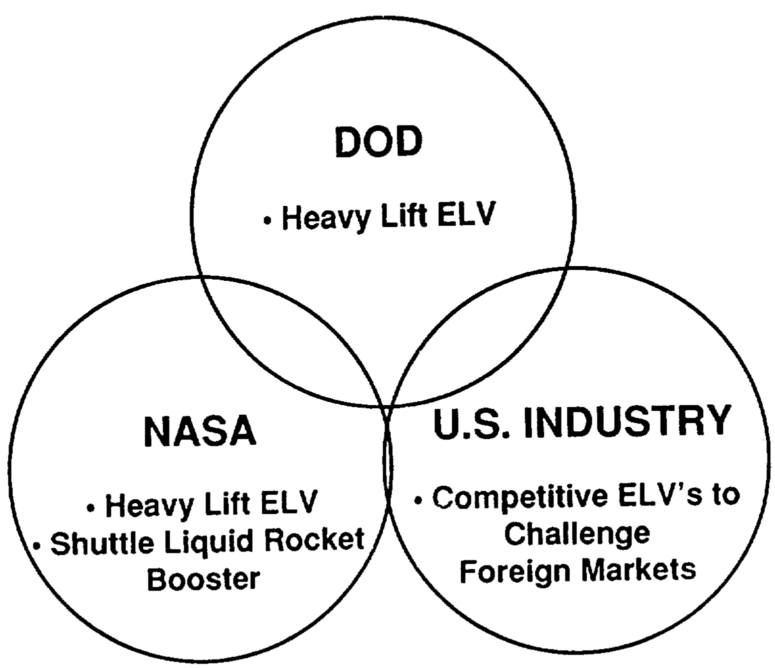
N91-28210

NEXT GENERATION

UNMANNED LAUNCH VEHICLES AND UPPER STAGES

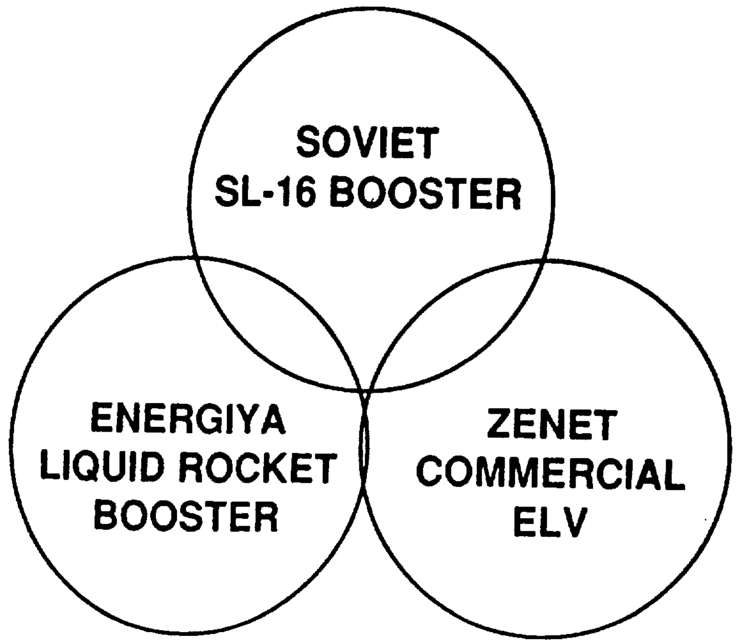
CHARLES R. GUNN
NASA
OFFICE OF SPACE FLIGHT
JUNE 27, 1990

