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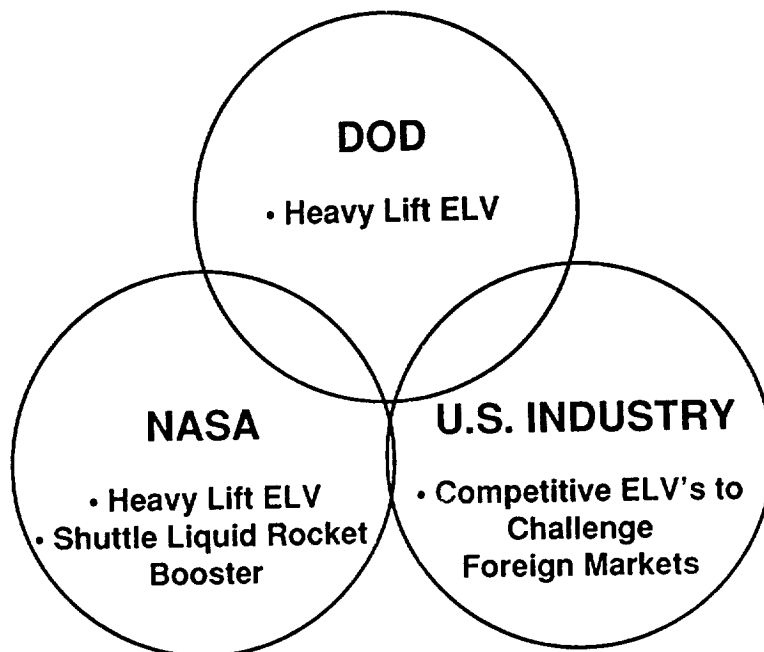
N91-28210

NEXT GENERATION

UNMANNED LAUNCH VEHICLES AND UPPER STAGES

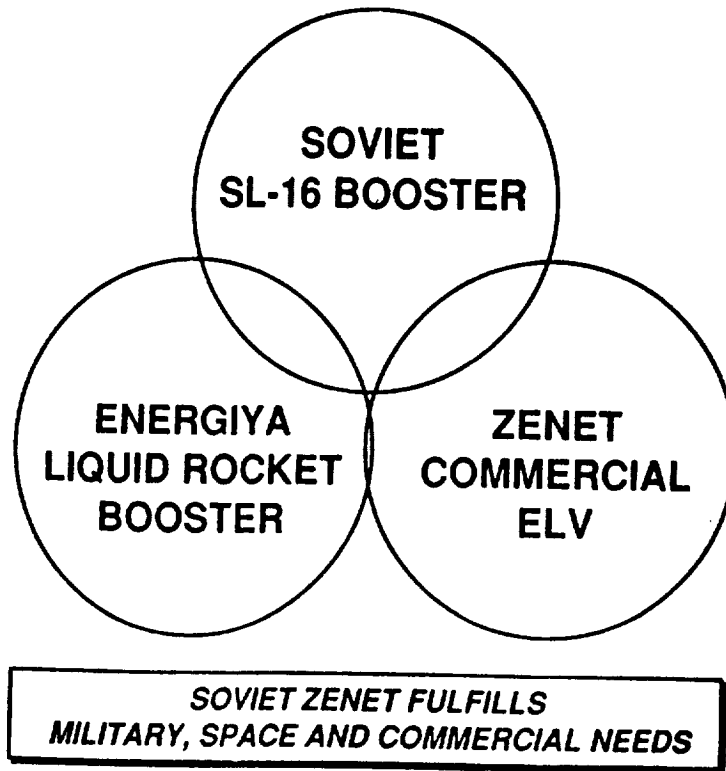
CHARLES R. GUNN
NASA
OFFICE OF SPACE FLIGHT
JUNE 27, 1990

