# Advanced Space Transportation Systems

## Space Station Evolution
## Beyond the Baseline 1991
## (2nd Symposium Evolution of SSF)

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**Chief, Advanced Transportation Branch**
**Advanced Program Development**
**Office of Space Flight**

# Agenda

- Heavy Lift Launch Vehicle
- Cargo Transfer Vehicle
- Space Transfer Vehicle Concepts
- Two-Way Personnel Transport
- Transportation Node Requirements
- Technology Needs

# National Space Launch Strategy

**a. The National Space Launch Strategy is composed of four elements:**

(1) Ensuring that existing space launch capabilities, including support facilities, are sufficient to meet U.S. Government manned and unmanned space launch needs.

(2) Developing a new unmanned, but man-rateable, space launch system to greatly improve national launch capability with reductions in operating costs and improvements in launch system reliability, responsiveness, and mission performance.

(3) Sustaining a vigorous space launch technology program to provide cost effective improvements to current launch systems, and to support development of advanced launch capabilities, complementary to the new launch system.

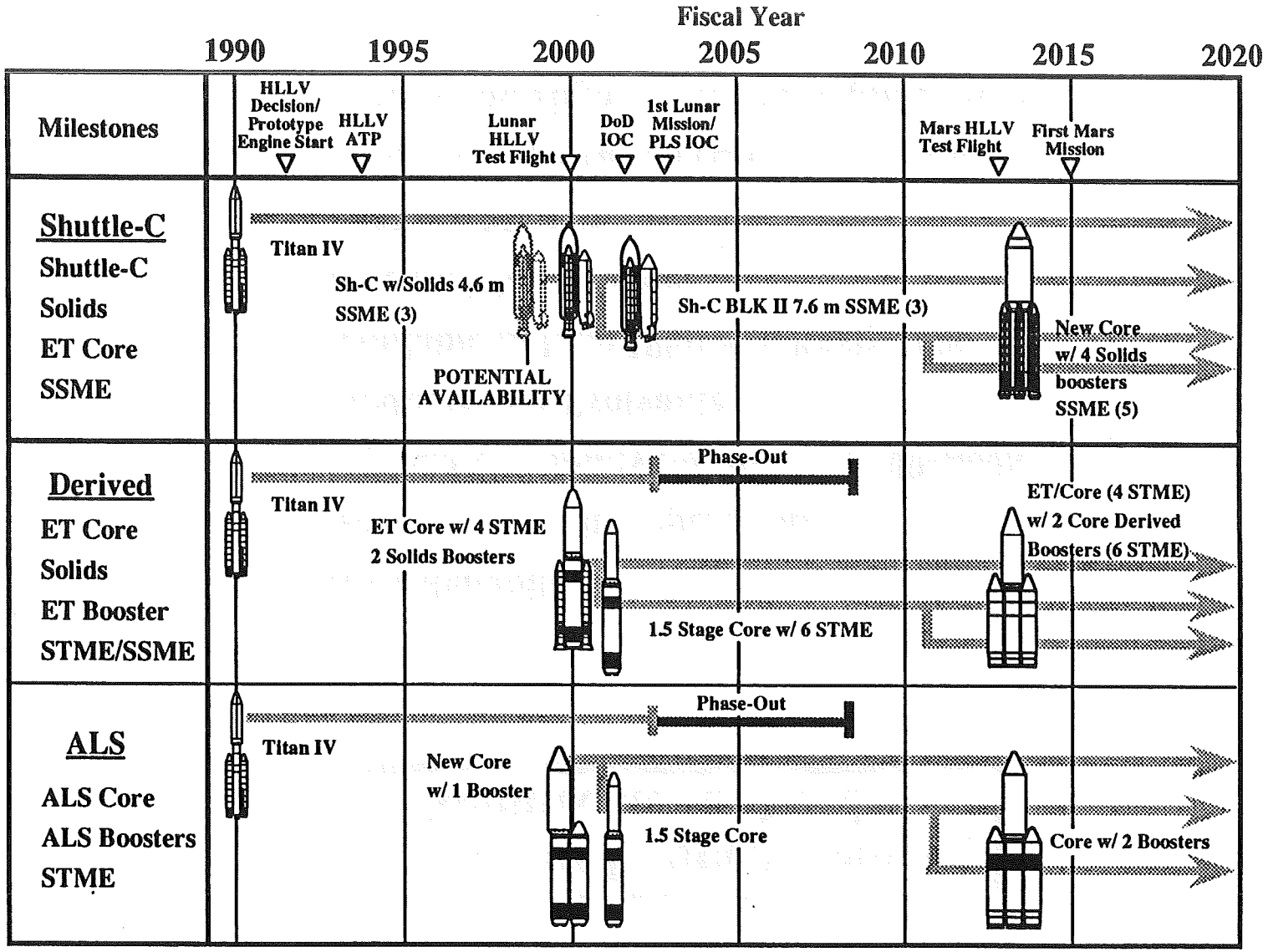
(4) Actively considering commercial space launch needs and factoring them into decisions on improvements in launch facilities and launch vehicles.

