N93-22084

3.0 MANNED EARTH-TO-ORBIT SYSTEMS

3.1 Advanced Manned Launch System – Theodore A. Talay, Langley Research Center

Several alternatives exist for the development of the next manned launch system. The Advanced Manned Launch System (AMLS), which represents a clean-sheet replacement for the Space Shuttle, faces competition from concepts such as (1) the Personnel Launch System, which would serve as a personnel transport to complement the Space Shuttle, and (2) an advanced version of the existing Space Shuttle. An AMLS system could begin operations sometime between 2005 and 2020, depending upon the level of national interest and support. It would probably demonstrate a payload capacity less than that of the Space Shuttle, although performance specifications are far from certain. Even the form of the AMLS is still under discussion. Design studies have considered a wide variety of options including all levels of hardware reusability; single-, dual- and multiple-staging; and airbreathing vs. rocket propulsion. An evaluation of the relative cost-effectiveness of these options is impossible without guidance regarding basic mission requirements such as total number of launches over the system's life cycle and the date required. The availability of more advanced technologies will enable single-stage-to-orbit (SSTO) designs that are in general not feasible using current technology.

Alternative AMLS design concepts vary in terms of performance, risk and operational factors. Airbreathing systems minimize the substantial launch pad investments associated with rocket systems, but they also introduce more stringent requirements in thermal protection, landing gear and air data.

LaRC AMLS studies indicate that:

- A near-term AMLS, operational circa 2005, should rely on a two-stage propulsion system.
- A longer-term system, operational circa 2015, could improve its performance by using a SSTO design concept.
- Additional studies of ground operations are needed to define life cycle costs and to better discriminate between air-breathing and rocket propulsion systems.
- Rocket systems maximize the performance of vehicles using payload-to-orbit as the primary figure of merit.
- Air-breathing options provide unique capabilities in terms of cruise, loiter, recall, offset launch and all-azimuth launch.

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ADVANCED MANNED LAUNCH SYSTEM

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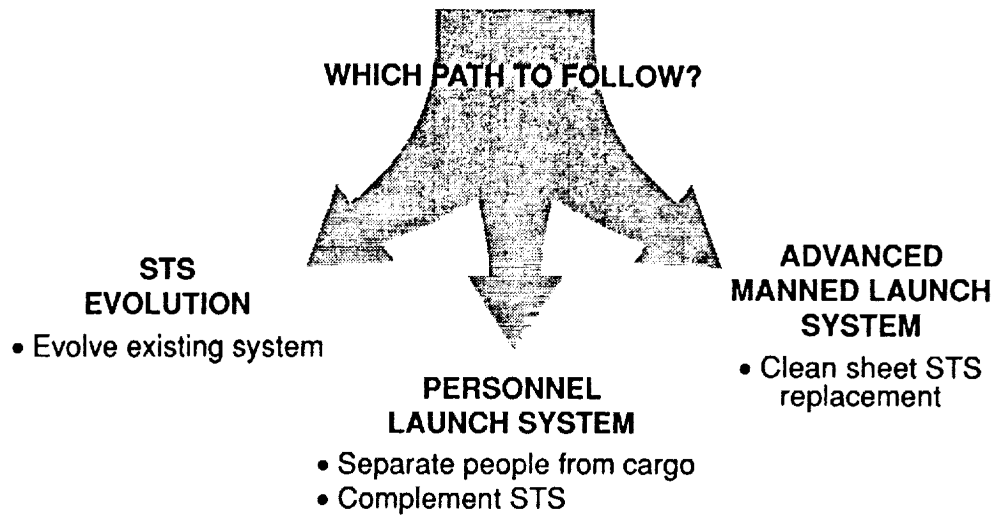
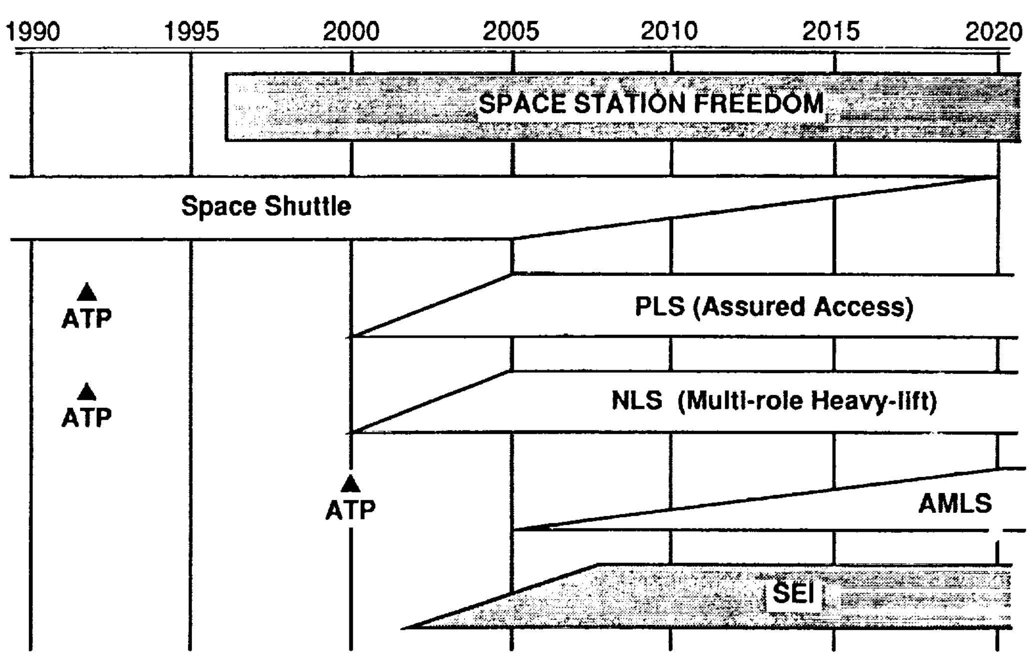
THE NEXT MANNED SPACE TRANSPORTATION SYSTEM