THE NEEDS

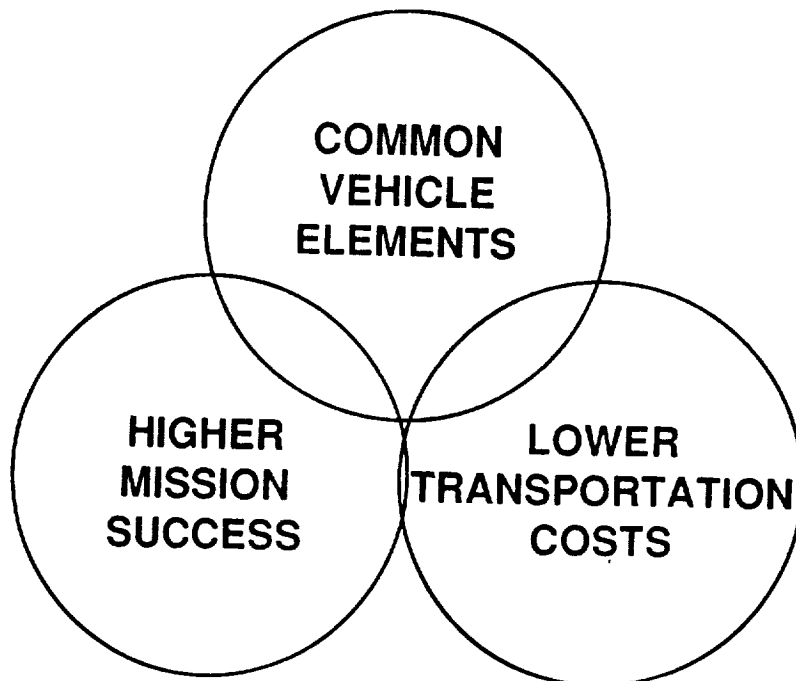


**A NATIONAL CONSORTIUM TO DEVELOP AND PRODUCE
COMMON VEHICLE ELEMENTS**

THE MODEL

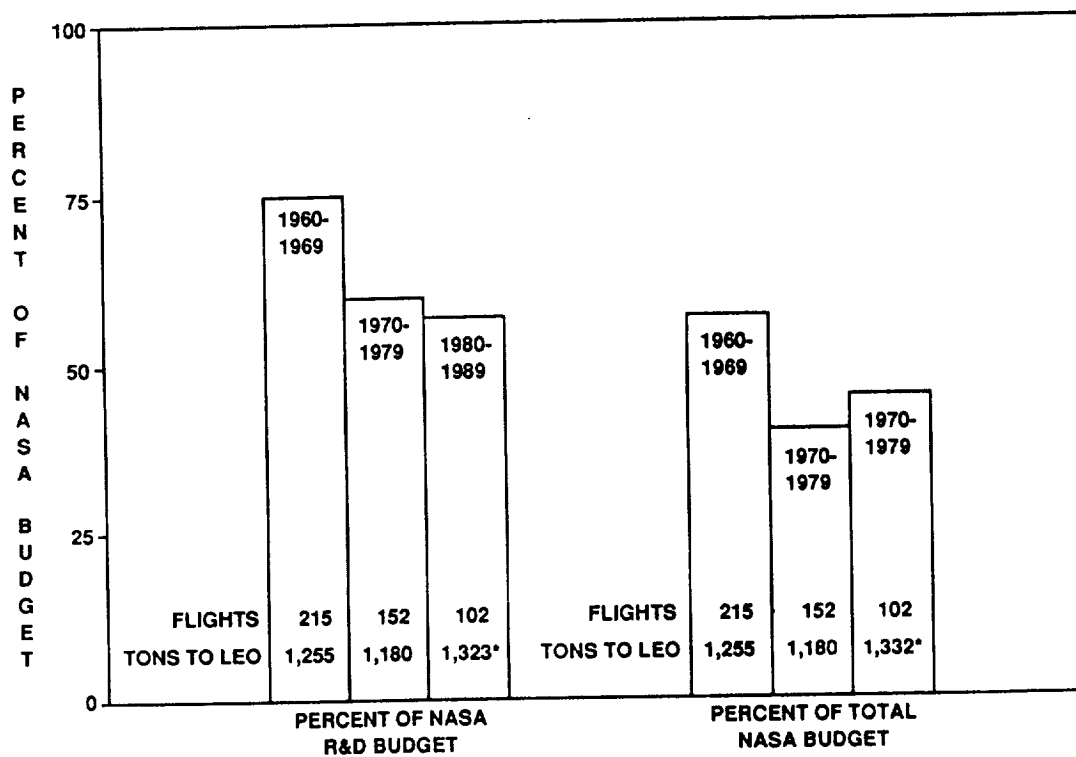


THE FOCUS



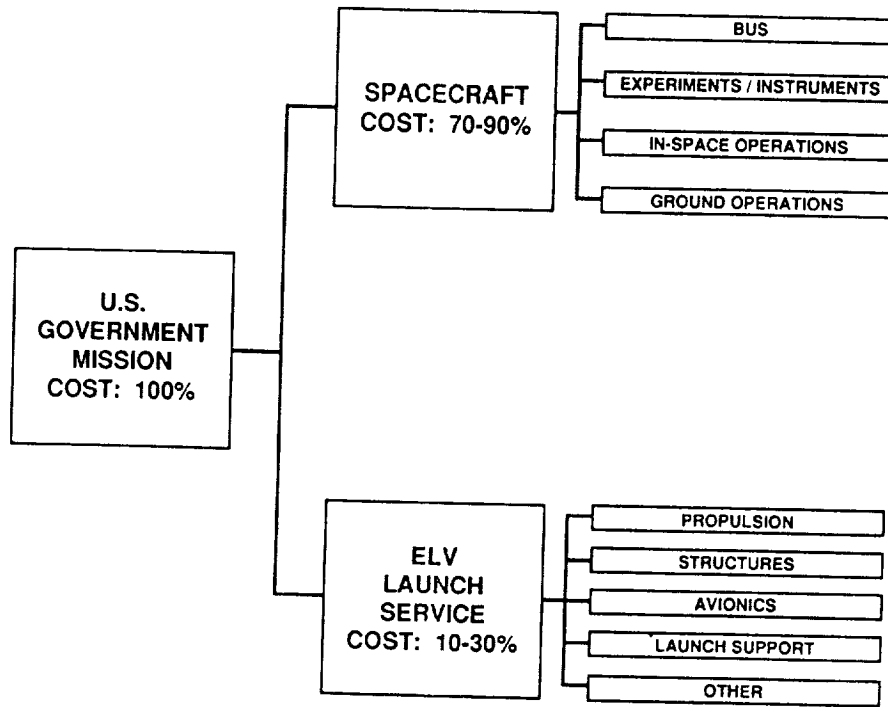
LOWER TRANSPORTATION COST

NASA SPACE TRANSPORTATION RESOURCES