**b. These strategy elements will be implemented within the overall resource and policy guidance provided by the President.**

# Heavy Lift Launch Vehicle Requirements/Needs

- High Reliability
- Good Availability/Operability
- Payload Capability 50–80k and 100–200k
- Modular and Evolvable
- Available in Late 1990 ~ to Early 2000
- Potential Applications
  - Space Station
  - Space Exploration (Lunar and Mars)
  - Low and High Orbit DoD Applications

# Basic Heavy Lift Vehicle Options

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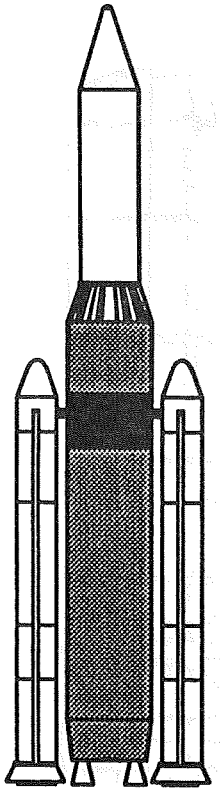
# Future Launch Vehicle Concept

## HLLV

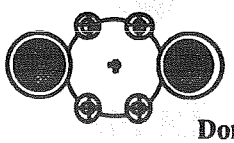


Titan IV Derived
Shroud
(STS Compatible)

Kickstage/CTV

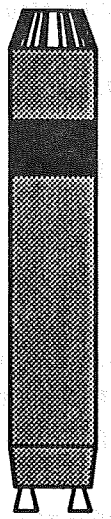
ASRM's

LC 39 Facilities



Don't Install:
- Inflight Separation Systems for 4 Outboard Engines
- Holddown Mechanisms

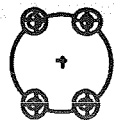
## Common Core
(ET Derived)



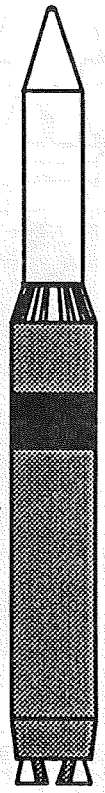
Forward Interstage
Forward Skirt
Tankage/Intertank
- Std Size/Materials
- Beefup for 1.5 Stg Application

Avionics
Thrust Structure/Propulsion System
- Inflight Separation System for 4 Outboard STME's
- Thrust Struct/Prop.Capability for 2 Center STME's

AFT Skirt
- Vehicle Holddown



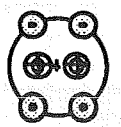
## 1.5 Stage



Titan IV Shroud

Upper Stage

LC 39 and LC 34
Facilities

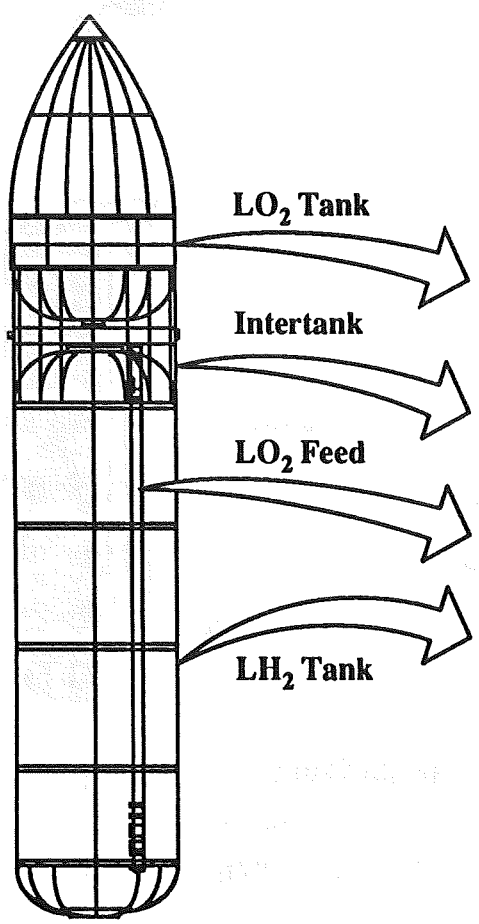


Install:
- Structure/Propulsion for 2 Center Engines
- Holddown Mechanisms

◉ Sustainer STME's ⊙ Staged STME's

# External Tank Application Potential

## Std ET




## Modifications/Changes

Add Avionics/Payload Adapter

Add Forward Skirt

Add Fwd Dome (Same as $LH_2$ Fwd Dome)
Add Barrel Section
Modify Feedline Outlet

Stiffen Panels

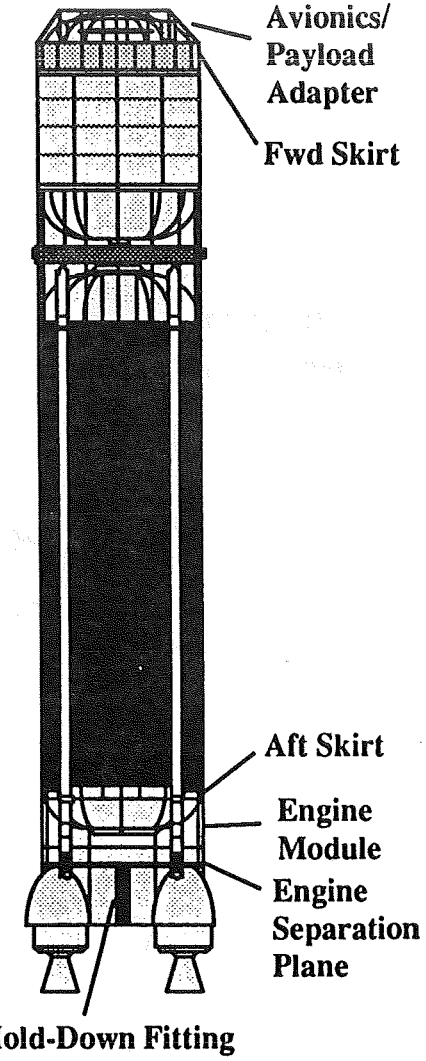
Add Feedline

Stiffen Barrels 1, 2, 3, & 4
Modify Aft Dome Frame for Engine Module Attach
Modify Feedline Outlet

