TPS: From Arc-jet to Flight

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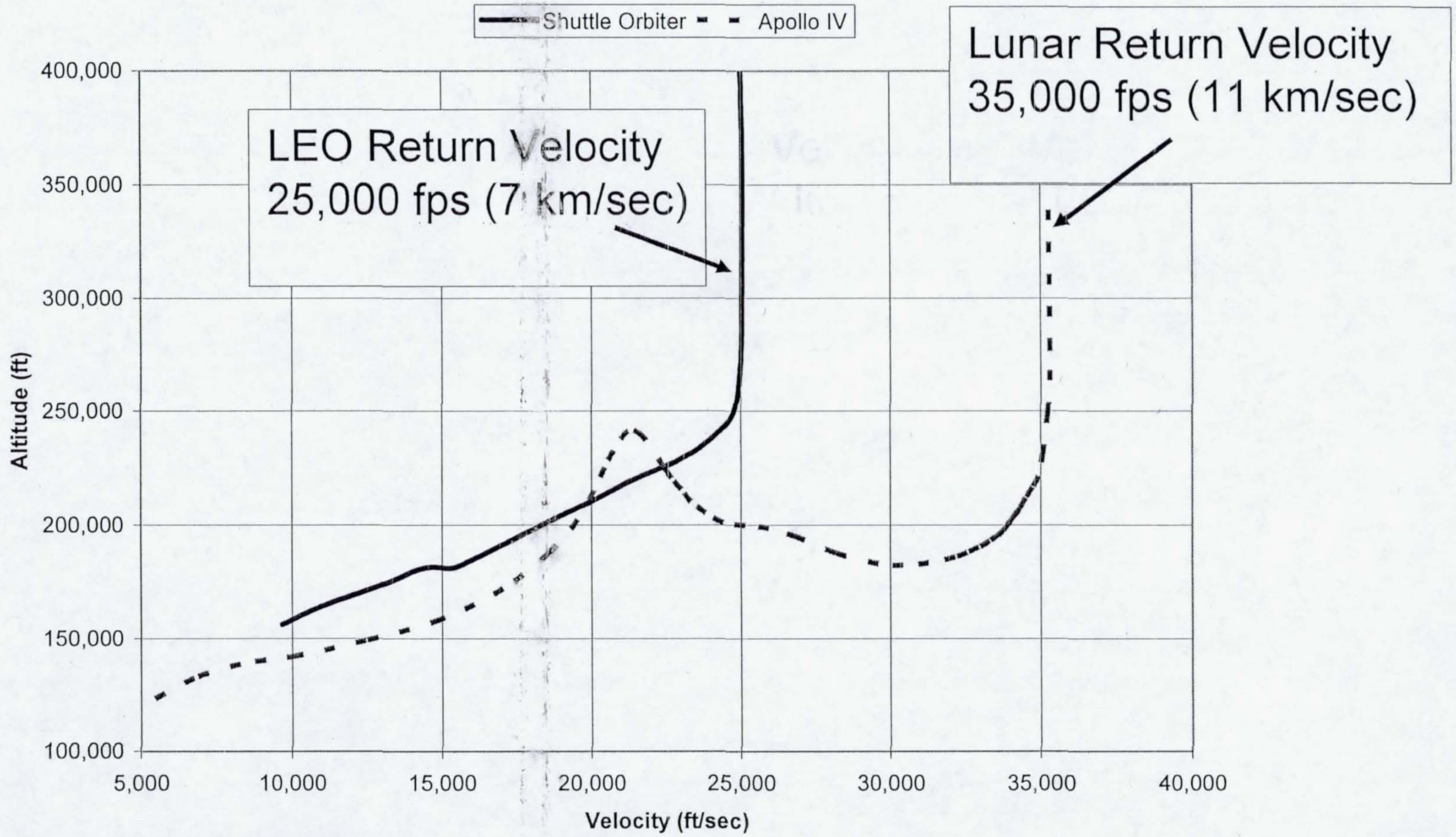
Background

- All space vehicles that reenter Earth's atmosphere from either LEO or from Lunar/Mars missions require thermal protection system (TPS) materials.
- TPS material development and verification require ground test facilities that simulate reentry aerothermodynamic environments.

