2.0 EARTH-TO-ORBIT CARGO SYSTEMS

The Earth-to-Orbit Cargo Systems session featured the following presentations:

- *Cargo Vehicle Architecture Options* by Mr. R. Eugene Austin of Marshall Space Flight Center
- *NLS Structures and Materials* by Dr. Jack O. Bunting of Martin Marietta

The Manned Earth-to-Orbit Cargo Systems session featured the following presentations:

- *Advanced Manned Launch System* by Dr. Theodore A. Talay of Langley Research Center
- *Advanced Crew Rescue Vehicle / Personnel Launch System (ACRV/PLS)* by Mr. Jerry Craig of Johnson Space Center
- *Single Stage to Orbit/SDIO* by Mr. James R. French of the Strategic Defense Initiative Organization
- *National Aero-Space Plane (NASP) Airframe Structures and Materials Overview* by Dr. Terence Ronald of the NASP Joint Project Office (JPO)

The Manned Transfer Vehicles session featured the following presentations:

- *Lunar Transfer Vehicle Studies* by Mr. Joseph Keeley of Martin Marietta
- *Mars Transfer Vehicle Studies* by Mr. Gordon Woodcock of Boeing
- *Aerobreaking Technology Studies* by Mr. Charles H. Eldred of Langley Research Center

The Advanced Propulsion session featured the following presentations:

- *Earth-to-Orbit Propulsion R&T Program Overview* by Mr. Steven J. Gentz of Marshall Space Flight Center
- *Advanced Rocket Propulsion* by Mr. Chuck O'Brien of Aerojet
- *Space Propulsion* by Mr. John Kazaroff of Lewis Research Center
- *Nuclear Concepts/Propulsion* by Mr. Thomas Miller of Lewis Research Center
- *Solid Rocket Motors* by Dr. Ronn Carpenter of Thiokol Corporation
- *Combined Cycle Propulsion* by Dr. Terence Ronald of NASP JPO

N93-22082

2.1 Cargo Vehicle Architecture Options - R. Eugene Austin, Marshall Space Flight Center

Many alternatives exist for evolving 300-600 klb. thrust Mars exploration-class launch vehicles. Three options of interest, which all baseline a National Launch System (NLS) common core with a diameter sized to match the Space Shuttle external tank (ET), differ primarily in the choice of strap-on boosters that would be used to increase the payload capacity of upgraded versions of the launch vehicle[1] .

- Option 1: Four advanced solid rocket motors (ASRM's)
- Option 2: Four LO_2/LH_2 ET boosters
- Option 3: Four LO_2/RP (kerosene) boosters

[1] NASA's cargo vehicle program has continued to evolve since the workshop. The effort to develop Option 1 has been cancelled.

Successful development of a NLS that can satisfy evolutionary requirements for future launch vehicles will require overcoming challenges in several different areas. Innovative component and system designs are needed to allow future vehicles to take full advantage of advances in the state of the art for materials and structures. New materials such as advanced composites and aluminum-lithium (Al-Li) alloys as well as improved thermal protection systems will reduce launch vehicle mass, improve manufacturability, and enhance the ability of system designers to satisfy mission requirements in terms of thrust-to-weight ratios, reliability, margins, shroud size and cost. For example, both pressurized and unpressurized structures fabricated using graphite-epoxy composites would weigh less than similar structures built with Al-Li, and Al-Li structures would weigh less than aluminum structures. The performance of metal matrix composites (MMC's), however, is not yet well-defined, and MMC's cannot be compared reliably with other structural materials.

The design of a particular structure varies widely according to material choice. Optimum performance is only possible if component designs are tailored to take advantage of a given material's strengths and to minimize the impact of its shortcomings. Additional investigations are necessary to determine if new materials are fully compatible with the environment associated with projected applications. For example, Al-Li 2090 may not be compatible with certain rocket fuels.

