BANTAM

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Code R Goals

Orbit
Reduce the payload cost to orbit by an order of magnitude, from $10,000 to $1,000 per pound, within 10 years and by an additional order of magnitude, from thousands to hundreds of dollars per pound, within 25 years

In-Space
Achieve with 15 years,

A factor of ten reduction in the cost of Earth orbital transportation
A factor of two to three reduction in propulsion system mass and travel time required for planetary missions.

Within 25 years,

Enable bold new missions to the edge of the solar system and beyond by reducing travel times by on to two orders-of magnitude.

Bantam

- 150 Kg Payload
- 200 nmi due east
- Reusable Launch Vehicle SSTO or TSTO
- $1.5M per launch
- 12 launches per year

Bantam Elements

- Launch Services Contract - KSC led
  - Challenge to find launches for $1.5M in FY 99
- Users Workshop - GSFC led
  - Workshop with Codes S & Y to establish users requirements
- Virtual Vehicle Concepts - MSFC led
  - Vehicle concepts that will drive technology needs
  - Vehicle studies FY 99-00 and downselect at the end of FY 00
- Supporting Technologies - MSFC led
  - Technologies worked in FY 99-01 will support vehicle concepts
  - Technologies supporting more than one concept have priority
- Flight Demonstration - MSFC led
  - Vehicle concept selected in FY 00 will be taken to Pathfinder experiment in FY 02-04

Reusable Technology Investment Planning (RTIP)

* Develop a comprehensive, long term technology development and demonstration plan for each of the seven technology areas.

* Plans will be used as a mechanism for funding In-House NASA tasks and Industry bids under NRA 8-21, Cycle 2

* Approximately $20M/yr funds available (total)

* Plans must support Code R Goals 9 & 10 (attached)

* Propulsion plan should show how activities support IHPRPT goals (attached)

* Planning process should involve appropriate NASA Centers, other Government agencies, Academia, and Industry

* Each proposed technology must show how it contributes to reducing the cost of access to space for small payload launch systems

Virtual Vehicle Concept Development (VVCD)

* Develop a set of innovative Virtual Vehicle Concepts that have the potential of meeting the small payload metrics and customer requirements

* Mature Vehicle concepts to a level adequate to assess the probability of technical and economic success allowing for a down select to one or two vehicles in the late 2000 timeframe per Level II Roadmap

* Evaluate alternate concepts proposed by Industry, academia, and other government sources for possible addition to Vehicle Fleet

* Virtual Vehicles will serve as the Target for the technology development program and will identify advanced technologies for consideration/incorporation into the program

* Virtual Vehicle Fleet will be continually monitored for additions or deletions as technologies mature and new concepts are developed

VVCD cont´d

* Virtual Vehicle Concepts will be maintained and matured in-house NASA using an integrated design center approach with potential involvement from outside sources

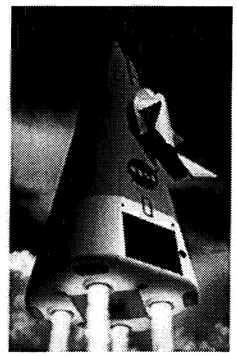
* Virtual Vehicle maturation will be based on:
  - Vehicle system design development
  - Assessment and management of technology risks
  - Feedback from Technology Development Program
  - Economic and cost analysis (development and operations)
  - Capability of meeting customer´s requirements
  - Synergy with other RLV programs (e.g. MSP)

* Develop a Future X proposal based on the Virtual Vehicle Concepts when appropriate