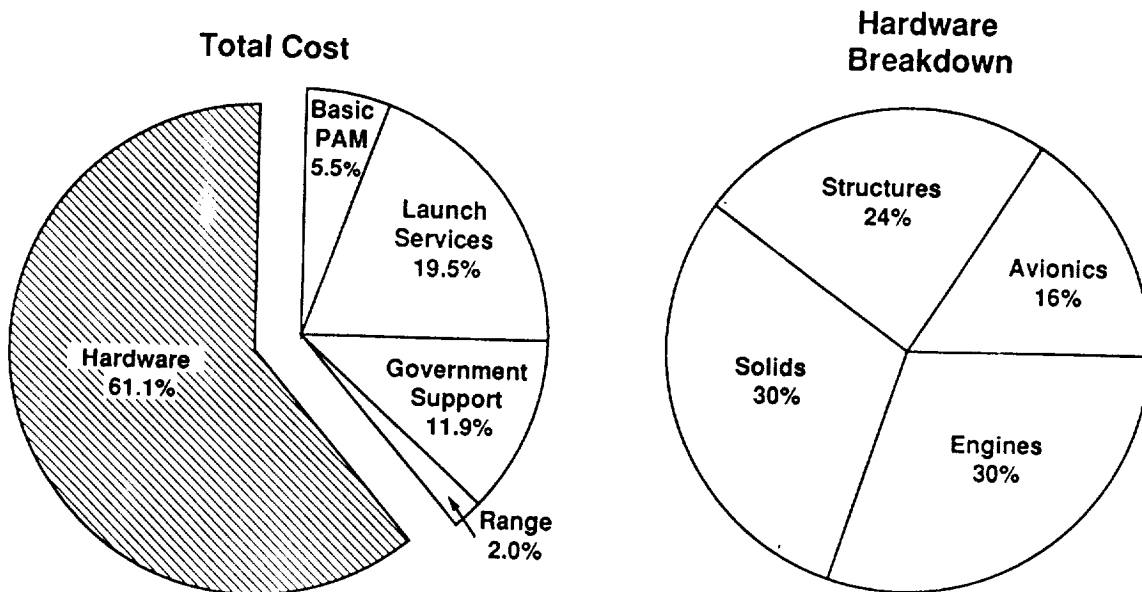
* W/O SPACE SHUTTLE ORBITER (3,763 TONS INCLUDING ORBITER)

PERSPECTIVE ON MISSION COST

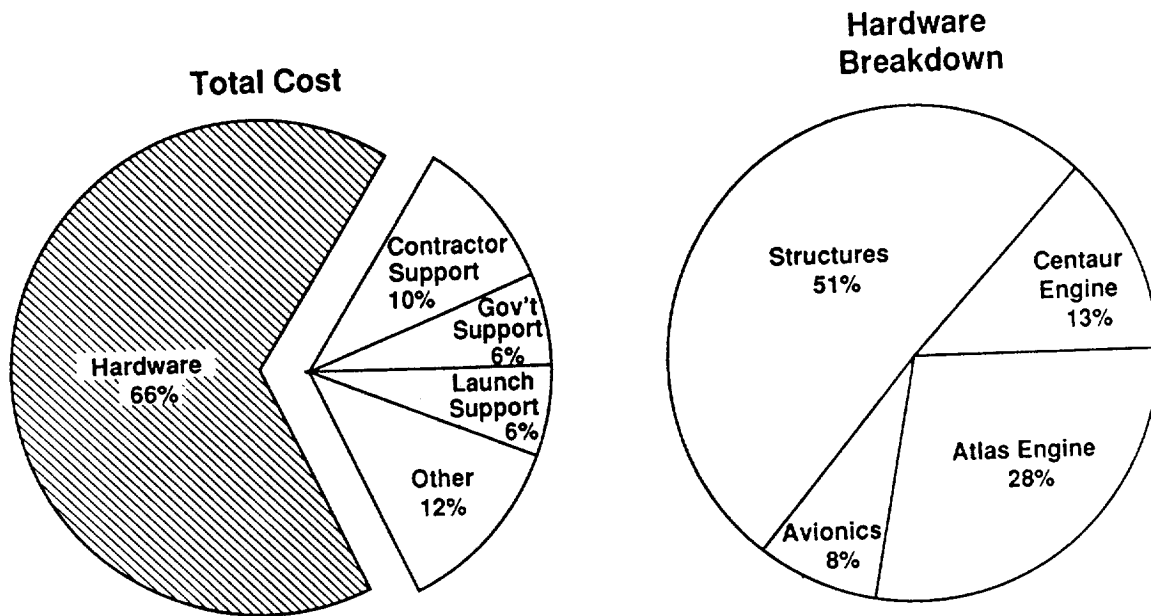


NOTE: U.S. GOVERNMENT MISSIONS ON MEDIUM & LARGE PERFORMANCE CLASS ELV's
(e.g., DELTA II AND LARGER)

