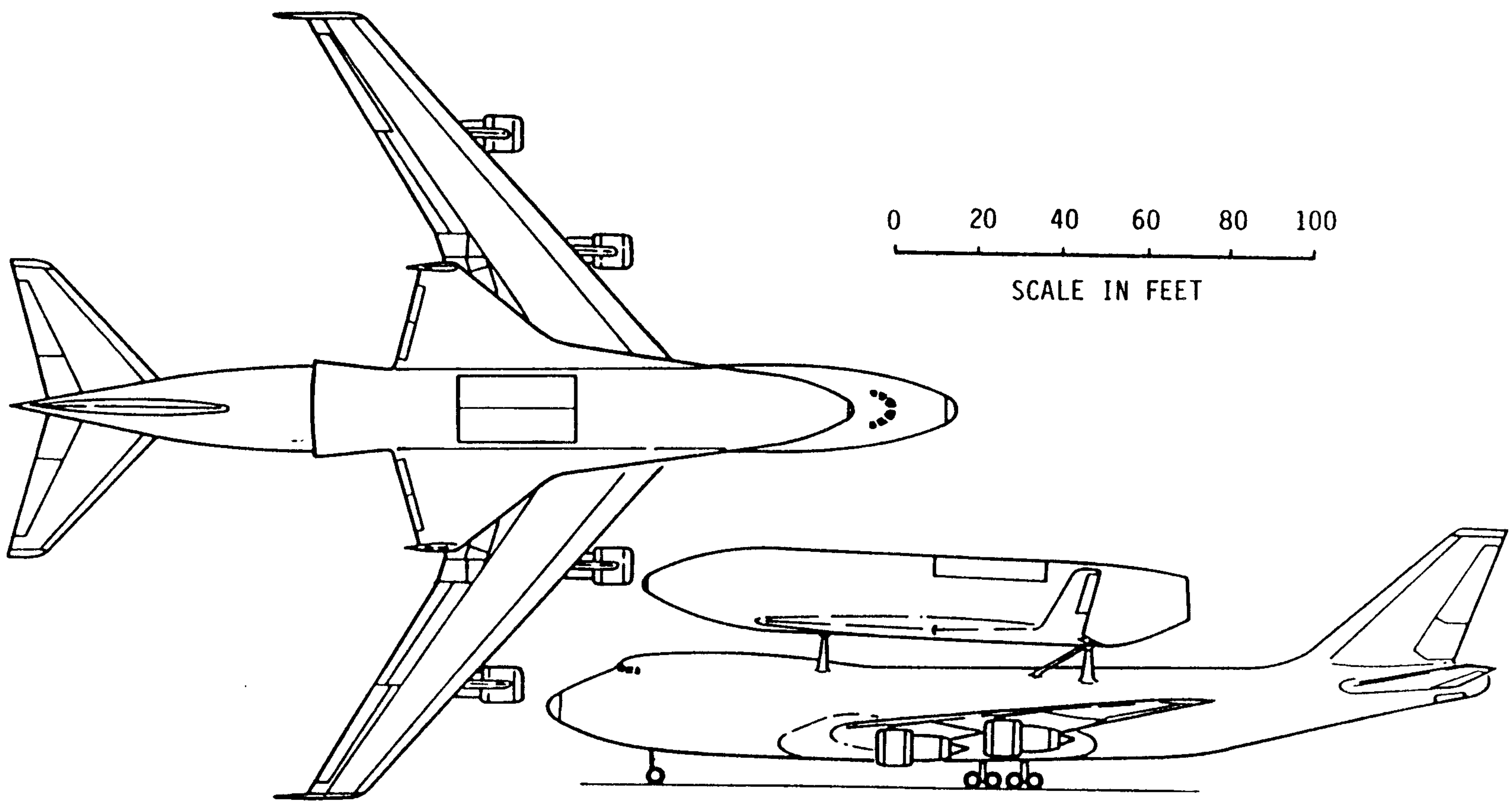
WORK PACKAGE 01 - NASA MSFC - BOEING PRIME
• U.S. LABORATORY OUTFITTING (MATERIALS PROCESSING) • PAYLOAD/EXPERIMENT INTEGRATION • GROUND SUPPORT EQUIPMENT

WORK PACKAGE 03 - NASA GSFC - GE PRIME
• ATTACHED PAYLOAD ACCOMMODATIONS - EQUIPMENT AND INTERFACE CHARACTERIZATION - PAYLOAD CONCEPT DEVELOPMENT - PAYLOAD OPERATIONS AND SAFETY ASSESSMENTS - COST DATA

SPACEPLANE MOUNTED ON B-747 CARRIER



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the Challenger accident, according to Edelson.

"Space science and applications was counting on 50 flights," Edelson said. "Now it looks like we'll have 19 at the most. Many missions will have to be terminated."

Spacelab Cancellations

NASA will cancel 11 major Spacelab missions, plus many more smaller Spacelab-class missions, including 8-10 Materials Science Labs and a dozen Spartan flights that were to have flown in 1987-89 (AW&ST Sept. 1, p. 40). The average delay for science free-fliers is 30 months, while attached payloads face an average 40-month delay. "That's a bad situation. There's no way to disguise it," Edelson told the American Astronautical Society at a meeting here.

Despite NASA's budget troubles as a result of the accident and the Gramm-Rudman-Hollings deficit reduction law, the agency must press ahead with new

SUGGESTED FEATURES OF SPACEPLANE

- TWO-WAY TRANSPORTATION LINK BETWEEN GROUND AND LEO
- LOW COST TO ORBIT
- PAYLOAD OF 6 . . . 7 TONS (14,000 lbs)
- EASY TO LAUNCH AND TO LAND
- NO HUMAN PILOTS
- EXISTING COMPONENTS
- LOW DEVELOPMENT COST, SHORT DEVELOPMENT TIME
- HIGH MARKET VALUE
- JOINT ENTERPRISE BETWEEN NASA AND INDUSTRY

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POTENTIAL USES OF SPACEPLANE

I.

- SELECTED MILITARY LAUNCHINGS
- ASTRONAUT RESCUE
- SPACE STATION CONSTRUCTION AND RESUPPLY MATERIALS
- PROPELLANTS FOR OMV AND OTV
- EARLY MATERIALS PROCESSING SYSTEMS
- RETURN OF PROPULSION/AVIONICS MODULES
- 747 COULD ALSO FERRY THE SHUTTLE
- FLIGHT TESTING COMPONENTS FOR OTHER PROGRAMS

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POTENTIAL USES OF SPACEPLANE

II.

- COMMERCIAL AND MILITARY SATELLITES
- SCIENTIFIC SATELLITES AND SPACE PROBES
- SERVICING OF MATERIALS PROCESSING FREE FLYERS
- SUB-UNITS FOR SPACE STATION (e.g. SPACEHAB)
- SATELLITE REPAIR AND SERVICE
- UP-AND-DOWN TRANSPORTATION OF SPACE STATION CREWS
- MULTIPLE LAUNCHINGS FOR ORBITAL ASSEMBLY OF LARGE SPACECRAFT
- RETURN OF SPENT UPPER STAGES
- RETURN OF DISABLED SPACECRAFT

PROGRAM TENETS AND REQUIREMENTS

NO NEW TECHNOLOGY

- Current State-of-the-art is such that a commercially optimized vehicle can favorably compete in the marketplace
- Uncertainty is minimized to allow commerically acceptable risks
- Development time would be short enough to justify captital investment

OPTIMIZED FOR FREIGHT HAULING

- Payload mass not reduced to accommodate crew requirements
- Landing payload same as launch payload
- Passengers may be carried in a self-contained pod

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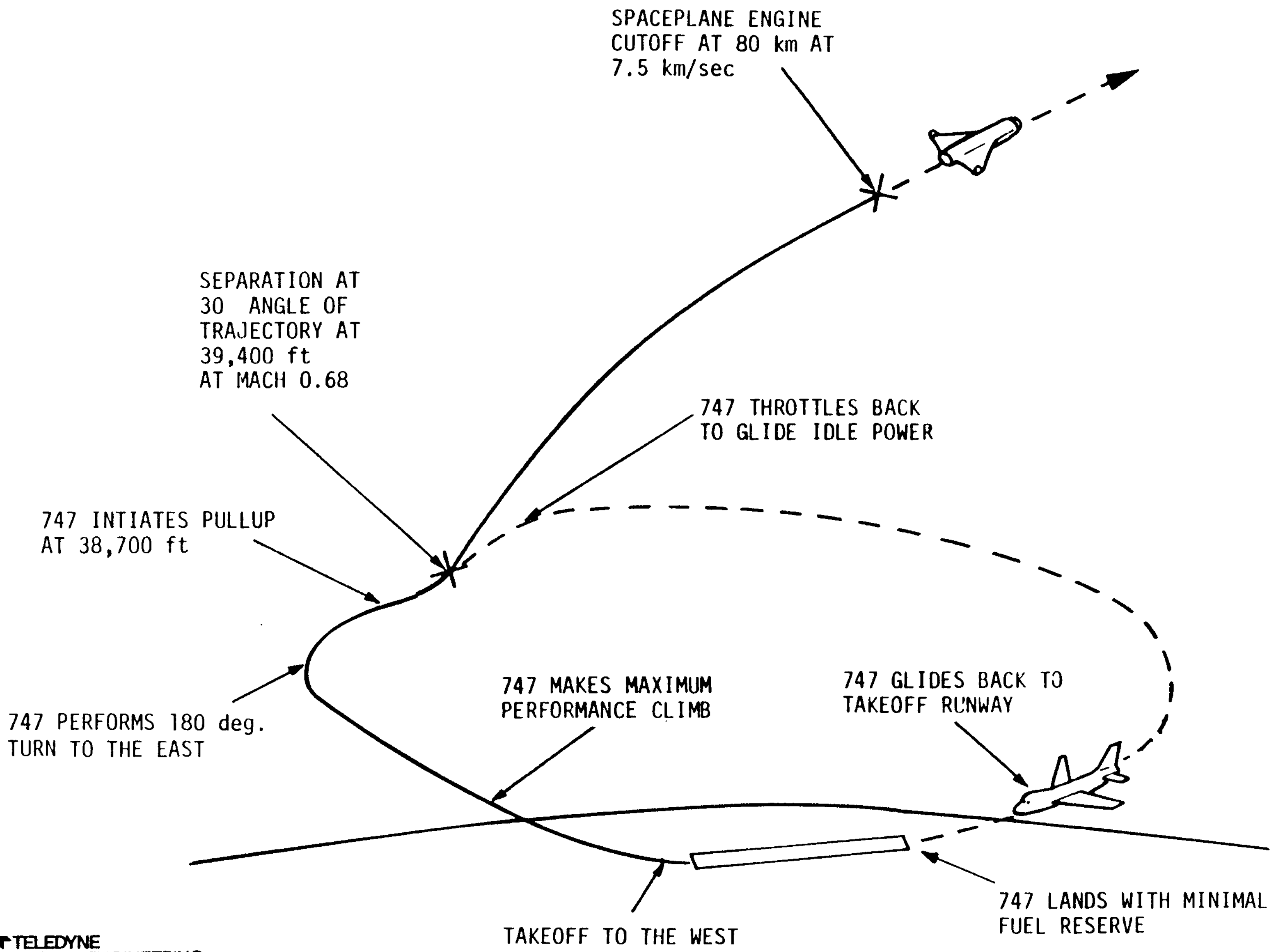
BACKGROUND ASSUMPTIONS IN ADDITION TO REQUIREMENTS

- BOEING 747 USED AS FIRST STAGE
- HYDROGEN, OXYGEN PROPELLANTS FOR MAIN, OMS, AND RCS
- USE OF ONE SPACE SHUTTLE MAIN ENGINE PLUS AUXILIARIES
- FLYBACK, FULLY REUSEABLE VEHICLE
- SIMPLICITY TO THE MAXIMUM EXTENT POSSIBLE