THE NEEDS



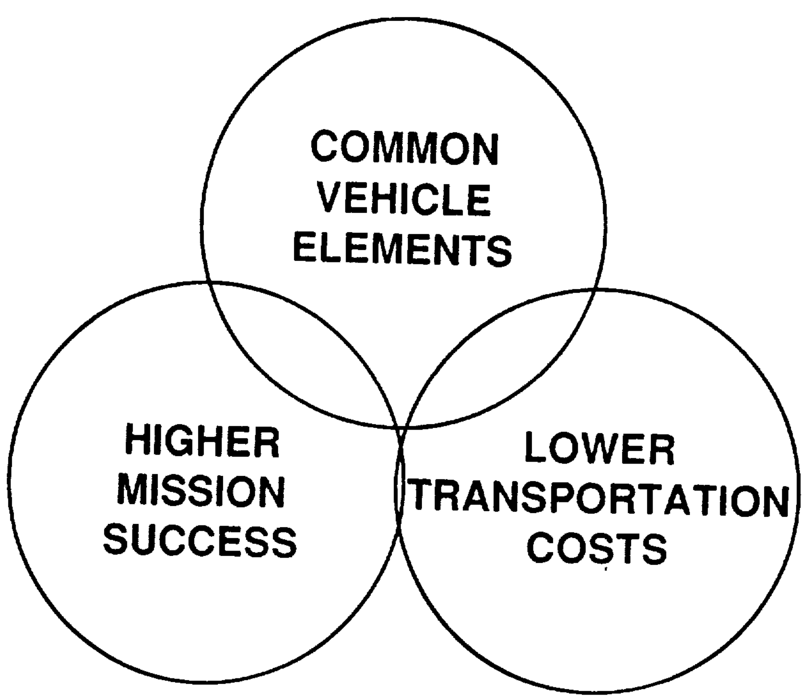
A NATIONAL CONSORTIUM TO DEVELOP AND PRODUCE COMMON VEHICLE ELEMENTS

THE MODEL



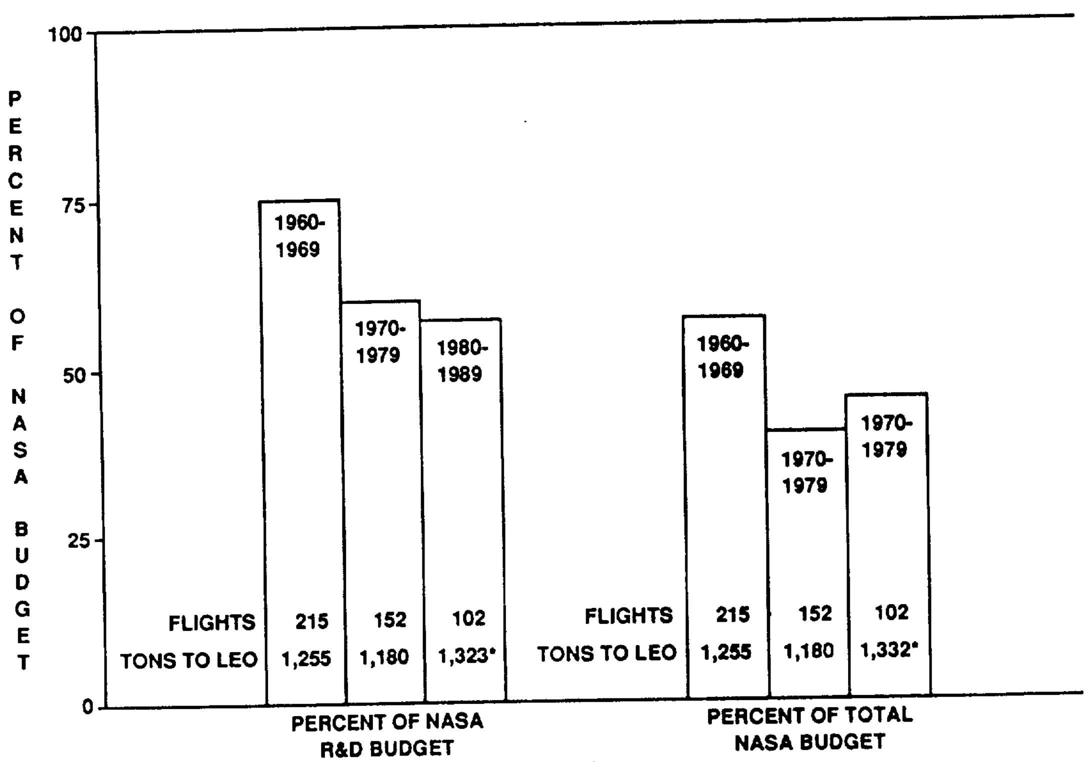
SOVIET ZENET FULFILLS
MILITARY, SPACE AND COMMERCIAL NEEDS

