A recent study has confirmed the feasibility of a near term, fully reusable, horizontal takeoff and landing two-stage-to-orbit (TSTO) launch vehicle concept. The vehicle stages at Mach 6.5. The first stage is powered by a turboramjet propulsion system with the turbojets being fueled by JP and the ramjet by LH₂. The second stage is powered by an SSME rocket engine. For about the same gross weight as growth versions of the 747, the vehicle can place 10,000 lbm. in low polar orbit or 16,000 lbm. to Space Station Freedom.

**Design Goals**

- Near-term staged system
- Doable technology levels
- Airbreathing first stage
- Rocket second stage
- Full reuseability
- All Azimuth launch
- Horizontal take-off and landing
- Bottom drop staging mode ease in handling and separation
- Integrated ferry capability
Evolution of BETA Airbreathing Launch Vehicle

- Original BETA
  - M stage = 8
  - 55,000 lbs. payload

- BETA II
  - 10,000 lbs. Payload
  - 75% rocket and 25% airbreathing booster
  - 1,000,000 Lbs.

Typical Mission Profile

- On-Orbit Operations
- Glide Boost/ Landing
- Termination from HAC Type Recovery
- Boost-Phase to Orbit
- On-Orbit Operations
- Glide Boost/ Landing
Optimum Trajectory

Altitude, K ft

Mach Number

q=100 lb/ft²
q=500 lb/ft²
q=1500 lb/ft²
Orbiter

Booster

Beta II General Arrangement

BOEING/USAF/NASA

- Two Stage to Orbit
- Mach 8.5 Staging
- Ten JP-7 Pulsed Turbopumps
- Two Hydrogen Pulsed Ramjets

Removeable ACC PPS in Wing/Hardened Canister

Gross Weight = 1,212,500 lbs
Shaping Weight = 822,000 lbs
Inert Weight = 488,700 lbs
BETA ENGINE OPERATING SCHEDULE

Beta

- Orbiter Rocket
- Booster Rocket
- Booster Turbojet
- Booster Ramjet

Beta II

- Booster Turbojet
- Booster Ramjet

Beta II Booster Weights

<table>
<thead>
<tr>
<th>Lbs.</th>
<th>0</th>
<th>1200000</th>
<th>2400000</th>
<th>3600000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payload (Orbiter)</td>
<td>345,160 lbs.</td>
<td>28.5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Propellants</td>
<td>377,651 lbs.</td>
<td>31.1%</td>
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<td></td>
</tr>
<tr>
<td>Margin</td>
<td>79,976 lbs.</td>
<td>6.6%</td>
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<tr>
<td>Propulsion</td>
<td>218,215 lbs.</td>
<td>18.0%</td>
<td></td>
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<tr>
<td>Empty - Propulsion</td>
<td>181,667 lbs.</td>
<td>15.0%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Crew + Residuals 9,815 lbs. 0.8%
Beta II Nacelle at Selected Operational Modes

Mach 6.5
2D Mixed Compression Inlet
2D C-D Nozzle
JP Fueled Turbojets
H2 Fueled Ramjet

Mach 3.0

Mach 1.5

Static to Mach 0.5

BETA Turbine-Bypass Engine Major Parameters
(Engine From Concurrent HSR Studies)
One-spool turbine bypass engine

<table>
<thead>
<tr>
<th>CORRECTED AIRFLOW</th>
<th>OVERALL PRESSURE RATIO</th>
<th>MAXIMUM T41</th>
<th>WEIGHT</th>
<th>LENGTH</th>
<th>DIAMETER</th>
</tr>
</thead>
<tbody>
<tr>
<td>625 lbm/sec</td>
<td>20.4</td>
<td>3960 R</td>
<td>6850 lbs</td>
<td>123 inches</td>
<td>66 inches</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sea Level Static Net Thrust</th>
<th>Maximum Dry 55143 lbf</th>
<th>Maximum Augmented 78400 lbf</th>
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</thead>
<tbody>
<tr>
<td>TSFC</td>
<td>0.9429</td>
<td>1.6382</td>
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</tbody>
</table>

25-5
Mach 6.5 Staging Beta Orbiter

- 10 lb Payload to 120 x 120 nmi Polar LEO
- All LOX-Hydrogen Propulsion
- 345,160 lb Gross
- 61,444 lb Inert
- \( \lambda = 0.811 \)

Beta II Orbiter Weights

- Payload 10,000 lbs. 2.5%
- Propellant 273,499 lbs. 79.3%
- Crew + Residuals 2,901 lbs. 0.8%
- Empty Weight 52,948 lbs. 15.4%
- Growth 5,595 lbs. 1.6%
BETA II

• Viable and robust
  -- Conservative design, structures, materials
  -- Minimum technology development
  -- 20% growth margin built in
  -- 747 weight class

• Potential for low cost operation
  -- Simple stage mating
  -- Airplane-like operations (intact, safe abort)
  -- Fully recoverable
  -- No ferry aircraft required

• Versatile
  -- 10K — polar
  -- 10 men + 10K — space station
  -- 30K — space station (expendable 2nd stage)
  -- All weather launch
  -- M 4-6 research aircraft (booster)
  -- Carrier for airbreathing M 6-25 research vehicle
  -- Multi-mission vehicle
Advanced Manned Launch System (AMLS) Prop. Status
John R. Olds
NASA Langley Research Center
Hampton, VA

(Paper Not Received in Time for Printing)