DESIGN DRIVERS

- CARRYING CAPACITY OF B-747
- THRUST OF SHUTTLE MAIN ENGINE

INITIAL LAUNCH PROFILE



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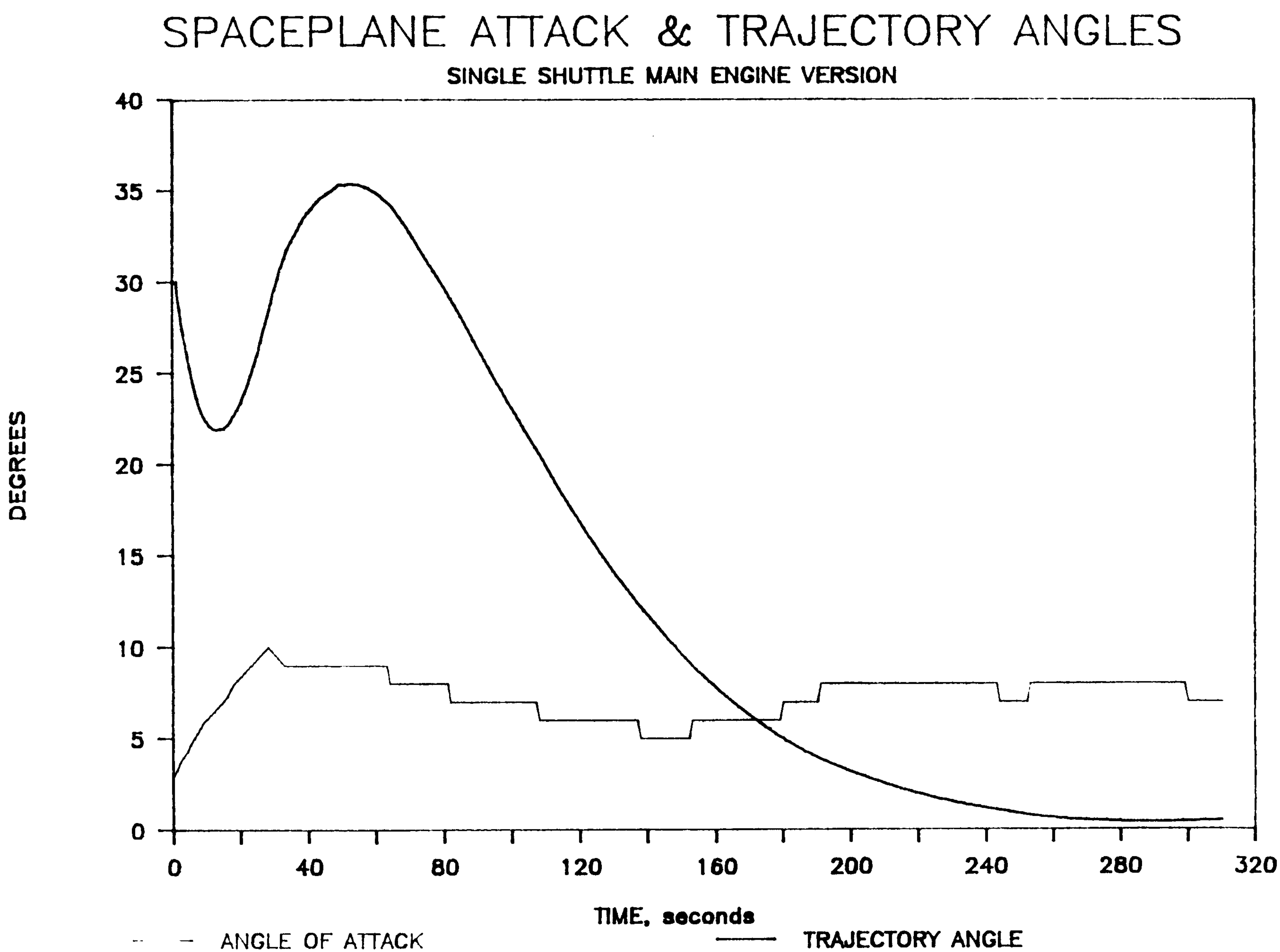
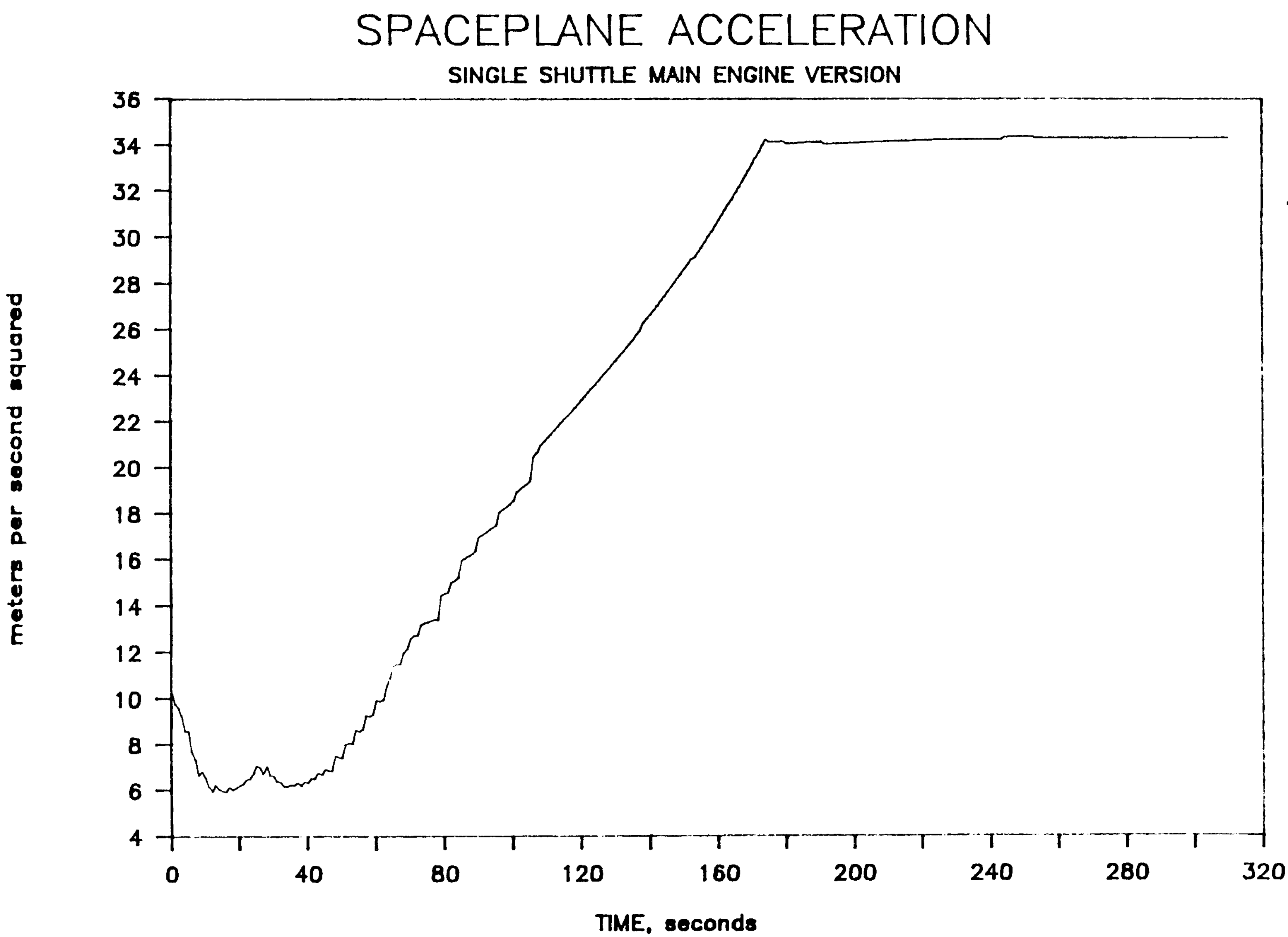
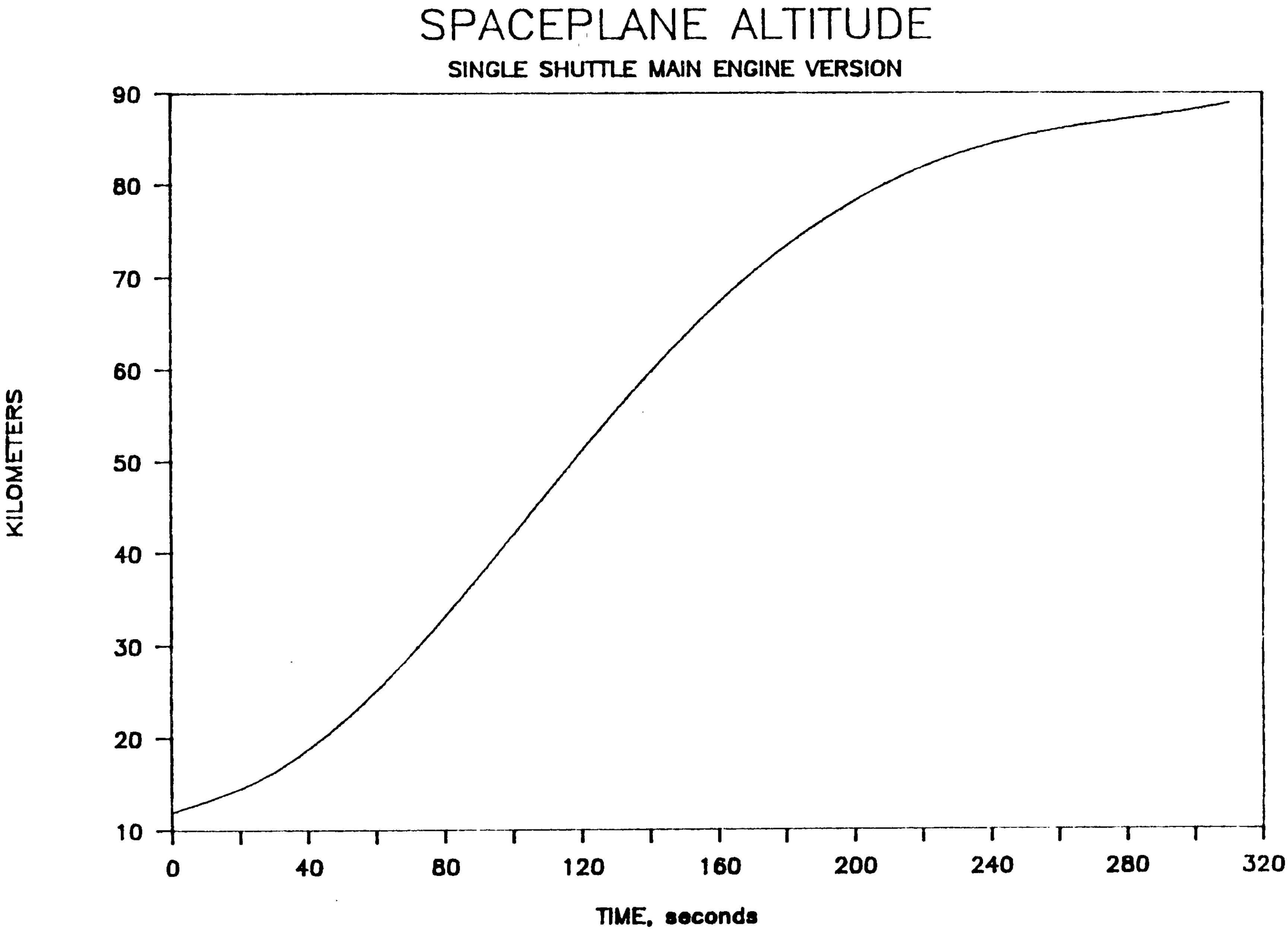
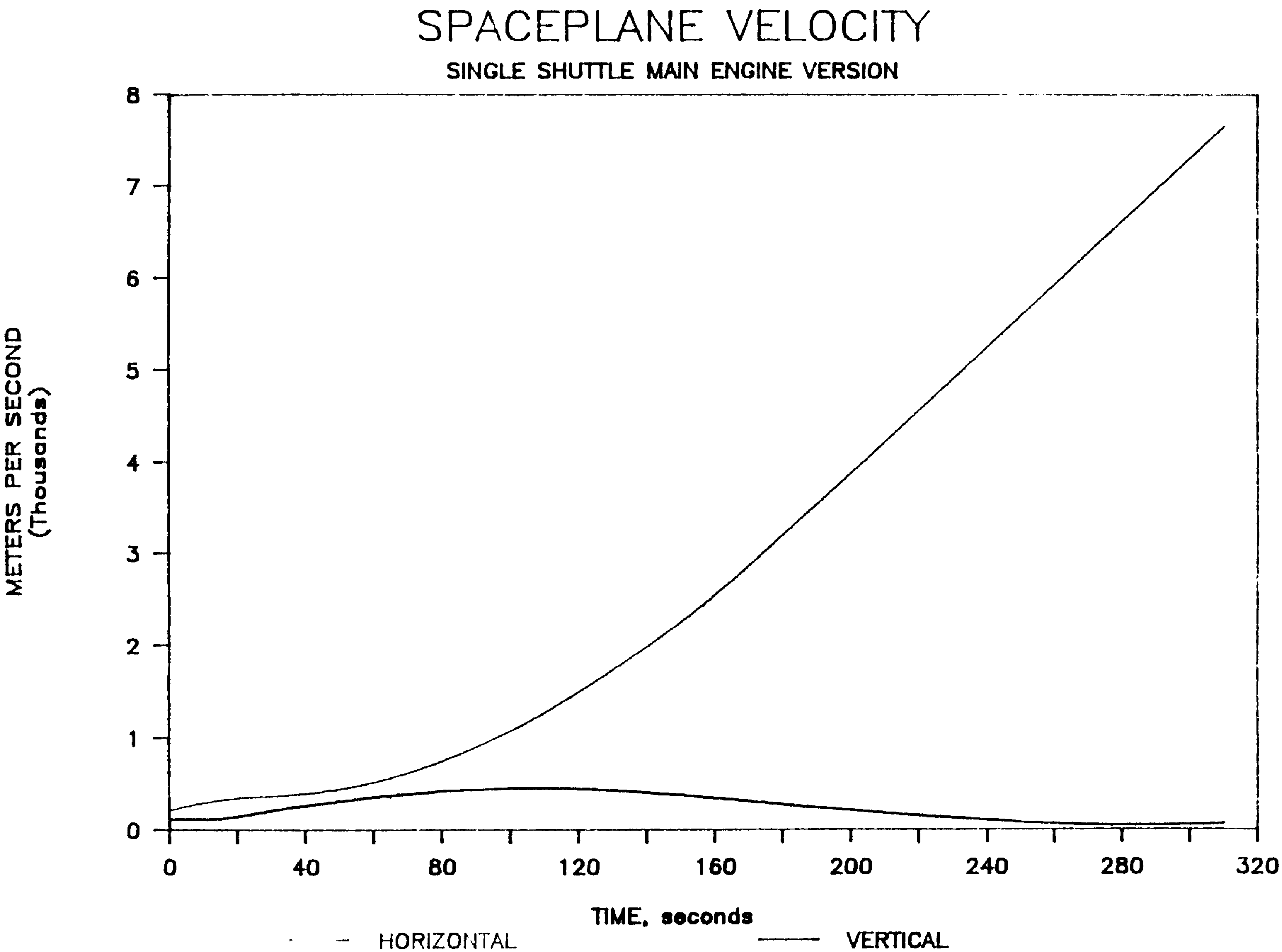