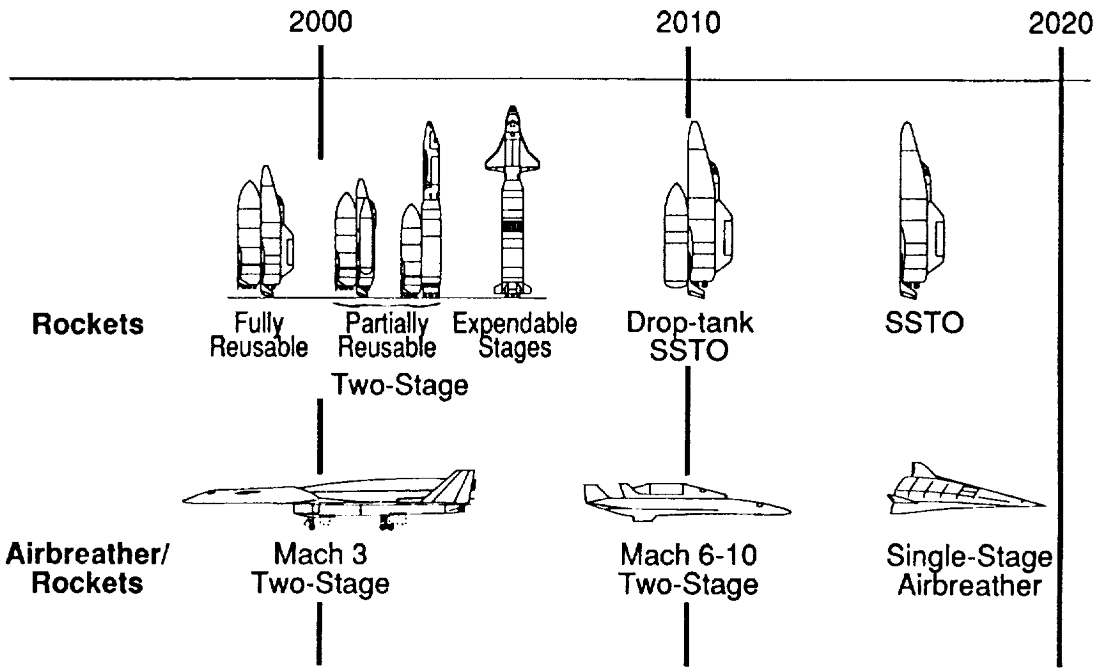
- Satisfy people/payload requirements
- Improve cost effectiveness
- Increase reliability
- Increase margins