Add Aft Skirt

Add Engine Module

## Common Core




1.5 Stage Driven  HLLV Driven  Applicable to Both Vehicles

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# Representative NLS Reference Vehicle Performance

| Vehicles | Payload ~ Klbs | | | |
|---|---|---|---|---|
| | SSF Mission | | 80 x 150 N.M. Orbit | |
| | Eng. Out | No Eng. Out | Eng. Out | No Eng. Out |
| | STME | STME | STME | STME |
| HLLV (2 ASRMs) | | | | |
| – Core w 3 Engines | - | 117 | - | - |
| – Core w 4 Engines | 101 | 109 | - | - |
| 1.5 Stage (6 Engines) | 14 | - | 49 | ~65 |
| 1.5 Stage (5 Engines) | - | - | - | 64 |

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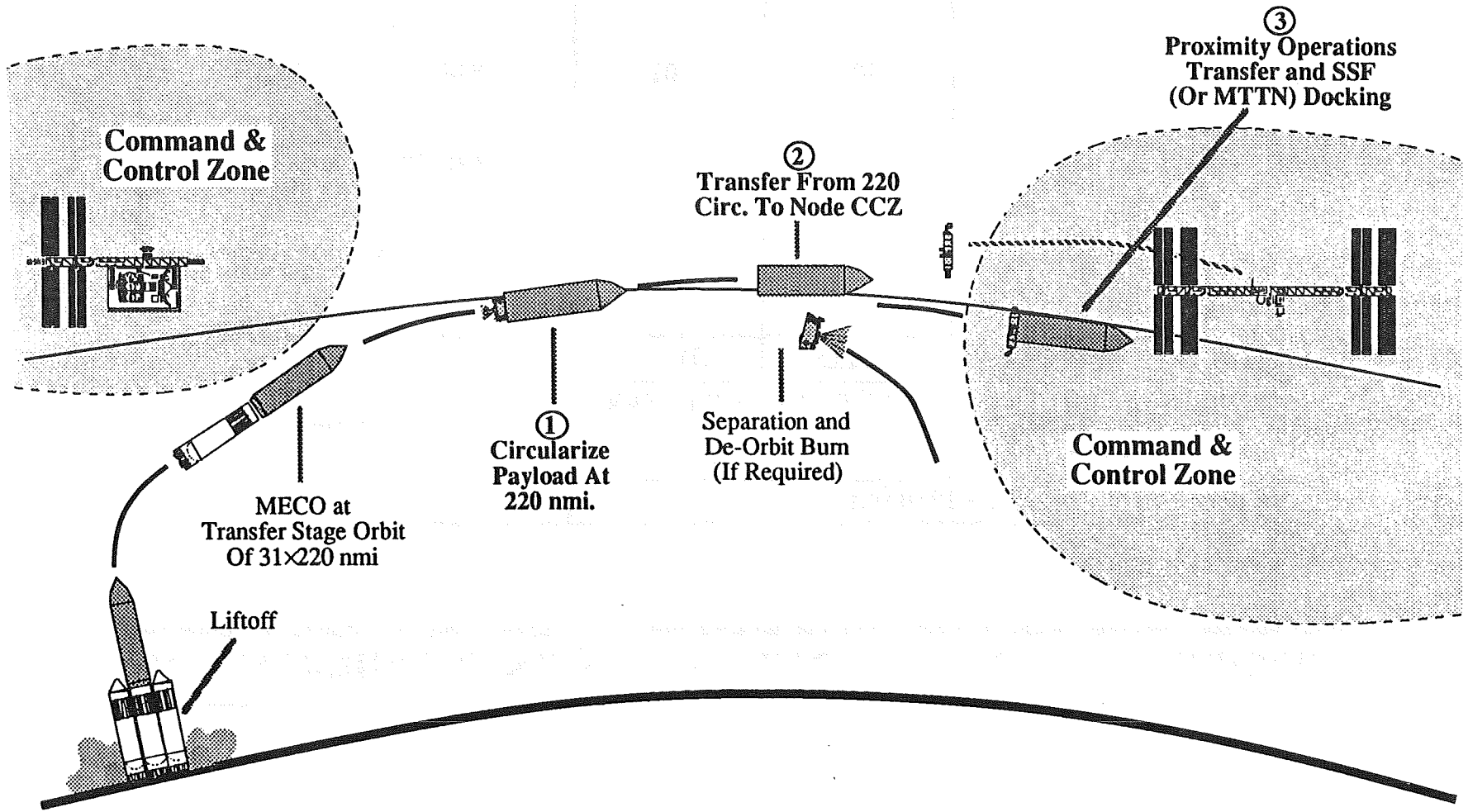
# Cargo Transfer Vehicle (CTV)

