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Revolution in Space Launch Systems for Medium-Weight Payloads

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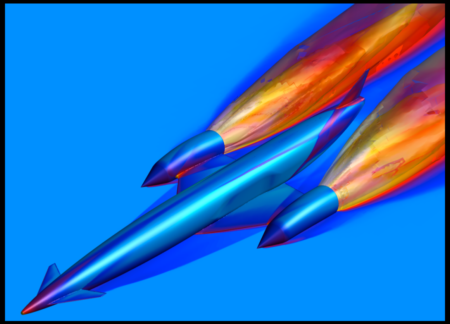

Panel on Revolution in Space Launch Vehicles: More Aircraft and Less Rocket

21st AIAA International Spaceplane and Hypersonic Systems and Technologies Conference
University of Xiamen, Xiamen, China
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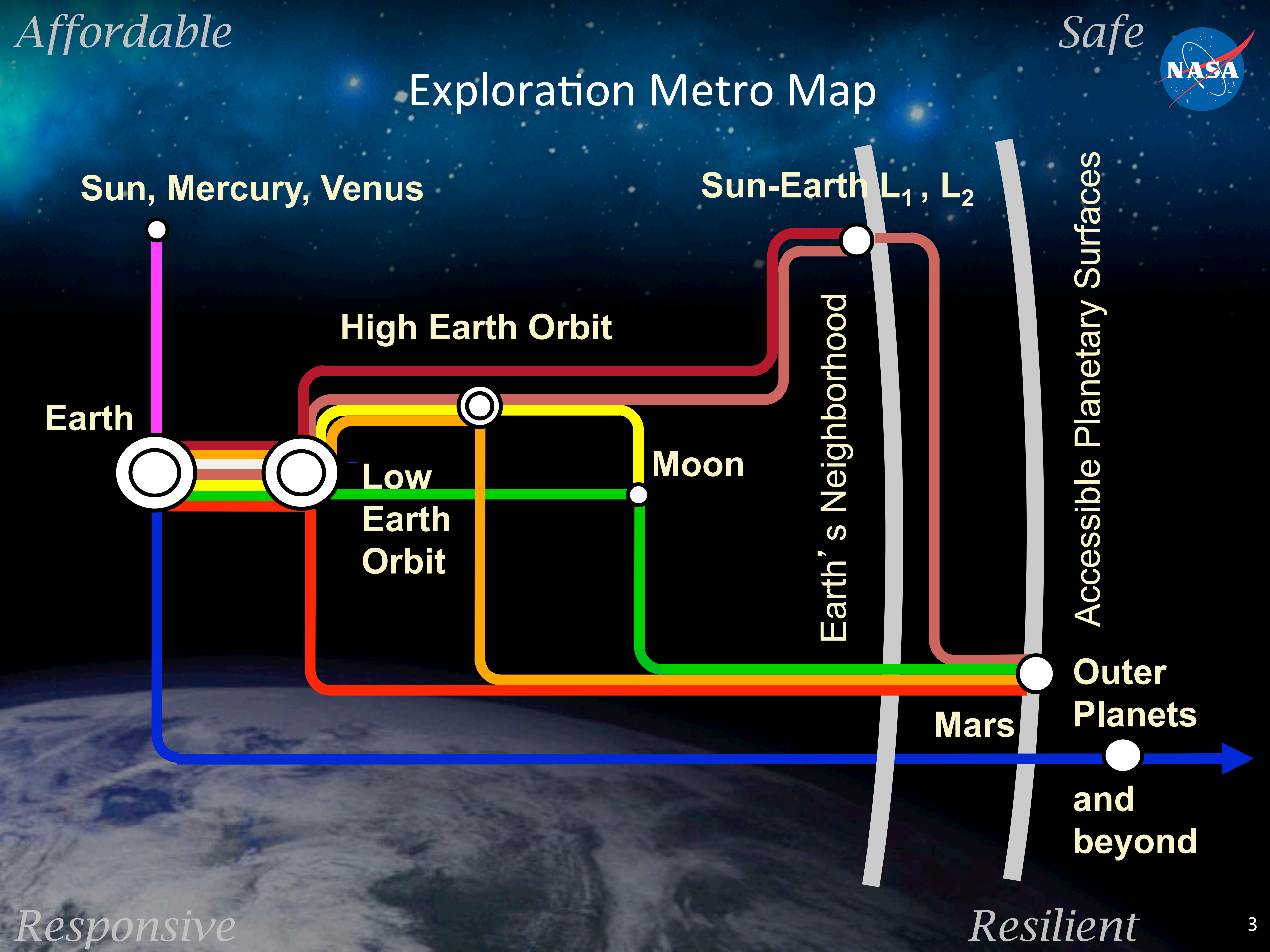
Outline