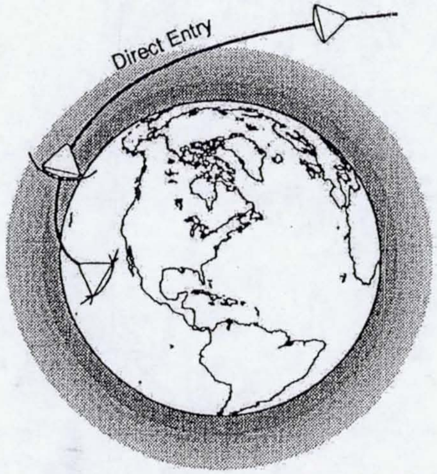
Reentry Trajectory Drives TPS Material Requirements



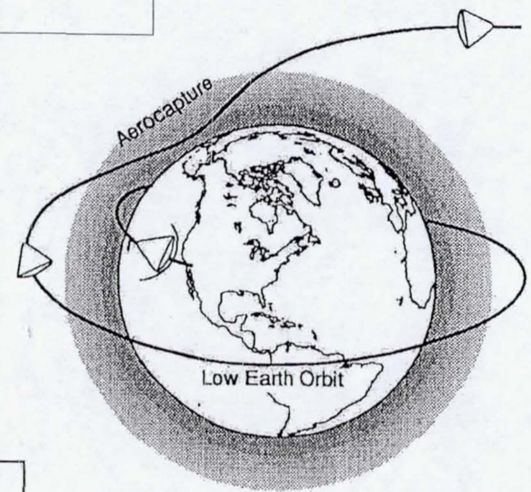
Lunar/Mars Return Aerothermodynamic Environments

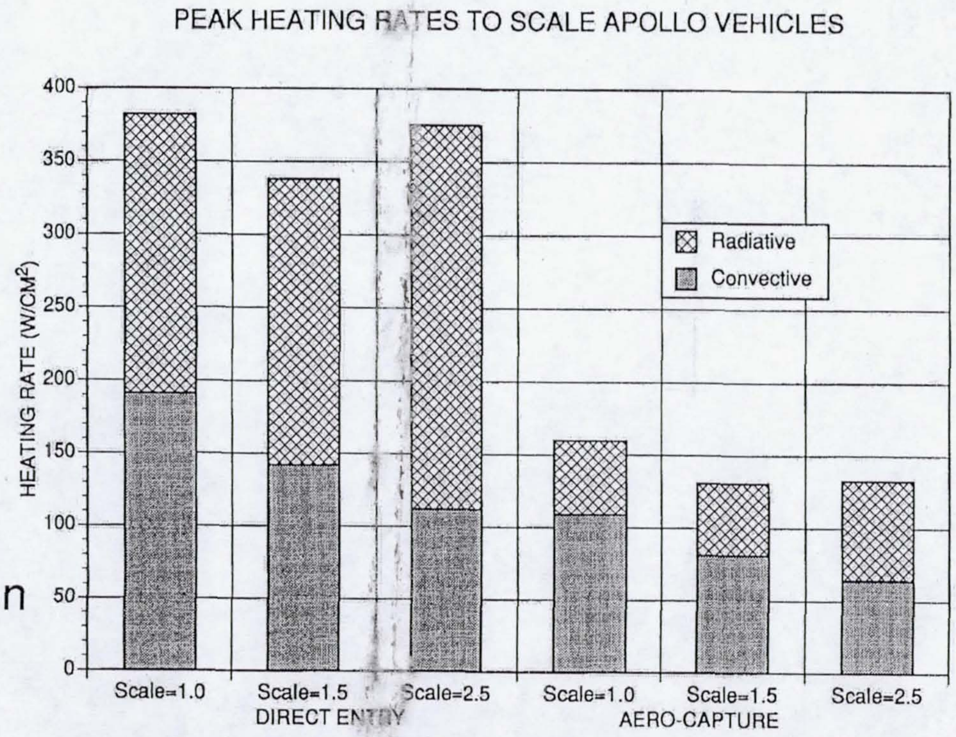
- High Enthalpy Gas
  - Lunar/Mars Return: Air @ 20,000+ Btu/lb_m (46 MJ/kg)
- High Convective Heating
  - Lunar/Mars Return: 200+ Btu/ft^2-sec (227+ W/cm^2)
- High Gas Cap Radiation Heating
  - Lunar/Mars Return: 200+ Btu/ft^2-sec (227+ W/cm^2)
- High Stagnation Pressures
  - 0.5 atmospheres
- Aerodynamic Shear Stress