## In-LEO Transportation Functions

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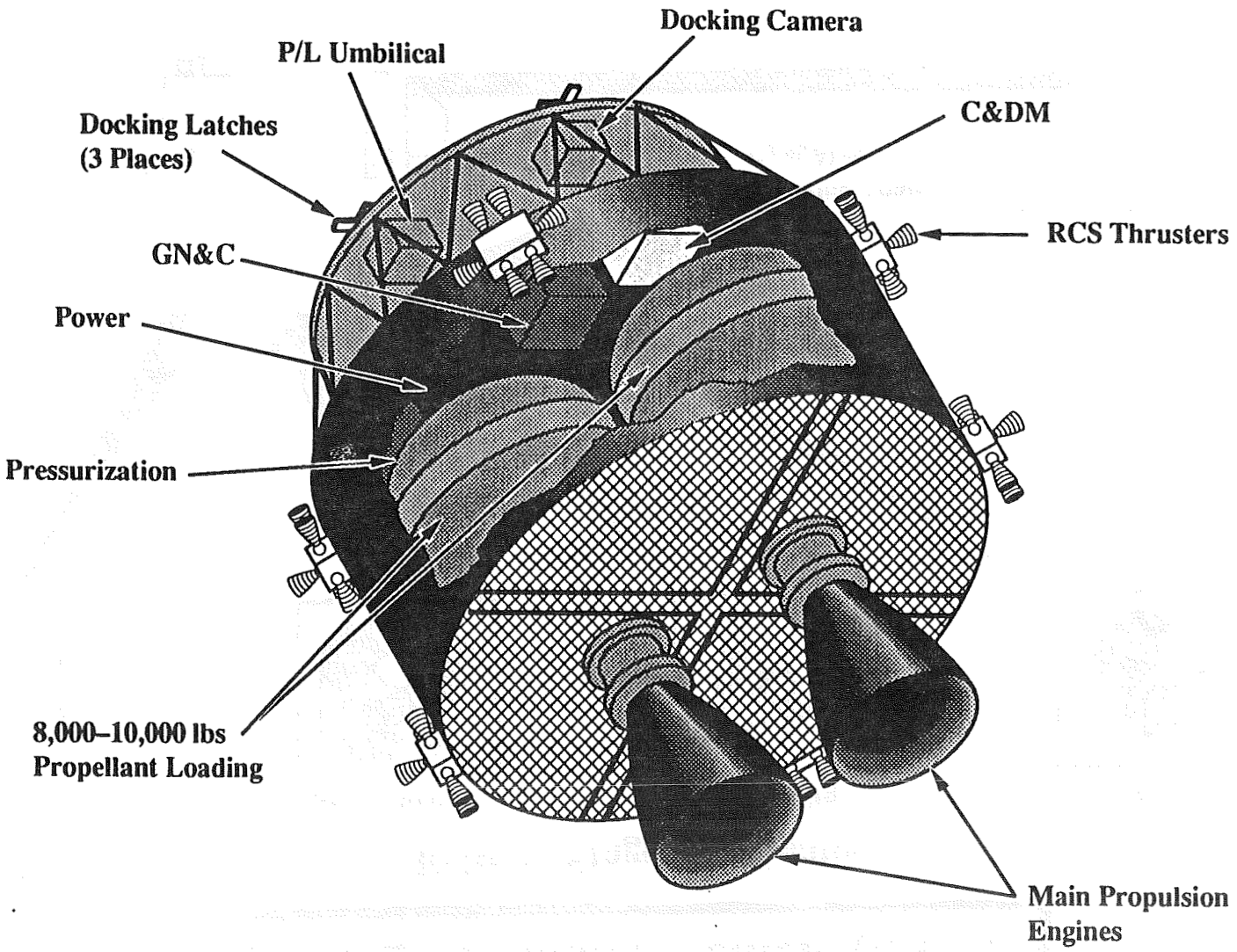
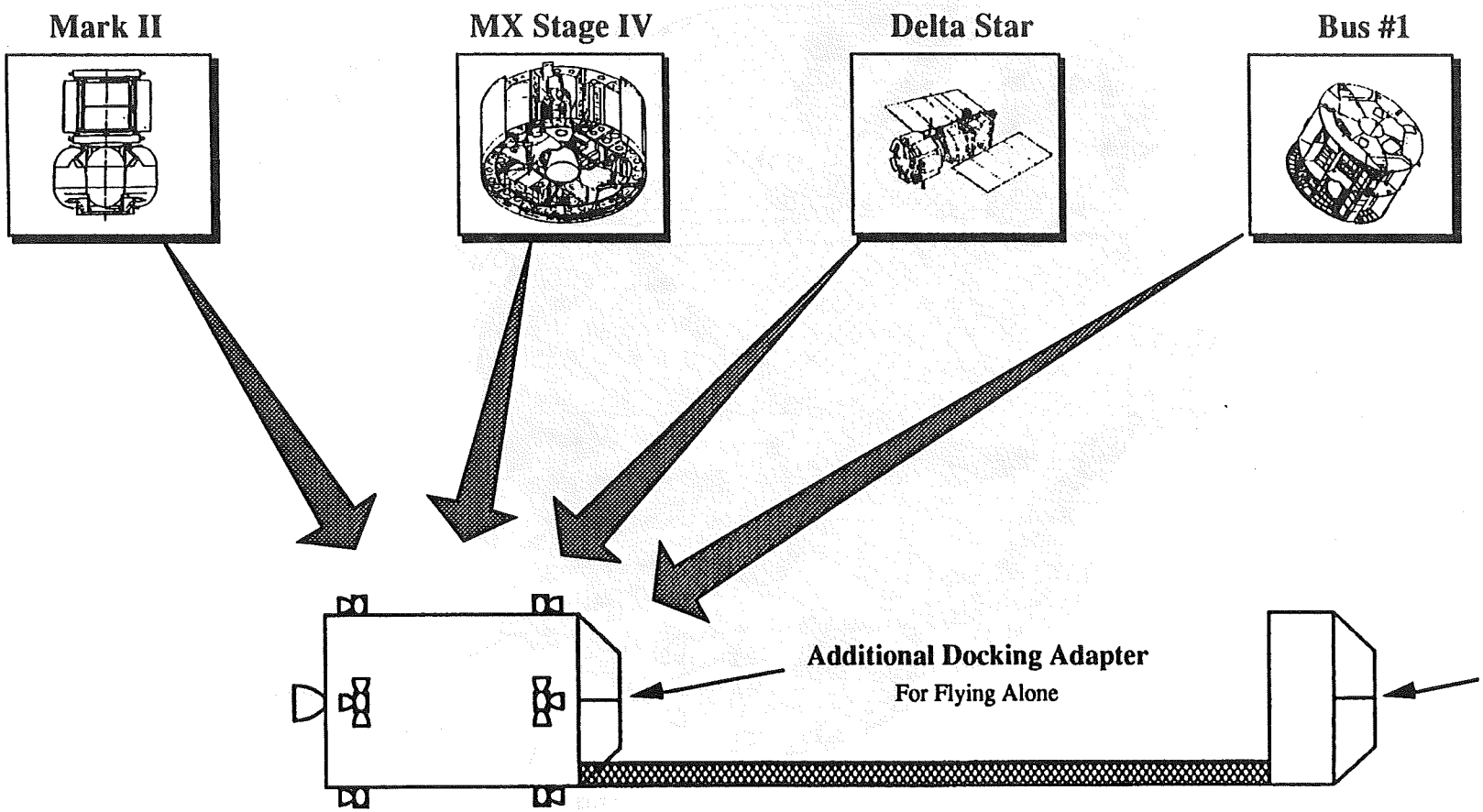
# Cargo Transfer Vehicle Concept