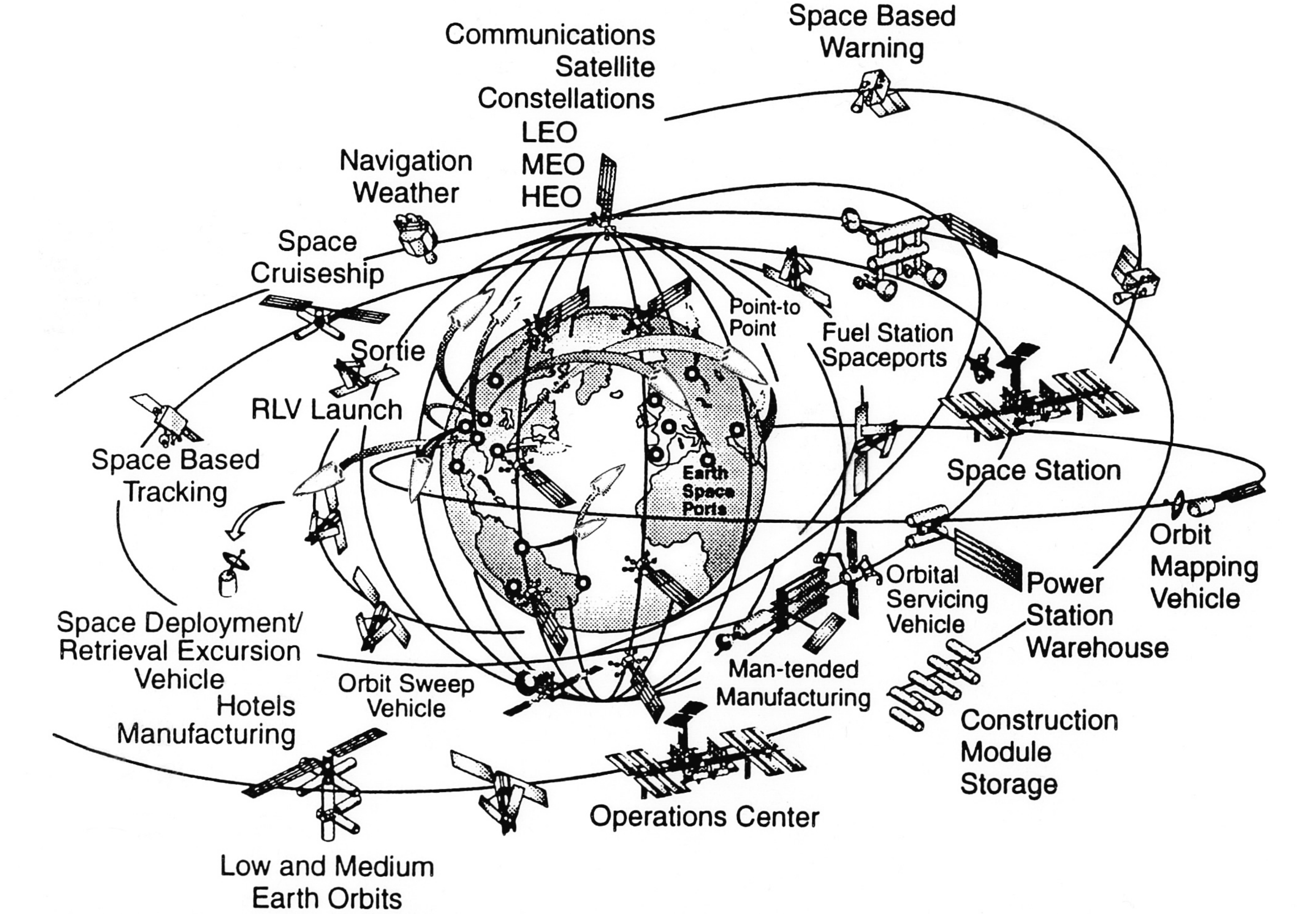
- Vision
- Requirements
- Design Trade Studies
  - Propulsion
  - Vertical versus horizontal takeoff
  - Margin
  - Cost
  - Staging Mach number
- A way forward