THE FOCUS



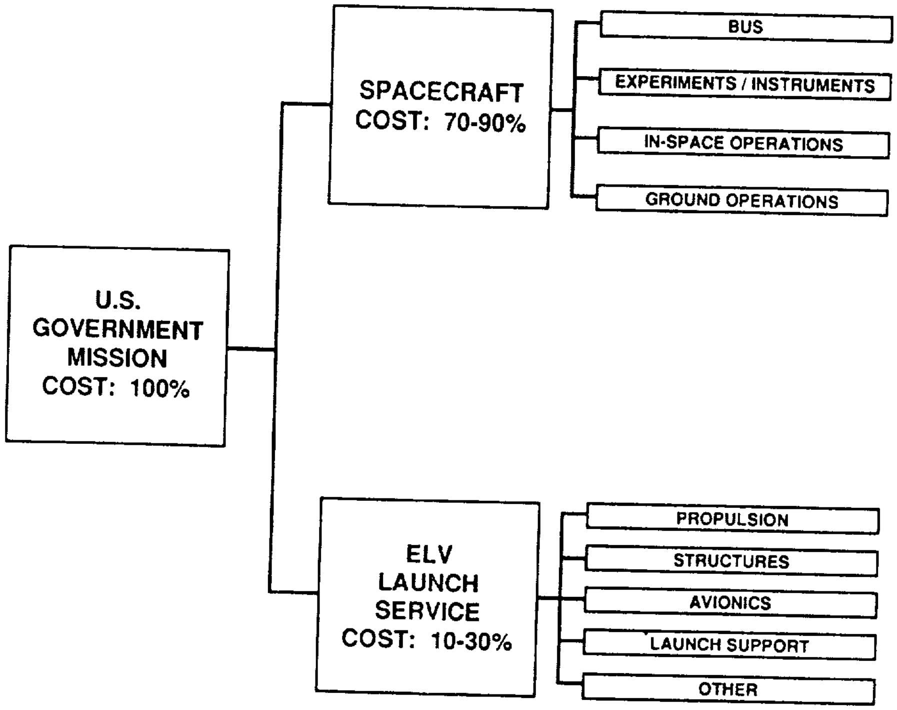
LOWER TRANSPORTATION COST

NASA SPACE TRANSPORTATION RESOURCES



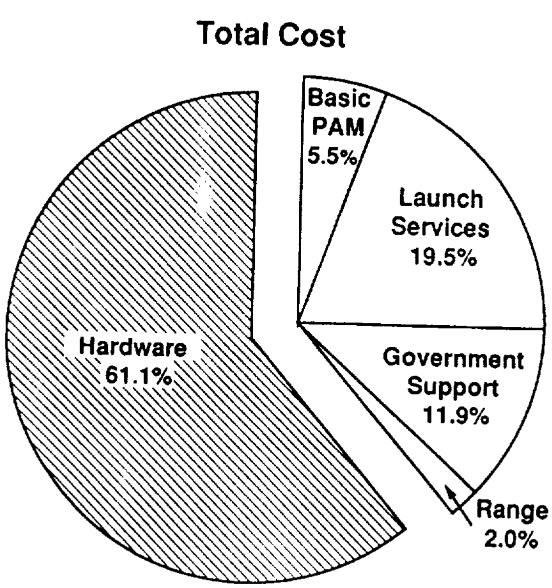
* W/O SPACE SHUTTLE ORBITER (3,763 TONS INCLUDING ORBITER)