# Cargo Transfer Vehicle (CTV)

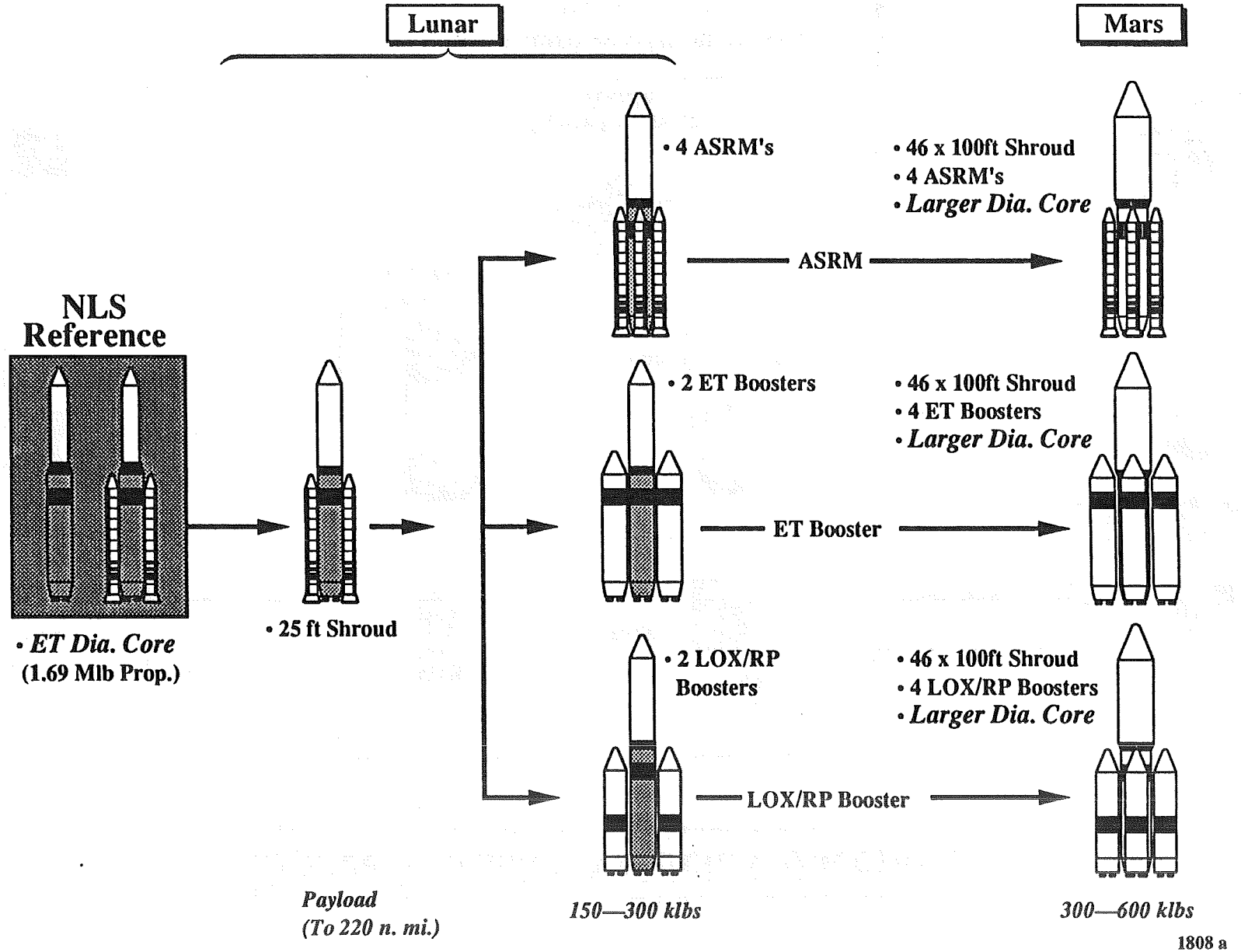
## Existing Stage Candidates




**Features**

- Performs Circularization & Phasing Burns
- Controls During Prox Ops
- Deorbits Strongback & Recovers
- Independent Return Flight to SSF
- Returns on STS

# Evolution Flow

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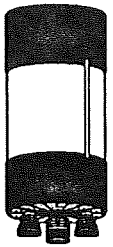
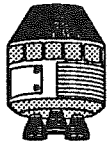
# Space Transfer Vehicle Concepts