Exploration Metro Map



Potential Infrastructures in Earth Neighborhood

(DOI: 10.2514/6.2004-5858)



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Requirements for Commercialization of Low Earth Orbits

(http://spacenews.com/reviving-the-aerospace-plane-program/)

- The affordability determines the degree to which near-Earth space can be commercialized.
  - A fully reusable Earth-to-LEO transportation system, using a revolutionary propulsion system and operated with commercial airline industry practices, could greatly reduce transportation costs to LEO for medium-weight (5–15 MT) payloads (humans and cargo).
- To fully develop human presence in near-Earth space—commute stations, tourist destinations, laboratories, and manufacturing and construction facilities—we need safe, responsive, and resilient vehicles for routine transport and emergency rescue with wide-entry windows, wide-ranging flight paths, and low rates of entry deceleration.
  - The desirable aerodynamic attributes for an emergency rescue vehicle are
    - Hypersonic L/D ~ 3.5
    - Deceleration ~ 1.1 g

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Progress in Transportation

- Historically, transportation progress has been contingent on revolutionary changes in propulsion modes.
- Aviation transformed when jet-powered aircraft replaced propeller-driven aircraft.

- The progress in space launch vehicles requires the replacement of rocket propulsion with air-breathing + rocket propulsion.
- Air-breathing flight milestones
  - Near-term: Mach 0 to 5.5
  - Mid-term: Mach 0 to 8
  - Long-term: Mach 0 to 11+

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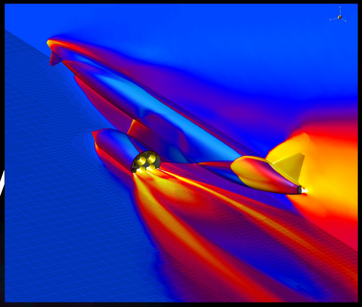
A Revolutionary Space Launch System

- TSTO system
- Current launcher propulsion choices
  - Turbo/ramjet engines
  - TBCC engines
  - RBCC engines
  - Turbo/ramjet + rocket engines
- Orbiter propulsion choice
  - Rocket engines
- Fully reusable – 200 missions
- Horizontal takeoff and landing
- Design for safety, responsiveness, and resiliency