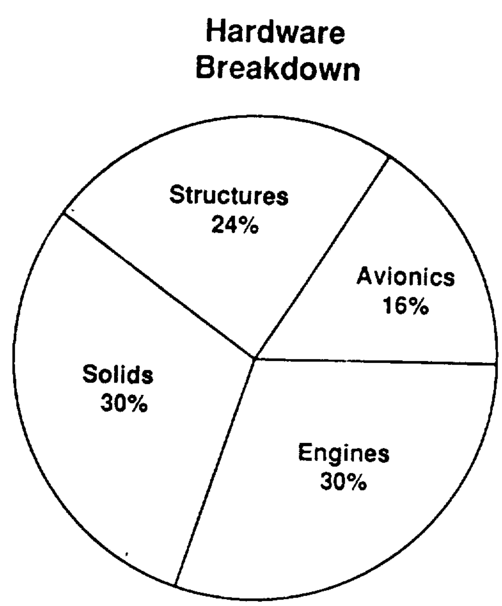
PERSPECTIVE ON MISSION COST



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

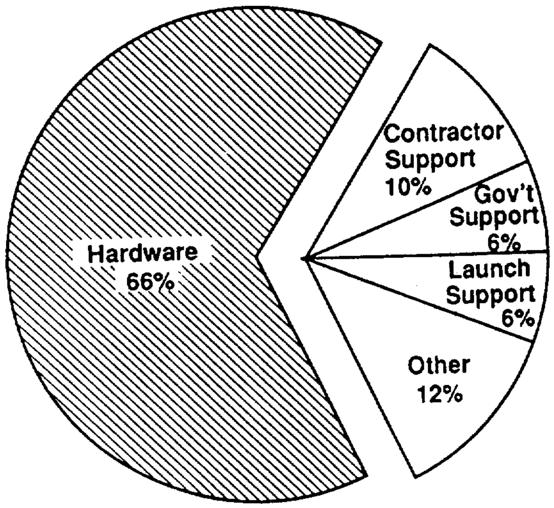
DELTA 7925 - RECURRING COST



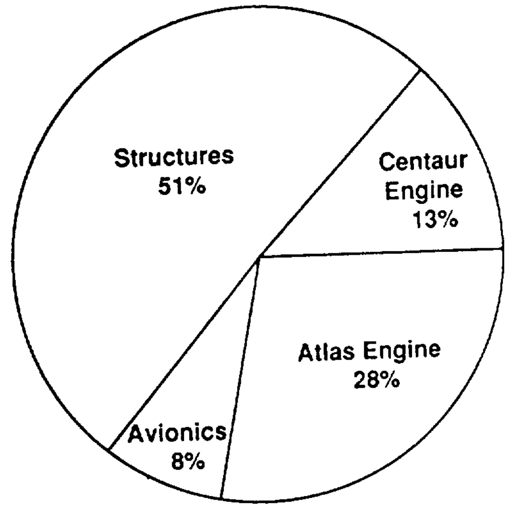


ATLAS / CENTAUR - RECURRING COST
(4 FLIGHTS / YEAR)