SPACEPLANE ATTACK & TRAJECTORY ANGLES
SINGLE SHUTTLE MAIN ENGINE VERSION
DEGREES
40
35
30
25
20
15
10
5
0
0
40
80
120
160
200
240
280
320
TIME, seconds
ANGLE OF ATTACK
TRAJECTORY ANGLE

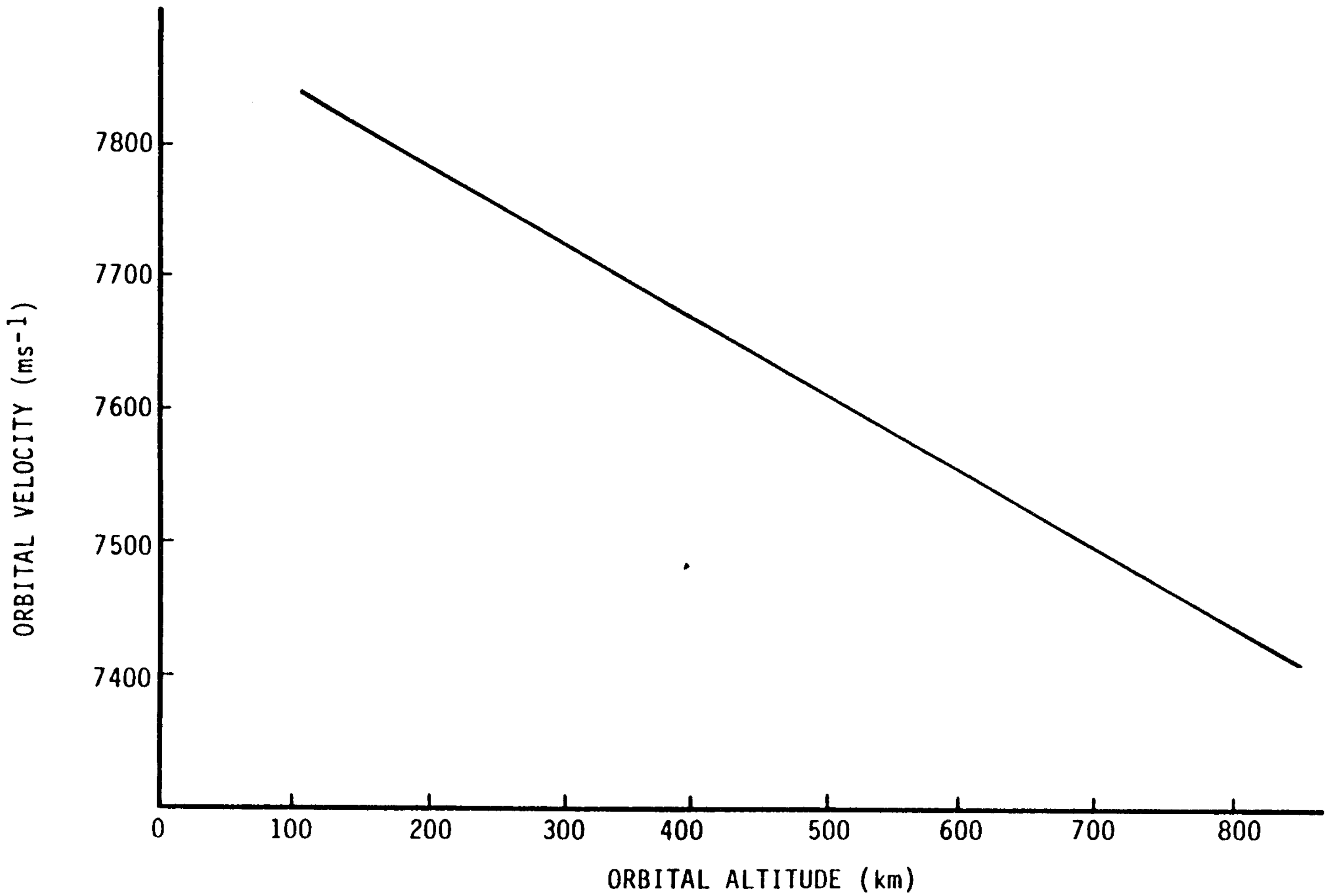

SPACEPLANE ACCELERATION
SINGLE SHUTTLE MAIN ENGINE VERSION
meters per second squared
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
0
40
80
120
160
200
240
280
320
TIME, seconds


SPACEPLANE ALTITUDE
SINGLE SHUTTLE MAIN ENGINE VERSION
KILOMETERS
90
80
70
60
50
40
30
20
10
0
40
80
120
160
200
240
280
320
TIME, seconds



SPACEPLANE VELOCITY
SINGLE SHUTTLE MAIN ENGINE VERSION
METERS PER SECOND
(Thousands)
0
1
2
3
4
5
6
7
8
0
40
80
120
160
200
240
280
320
TIME, seconds
HORIZONTAL
VERTICAL

ORBITAL VELOCITY VS ORBITAL ALTITUDE



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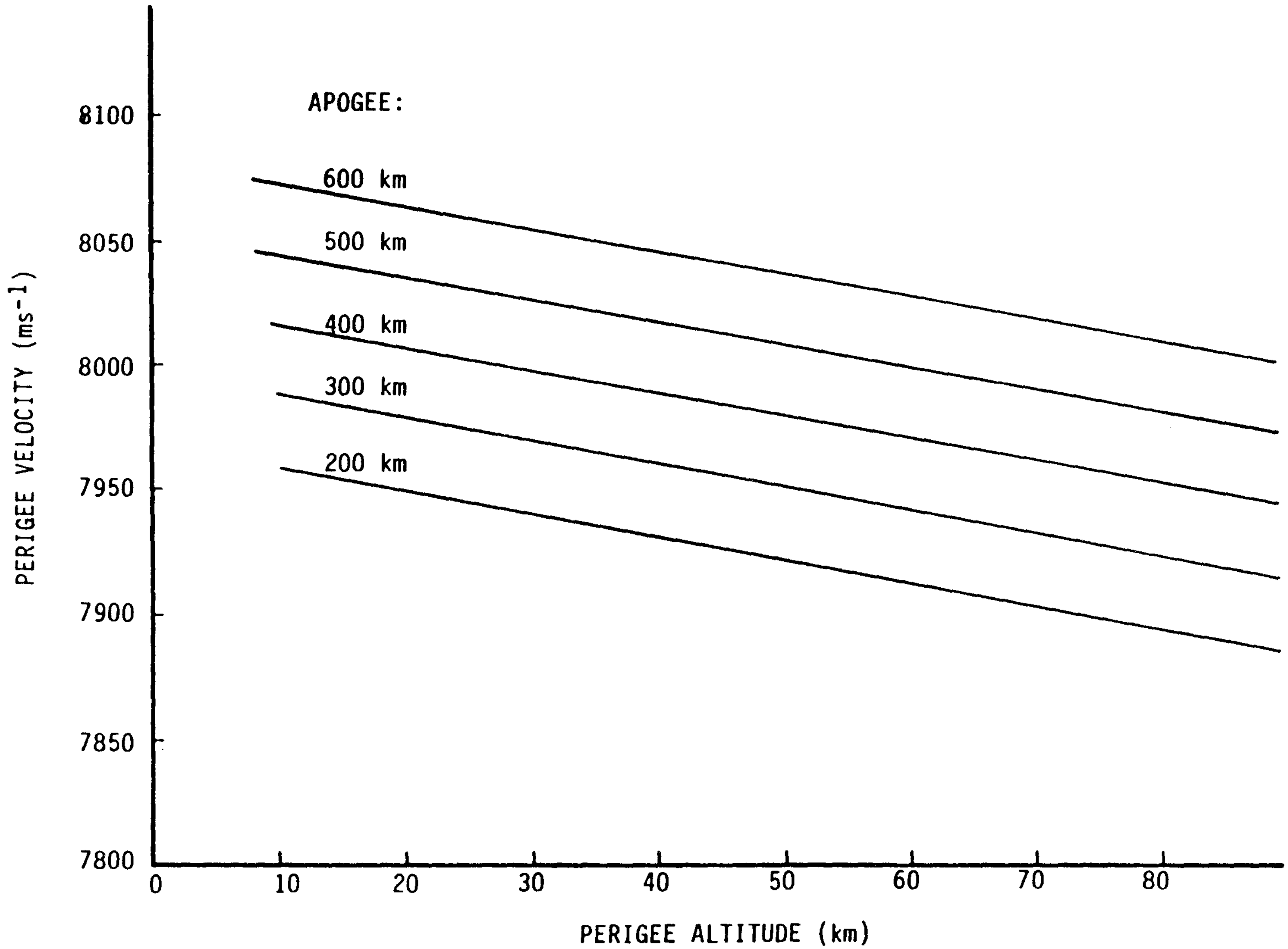
PERIGEE VELOCITY VS PERIGEE ALTITUDE