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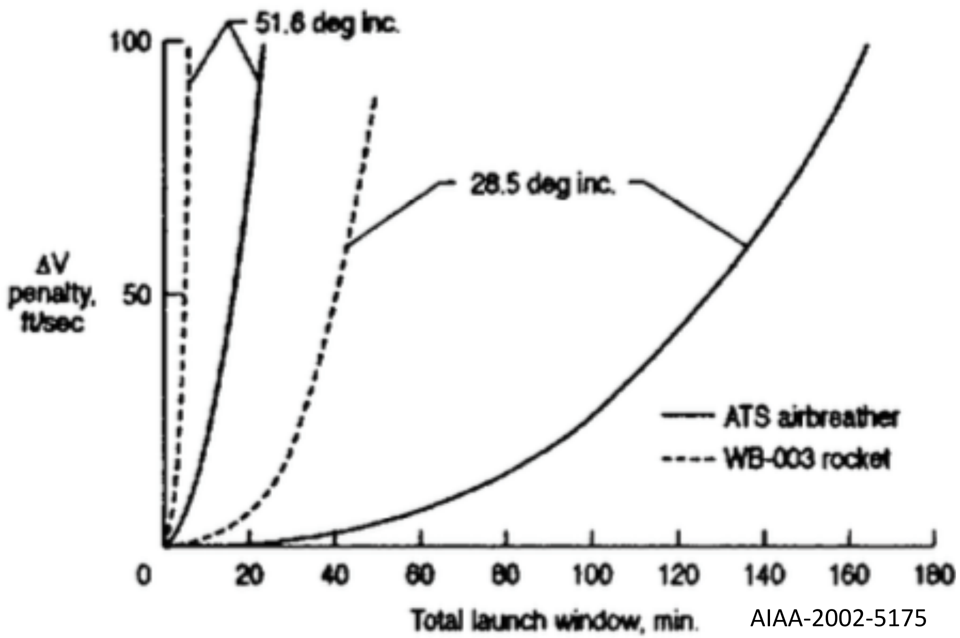
Horizontal Launch Versus Vertical Launch

Launch Windows



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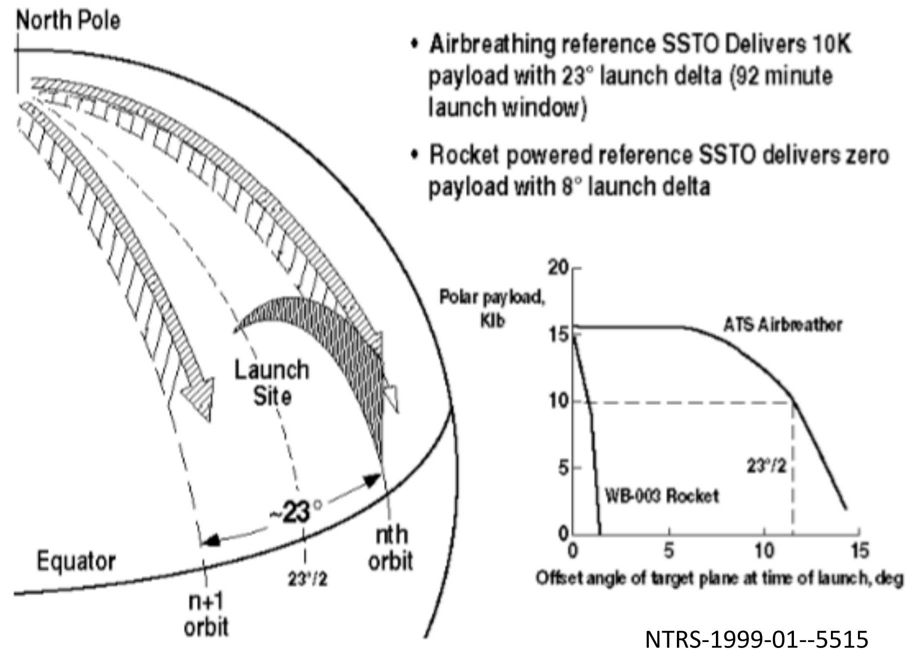
Rapid Rescue and rendezvous