Total Cost

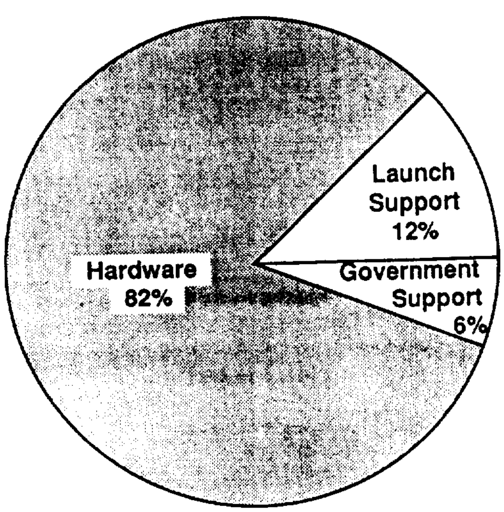


Hardware Breakdown

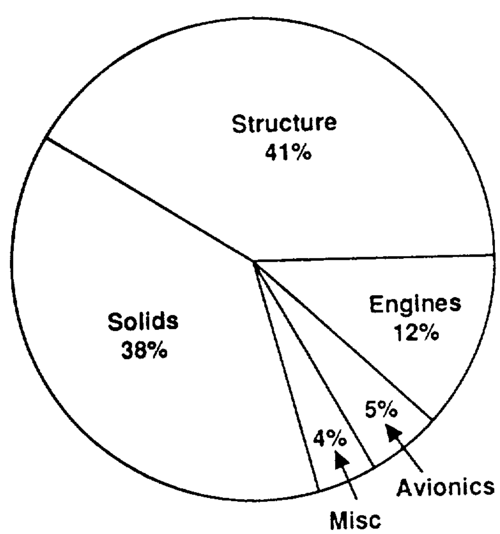


TITAN III - RECURRING COST

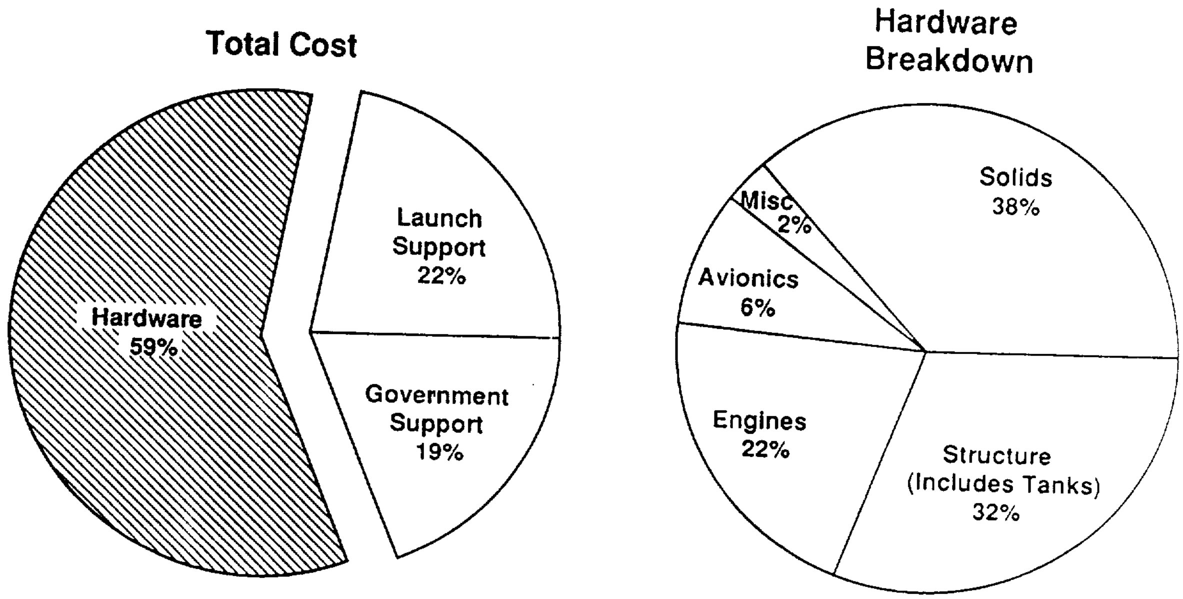
Total Cost



Hardware Breakdown



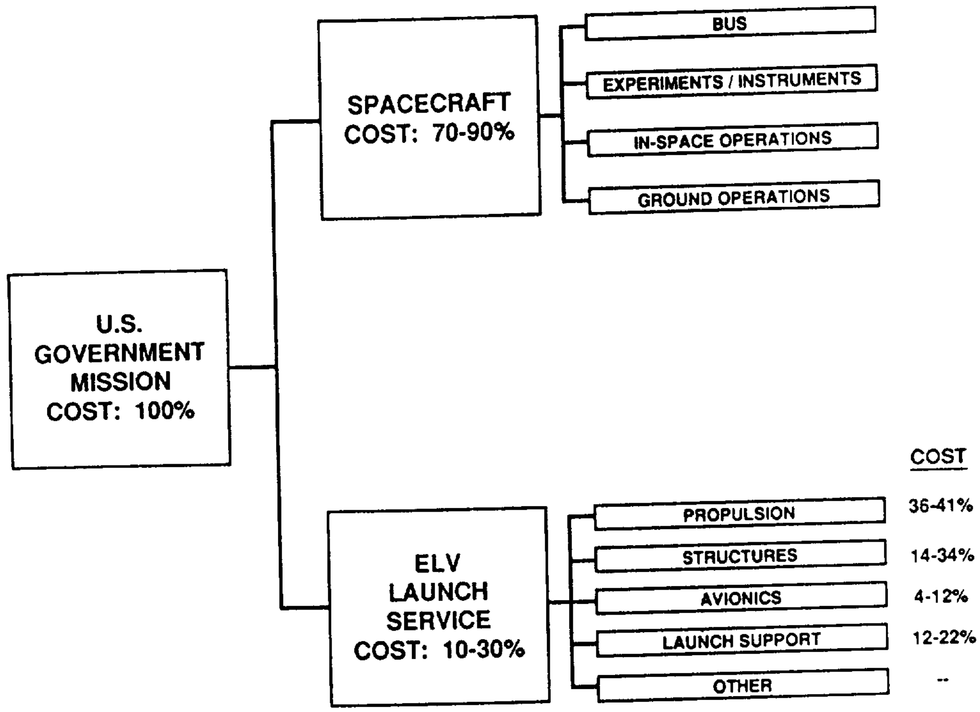
TITAN IV - RECURRING COST
(4 FLIGHTS / YEAR)