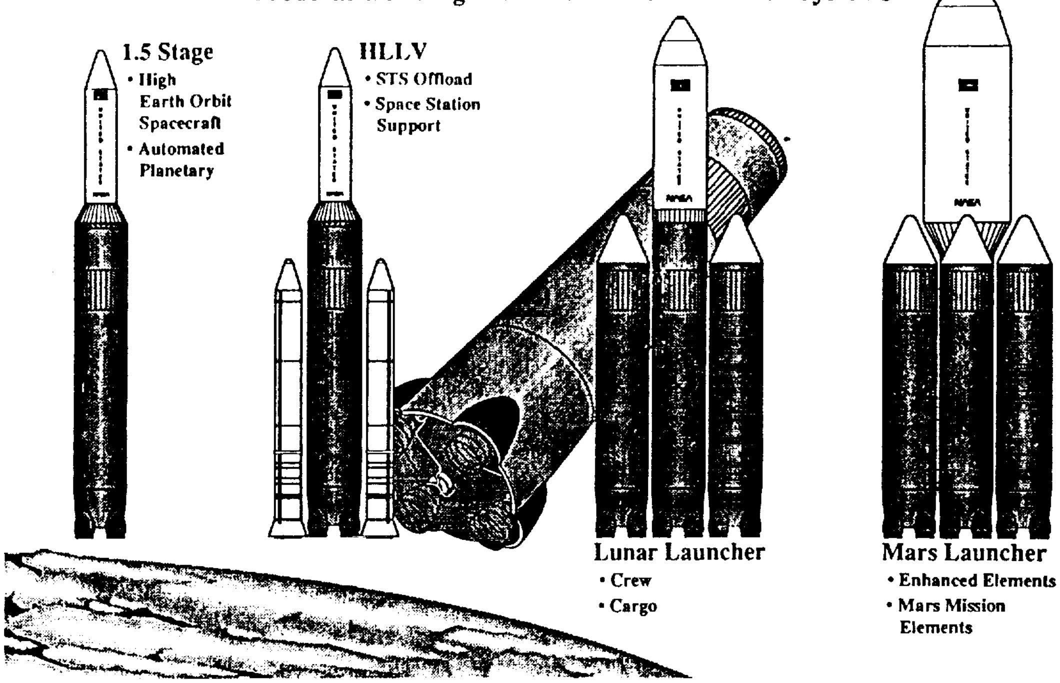
A comparison of comparable manufacturing and design processes associated with aluminum and Al-Li reveals that system costs are driven much more by structural weight and launch costs than by the cost of the raw materials. When using Al-Li, which brings bulk costs that are three times higher than those of aluminum, system costs are reduced by selecting a manufacturing process such as integral machining that minimizes the final weight of a given structure, even though it may increase raw material requirements by a factor of four because of increased machining waste.

Space Transportation Structures And Materials Technology Workshop

Cargo Vehicle Architecture Options

R.E. Austin/MSFC
September 23, 1991

"Common Core"
A Modular Building Block For National Launch Systems



Requirements

Requirements Potential

1995 - 2000	SEI Lunar (2000 - 2015)	SEI Lunar (2015 - 2020)
• Space Station Support • Unmanned Planetary • Observatories/Platforms	• Transportation Node • Propellants • MTV Systems • Surface Payloads • ~ 0.3 To 0.5 Million Pounds Per Mission	• Transportation Node • Propellants • MTV Systems • Surface Payloads • ~ Two Million Pounds Per Mission