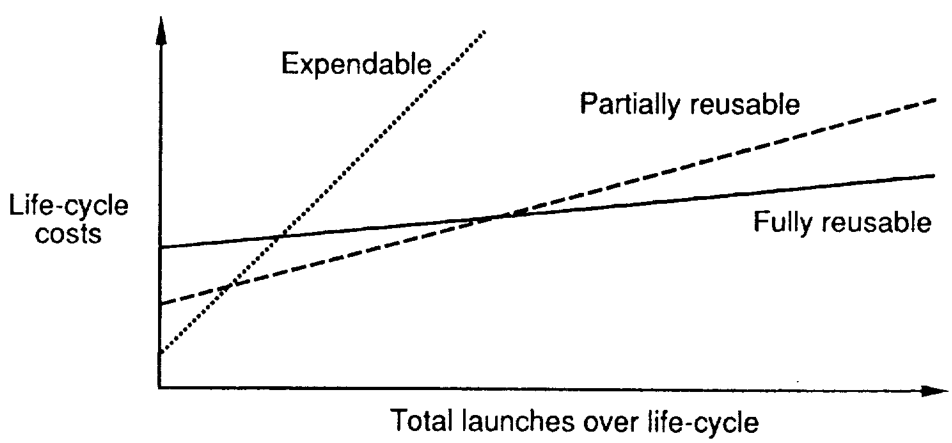
SPACE TRANSPORTATION ARCHITECTURE OPTION