ENGINE COSTS

ENGINE	THRUST K LBS	PROPELLANTS	COST, FY 1990$
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_2O_4	\$4 - 5M - Each (Quantity of ?)
VIKING HM-60 (ARIANE V)	250	H_2 / O_2	--

PERSPECTIVE ON MISSION COST

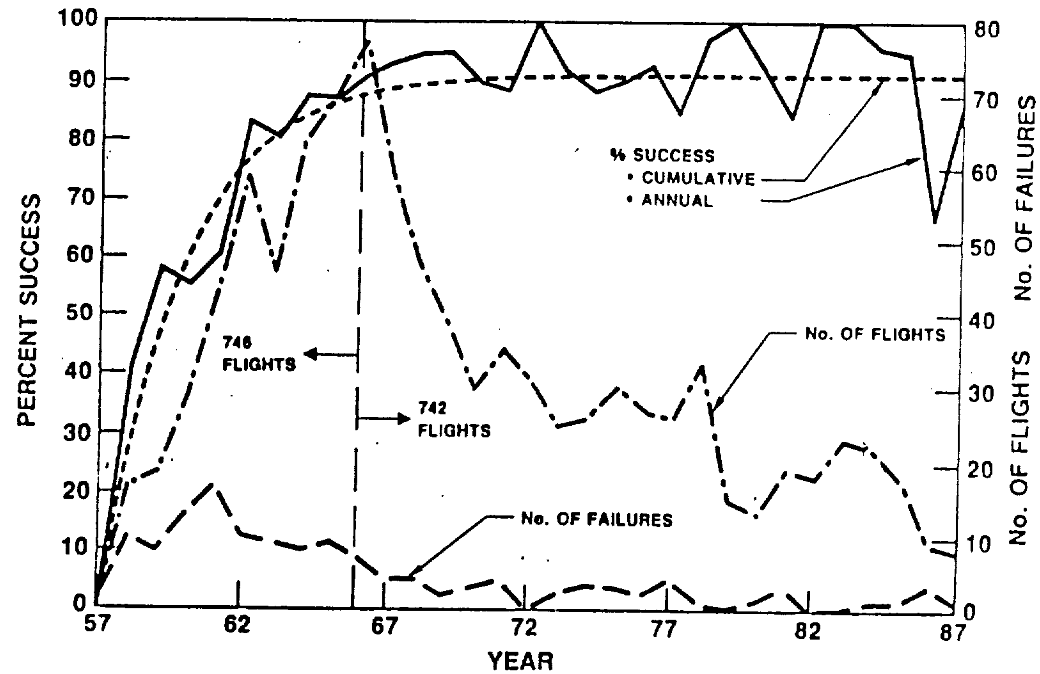


NOTE: U.S. GOVERNMENT MISSIONS ON MEDIUM & LARGE PERFORMANCE CLASS ELV's (e.g., DELTA II AND LARGER)