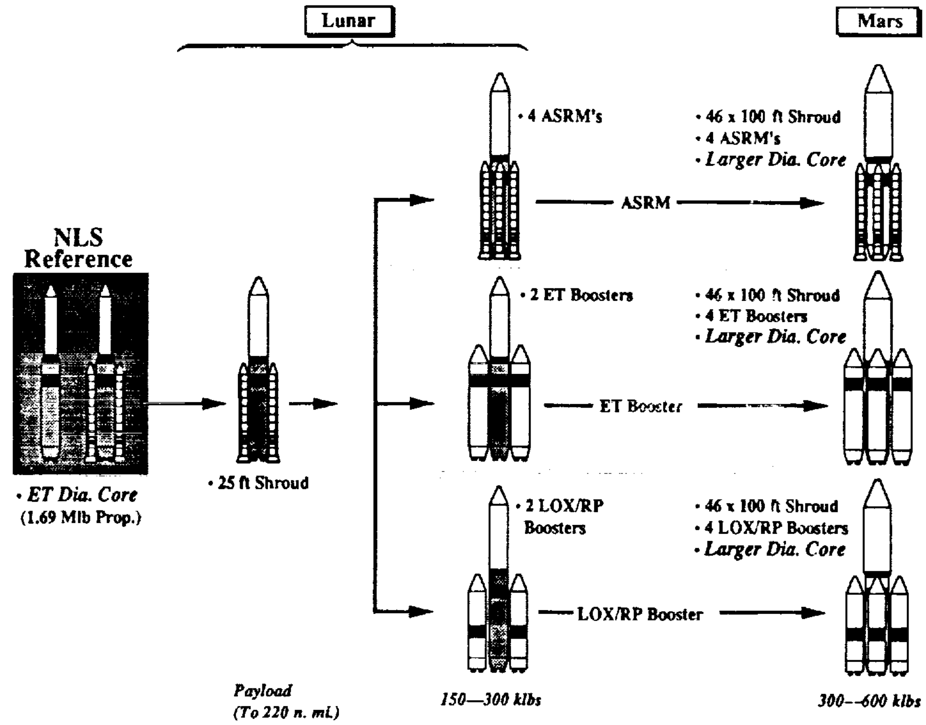
Generalized Vehicle Requirements

Size: 80 - 120 KLbs, 15 Ft. Dia.	150 - 300 KLbs, 15 - 33 Ft. Dia.	300 - 600 KLbs, 45 - 65 Ft. Dia.
Rate: 1 - 3/Year	2 - 6/Year	3 - 7/Year

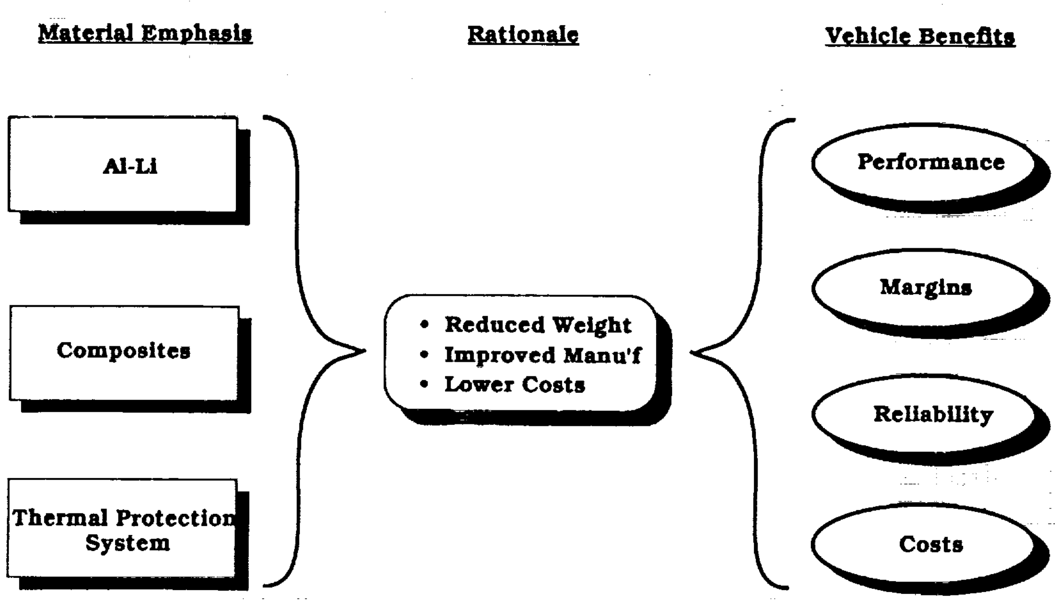
Evolution Challenges

• 1.5 Stage Performance w "Common Core"	• HLLV Performance • Shroud Size • Weight • Cost	• HLLV Performance • Shroud Size • Weight • Cost