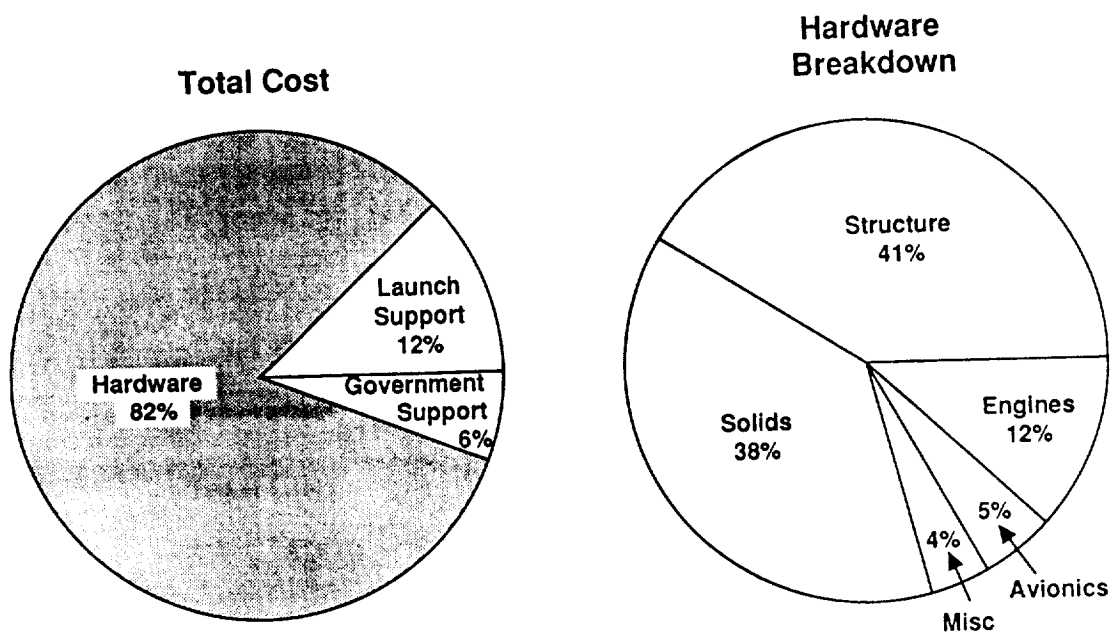
DELTA 7925 - RECURRING COST



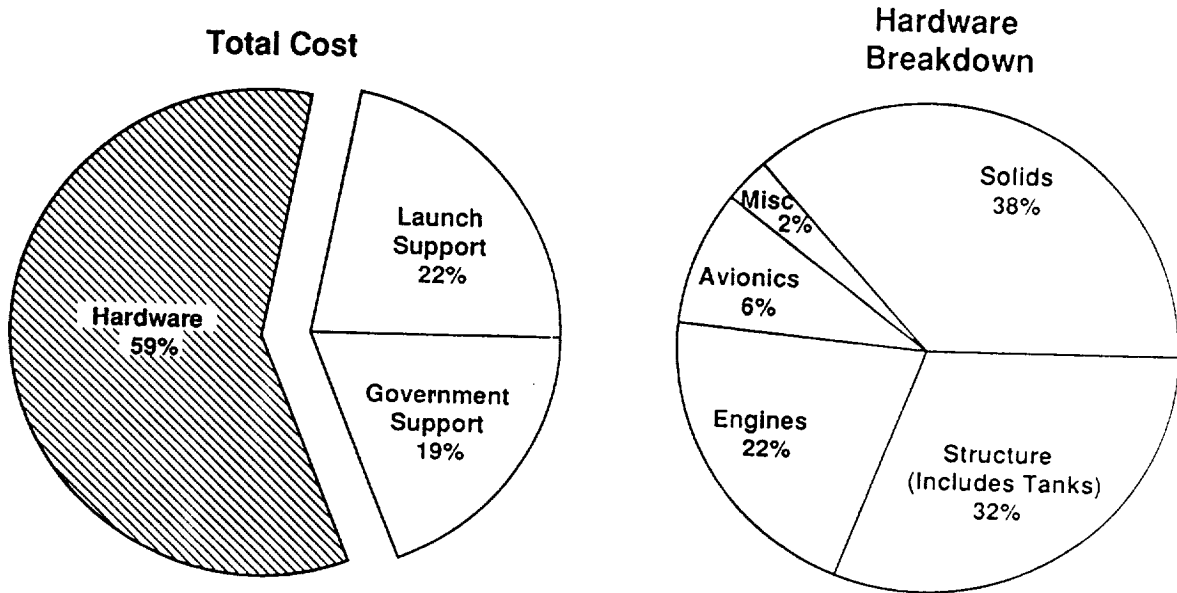
ATLAS / CENTAUR - RECURRING COST (4 FLIGHTS / YEAR)