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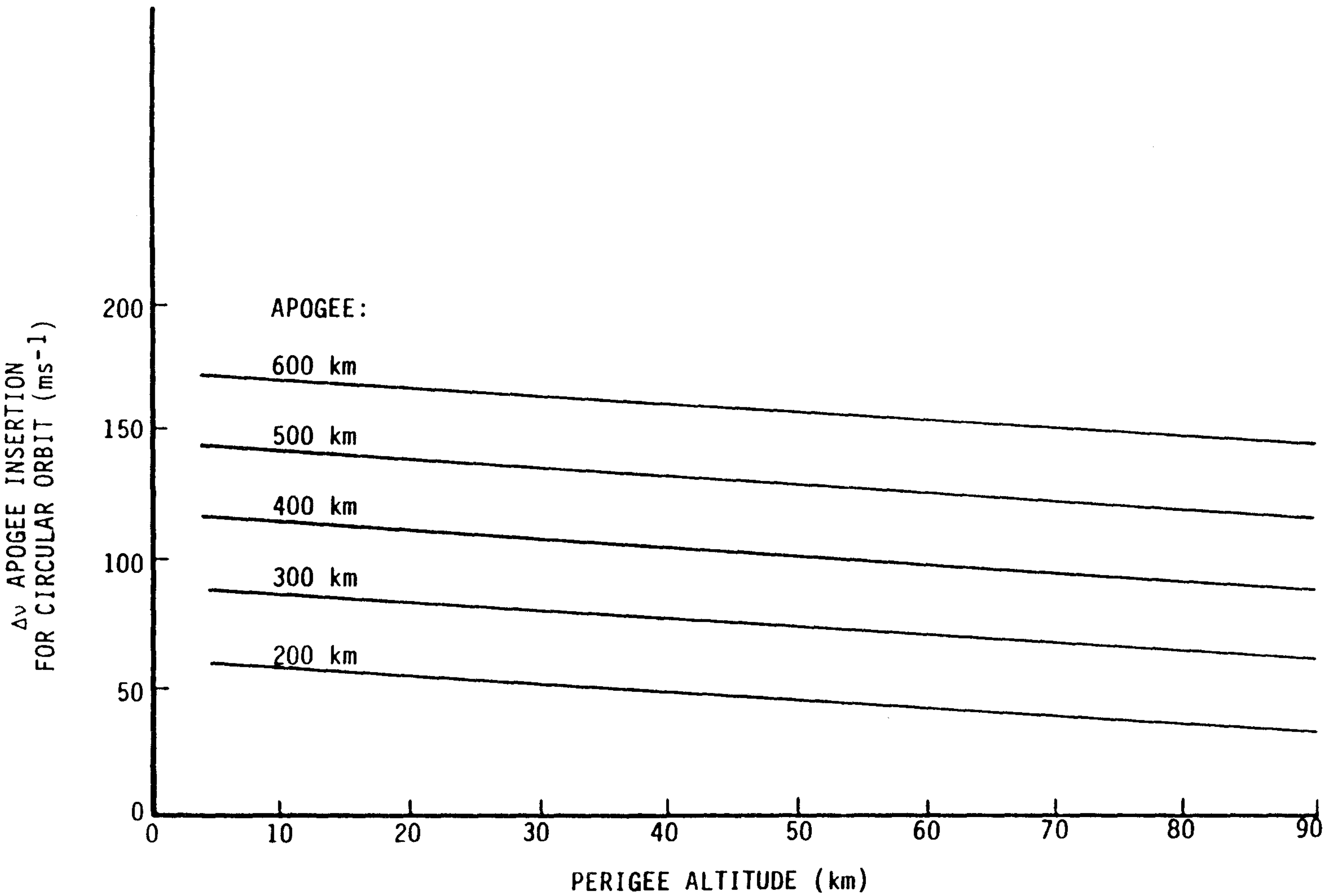
Δv REQUIREMENT FOR ORBIT CIRCULARIZATION VS PERIGEE ALTITUDE



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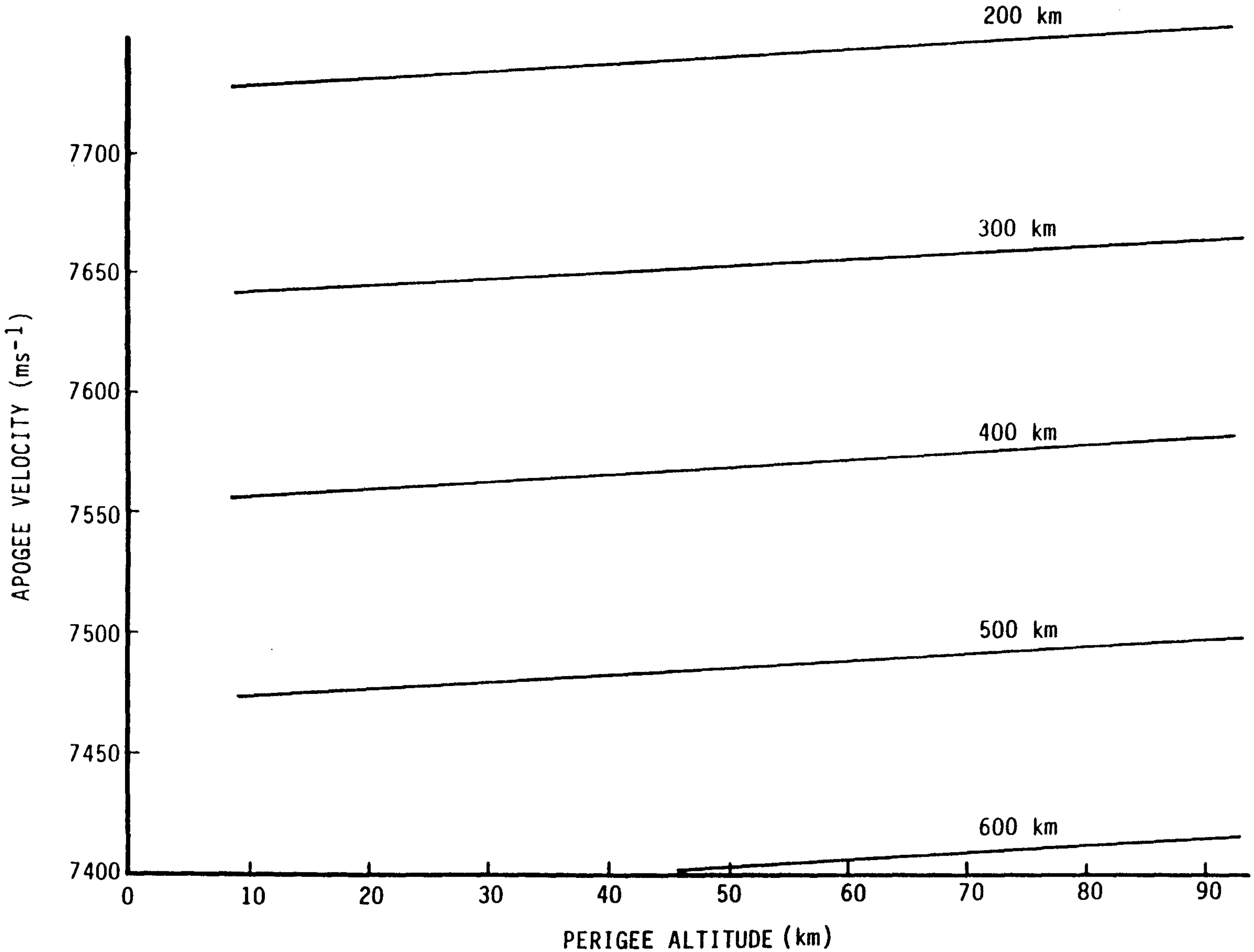
APOGEE VELOCITY VS PERIGEE ALTITUDE



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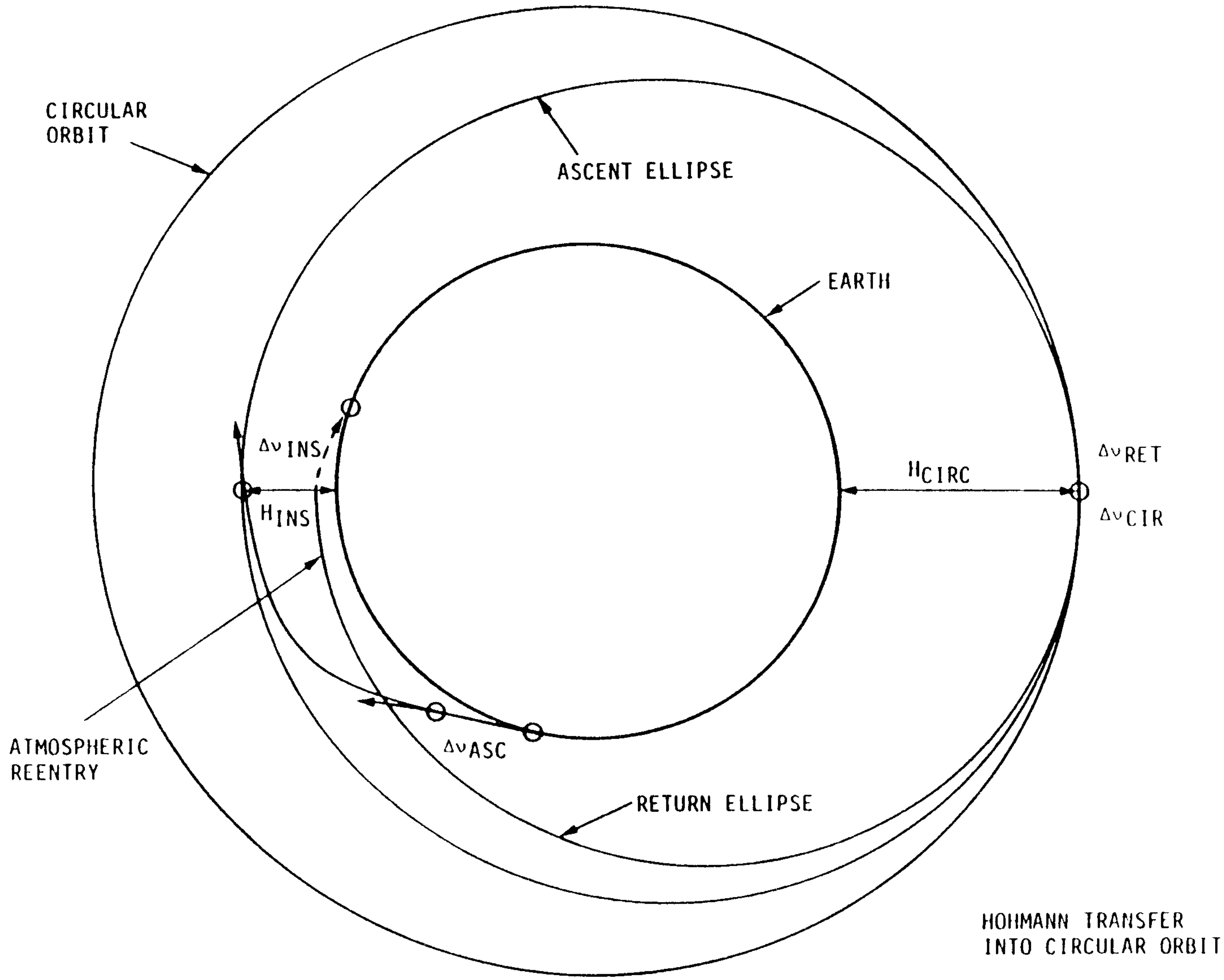
ASCENT AND RETURN TRAJECTORIES OF SPACEPLANE
(Not to scale)