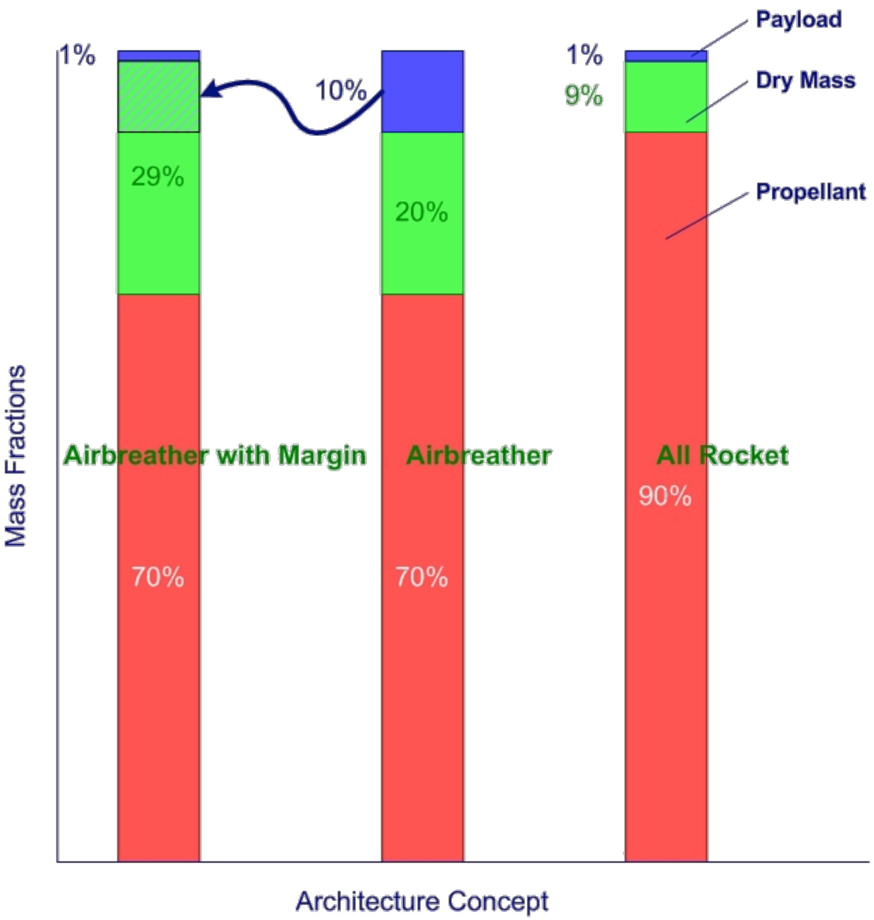


NTRS-1999-01--5515

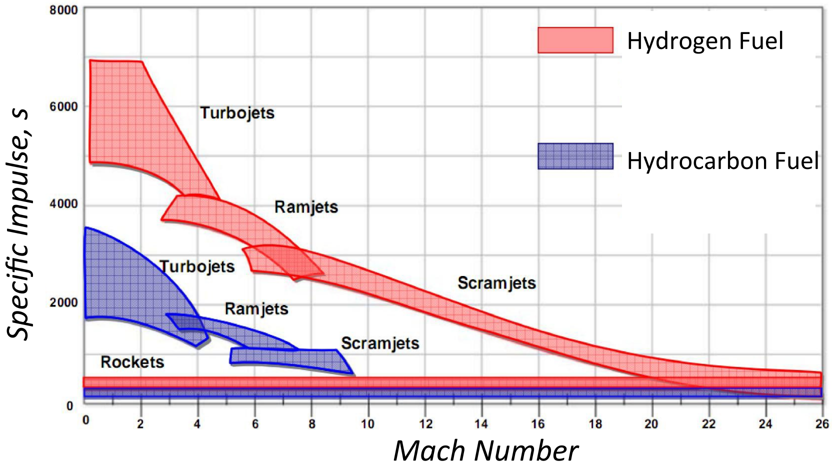
- Airbreathing propulsion offers expanded operational flexibility.
- Rocket-powered launch vehicles use substantially more propellant for a given delta-v than systems with some airbreathing propulsion.