TITAN III - RECURRING COST



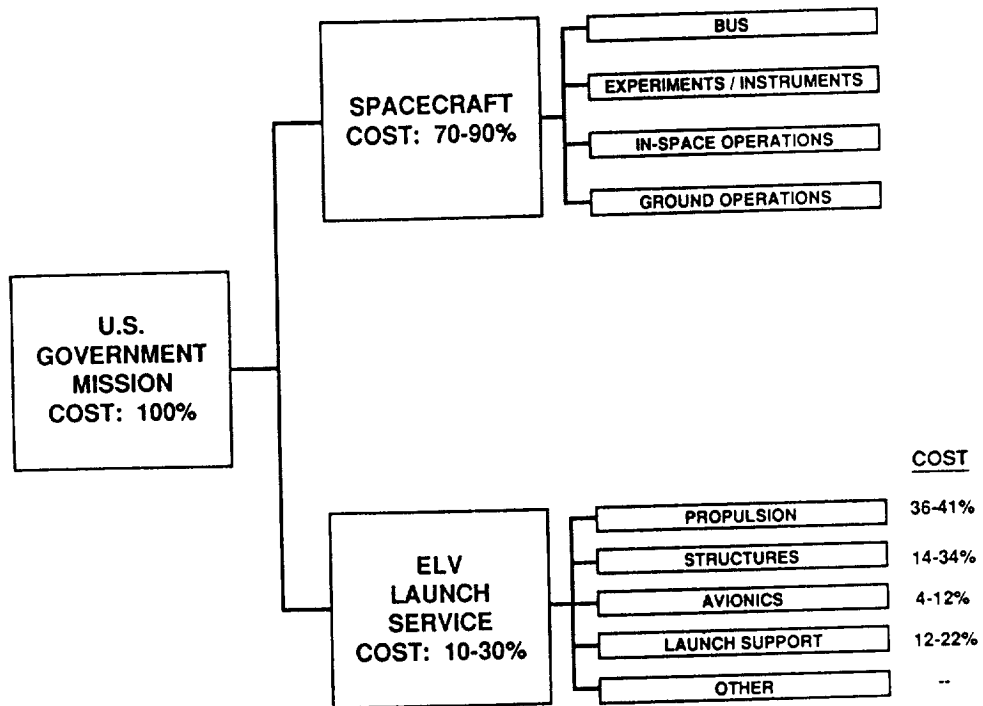
TITAN IV - RECURRING COST (4 FLIGHTS / YEAR)



ENGINE COSTS

<u>ENGINE</u>	<u>THRUST K LBS</u>	<u>PROPELLANTS</u>	<u>COST, FY 1990\$</u>
SSME (STS)	470	H ₂ / O ₂	\$44M - Each (Quantity of 4)
MB-3 SET (ATLAS II)	423 / 85	RP-1 / O ₂	\$13 - 14M - Set (Quantity of 18)
RS-27 (DELTA II)	237	RP-1 / O ₂	\$8 - 9M - Each (Quantity of 20)
RL-10 SET (CENTAUR)	33	H ₂ / O ₂	\$4½ - 5M - Set (Quantity of 20)
VIKING-VI (ARIANE IV)	150	A-50 / N ₂ O ₄	\$4 - 5M - Each (Quantity of ?)
VIKING HM-60 (ARIANE V)	250	H ₂ / O ₂	--