POST-SHUTTLE AMLS OPTIONS STUDIES



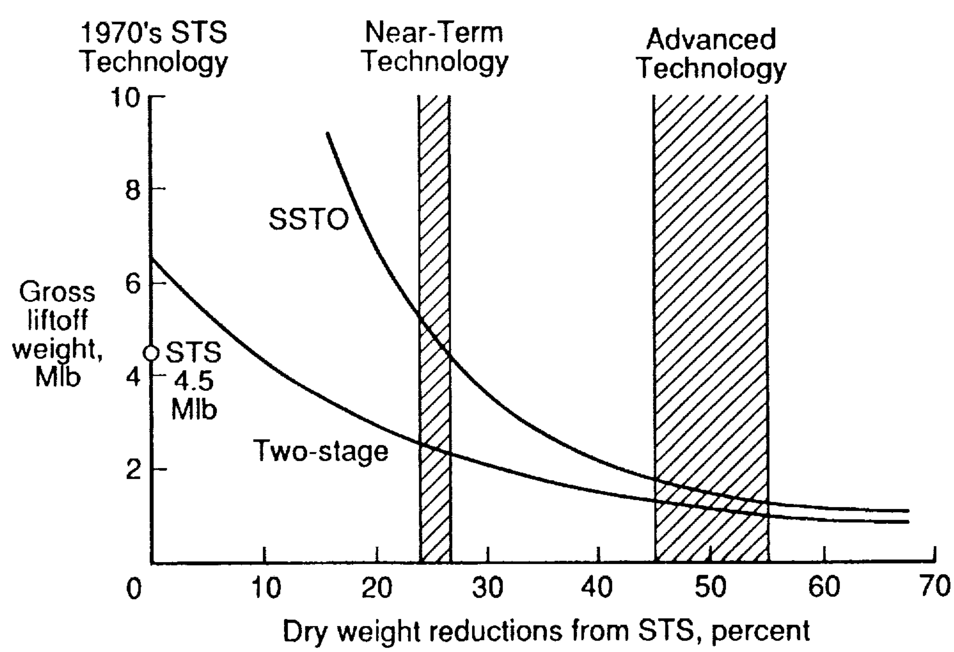
EFFECTS OF VEHICLE REUSABILITY ON LIFE-CYCLE COST TRENDS



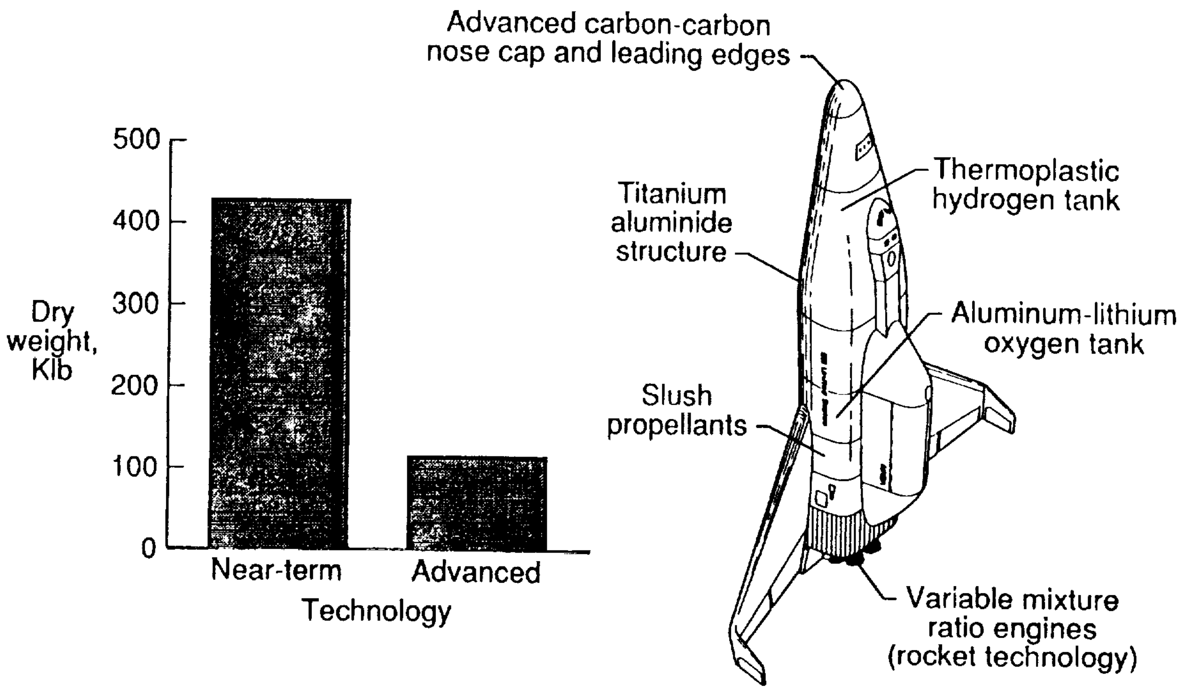
TECHNOLOGIES FOR AMLS VEHICLE OPTIONS

Key Technologies	Space Shuttle (reference)	Near-Term Technology	Advanced Technology
Structures	• Al structures • Al tanks • Limited composites • Ceramic TPS	• Composite structures • Reusable Al-Li tanks • Durable metallic or ceramic TPS	• Ti-Al composite structures and TPS • Reusable thermoplastic hydrogen tanks • Reusable Al-Li oxygen tanks
Propulsion	• SSME	• Lightweight SSME derivative • Turbojet/ramjet • ATR	• Extra lightweight SSME derivative • Variable mixture ratio rocket • Turborocket, ramjet, scramjet propulsion
Subsystems	• Hydraulic power • Monoprop APU • Hypergolic OMS/RCS • Fuel cells	• Electromechanical actuators • All-electric • Lightweight fuel cells, batteries • Cryogenic/gaseous OMS/RCS • Fault-tolerant/self check	• Lightweight subsystems using advanced materials • Actively cooled or carbon-carbon inlets and nozzles