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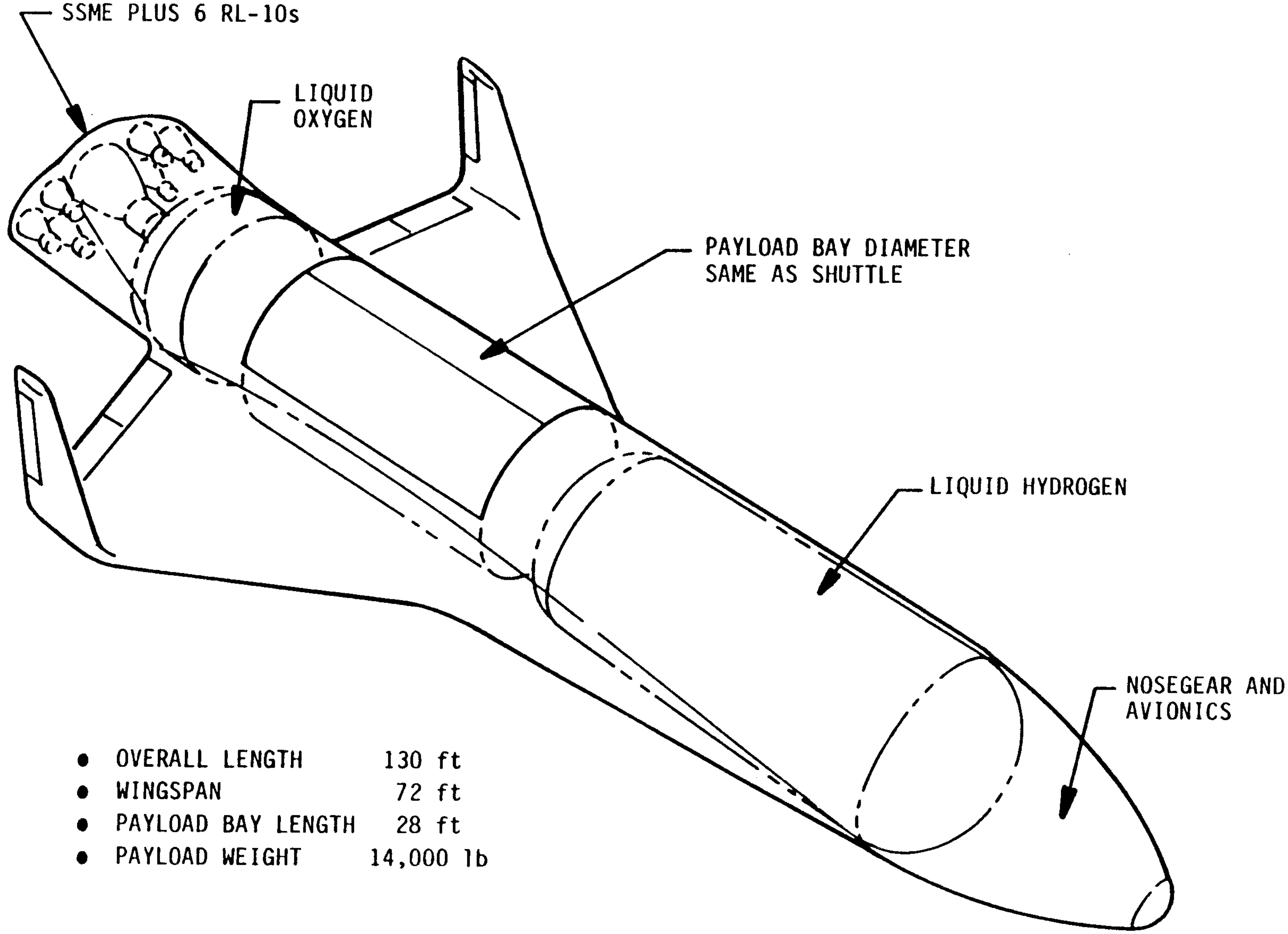
UNMANNED SPACEPLANE ORBITER VEHICLE



- OVERALL LENGTH 130 ft
- WINGSPAN 72 ft
- PAYLOAD BAY LENGTH 28 ft
- PAYLOAD WEIGHT 14,000 lb

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SPACEPLANE CHARACTERISTICS

PHYSICAL		
• OVERALL LENGTH	40m	(130 ft)
• WING SPAN	22m	(72 ft)
• BODY DIAMETER	5.8m	(19 ft)
• TAKEOFF MASS	172,000 Kg	(380,000 lb)
• LANDING MASS (No Payload)	18,400 Kg	(40,600 lb)
PERFORMANCE		
• DESIGN ALTITUDE	400 Km	(216 nmi) circular orbit
• PAYLOAD MASS	6300 Kg	(14,000 lb)
• PAYLOAD DIAMETER	same as Shuttle	
• PAYLOAD LENGTH	8.5m	(28 ft)

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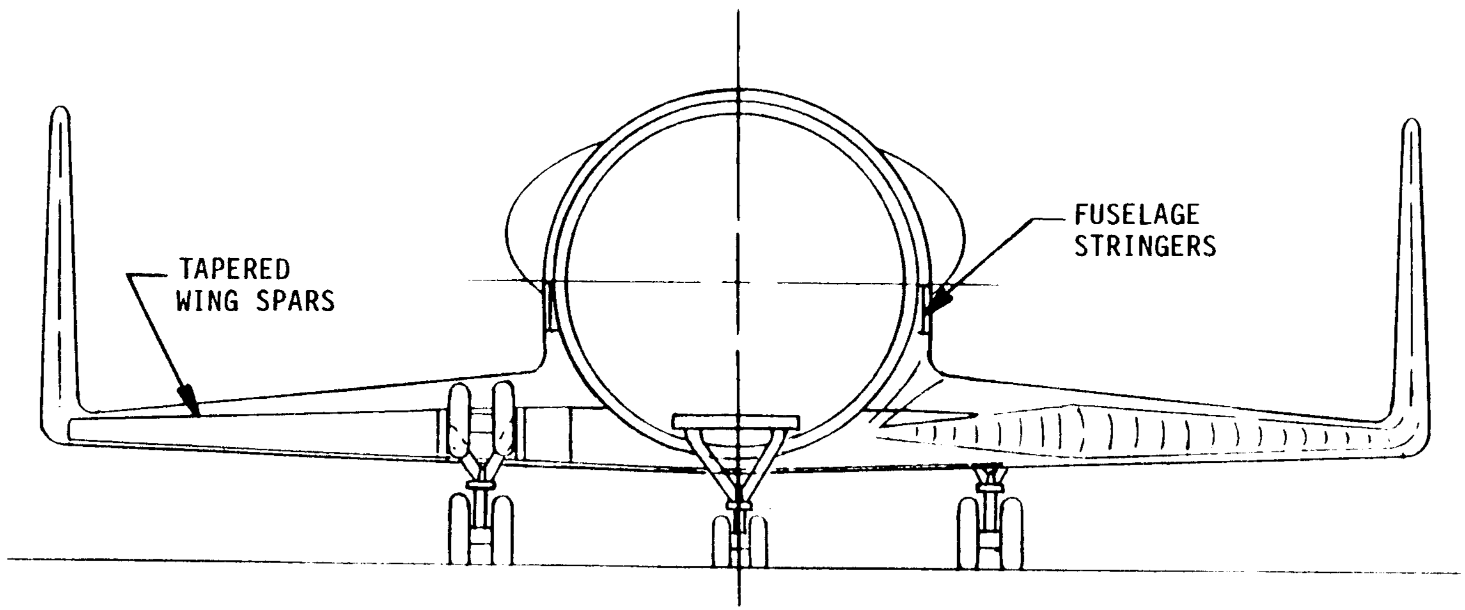
SPACEPLANE SECTION VIEW



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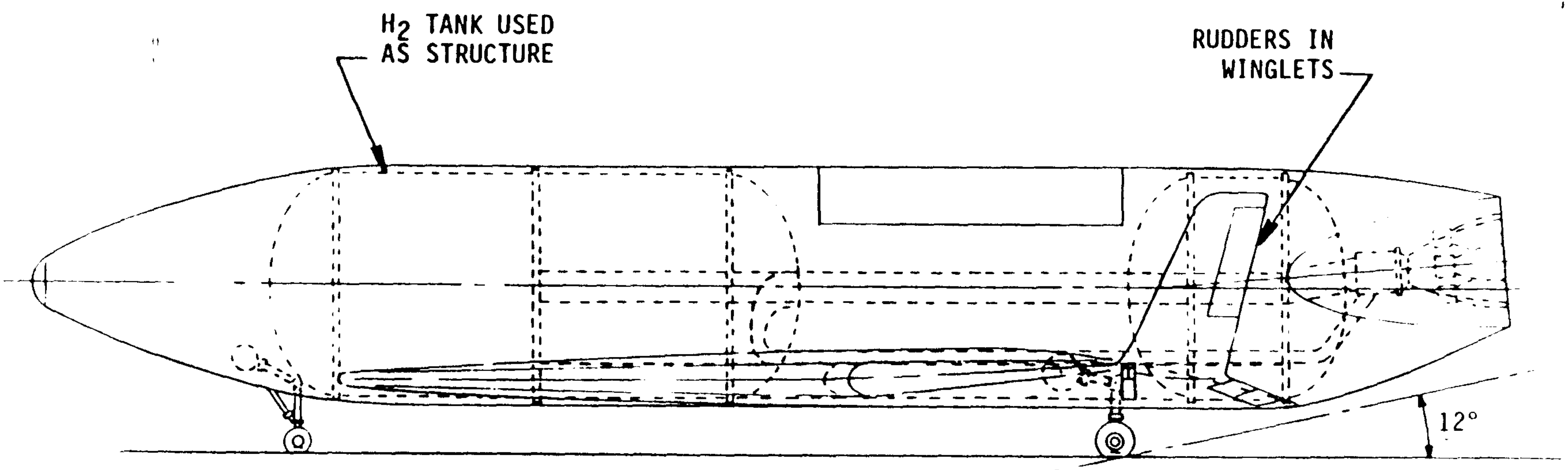
SPACEPLANE SIDE SECTION



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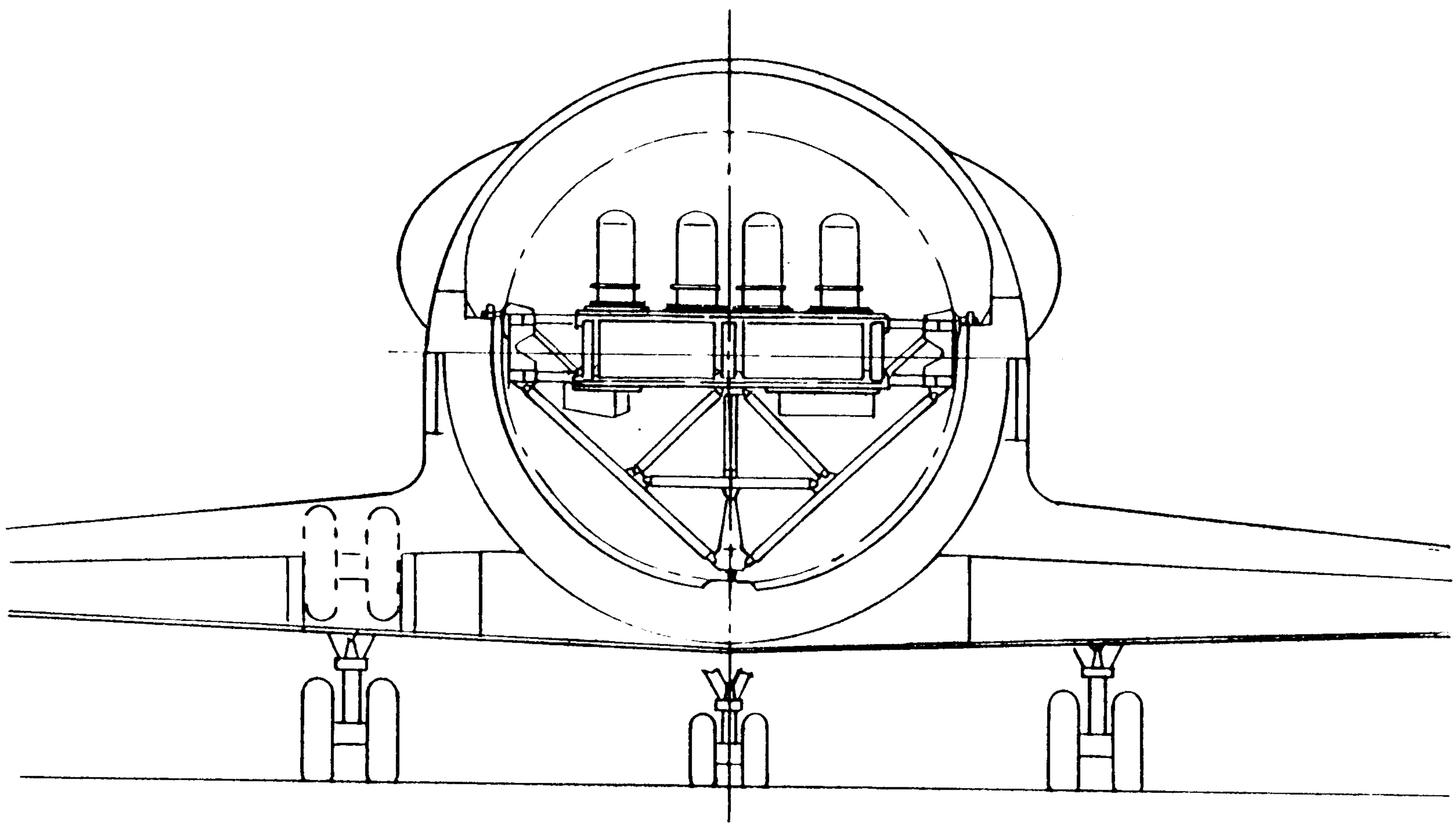
PAYLOAD BAY SECTION VIEW
SHOWING TYPICAL SHUTTLE PAYLOAD WITHIN BAY ENVELOPE