Advantages of Air-Breathing Propulsion

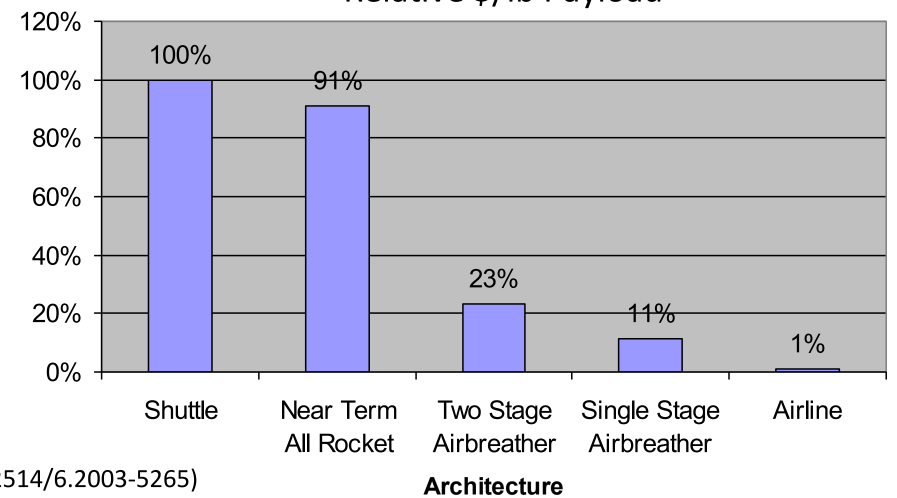
Mass Allocations
Same TOGW, SSTO Vehicles



Propulsive Performance:
Air-breathing Engine versus Rocket Engine



Relative $/lb Payload



(Data adapted from DOI: 102514/6.2003-5265)

- Air-breathing systems provide increased margin and cost less to deliver payload.