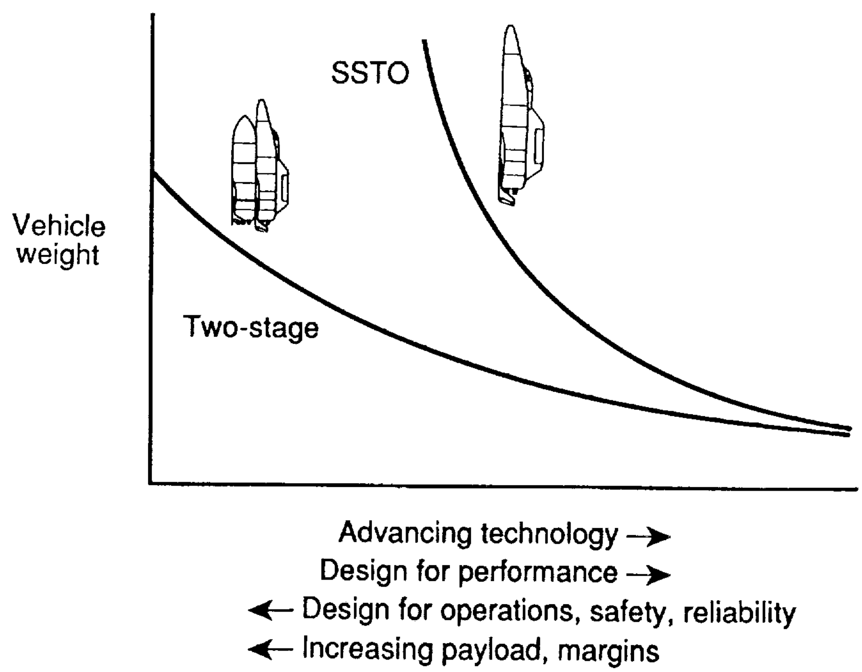
TECHNOLOGY EFFECT ON ROCKET LAUNCH VEHICLE WEIGHT



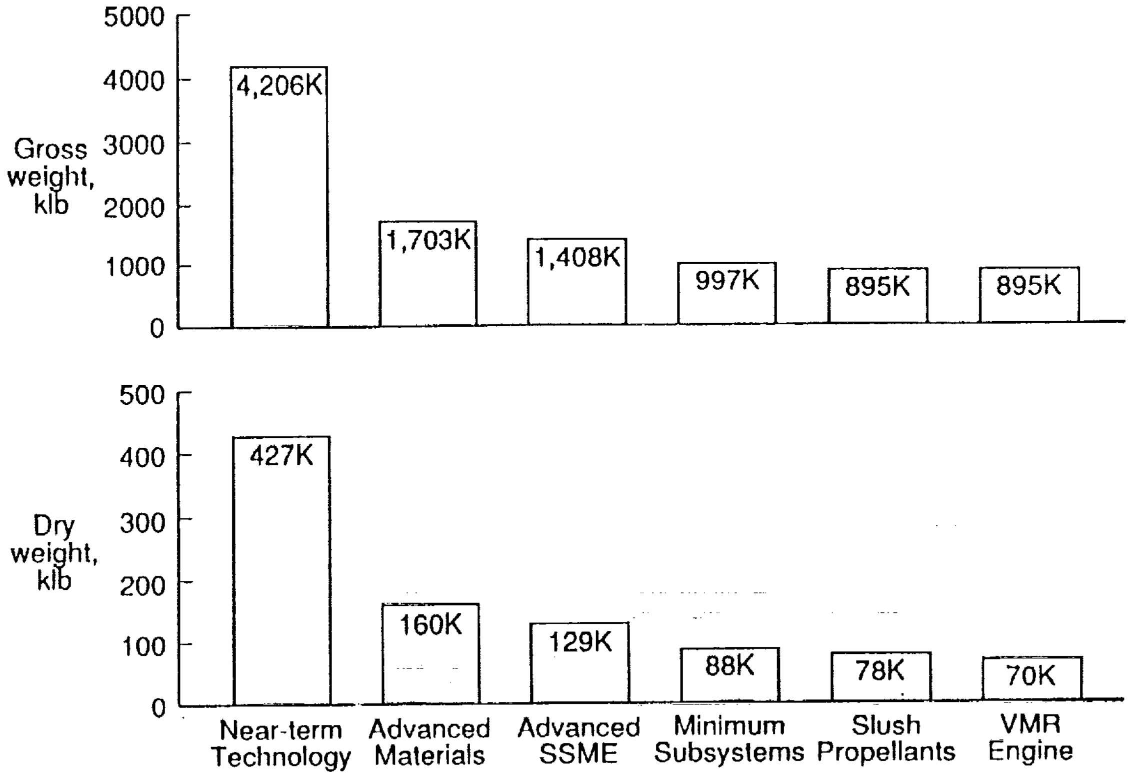
NASP MATERIAL AND STRUCTURE TECHNOLOGY BENEFITS FOR ROCKET SSTO



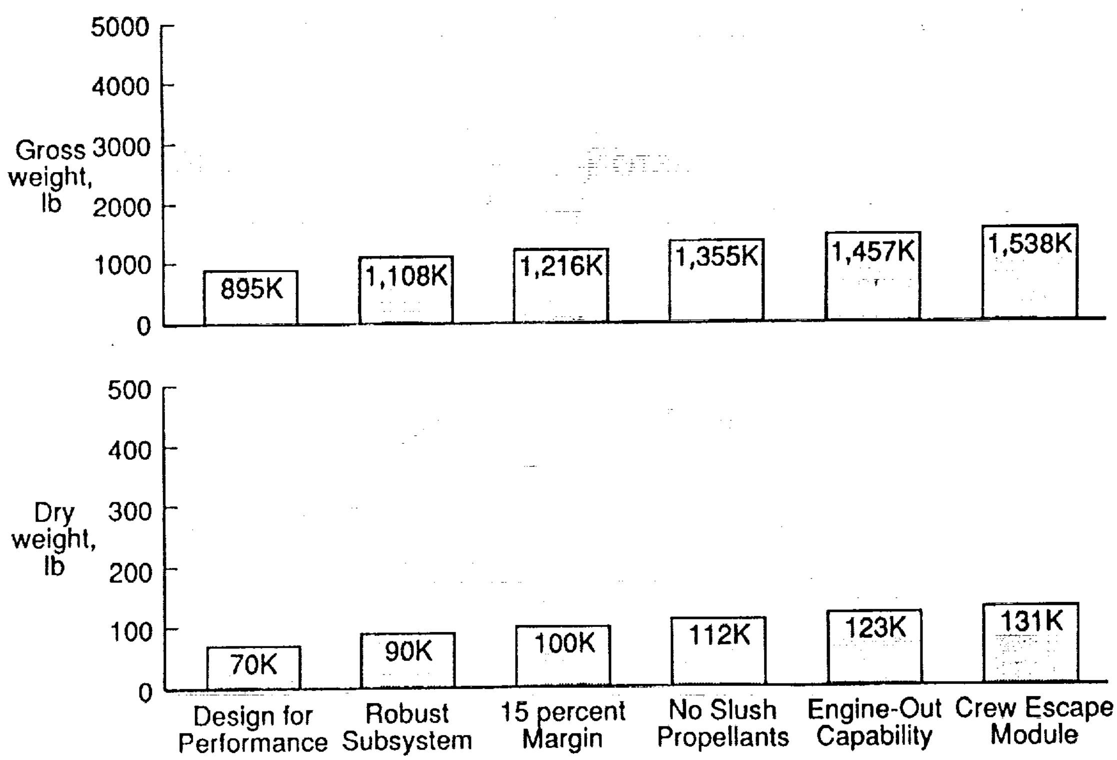
FACTORS INFLUENCING ROCKET VEHICLE SIZING