***** REMEMBER: COST IS KING ******

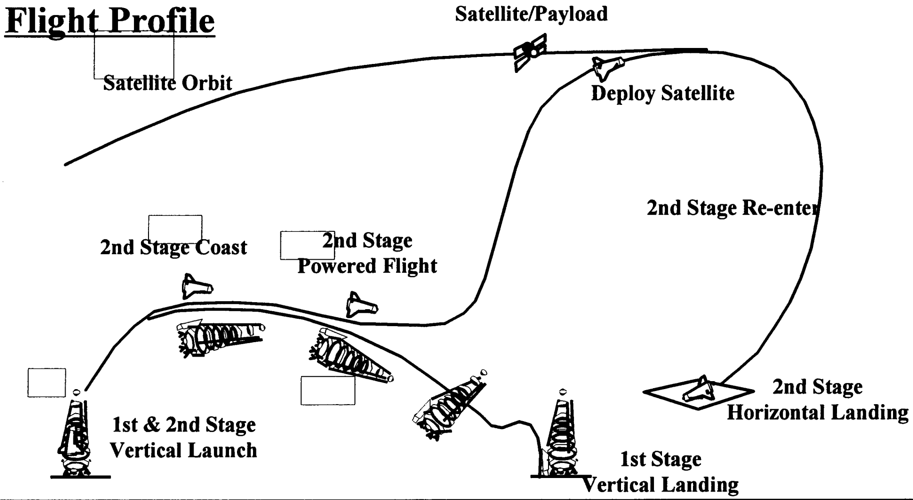
Concept 1 - VT/VL Vehicle

Vehicle Concept
- Fully Reusable Vertical Takeoff/Vertical Landing, 1st Stage
- Fully Reusable Horizontal Landing, Lifting Body 2nd Stage
- H2O2/JP GG Cycle 1st and 2nd Stage Propulsion Systems with E-D Nozzles
- LO2/JP & LO2/H2 Options



Benefits
- Reduced Operations Costs with Storable Propellants
- Improved Performance with E-D Nozzles and Lightweight Components

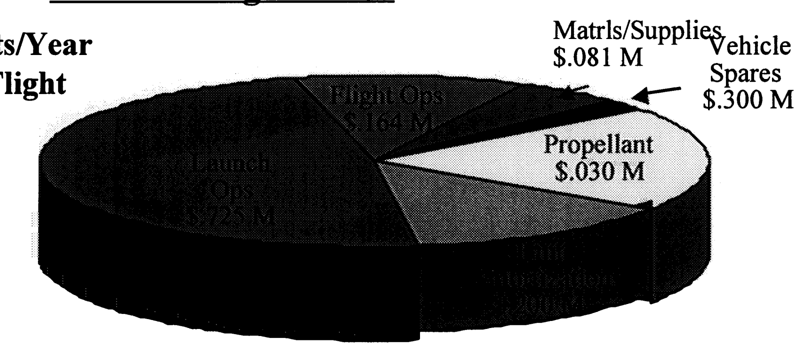
Flight Profile



Critical Technologies
- Robust, Lightweight, High Performance, H2O2/Kerosene Propulsion Systems
- Highly Throttlable Engines
- E-D Nozzles
- Advanced Thermal Protection Systems (TPS)
- Low Weight Tanks, Structures, and Components
- H2O2 Compatible Handling and Storage Facilities
- Automated Range Safety System
- Autonomous Launch and Landing Systems
- Automated Mission Planning