PERSPECTIVE ON MISSION COST

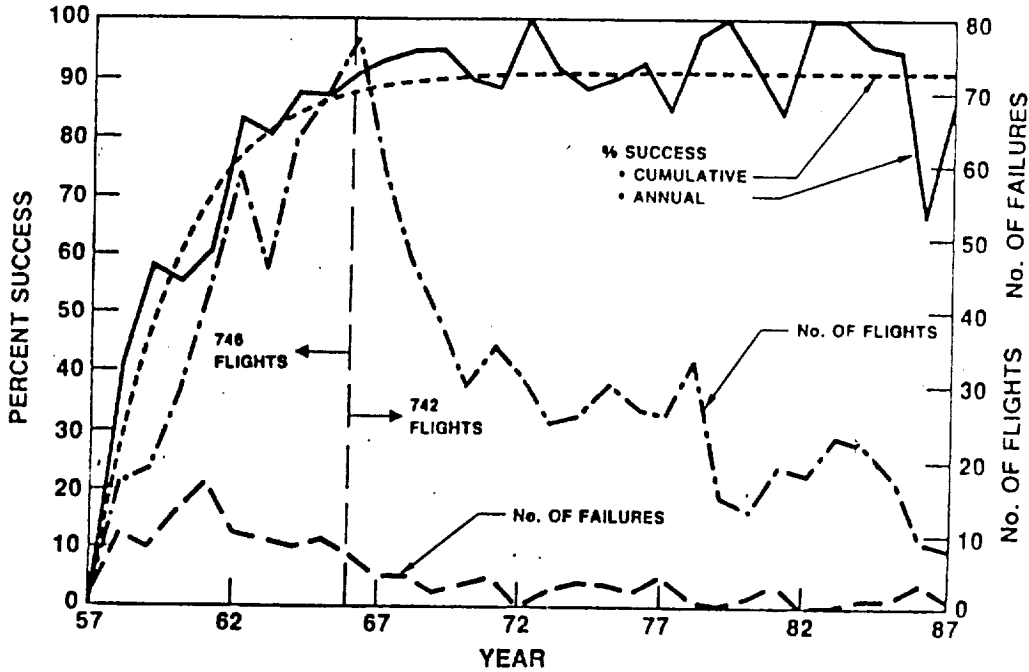


NOTE: U.S. GOVERNMENT MISSIONS ON MEDIUM & LARGE PERFORMANCE CLASS ELV's (e.g., DELTA II AND LARGER)