DESIGN FOR PERFORMANCE ROCKET SSTO VEHICLE



DESIGN FOR OPERATIONS ROCKET SSTO VEHICLE



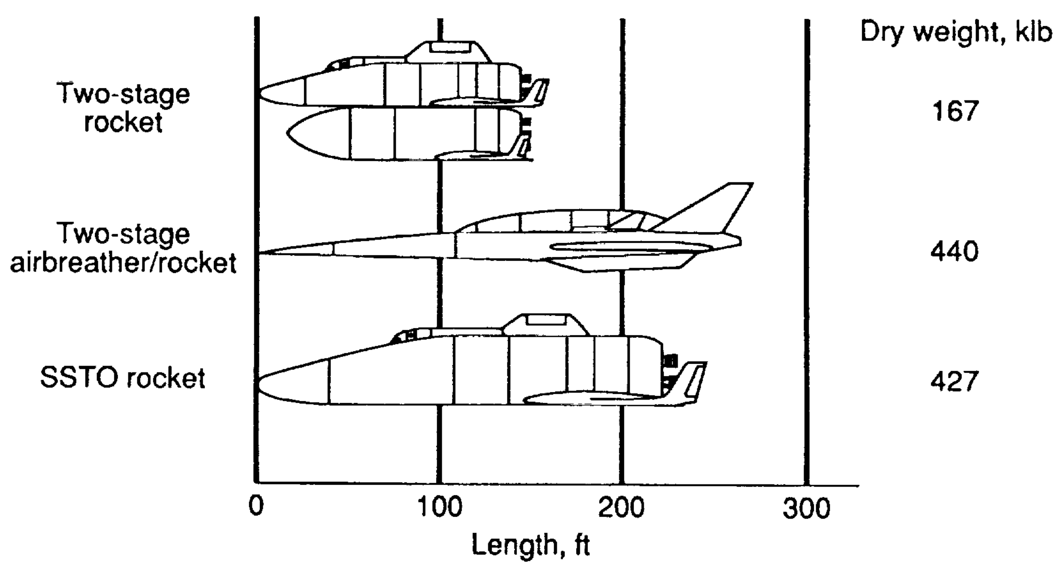
AMLS DESIGN COMPARISONS

- Design to same mission requirements and technology levels
- Compare rocket vs. airbreather systems
- Compare single-stage vs. two-stage systems