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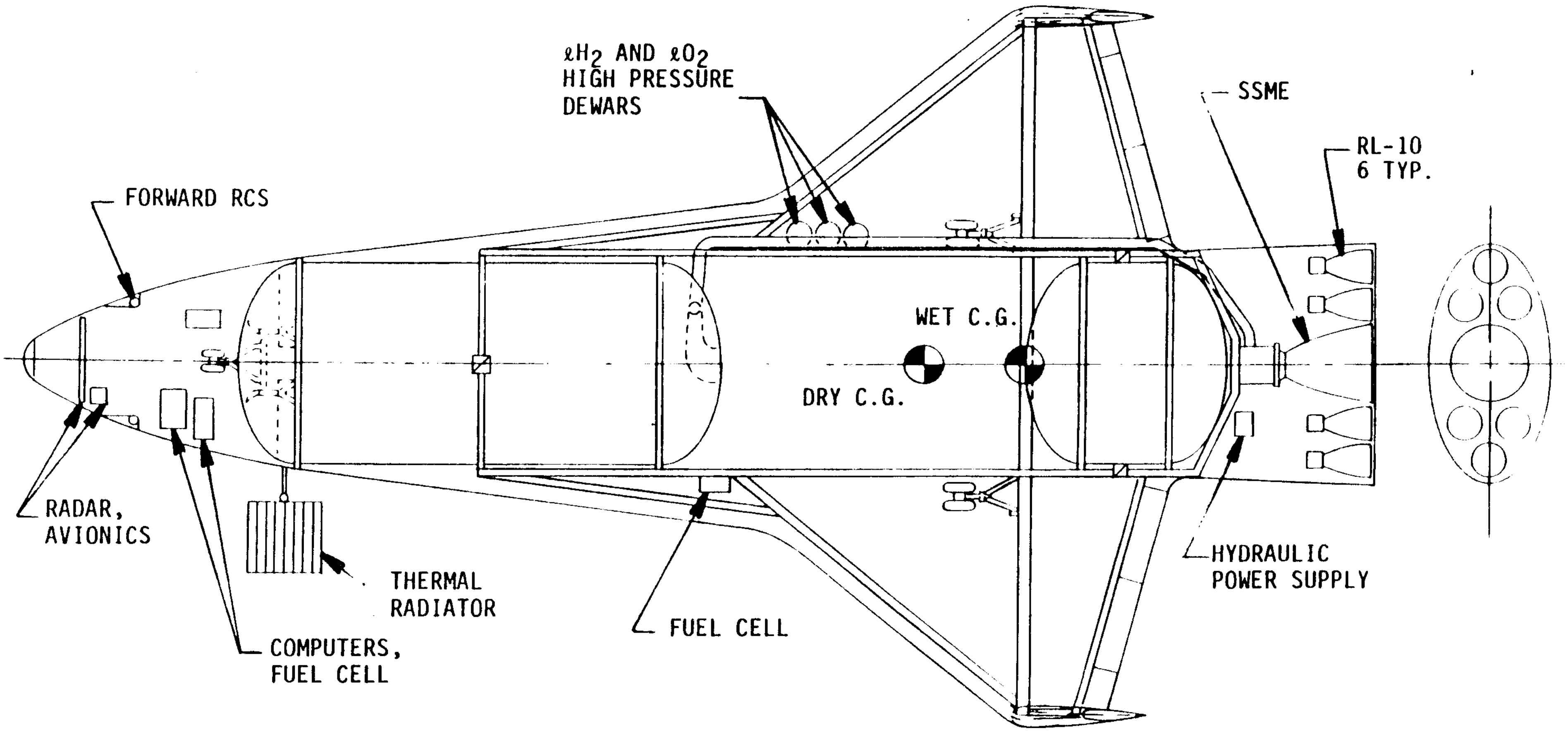
SPACEPLANE SYSTEMS LAYOUT



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MASS BREAKDOWN COMPARISON - STS ORBITER & EXTERNAL TANK vs. SPACEPLANE
Info for OV 103 DISCOVERY with lightweight ET (STS-6 and later)

LINE ITEM	STS MASS lb	% OF DRY WT	SPACEPLANE MASS, lb	% OF DRY WT	% RATIO
LIGHTWEIGHT ET, TANKS ONLY	40350	17.1	8400	20.7	1.21
ET INTERTANK, INSULATION, ELECTR	25650	10.9	0	0.0	0.00
WINGS & TAIL, NO TILES	18425	7.8	6300	15.6	1.99
BODY, NO CREW MODULE, NO OMS	34518	15.9	7200	17.8	1.21
TILES & OTHER INSULATION	25251	10.7	1400	3.5	0.32
LANDING GEAR, SEPARATION SYS	7222	3.1	2200	5.4	1.77
PROPULSION, ASCENT	31124	13.2	7200	17.8	1.34
REACTION CONTROL SYSTEM	3142	1.3	700	1.7	1.30
OMS & STRUCTURE, (RL-10s)	6027	1.3	2100	5.2	2.03
APUs, FUEL CELLS, DEWARS	3912	1.7	1100	2.7	1.63
ELECTRICAL CONVERSION, DISTR	10483	4.5	500	1.2	0.28
HYDRAULIC CONVERSION, DISTR	1866	0.8	0	0.0	0.00
SURFACE CONTROLS, PEDALS	2784	1.2	1400	3.5	2.92
AVIONICS	4440	1.9	1000	2.5	1.31
AVIONICS CREW INTERFACE	2100	0.9	0	0.0	0.00
ENVIRON CONTROL, COOLING, RADIAT	5291	2.2	600	1.5	0.66
CREW MODULE, PROVISIONS	8283	3.5	0	0.0	0.00
RMS, PAYLOAD PROVISIONS	2087	0.9	0	0.0	0.00
PURGE & VENT	1480	0.6	400	1.0	1.57
MARGIN	0	0.0	6000	14.8	
TOTAL DRY WEIGHT	234435	100.0	46500	100.0	
PROPELLANTS, MASS FRACTION	1688200	.878	333500	.878	

STS WITHOUT CREW MODULE, ET INTERTANK,
AVIONICS CREW INTERFACE, RMS: 196315 LB DRY, MASS FRACTION BECOMES .896
NOTE: FIRST FLIGHT VEHICLE Mf=.878, 15% MARGIN.

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747 AIRPLANE TAKEOFF MASS BREAKDOWN

ITEM DESCRIPTION	WEIGHT (lb)
MANUFACTURER'S EMPTY WEIGHT	342,000
ENGINE MODIFICATIONS	2,000
STRUCTURAL MODS, INCLUDING WING SPAR	25,000
LAUNCH CREW AND CONSOLES	4,000
HYDROGEN SYSTEMS	1,000
747 OPERATING EMPTY WEIGHT	374,000
747 THRUST AUGMENTATION PROPELLANT	5,000
SPACEPLANE WITH FULL FUEL	380,000
747 ZERO FUEL WEIGHT	759,000
KEROSENE	74,000
TAKEOFF GROSS WEIGHT - Same as commercial	833,000

MARGIN: APPROX. 20,000 lb REMOVABLE FROM MANUFACTURER'S EMPTY WEIGHT

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WHY IT IS REASONABLE TO EXPECT THIS VEHICLE TO WEIGH ONLY 28% OF SHUTTLE ORBITER'S WEIGHT

(Sheet 1 of 2)

UNMANNED

- No crew cabin, middeck, life support systems, and hatches

LOWER MAXIMUM PAYLOAD

- 15,000 lb instead of orbiter's 65,000 lb maximum design

NO TILES

- Skin is part of load-bearing structure, unlike the 18,000 lb of Shuttle tiles

SIMPLER STRUCTURE

- 50% of fuselage length is pressurized, load-bearing tankage
- Landing gear needs to support only 1/3 of Shuttle's weight
- Vibration during launch is much less
- Maximum dynamic pressure occurs at higher altitude

LIGHTER ENGINES

- One, not three Shuttle main engines
- 2,200 lb of auxiliaries (plus fuel) replaces 4,600 lb OMS (plus fuel)

BETTER PROPELLANTS

- Orbital maneuvering performed with H2-O2, not hypergols
- No tank mass devoted to storage of OMS propellants

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WHY IT IS REASONABLE TO EXPECT THIS VEHICLE TO WEIGH ONLY 28% OF SHUTTLE ORBITER'S WEIGHT

(Sheet 2 of 2)

NEWER MATERIALS

- Graphite/Epoxy spars and stringers instead of aluminum
- Newer aluminum alloys are 10% lower density, and 5% stiffer

FEWER FLUID SYSTEMS

- Spaceplane has no ammonia, freon, hydrazine, methylhydrazine, nitrogen tetroxide, or nitrogen systems