Cost Per Flight Goals

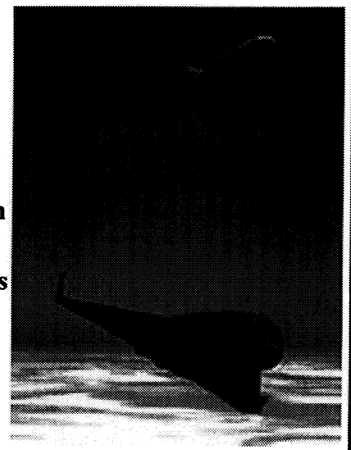
12 Flights/Year
$1.5 M/Flight



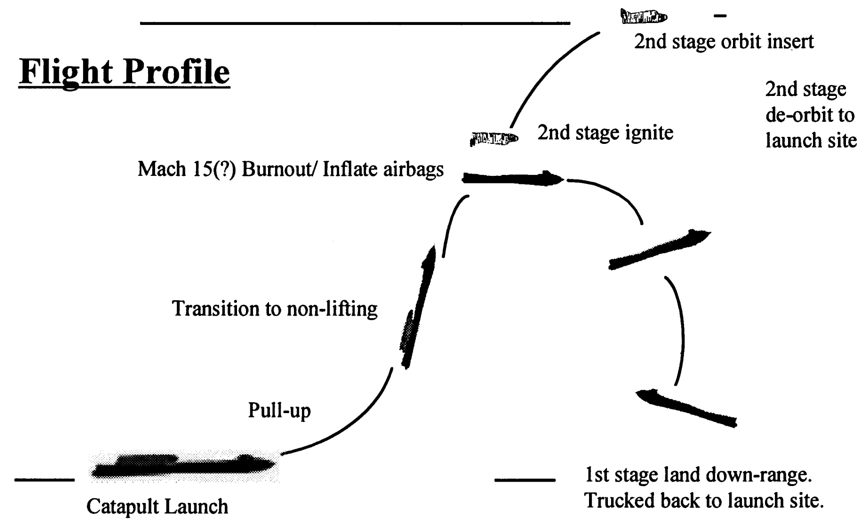
Concept 2 - HT / HL

Vehicle Concept

- Lifting Body Boost Stage
- Catapult Assist Take Off
- Two 'Racetrack' Aerospikes, RP/LOX or RP/H2O2, GG Cycle,
- Dorsal Fin & Small Wing Tip Fins
- HL20 Type 2nd Stage Inverted and Nested on Booster for Ascent
- Semi-Rigid Airbags Inflate to Separate Stages and Retain Booster Lee-ward Aerodynamic Shape for Re-entry



Flight Profile

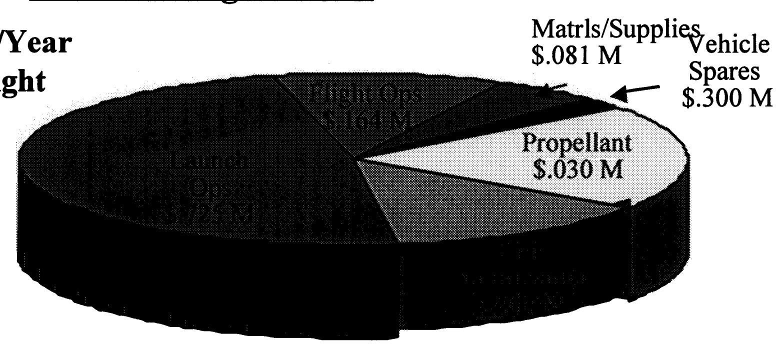


Critical Technologies

- Conformal Tanks
- Integrated TPS
- Racetrack Aerospikes, Composite(light weight) Nozzle
- Active Vehicle Control
- Airbags for Stage Separation & Booster Re-entry Aero
- Automatic Flight Termination
- Automatic Mission Planning
- Catapult Assist

Cost Per Flight Goals

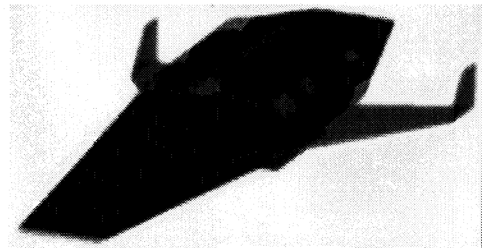
12 Flights/Year
$1.5 M/Flight



Concept 3a - HT / HL

Vehicle Concept

- Horizontal Takeoff/Horizontal Landing (HTHL) Rocket-Based Combined Cycle (RBCC) Reusable 1st-Stage Booster Vehicle
- Expendable, Low Thrust, Pressure-Fed FASTRAC Upper Stage Engine
- Powered Ramjet Cruise back to Launch Site
- Unpowered Landing
- 1st-Stage Propellants: LO2/LH2
- Vehicle Length: 89 feet
- Gross Weight: 106K lbm
- Dry Weight: 35K lbm