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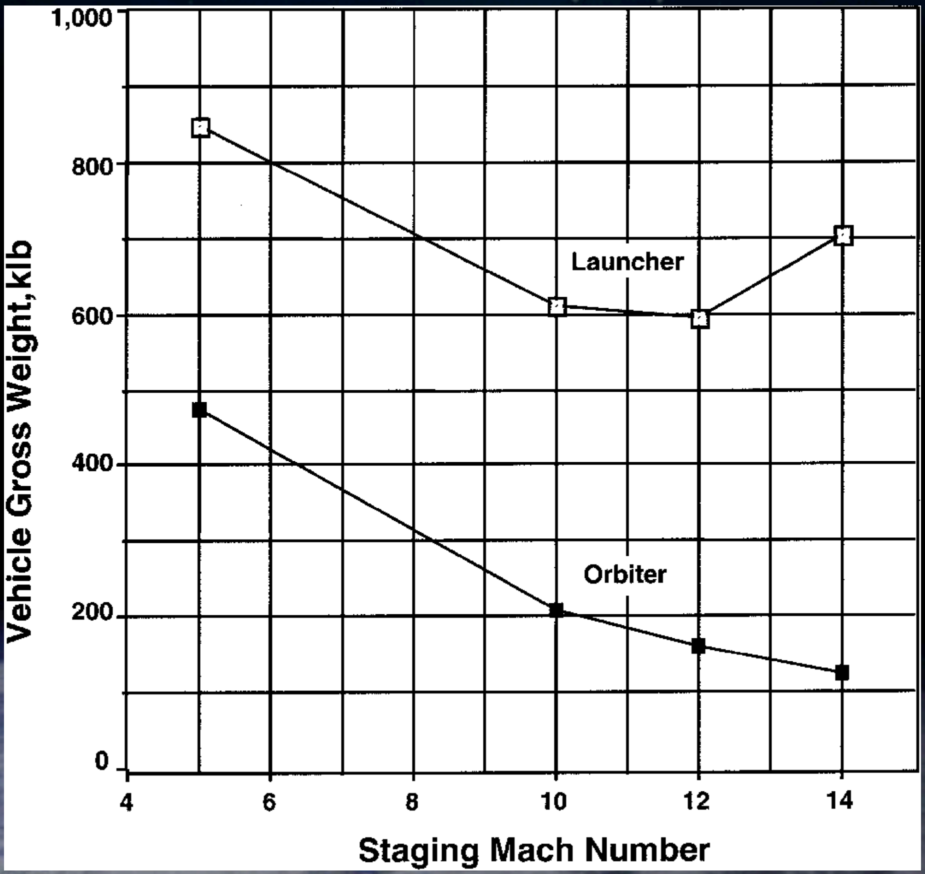
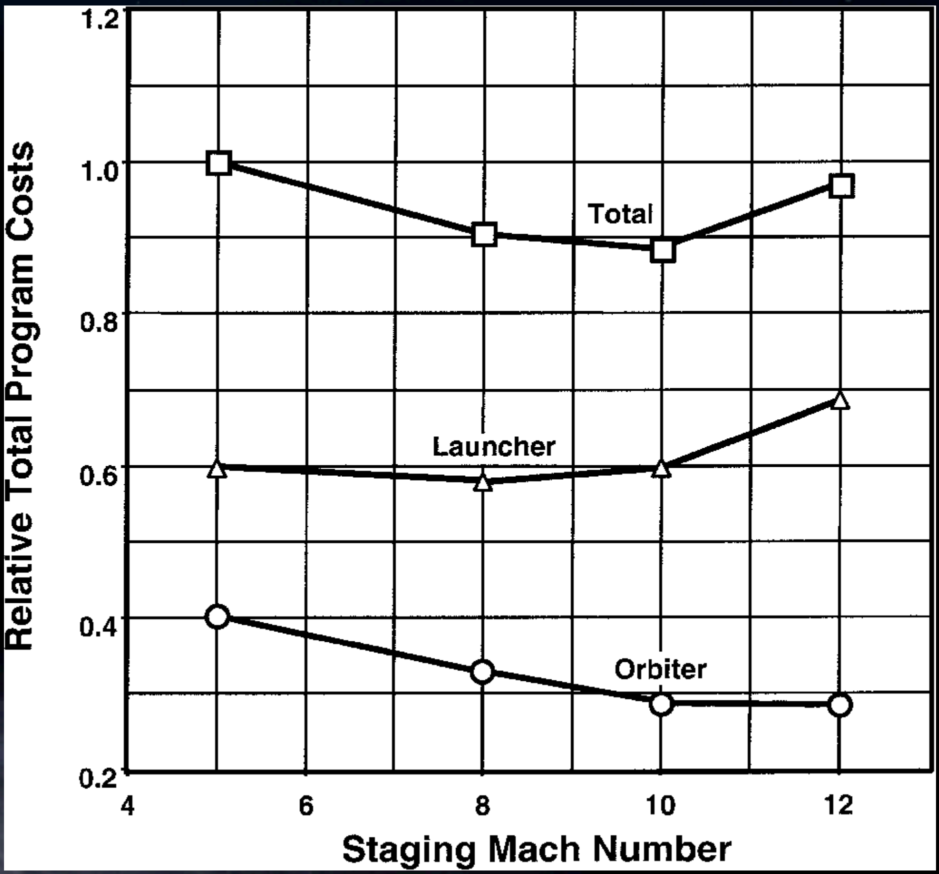
Optimum Staging Mach Number

(DOI: 10.2514/2.5886)