Convective and Radiation Heat Flux



Gas Cap Radiation Heating
Comparable Level as Convective

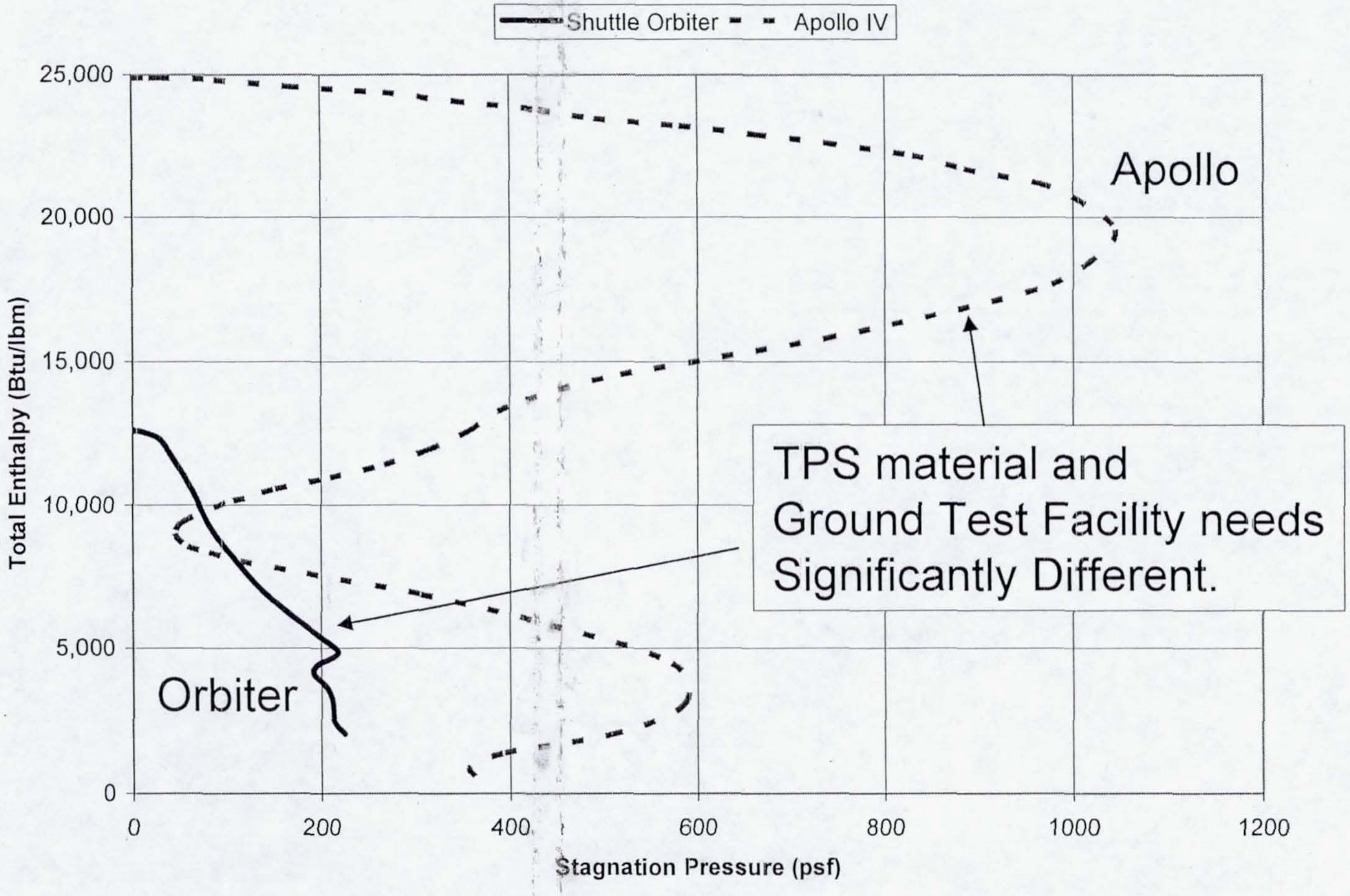




Increasing Radius increases Radiation and decreases Convection.