*1.5 Stage*

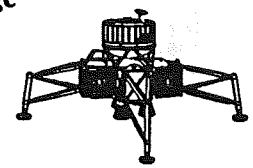
**Third Stage**



**Trans-Lunar Injection Stage**



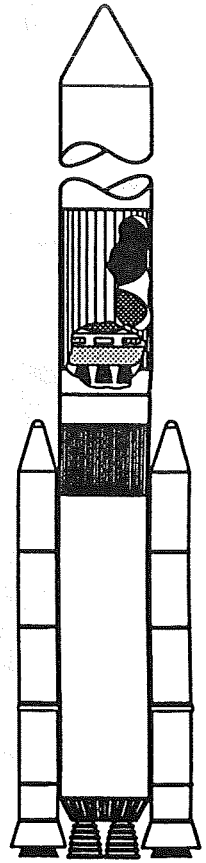
**Lunar Orbit Injection/ Trans-Earth Injection**



**Lunar Excursion Vehicle**

**Common Hardware Development**

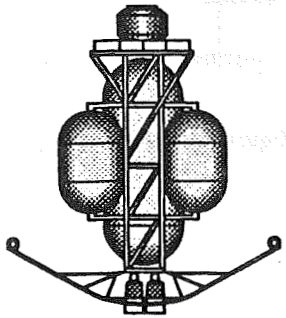
- Engines
- Avionics
- Tankage



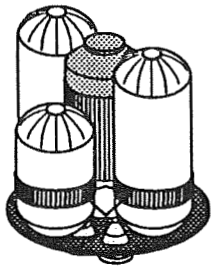
*HLLV*

# Lunar Transportation Options

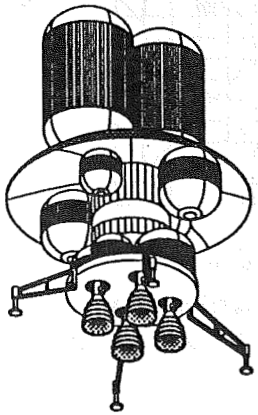
## *Lunar Transfer*



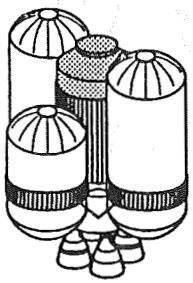
**Chemical/Aerobrake Single Stage**



**Chemical/Aerobrake 1 1/2 Stage**



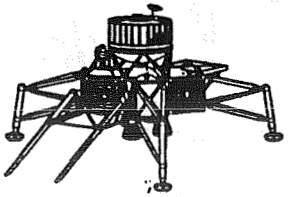
**Chemical/Aerobrake Single P/A**



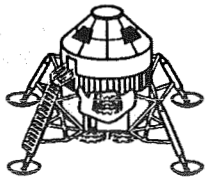
**Chemical - All Propulsive Module w/Recoverable P/A**