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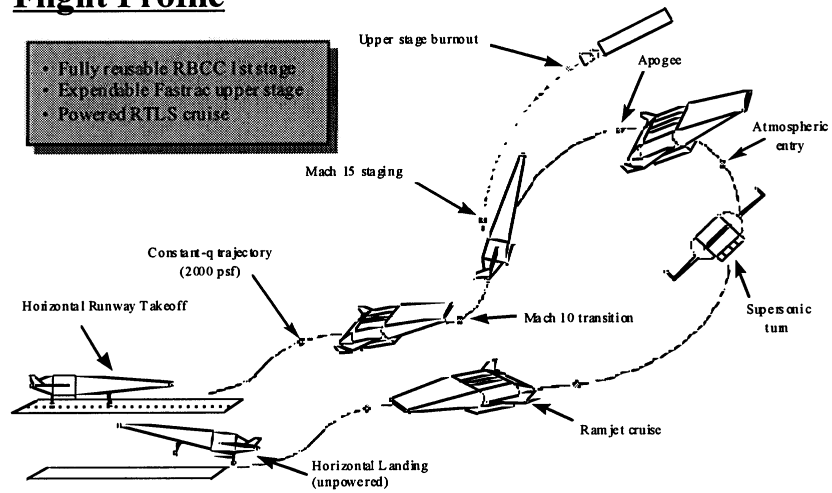
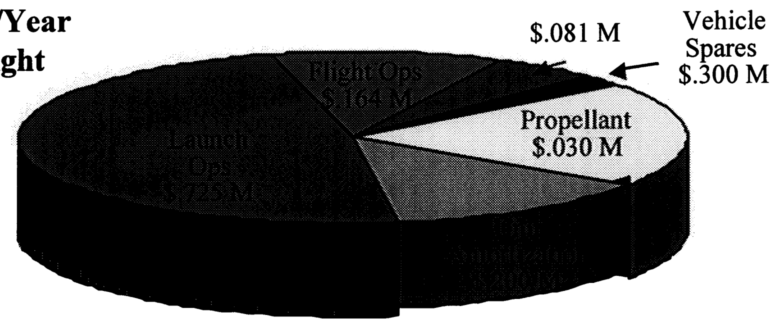


Critical Technologies

- Reusable 1st-Stage
  - RBCC Propulsion System
  - LOX Composite Tanks
  - Advanced TPS Systems (SHARP, TUFI, AFRSI)
  - Autonomous Launch & Landing System
  - Autonomous Flight Termination System (AFTS)
- Expendable 2nd-Stage
  - Low Cost Expendable Upper Stage Hardware
  - Small Scale FASTRAC Engine
  - Low Cost Upper Stage Avionics

Cost Per Flight Goals

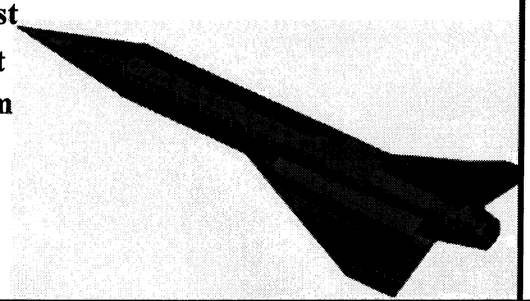
12 Flights/Year
$1.5 M/Flight



Concept 3b - HT / HL

Vehicle Concept

- Single-Stage, Fully Reusable Vehicle Concept with Launch Assist
  - HTHL RBCC Vehicle
  - Powered Landing at Launch Site
  - Catapult Launch Assist
- Vehicle Length: ~150 feet
- Gross Weight: ~400K lbm
- Dry Weight (1st-Stage): ~50K lbm



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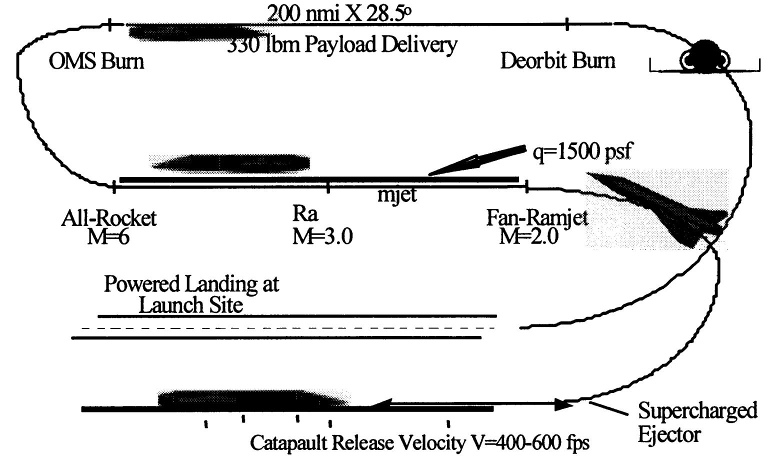
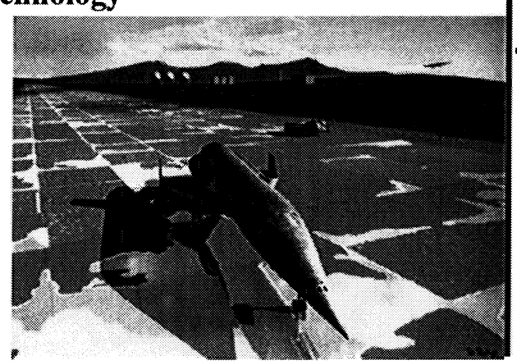