Scaling from Ground Test to Flight

Total Enthalpy and Stagnation Pressure

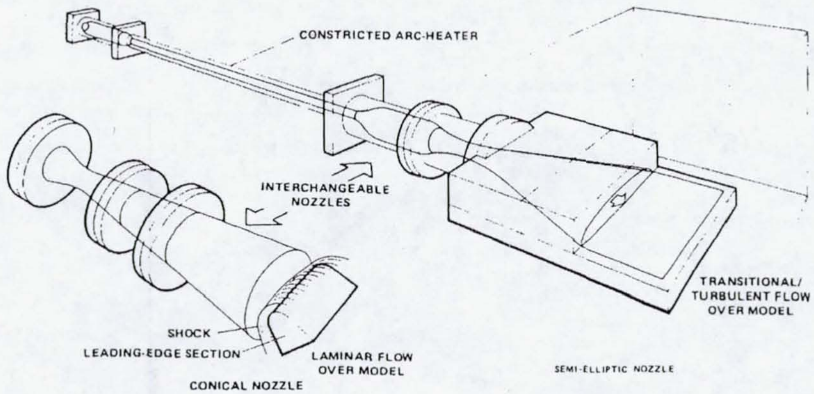


Ground Test Facility Needs

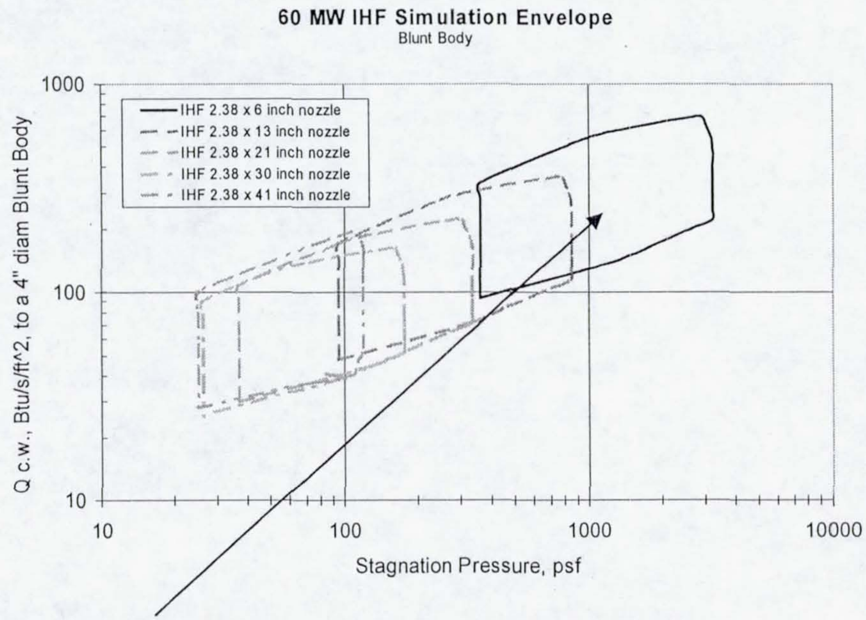
- High Enthalpy Gas Facilities
  - Both air and CO_2
  - Large range of stagnation pressures
- Combined Convective and Radiative Heating