**Chemical - All Propulsive Expendable**

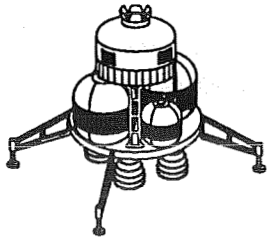
## *Lunar Lander*



**Single Stage**



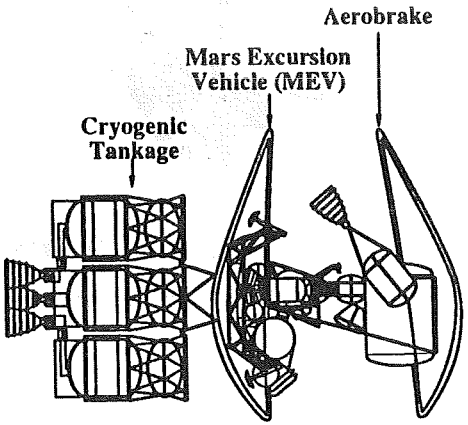
**Two Stage**



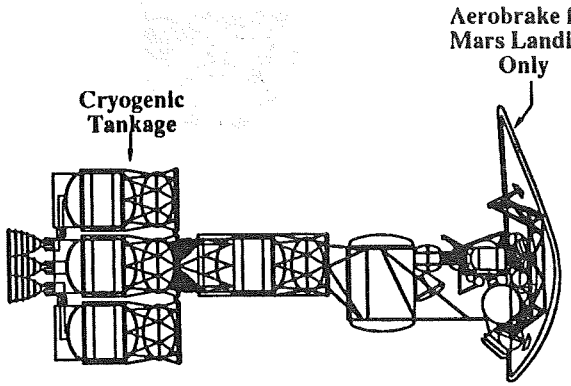
**Single P/A**

*** Not to Scale ***

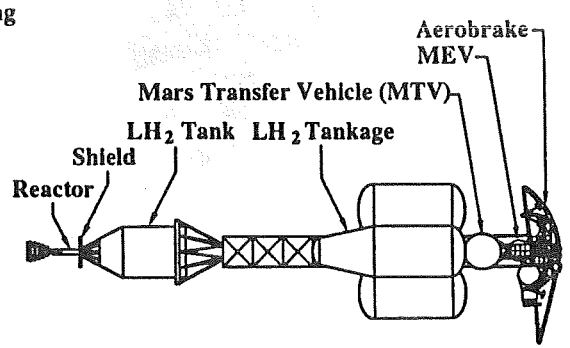
# Mars Transportation Options



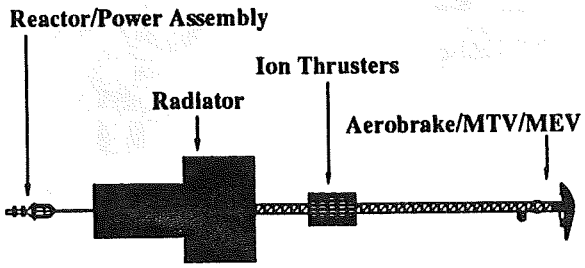

*Cryogenic/Aerobrake Reference Configuration*




*Cryogenic/All Propulsive Configuration*

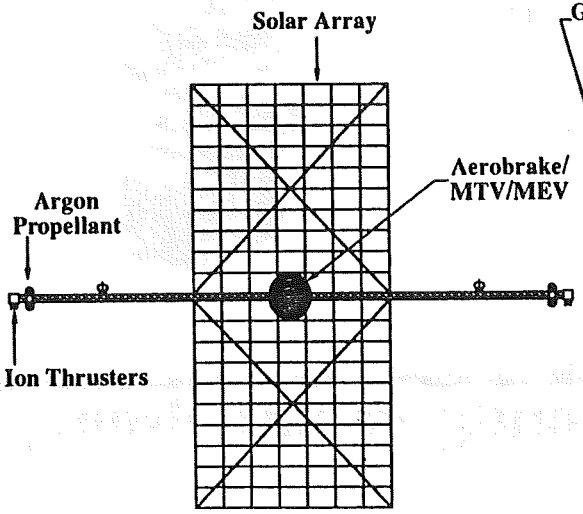


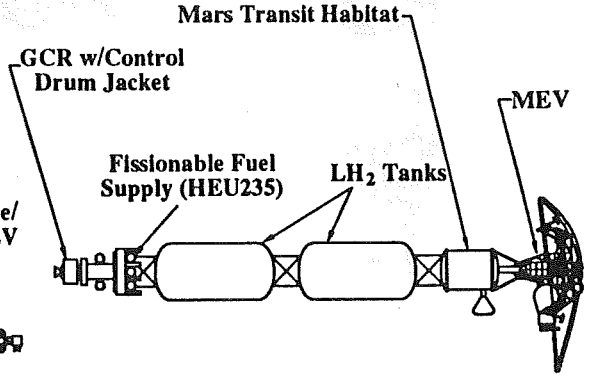

*Nuclear Thermal Propulsion Configuration*




*Nuclear Electric Propulsion Configuration*

*Solar Electric Propulsion Configuration*




*Gas Core Nuclear Reactor Configuration*

# Augustine Committee Recommendation

"That NASA initiate design effort so that manned activity in the Space Station could be supported in the absence of the Space Shuttle. Crew recovery capability must be available immediately, and ***provision made for the relatively rapid introduction of a two-way personnel transport module*** on a selected expendable launch vehicle.

# ACRV-D Baseline Concept

Summary of Design Deltas from ACRV-CERV

## Crew Module

(12,000 to 15,000 lbm)

**New Components**

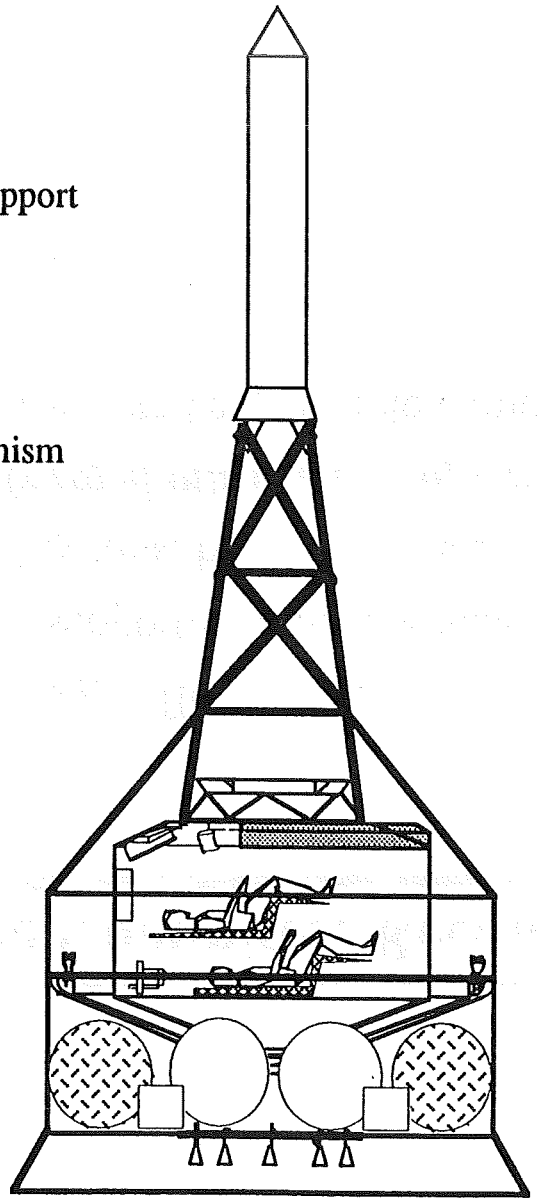
- External Structure for LES Support
- 2 string laser docking system
- Hand controllers

**Replaced Components**

- Berthing with docking mechanism

**Increased Components**

- 2 more battery modules
- 1 more EPDC string
- ECLSS LiOH expendables
- 2 more RCS jet drivers
- S-band data capability
- UHF voice comm capability
- 1 more multi-function display
- 2 more GPS strings
- Parachute size
- 33% more wiring



## Service Module

(2900 to 7400 lbm)

**New Components**

- Cold gas RCS

**Replaced Components**

- Hydrazine with MMH/NTO
- Integrated OMS/RCS system

**Increased Components**

- 5 more battery modules
- 1 more EPDC string
- ECLSS consumables
- 33% more wiring