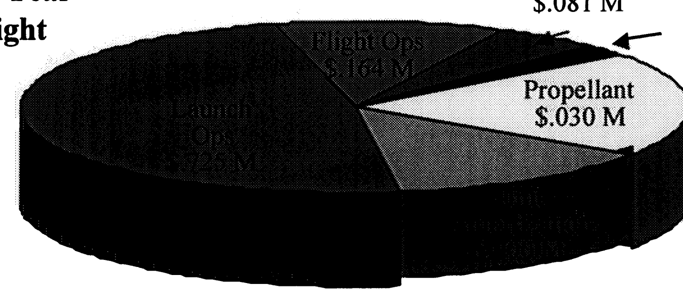
Critical Technologies

- Reusable 1st-Stage
  - LO2/LH2 RBCC Engine - Supercharged Ejector Ramjet
  - Catapult Launch Assist
  - Integral Composite Tanks
  - Lightweight Subsystem Technology
  - Lightweight Materials
    - Graphite/PEEK
    - Titanium-Aluminide



Cost Per Flight Goals

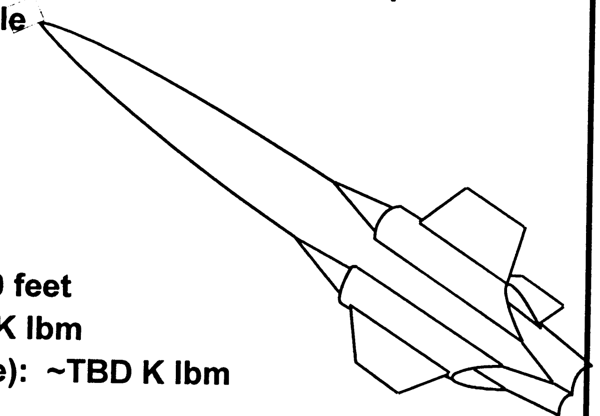
12 Flights/Year
$1.5 M/Flight



VC-3c: VT / HL - Concept 3c

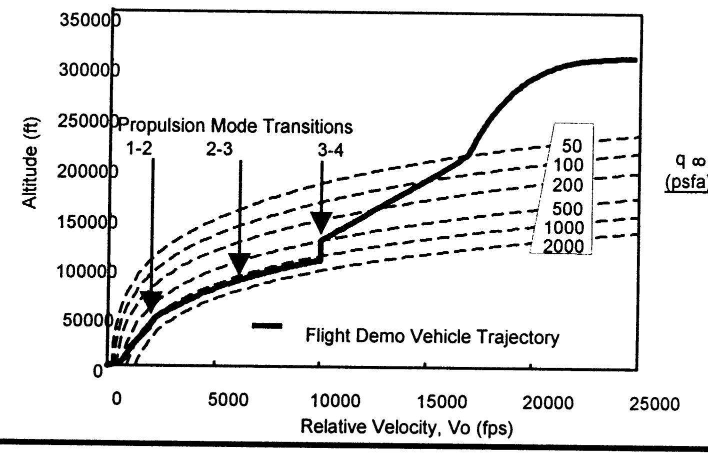
Vehicle Concept

- Single-Stage, Fully Reusable Vehicle Concept
- VTHL RBCC Vehicle



- Vehicle Length: ~100 feet
- Gross Weight: ~100 K lbm
- Dry Weight (1st-Stage): ~TBD K lbm

Flight Profile



Critical Technologies

- LO2/LH2 RBCC Propulsion System
- Integrated Vehicle/Propulsion System
  - Composite Tanks
  - Lightweight Subsystem Technology
  - Lightweight Materials