HIGHER MISSION SUCCESS

U.S. Launches, 1957-1987

VANGUARD, JUPITER, THOR/DELTA, JUNO, ATLAS, SCOUT, REDSTONE, SATURN, TITAN, STS



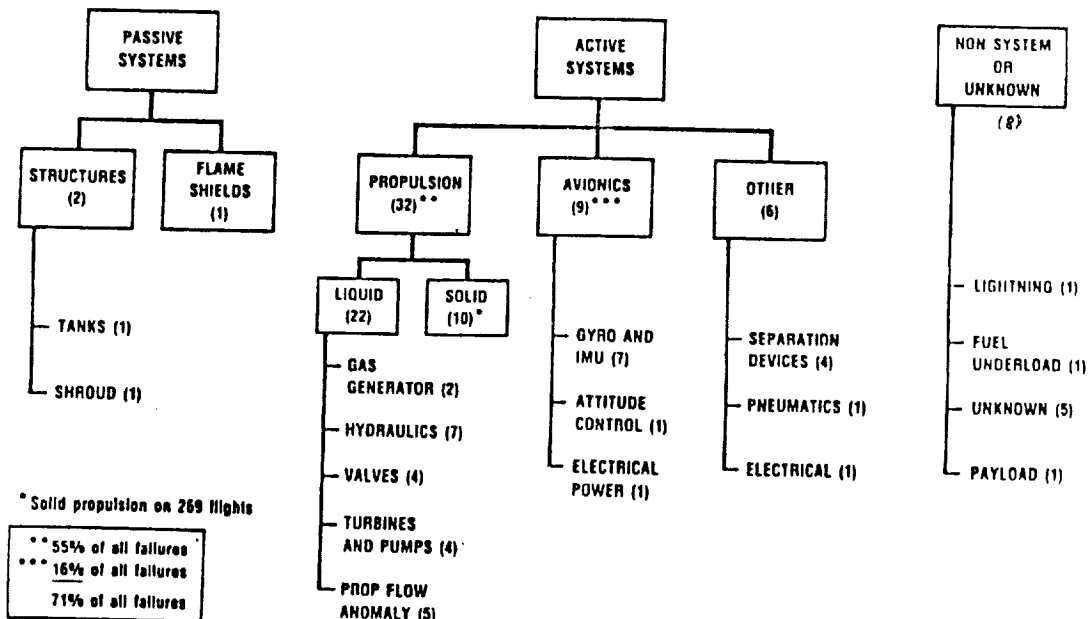
Subsystem Sources of Failure

1966-1987

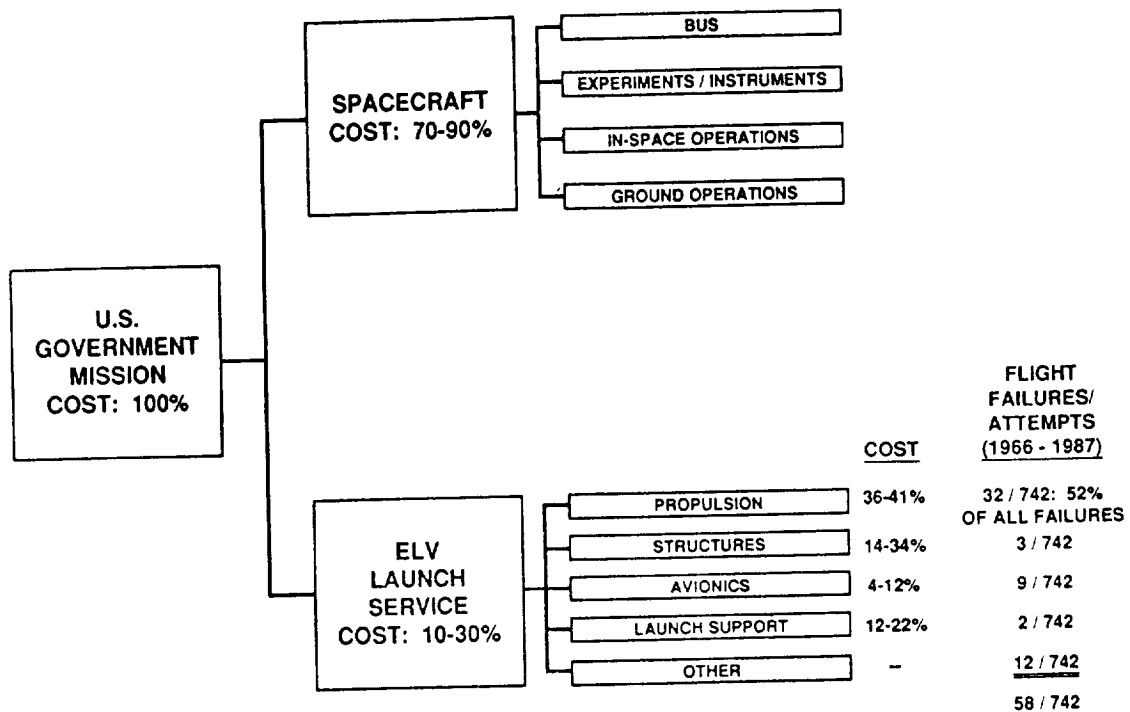
742 TOTAL FLIGHTS

(1966-1987) — ATLAS, THOR/DELTA, TITAN, SCOUT, STS

58 FAILURES



PERSPECTIVE ON MISSION COST AND FAILURES



NOTE: U.S. GOVERNMENT MISSIONS ON MEDIUM & LARGE PERFORMANCE CLASS ELV's (e.g., DELTA II AND LARGER)

SUMMARY OF FLIGHT EXPERIENCE

- PROPULSION SYSTEM COSTS ARE LARGEST FRACTION OF ELV (35%)
- PROPULSION SYSTEMS HAVE HIGHEST FAILURE RATE
 - 52% OF ALL FAILURES
 - >50% OF FAILURES ATTRIBUTED TO POOR WORKMANSHIP OR HUMAN ERROR
- LIQUID ENGINE FAILURES
 - 1/3 IN ENGINE - (NO CRYO ENGINE FAILURE)
 - 2/3 IN ASSOCIATED SYSTEMS (FEED LINES, VALVES, PRESSURIZATION SYSTEM, ACTUATORS, HYDRAULIC PUMP, ETC.)
 - 75% OF ALL ENGINE FAILURES OCCUR AT STARTUP
- PROPULSION SYSTEM BENIGN TO CATASTROPHIC FAILURE RATIO 10:1
 - ENGINE OUT CAPABILITY WOULD HAVE INCREASED MISSION SUCCESS
 - HIGH RELIABILITY ENGINE INSTRUMENTATION ESSENTIAL

RECOMMENDATIONS FOR NEXT GENERATION SPACE TRANSPORTATION

- **ESTABLISH A NATIONAL CONSORTIUM:**
 - AGGREGATE NASA / DOD / ELV COMMERCIAL INDUSTRY REQUIREMENTS
 - AGREE ON COMMON PROPULSION ELEMENTS
 - ENGINE
 - PROPELLANT TANK MODULES
 - PRESSURIZATION SYSTEM
 - THRUST VECTOR CONTROL SYSTEM
 - SYSTEM MANAGEMENT SCHEME
 - AGREE ON SHARING OF:
 - MANAGEMENT
 - NON-RECURRING COSTS
 - PRIORITY OF PRODUCTION / LAUNCH ASSETS
 - FLIGHT FAILURES CORRECTIVE ACTIONS

RECOMMENDATION FOR NEXT GENERATION SPACE TRANSPORTATION (CONTINUED)

- **FOCUS MORE DESIGN ENGINEERING ON ENGINE SUPPORT SYSTEMS**
 - 2/3 OF PROPULSION SYSTEMS FLIGHT FAILURES
- **REASSESS PROGRAM MANAGEMENT OF NEXT ENGINE DEVELOPMENT - FRESH PERSPECTIVE ON:**
 - MISSION SUCCESS vs HIGHEST PERFORMANCE
 - PRODUCIBILITY vs LOWEST WEIGHT AND SMALLEST ENVELOPE
 - DURABILITY vs FREQUENT FIELD CHANGE-OUT
 - REUSEABLE vs EXPENDABLE

CHALLENGE THE INDUSTRY **(SPACE AND AIRCRAFT ENGINE MANUFACTURERS)**

- **\$100K AND 12 MONTHS TO DESIGN AND BUILD A 250 KLB THRUST H₂ / O₂ ENGINE**
- **U.S. GOVERNMENT TO CONDUCT TEST FIRE DEMONSTRATION**

LOW COST ENGINE DEMONSTRATION

- **TO BUILD A 250K LB THRUST H₂ / O₂ ENGINE FOR \$100K IN 12 MONTHS MUST:**
 - **"CHARGE" THE TEAM - THEN HANDS-OFF AND LET TEAM WORK. RECOGNIZE ACCOMPLISHMENTS**
 - **FORM SMALL "CAN-DO" TEAM AT A SINGLE LOCATION - THE RIGHT PEOPLE**
 - **BREAKOUT OF CURRENT HIGH TECH, HIGH COST, COMPLEX AEROSPACE CULTURE**
 - **KEEP EFFORT SMALL AND MANAGEMENT SIMPLE - AVOID TIME CONSUMING, COSTLY BUREAUCRACY AND REPORTING**