## Additional Elements

- Launch Escape System (4750 lbm)
- Launch Shroud (900 lbm)
- Launch Vehicle Adapter (160 lbm)

## Liftoff Mass

28,210 lbm

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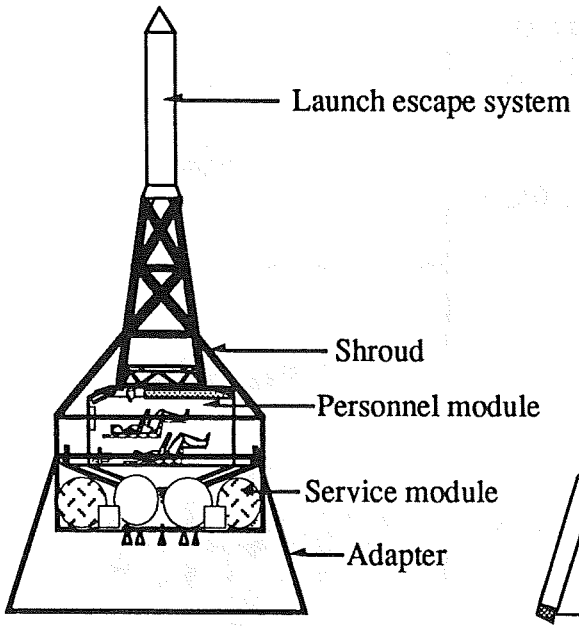
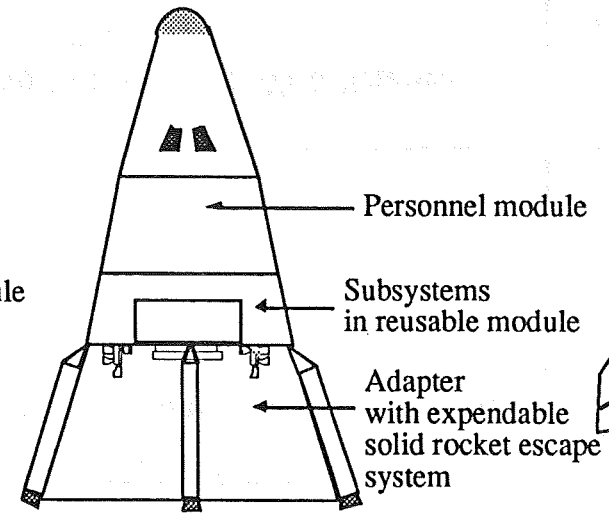
# Two-way Transportation System Options



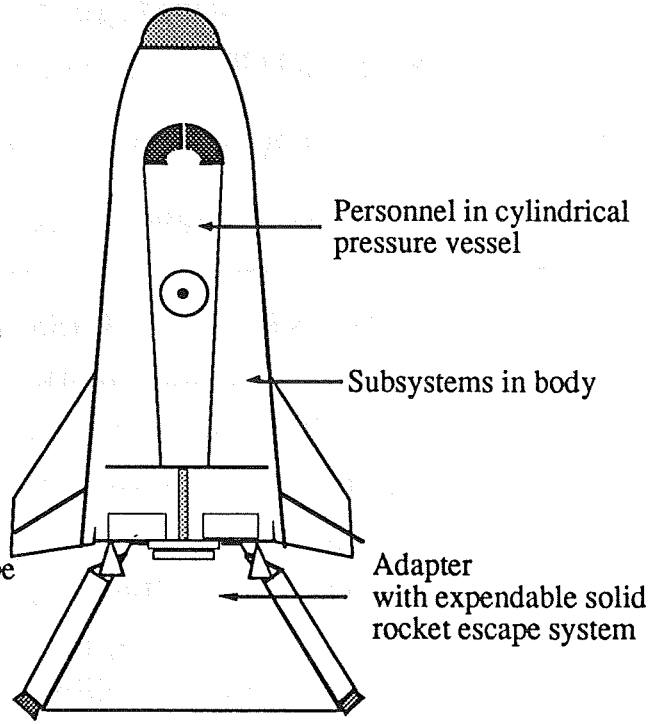

**ACRV-derived**

**(ACRV-D)**

- JSC Inhouse Design
- SCRAM Based with more robust Service Module




**Biconic**

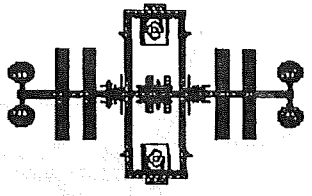
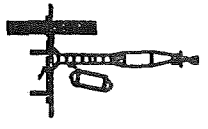



**HL-20**

**Lifting Body**

- LaRC Preferred Concept

# SEI Transportation Nodes Options

| | PRO's | CON's |
|---|---|---|
|  SSF Based | • Enhanced SSF Utilization<br>• No New Major SSF Elements<br>• No Crew Transfer For Operations | • Additional Free Flying Science Platforms<br>• Dynamic μ-g environment may Interfere With Science<br>• Assembly Intensive Philosophy<br>• Increased SSF Resource Requirements<br>• SSF Hooks And Scars |
|   Free Flying Node | • No Interference With Science Programs<br>• Removes Potentially Hazardous Systems (Nuclear, Etc.)<br>• Reduced Schedule Risk<br>• No Propellant Venting at SSF<br>• Node Utilizes SSF Hardware | • Man Tended System<br>• New Platform Required<br>• Crew Transport for EVA Contingencies<br>• Additional Logistics Operations |

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# Technology Needs

- Launch Vehicles
  - Propulsion
  - Avionics
  - Materials
  - Operations

- Space Transfer Vehicles
  - Propulsion
  - Avionics
  - Aerobraking
  - Cryogenic Fluid Storage and Transfer