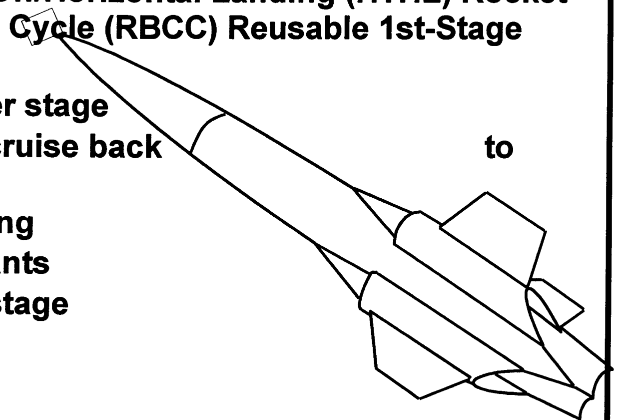
Cost Per Flight Goals

12 Flights/Year
$1.5 M/Flight

VC-3d: HT / HL - Concept 3d

Vehicle Concept

- Horizontal Take-Off/Horizontal Landing (HTHL) Rocket-Based Combined Cycle (RBCC) Reusable 1st-Stage Booster Vehicle
- Expendable upper stage
- Powered ramjet cruise back to launch site
- Unpowered landing
- LO2/LH2 propellants
- Launch assist/2 stage



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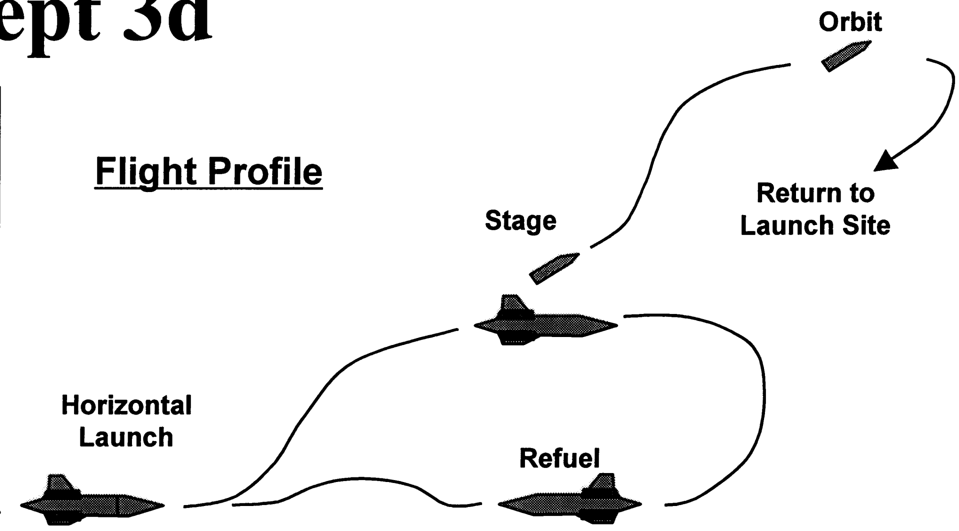


Critical Technologies

- LO2/LH2 RBCC Propulsion System
- Integrated Vehicle/Propulsion System
  - Composite Tanks
  - Lightweight Subsystem Technology
  - Lightweight Materials
  - Vehicle & Propulsion Controls
- Expendable second stage

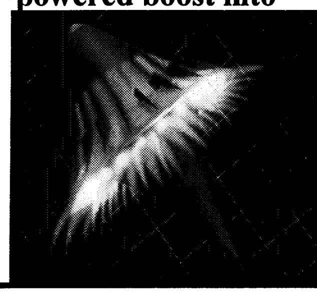
Cost Per Flight Goals

12 Flights/Year
$1.5 M/Flight

Concept 4 - Laser Lightcraft

Vehicle Concept

- **Single stage to orbit laser-powered launch vehicle**
- **Thrust produced by pulsed laser-induced blast wave propagation & expansion**
- **Infinite specific impulse during ascent thru atmosphere**
- **Onboard propellant used for final laser-powered boost into space & orbit**
- **1st stage: 100 MW - 1 GW "reusable"pulsed CO2 laser**
- **Gross mass: ~1,000 kg**
- **Dry mass: ~200 kg**
- **Vehicle diameter: 1 - 2 meters**