FEWER PAYLOAD SERVICES TO CUSTOMER

- design is for freight hauling, not universal utility

LIGHTER AVIONICS

- Newer technology electronics, no quadruple redundancy

LOWER POWER LEVELS

- Less generating equipment and less heat to be dissipated by radiators

HORIZONTAL ONLY

- Structure and systems need not accommodate vertical processing and launch

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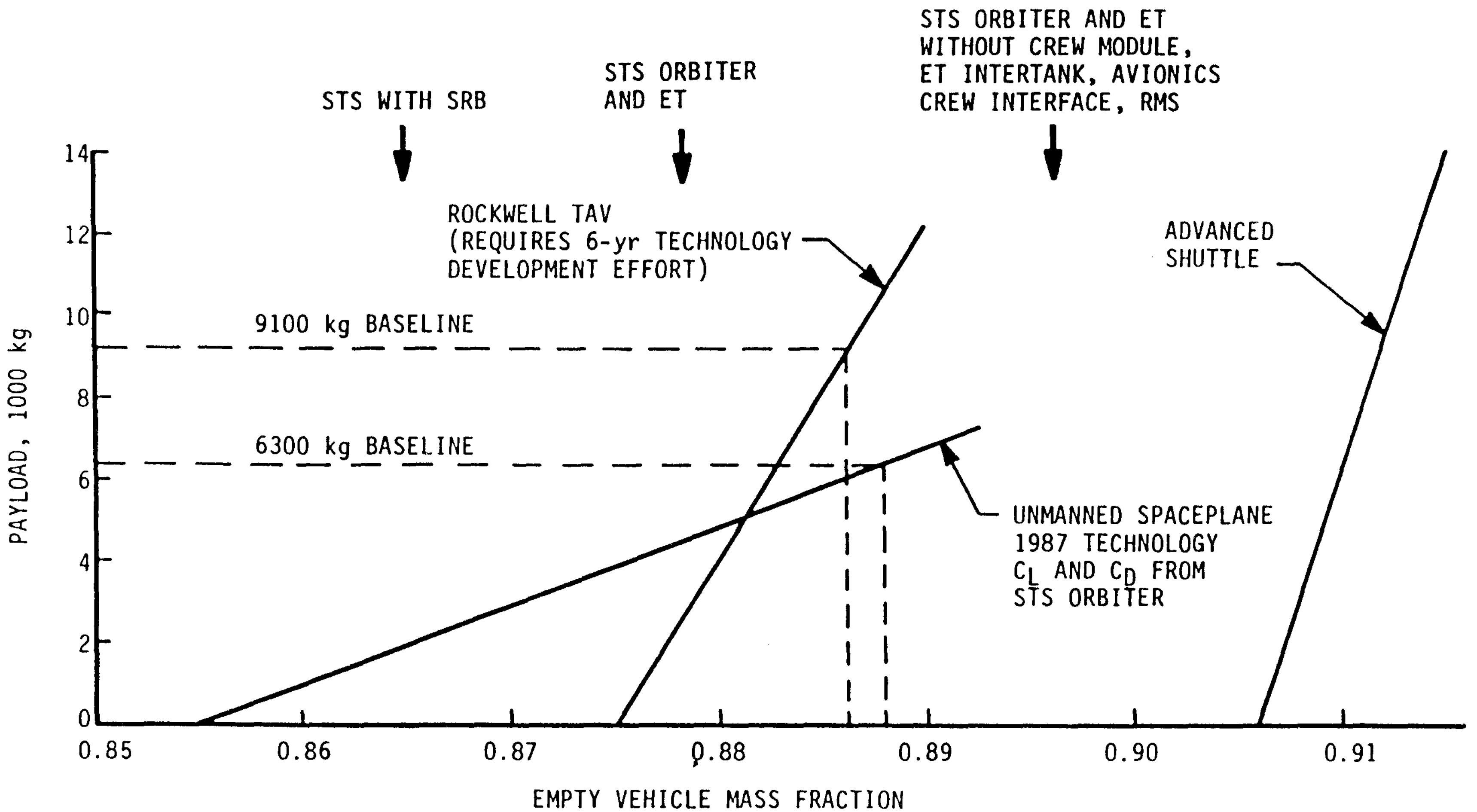
PAYLOAD SENSITIVITY TO MASS FRACTION



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PERFORMANCE OF SPACEPLANE GROWTH FAMILY

VEHICLE SYSTEM	FEATURES	SEPARATION	PAYLOAD, lb 28 deg / polar	COST, no DDTE $/FLT- $/lb
FIRST FLIGHTS	INITIAL SPACEPLANE BUILD. 747 WITHOUT THRUST AUGMENTATION Mf =.878	25,000 ft 15 deg m 0.80	3200 / no	5M / 1600
BASELINE	LIGHTENED INITIAL SPACEPLANE. 747 WITH H2 AFTERBURNERS Mf =.882	39,000 ft 30 deg m 0.68	8600 / 3100	5M / 590
GROWTH 1	LIGHTWEIGHT SPACEPLANE H2 AFTERBURNERS Mf =.889	39,000 ft 30 deg m 0.68	11,700 / 6800	5M / 430
GROWTH 2	747 WITH SSME Mf =.889	46,000 ft 30 deg m 0.85	13,400 / 7600	6M / 450
GROWTH 3	NEW CARRIER AIRCRAFT WITH 8 X J58 ENGINES Mf =.889	85,000 ft 30 deg m 2.5	28,200 / 20,500	6M / 220

ASSUMPTIONS: 3100 lb (1%) METEOROLOGICAL RESERVE ALLOWED THROUGHOUT. ALL OTHER PROPELLANT RESERVES CONSUMED BY RCS, FUEL CELLS. STS ORBITER AERODYNAMICS USED, 1100 lb PAYLOAD INCREASE ALLOWED FOR ASSUMED IMPROVEMENTS (15% DRAG REDUCTION). LAUNCH TRAJECTORIES NOT OPTIMIZED, PAYLOAD GAIN FROM OPTIMIZATION NOT CONSIDERED.

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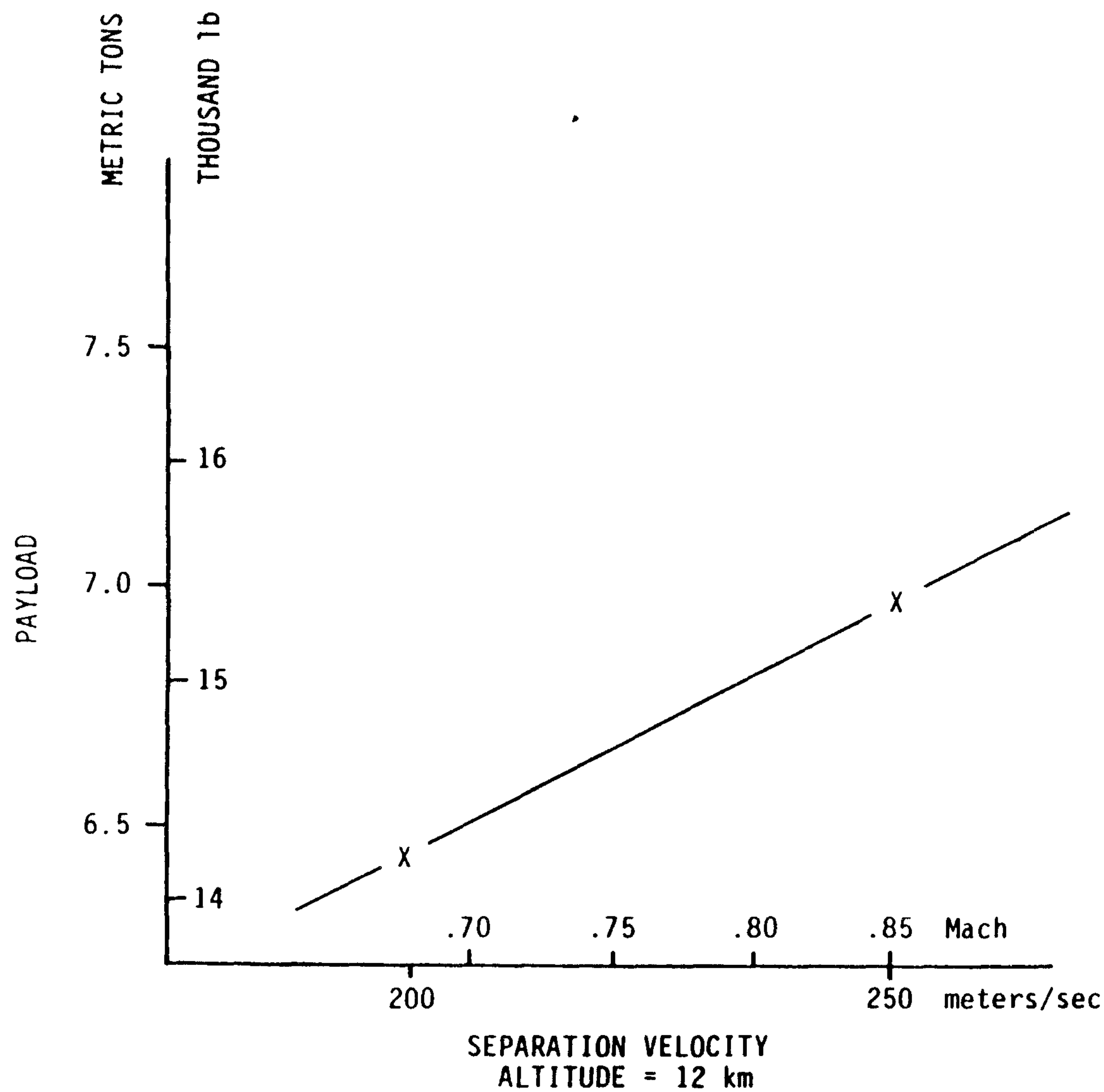
SYSTEM RELIABILITY COMPARISON

FLIGHT	FAILURE	SPACEPLANE FAILURE/RECOVERY
5/86 ARIANE 2	THIRD STAGE IGNITION FAILURE CAUSE UNDER STUDY.	SPACEPLANE IS SINGLE STAGE. IF SSME FAILS TO IGNITE, GLIDE ON RL-10 SYSTEM, DUMP FUEL, RETURN TO BASE.
5/86 DELTA	FIRST STAGE ENGINE SHUTDOWN DUE TO RELAY BOX SHORT CIRCUIT	IF MAIN ENGINE SHUTDOWN THEN DUMP FUEL, GLIDE TO EMERGENCY BASE.
4/86 TITAN 34D	SOLID ROCKET BOOSTER FAILURE	SPACEPLANE USES LIQUID FUELS; NO BOOSTERS.
1/86 STS 51-L	SRB JOINT FAILURE	SPACEPLANE USES LIQUID FUELS; NO BOOSTERS.
9/85 ARIANE 3V15	THIRD STAGE IGNITION FAILURE DUE TO HYDROGEN LEAK	SINGLE STAGE. IF RL-10 FAILS TO IGNITE, DUMP FUEL, FLY 747 TO BASE.
8/85 TITAN 34D	PRE-MATURE SHUTDOWN OF AEROJET LIQUID FUEL MAIN ENGINE	IF MAIN ENGINE SHUTDOWN, DUMP FUEL, GLIDE TO EMERGENCY BASE.

PAYLOAD TO 400 km (216 n mi.) CIRCULAR ORBIT



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LAUNCH VEHICLE COMPARISONS

PARAMETER \ VEHICLE	SPACEPLANE	SHUTTLE	H-2	HOTOL	TITAN-4 CENTAUR	DELTA 3920	ORIENT EXPRESS	HERMES ARIANE 5
MASS AT LAUNCH Tonnes	378 (172 SP ONLY)	1887	239	200	677	194	177	TBD
LAUNCH METHOD	RUNWAY/ AIRPLANE	VERTICAL ROCKET	VERTICAL ROCKET	RUNWAY/ TROLLY	VERTICAL ROCKET	VERTICAL ROCKET	RUNWAY	VERTICAL ROCKET
MASS AT LANDING Tonnes	18	73	ELV	35	ELV	ELV	68	18
LANDING METHOD	UNPOWERED RUNWAY	UNPOWERED RUNWAY	NONE	POWERED RUNWAY	NONE	NONE	POWERED RUNWAY	UNPOWERED RUNWAY
PAYLOAD TO 28° LEO Tonnes	7	23	2.0 GEO	7	18	3.4	14	4.5
COST PER LAUNCH Millions of dollars	8	180	60	5.25	115	35	11	37.6
COST PER POUND Dollars	318	3600	15k GEO	350	2900	4700	360	3583
PRICE PER POUND Dollars	430	1400	TBD	TBD	16k GEO 7.0k LEO	5.8k GEO 3.5k LEO	360	4177
YEAR OPERATIONAL	1990/91	1988	1992	1999	1989	1988	2005?	2000
MANNED/UNMANNED/ PASSENGER OPTION	P	M	U	P	U	U	M	M
ORBIT STAY TIME (MAX)	TBD	7 DAYS	NOT CAPABLE	1 DAY	NOT CAPABLE	NOT CAPABLE	1 DAY	3 DAYS

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SPACEPLANE COMPARISONS TO HOTOL

SIMILARITIES TO HOTOL

- Payload in both approximately 7,000 kg
- Both have completely reuseable thermal protection system
- Both have twice the glide ratio of Shuttle
- Both are unmanned, capable of passenger-carrying cargo pod

DIFFERENCES FROM HOTOL

- Spaceplane is air launched, no trolley on runway
- No airbreathing engines on spaceplane
- Spaceplane has no landing go-around capability