Near-term Technology	Advanced Technology
• Rocket two-stage	• Rocket two-stage
• Air-breather/rocket two-stage	• Airbreather/rocket two-stage
• Rocket single-stage	• Rocket single stage (SSME-derived)
	• Rocket single stage (VMR)
	• Airbreather/rocket single stage (ATR)
	• Airbreather/rocket single stage (SCRAM)

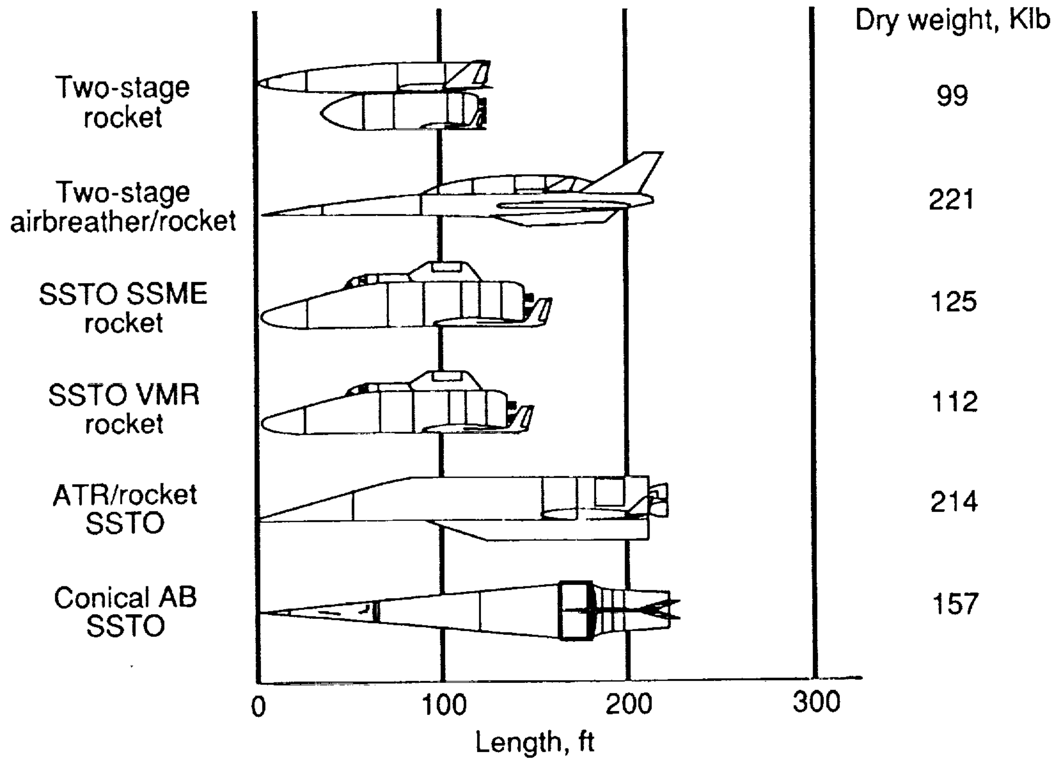
NEAR-TERM TECHNOLOGY AMLS

10K POLAR MISSION

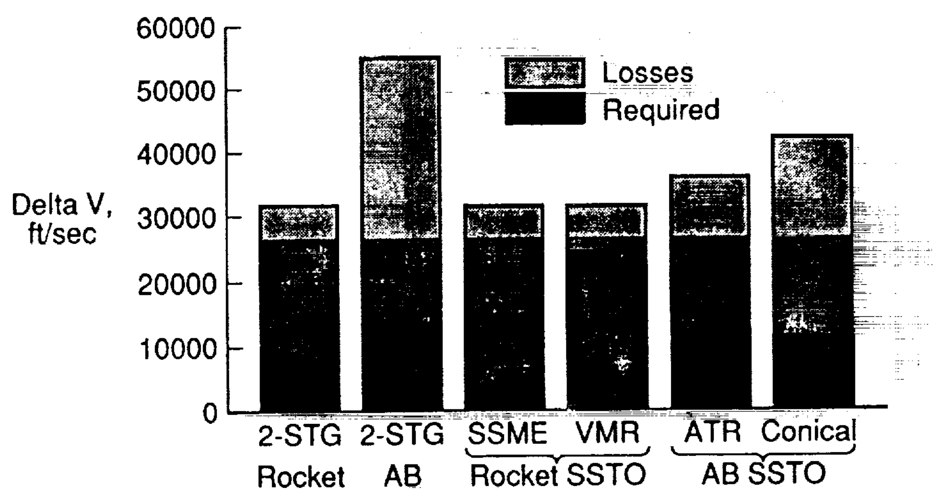


ADVANCED TECHNOLOGY AMLS

10K POLAR MISSION



TOTAL IDEAL VELOCITY REQUIRED TO REACH ORBIT

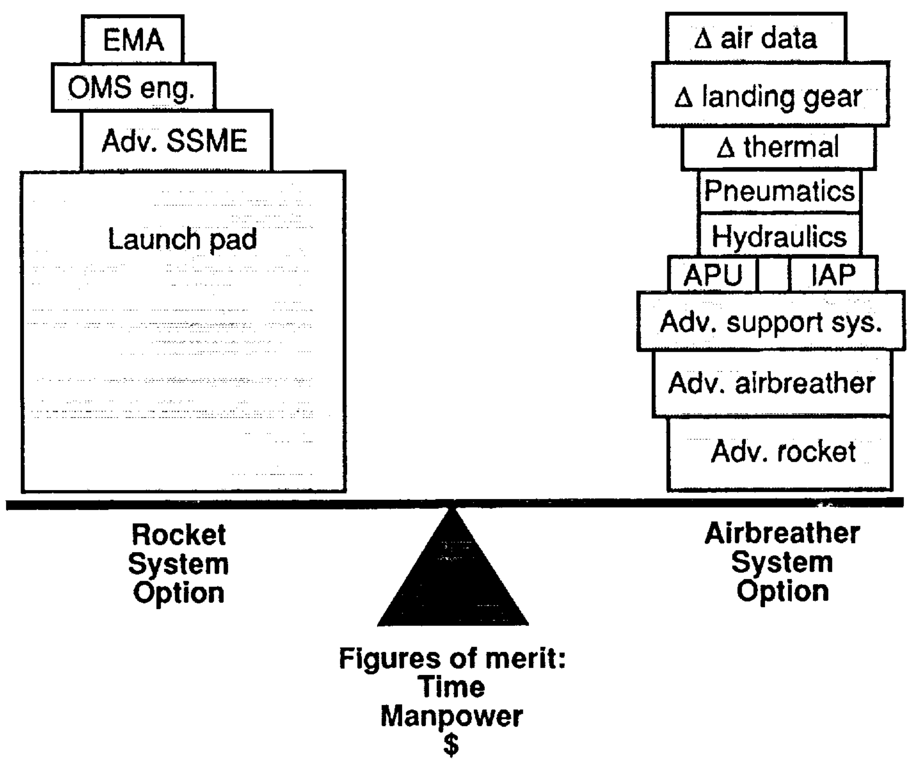


RELATIVE PROPELLANT COSTS

Hydrogen costs = 20 x Oxygen costs

Technology level	Vehicle	Oxygen (liquid or triple point), Klb	Hydrogen (liquid or slush), Klb	Ratio of propellant costs to baseline rockets
Near term	Two-stage rocket	932	155	1.00
	Two-stage AB	53	548	2.73
Advanced	Two-stage rocket	598	100	1.00
	Two-stage AB	237	179	1.47
	SSME-SSTO	1024	171	1.00
	VMR-SSTO	1059	126	0.81
	ATR-SSTO	638	192	1.01
	Conical AB SSTO	0	452	2.03

OPERATIONS TRADE



KEY FINDINGS OF LaRC STUDIES

- IOC/technology levels crucial to vehicle options
  - IOC 2005 (near-term technology) – two-stage systems
  - IOC 2015 (advanced technology) – SSTO
- Ground operations (a key to life-cycle cost) require detailed system and facility trades to discriminate between rocket and air-breathing options
- Missions and flight operations may be discriminator
  - Rocket options best for payload-to-orbit accelerator missions (lowest dry weight two-stage and SSTO systems indicative of lowest DDT&E costs)
  - Air-breathing options provide unique capabilities
    - Offset launch } Selectable orbital elements
    - All-azimuth launch } Selectable orbital elements
    - Cruise capability
    - Loiter
    - Recall