Evolution Flow



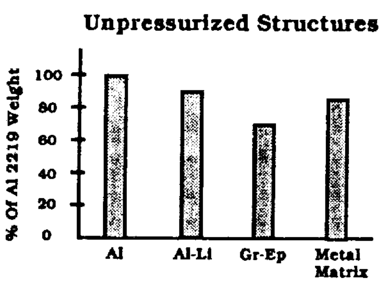
Launch Vehicle Material Emphasis

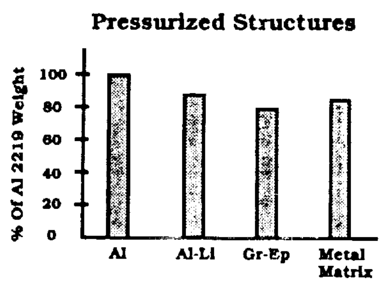


Materials Applications

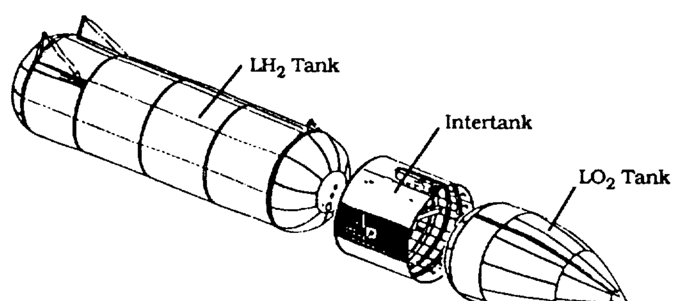
Material	Unpressurized Structures	Pressurized Structure
Al 2219	Shrouds, Skirts, Intertanks	Propellant Tanks
Al-Li	Shrouds, Skirts, Intertanks	Propellant Tanks
Gr-Ep	Shrouds, Skirts, Intertanks	Propellant Tanks w Liners
Metal Matrix	TBD	TBD

Weight Comparison





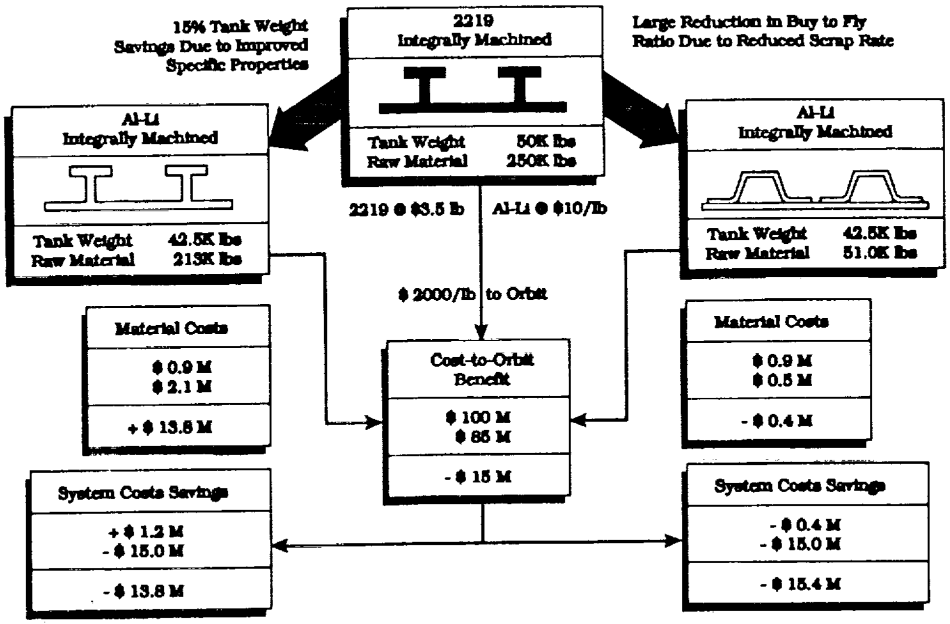
Weldalite^{TM} External Tank



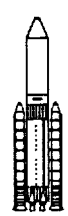
Element	LWT	Delta Weight Savings (lbs) Weldalite^{TM} Substitution	Weldalite^{TM} Resizing
LO_2 Tank	11903	438	1780
Intertank	12166	409*	936**
LH_2 Tank	27981	1003	4270
Misc.	13595	304	304
Total	65645	2154	7290

*540 Additional Pounds Saved Using 2090 Alloy
**511 Additional Pounds Saved Using 2090 Alloy

Benefits of Using Al-Li Alloys For Cryogenic Tanks

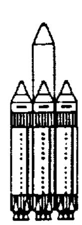


Relative Vehicle Performance



Lunar

- Al-Li Improves Payload Capability By 5%
- Gr-Epoxy Improves Payload Capability By Approximately 12%
- Metal Matrix Improves Payload Capability By Approximately 8%



Mars

- Al-Li Improves Payload Capability By 4%
- Gr-Epoxy Improves Payload Capability By Approximately 10%
- Metal Matrix Improves Payload Capability By Approximately 6%

Summary

- **Improved Vehicle Design**
  - **Margins**
  - **Reliability**

- **Cost Reduction**
  - **Improved Manufacturing**
  - **Less Scraps**

- **Reduction Of Vehicle Dry Weight By > 15%**
  - **Al-Li**
  - **Composites**
  - **TPS**