HIGHER MISSION SUCCESS

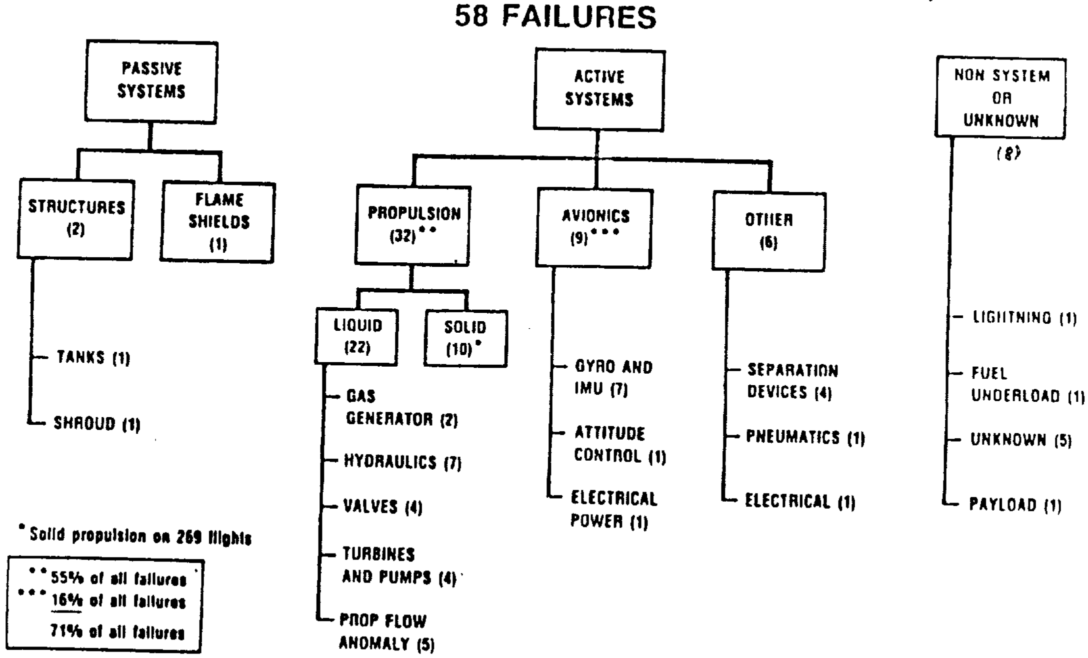
U.S. Launches, 1957–1987

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

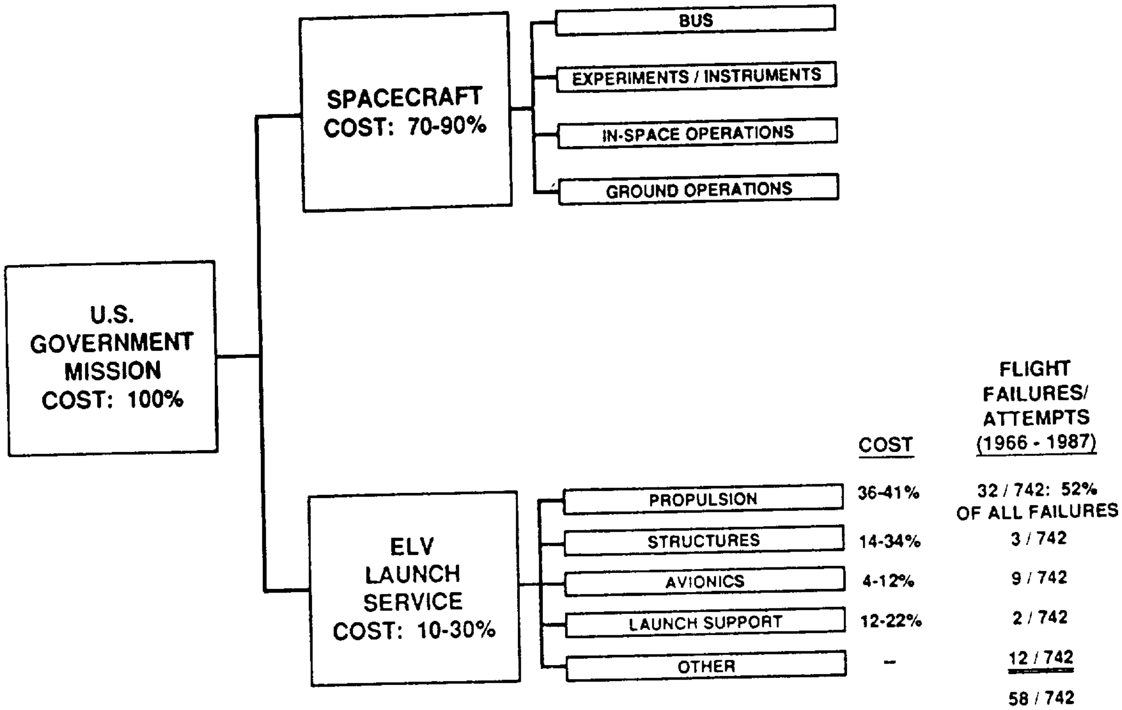


Subsystem Sources of Failure

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 H_2 / O_2 ENGINE
- U.S. GOVERNMENT TO CONDUCT TEST FIRE DEMONSTRATION