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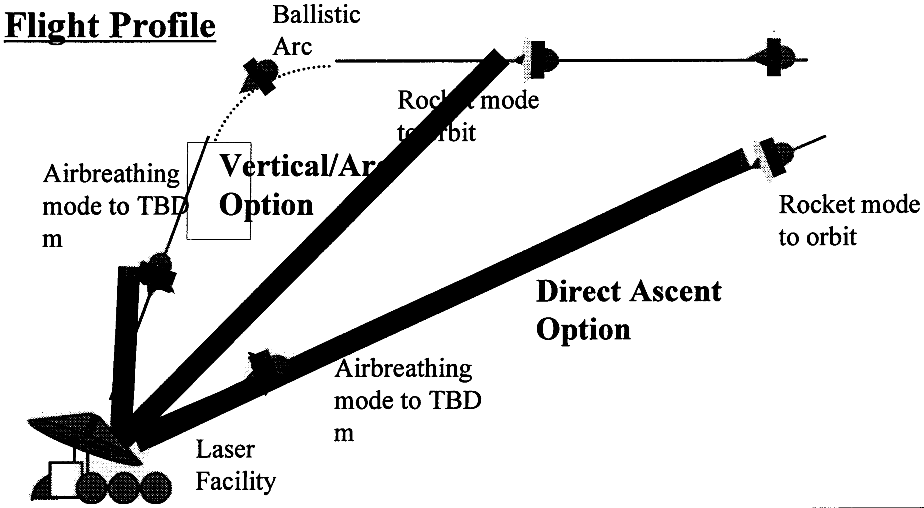
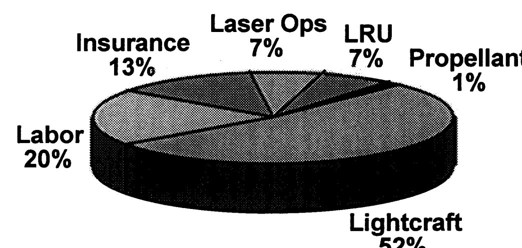


Critical Technologies

- **Laser "1st-Stage"**
  - Upgrades to 100 MW - 1 GW (inter-program cost sharing)
  - Pointing, tracking & stability
  - Frequency compensation/correction with altitude
- **Lightcraft "2nd/Upper-Stage"**
  - Lightweight materials
  - Inverse-bremstrahlung heating & ablation
  - Rocket-mode propellant injection & heating
  - Airbreathing/rocket mode thrust cavity gas dynamics
  - Propellant storage & feed technology

Recurring Costs

Cost Breakdown ($M)	
Propellant	0.010
Labor	0.150
LRU	0.050
Lightcraft	0.400
Insurance	0.100
Laser Ops	0.050



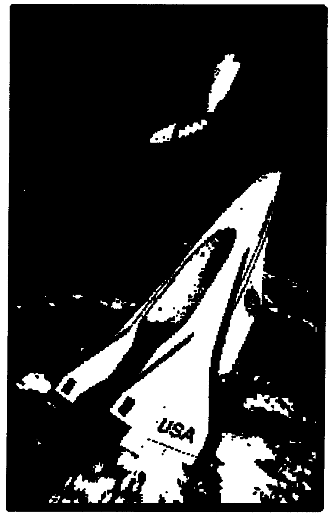
Based on 150 kg payload, 24 flights/year

Recurring Cost per Flight = $0.760 M

VC-5: HT / HL - Concept 5

Vehicle Concept

- Turbine-Based Combined Cycle Propulsion System
- First-stage demonstrator:
  - Mach 5 or greater
  - Turbine-powered take-off/landing
  - 10 Klb gross weight
  - 40 ft long
  - Reusable