NASA Ames Arc-jet Facility

60MegaWatt Interaction Heating Facility



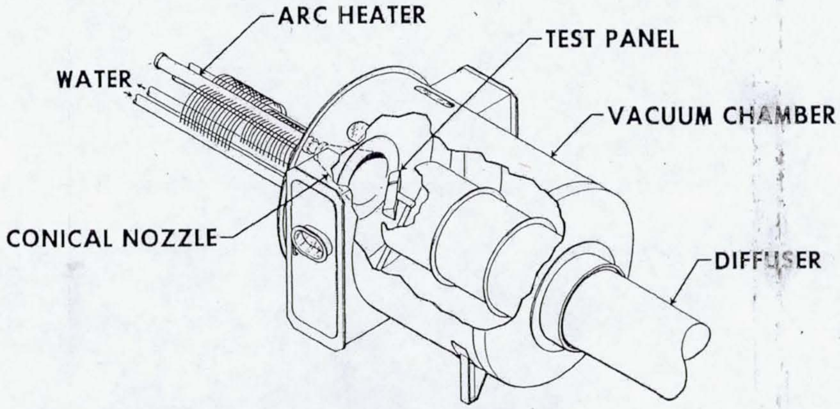
Test Gases: Air and Nitrogen

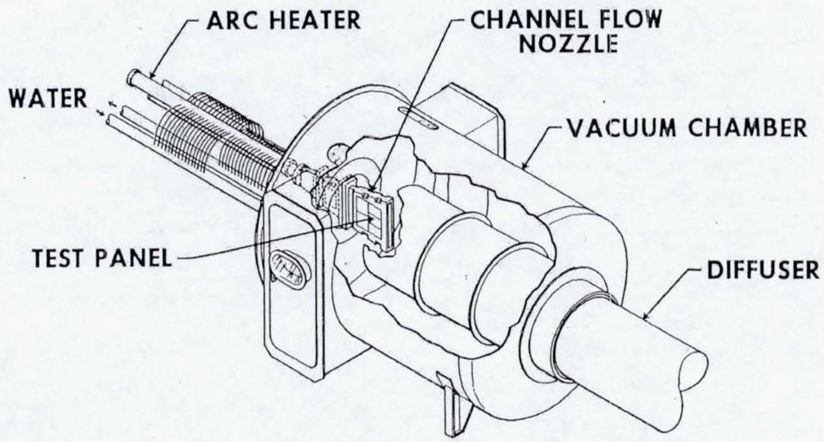


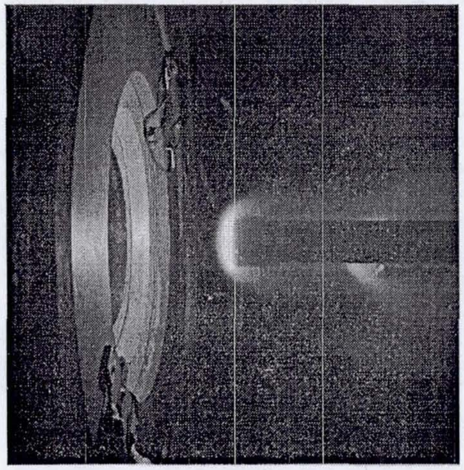
High Convective Heating and High Stagnation Pressures can be achieved on small test specimens.

NASA JSC Arc-jet Facilities

Orbiter TPS Certified Facility







Test Gases: Simulated Air; Nitrogen

Stagnation Heat Fluxes:
Stagnation Pressures:

Concluding Remarks

- Future Lunar/Mars missions require ground test facilities for TPS material development and flight certification.
- Existing arc-jet facility capabilities need to be updated and expanded.
  - Combined convective and radiation heating.
  - CO_2 test capability for Mars entry.

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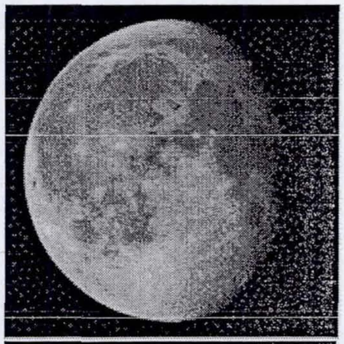

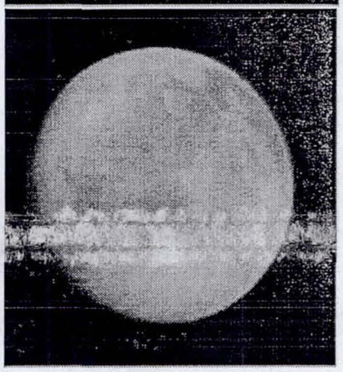

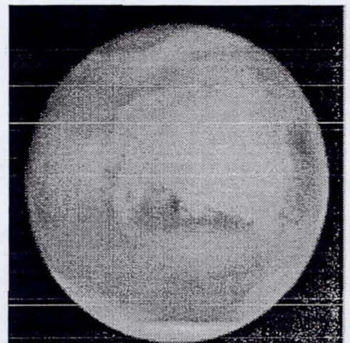

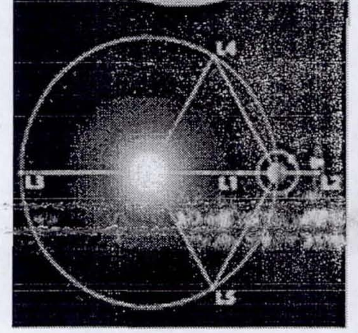

A Technical Workshop

Sponsored by the Development Programs Division,
NASA Office of Exploration Systems
&
Hosted Jointly by
The Lyndon B. Johnson Space Center
The Langley Research Center

March 1st thru 3rd, 2004

Hilton Hotel and Conference Center
The University of Houston
4800 Calhoun Rd.
Houston, Texas 77204

OVERVIEW

Monday, 1 March 2004, in the Plaza Room

TIME	EVENT
7:45 – 8:30 AM	Registration and Refreshments
8:30 – 8:45 AM	Welcome
8:45 – 9:30 AM	**Overview of NASA Vision for Exploration (TSI)** *John Mankins, NASA HQ*
9:30 – 10:30AM	**Materials Needs for Exploration** *Mr. John Connell, NASA Langley Research Ctr*
10:30 – 10:45 AM	Break
10:45 – 11:45 AM	**Revolutionary Materials** *Dr. Richard Smalley, Nobel Laureate, Rice University: Carbon Nanotubes and Space Applications.* Presentation and Discussion
11:45 – 12:45 PM	Lunch
12:45 – 1:45 PM	**Carbon Nanotube Woven Garment** *Mr. Ray H. Baughman* *Robert A. Welsh Professor of Chemistry and NanoTechnology, University of Texas-Dallas*
1:45 – 3:45 PM	Catalytic Presentations & Discussions
3:45 – 4:00 PM	Break
4:00 – 5:00 PM	Catalytic Sub Session Reports and Discussion