LOW COST ENGINE DEMONSTRATION

● DEMONSTRATE ENGINE WORTHINESS

- RIGHT PEOPLE AND WORK ENVIRONMENT AS ABOVE
- INSTRUMENT ENGINE
- MAXIMUM STARTS AND RUN TIME
- RUN TO FAILURE / IMPENDING FAILURE

● RESULTS

- CASE I - ENGINE SUCCESSFULLY STARTS AND ACCUMULATES LONG RUN TIME WITHOUT MAJOR PROBLEMS

RESULT - LOW COST ENGINE METHODS, TECHNIQUES, HARDWARE DEMONSTRATED

- CASE II - ENGINE FAILS EARLY

ACTION - DETERMINE CAUSE AND CORRECTIVE ACTION

RESULT - HARD FACTS ON PITFALLS TO AVOID IN LOW COST ENGINE - HOW TO DO IT RIGHT

NEXT GENERATION COMMERCIAL ELV NEEDS ESTIMATE (PROPULSION ONLY)

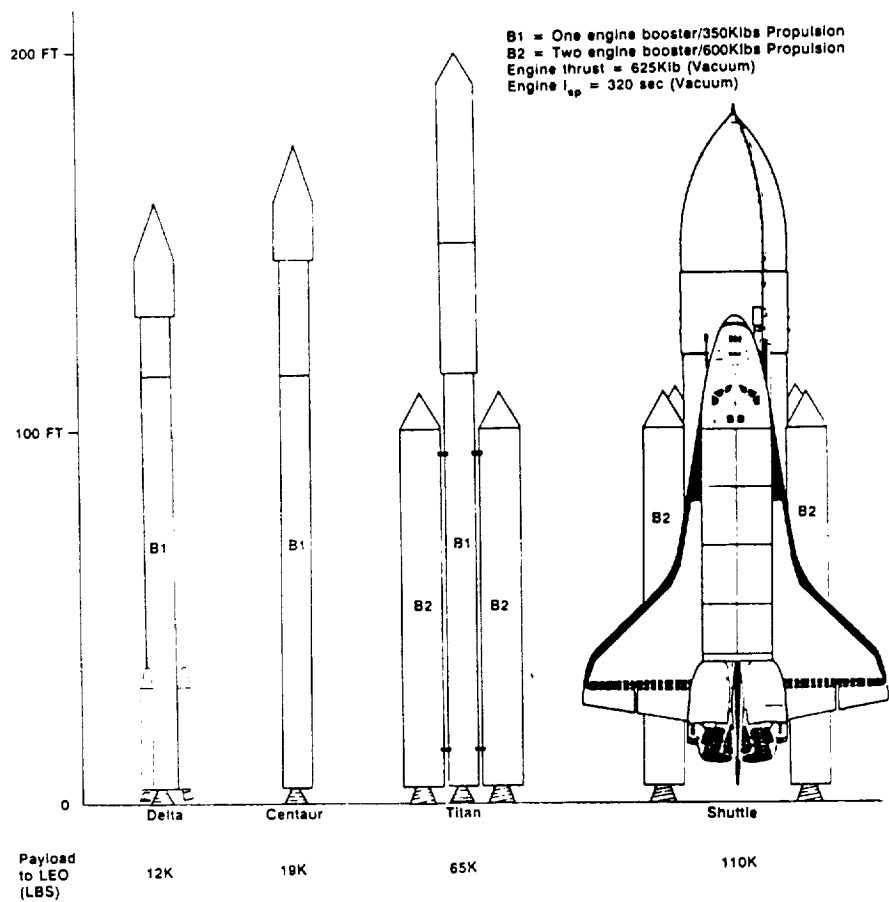
● BOOSTER

- CAPABILITY TO LEO 50 - 70K LBS
- 500 - 600K LBS THRUST LEVEL CORE ENGINES
- ENGINE SYSTEM - OUT CAPABILITY
- CLEAN PROPELLANTS - H_2 / O_2 OR HYDRO CARBONS / O_2
- STAND ALONE STRUCTURE
- 14 - 18 FEET DIAMETER
- 90 - 110 FEET LONG
- MODULAR STRAP-ON LIQUID / SOLID ROCKET MOTORS CAPABILITY
- RECOVERABLE OPTION
- LOW COST - MAX \$20M IN FY 1990 \$ FOR TOTAL BOOSTER
 - WITH LIQUID / SOLID ROCKET MOTORS
 - BLOCK BUY OF 20

● SECOND STAGE

- CAPABILITY TO GTO 15 - 20K LBS
- 35 - 45K LBS THRUST LEVEL CORE ENGINES
- ENGINE SYSTEM-OUT CAPABILITY
- H_2O_2 PROPELLANTS
- STAND ALONE STRUCTURE
- 14 - 18 FEET DIAMETER
- LOW COST - MAX. \$25M IN FY 1990 \$ FOR TOTAL STAGE

Single LOX/RP1 Engine One Engine & Two Engine Booster Stages



SPACE TRANSFER VEHICLES