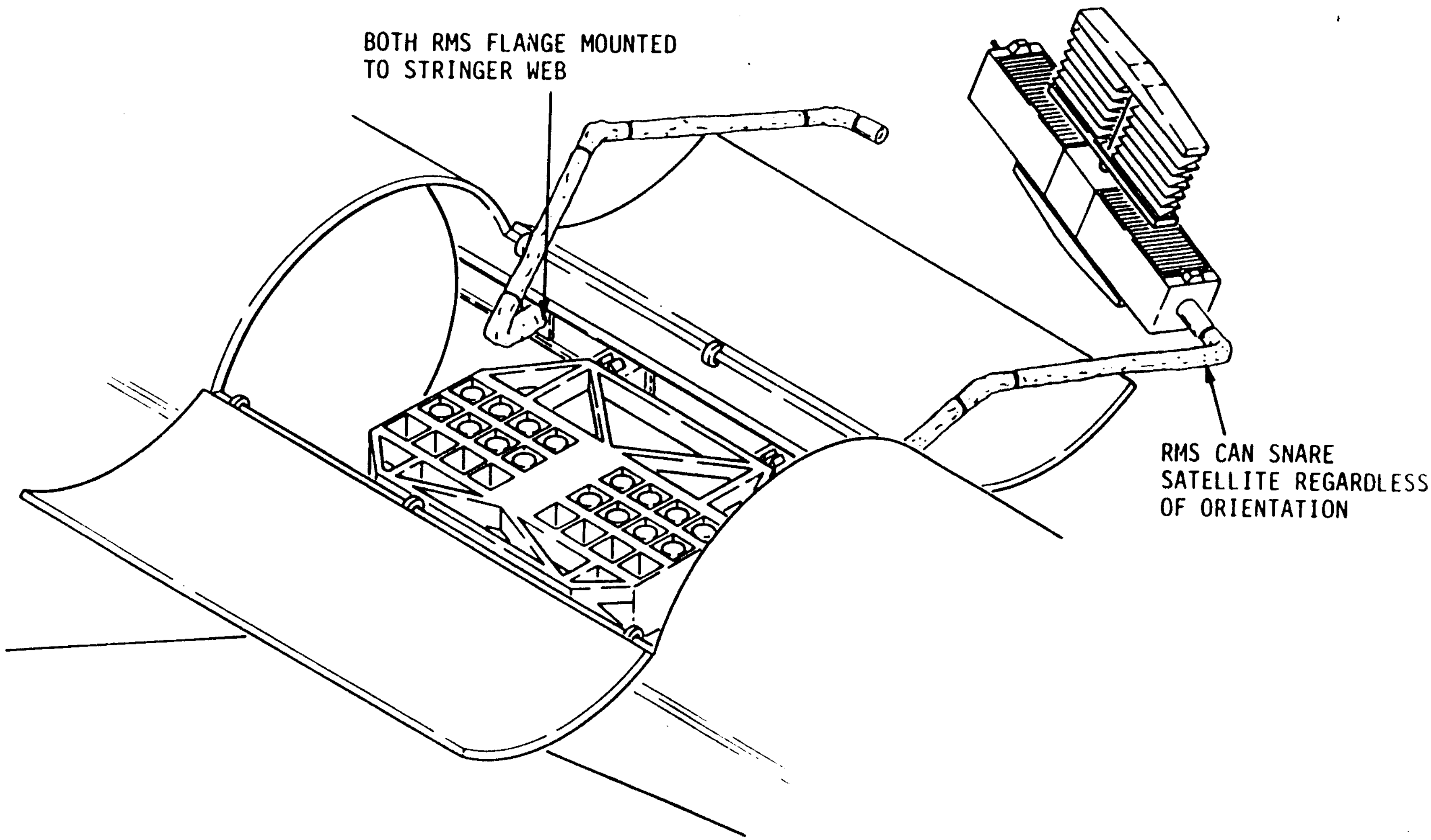
SPACEPLANE ADVANTAGES COMPARED TO HOTOL

- Engine ignition above 75% of the atmosphere at mach 0.68
  Spaceplane need not climb through densest part of atmosphere
- Carrier plane can ferry Spaceplane without reducing lifetime of expensive engine components
- Spaceplane has no need to develop new systems, such as scramjets

DISADVANTAGES COMPARED TO HOTOL

- Long-term development may favor the airbreathing HOTOL by the year 2000 or 2005

SERVICING OF MATERIALS PROCESSING FREE-FLYER ARRAY OF MODULES EXCHANGED SIMULTANEOUSLY



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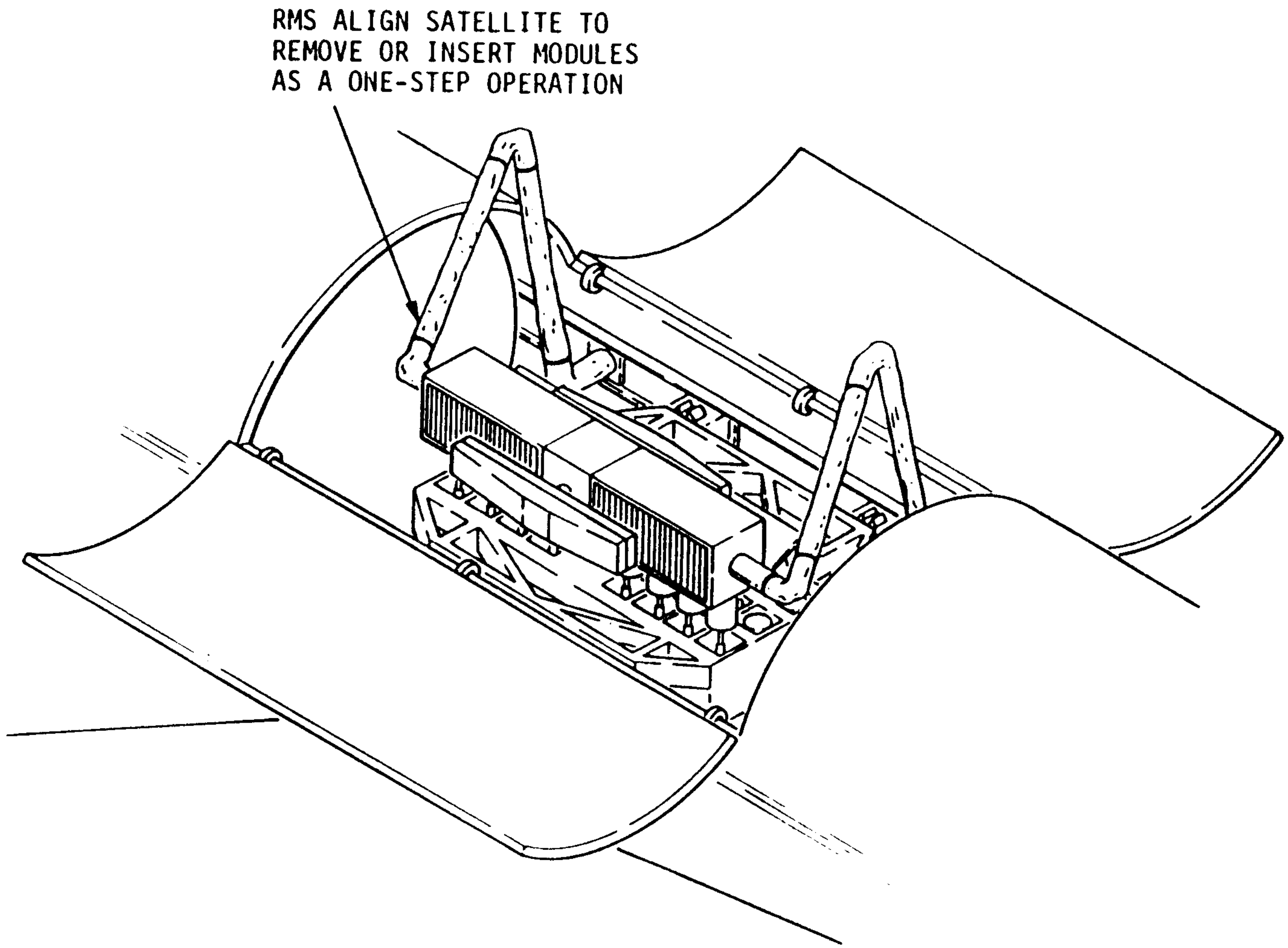

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WHY THIS VEHICLE WILL BE CHEAPER TO OPERATE THAN THE SHUTTLE

UNMANNED

- No need to round-trip carry pressure vessel, life support system, crew
- Vehicle safety requirements (& masses thereof) are less
- No astronaut training, staffing, support expenses

MORE COMPLETELY REUSEABLE

- 20 million dollar external tank not discarded on every flight
- Metal skins have much longer service lifetime than tiles
- SSME burn time per flight approximately half that of Shuttle
- Airplane first stage much more reuseable than solid rocket boosters

AIR LAUNCHED

- Spaceplane performance requirements lessened by airplane performance (Airplane takes the place of the solid rocket boosters)

- Initial engine specific impulse is higher due to lower density air

FEWER LAUNCH AND LANDING SITE FACILITIES

- No need to "clear the pad" during rcs fueling, less need for landing site toxic gas purge, due to lack of hypergolic propellants

- Airplane first stage requires only airplane type support

OPTIMIZED FOR FREIGHT HAULING

- Design not compromized to be all things to all users
- Fewer payload interfaces
- Shorter maximum orbit stay time

COMPARISON TO PRATT & WHITNEY/BOEING USAF VEHICLE

	BOEING/P&W	SPACEPLANE
SEPARATION TRAJECTORY	46 deg	30 deg
SEPARATION ALTITUDE	37,000 ft	39,400 ft
SEPARATION MASS	269,080 lbm	380,000 lb
SEPARATION VELOCITY	M .82	M .68
747 T.O. MASS	860,000 lb	833,000 lb
THRUST AT SEPARATION	310,500 lbf	539,870 lbf
WEIGHT AT CUTTOFF	23,590 lbm	54,411 lbm
F/M AT SEPARATION	1.15	1.42
PAYLOAD	3,450 lb (100 nmi, Polar)	14,300 lb (216 nmi, 28 deg) 9,000 lb (216 nmi, Polar)

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COST ESTIMATE SUMMARY

	MILLIONS OF $
VEHICLE DDT&E THROUGH TEST FLIGHTS, INCLUDING ONE PROTOTYPE AND TWO FLIGHT UNITS, BASED ON AIRBORNE OPTICAL SENSOR FUNDED PROPOSAL	940
(SAME, BASED ON RCA COST ESTIMATE)	(591)
OPERATIONS FOR FIVE YEARS	1,193
CARRIER AIRCRAFT	250
TOTAL	2,383

COST RECOVERY: RETAINER FEES NOT CONSIDERED (USAF RECON, ASTRONAUT RESCUE, SHUTTLE CARRIER)

YEAR	FLIGHTS PER YEAR	CHARGE PER FLIGHT	VALUE (MILLIONS OF$)
1	10	25	250
2	20	22	440
3	30	20	600
4	40	17	680
5	40	15	600
		TOTAL	2,570

CAPITAL COSTS ARE RECOVERED 5 YEARS AFTER FIRST OPERATIONAL FLIGHT

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WHY BUILD THIS VEHICLE?

COMPARED TO SHUTTLE

- Much cheaper freight rate, even compared to subsidized rates

COMPARED TO ORIENT EXPRESS AND HOTOL

- No new technology, can be brought on line years sooner
- Much less expensive to develop

COMPARED TO SMALL ELVs

- Cheaper to fly
- Minimal launch site required
- Larger payload except for Titan 34D

COMPARED TO HEAVY LIFT ELV

- Ease of cargo manifesting
- Turnaround time will be much less
- Launch site is cheaper
- More launch sites are available

OTHER REASONS

- It is needed, paying customers are presently being turned down
- Value in being "The first commercial Spaceplane"
- There is money to be made, can compete favorably with subsidized launchers
- Any landing site with long runway

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WHAT IS THE NEXT STEP?

- DETERMINE THE AVENUES FOR BUYING TAXPAYER-DEVELOPED COMPONENTS (e.g., SHUTTLE MAIN ENGINES) FOR USE IN A PROFIT-MAKING VENTURE
- INVESTIGATE USE OF H2/O2 RCS AND ELECTRIC THRUST VECTOR CONTROL SYSTEM TO COMPLETELY ELIMINATE THE HYDRAZINE SYSTEMS
- CALCULATE REENTRY TEMPERATURES
- PERFORM A RIGOROUS STRESS ANALYSIS OF THE STRUCTURE
- MEASURE LIFT AND DRAG COEFFICIENTS