LOW COST ENGINE DEMONSTRATION

- TO BUILD A 250K LB THRUST H_2 / O_2 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**

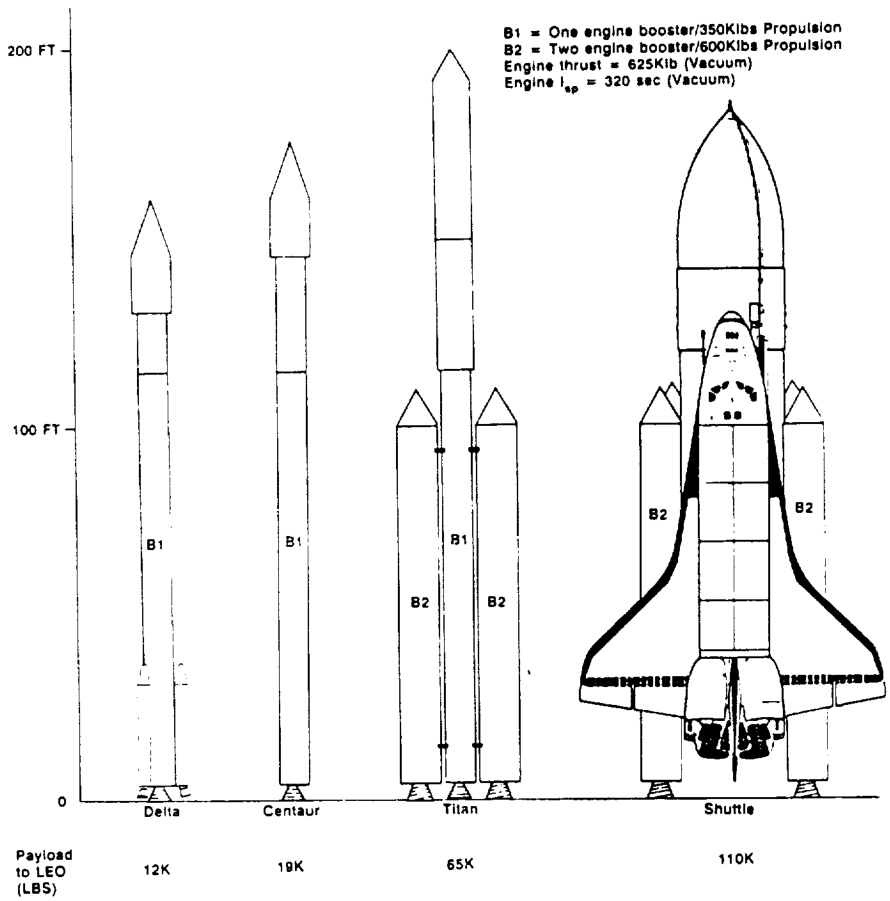
    RESULT - **HARD FACTS ON PITFALLS TO AVOID IN LOW COST ENGINE - HOW TO DO IT RIGHT**

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