Sensitivity of TOGW to staging Mach number



Sensitivity of LCC to staging Mach number



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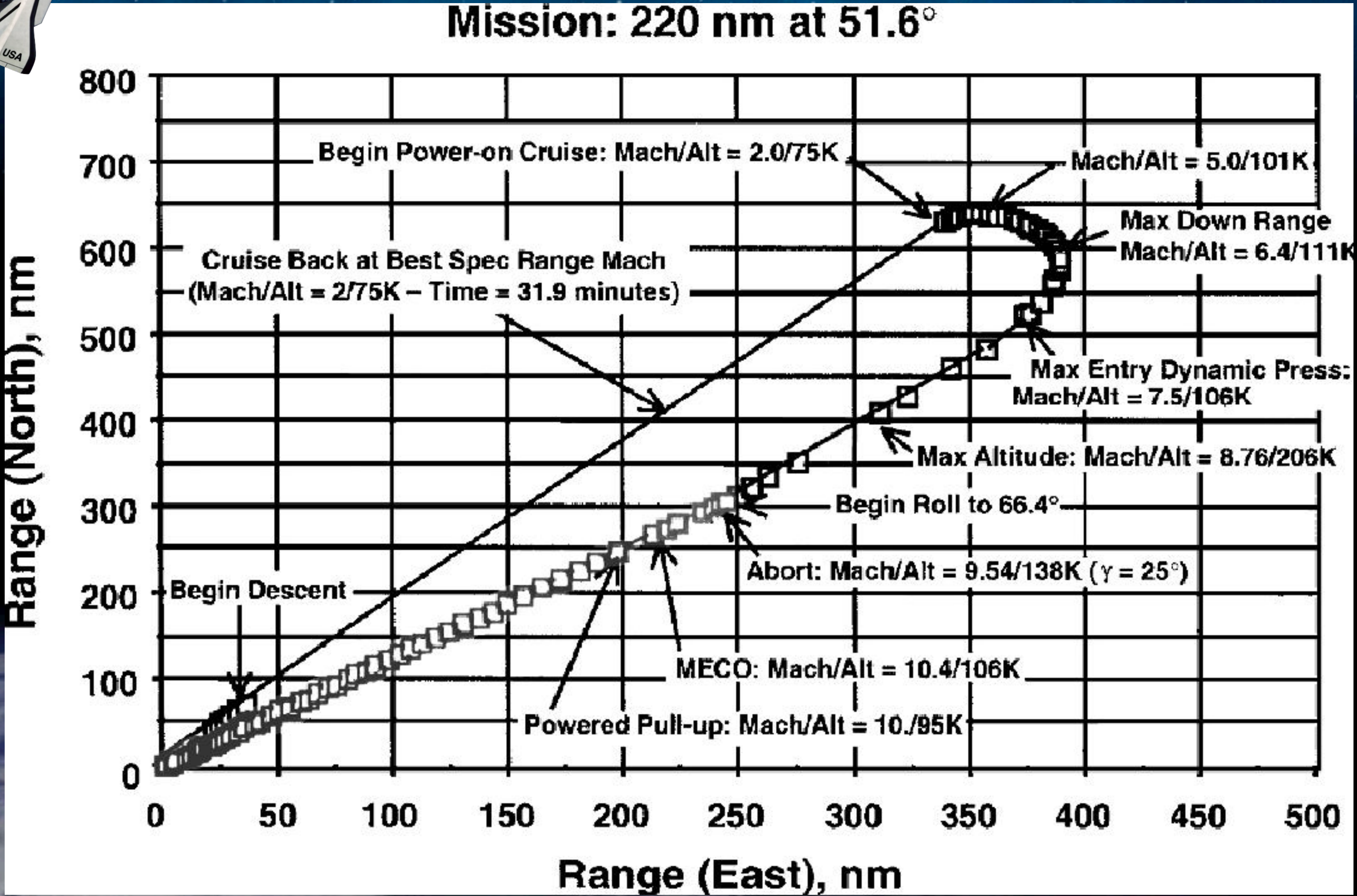
Resiliency – Example

(DOI: 10.2514/2.5886)



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A Way Forward

- Revive the development effort for a revolutionary Earth to low Earth orbit transportation capability.
- Demonstrate reusability of a rocket engine for 200 missions
- Demonstrate a Mach 5.5 turbo/ramjet engine ➔

  Flight test an X-plane (the first stage) ➔

  Develop an operational first stage
- Demonstrate a Mach 8 engine ➔

  Demonstrate a Mach 11 engine
- Develop an operational TSTO system
  - Air-breathing propulsion up to Mach 5.5
  - A 10-MT payload to low earth orbit