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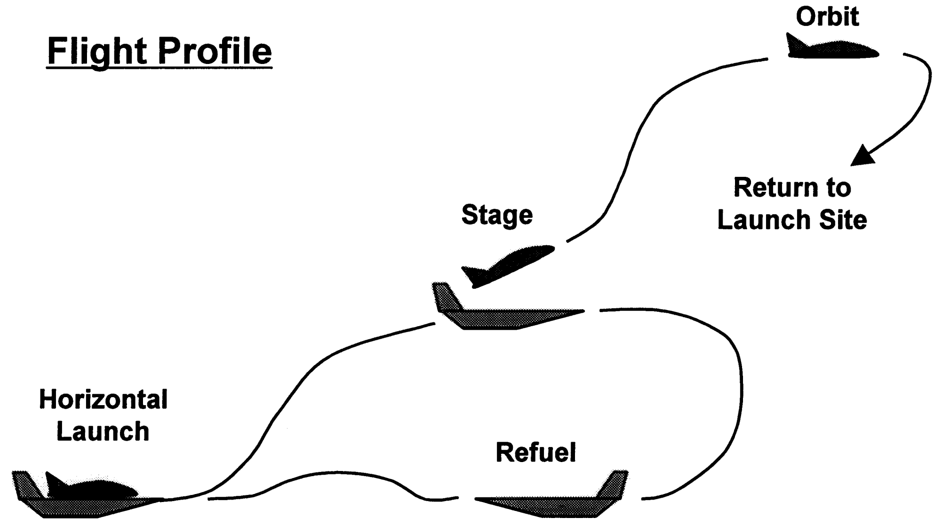


Critical Technologies

- Turbine-Based Combined Cycle Propulsion
  - Propulsion components (from inlet to nozzle)
  - Integrated propulsion system technologies
  - Airframe integration
  - Variable geometry actuation/sealing/thermal
- Integrated vehicle/propulsion control
- Vehicle TPS

Cost Per Flight Goals

12 Flights/Year
$1.5 M/Flight

Concept 6- Bimese Launch Concept for Bantam

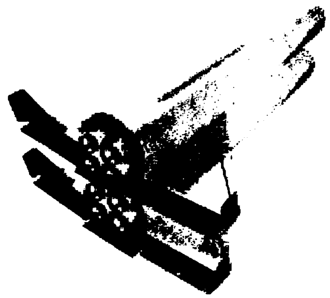
Point of Contact: Theodore A. Talay, 757-864-4505, t.a.talay@larc.nasa.gov Vehicle Analysis Branch, NASA Langley Research Center

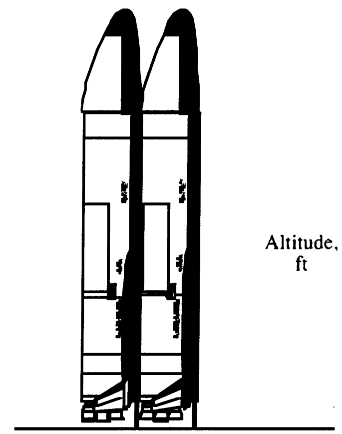
Vehicle Concept

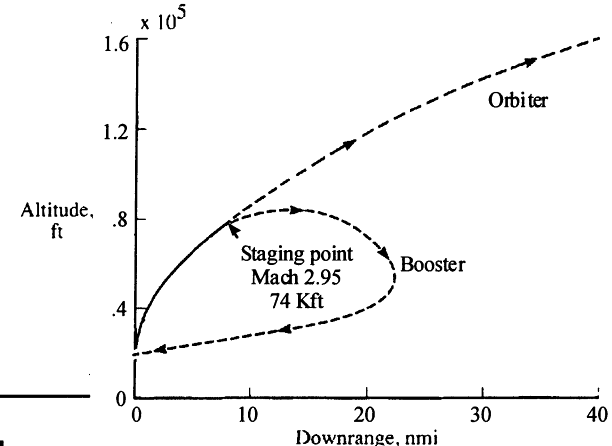
ï Fully Reusable Vertical Takeoff/Horizontal Landing Stages
ï LOX/RP-1 Propulsion
Isp = 347 sec; T/W = 110
ï LOX/RP-1 & LOX/LH2 options

Benefits

ï Identical stages
Development based on one stage only. Reduced operations compared to non-identical stages.
ï Low staging Mach number (2.95) allows glideback to launch site (rapid turnaround, no added return propulsion requirements)
ï Potential boosters for medium-lift launch vehicle







Wgross = 298 Klb
Wdry = 29 Klb
Body length = 58 ft

Bantam Concept

Critical Technologies

ï Robust, Lightweight, High Performance LOX/RP-1 Propulsion Systems
ï Highly Throttleable Engines
ï Advanced Thermal Protection Systems (TPS)
ï Low Weight Tanks, Structures, and Components
ï Simple, Operable Crossfeed System
ï Advanced GNC Systems for Glideback
ï Autonomous Launch and Landing Systems
ï Automated Mission Planning