Exploration of Jovian Atmosphere Using Nuclear Ramjet Flyer

by

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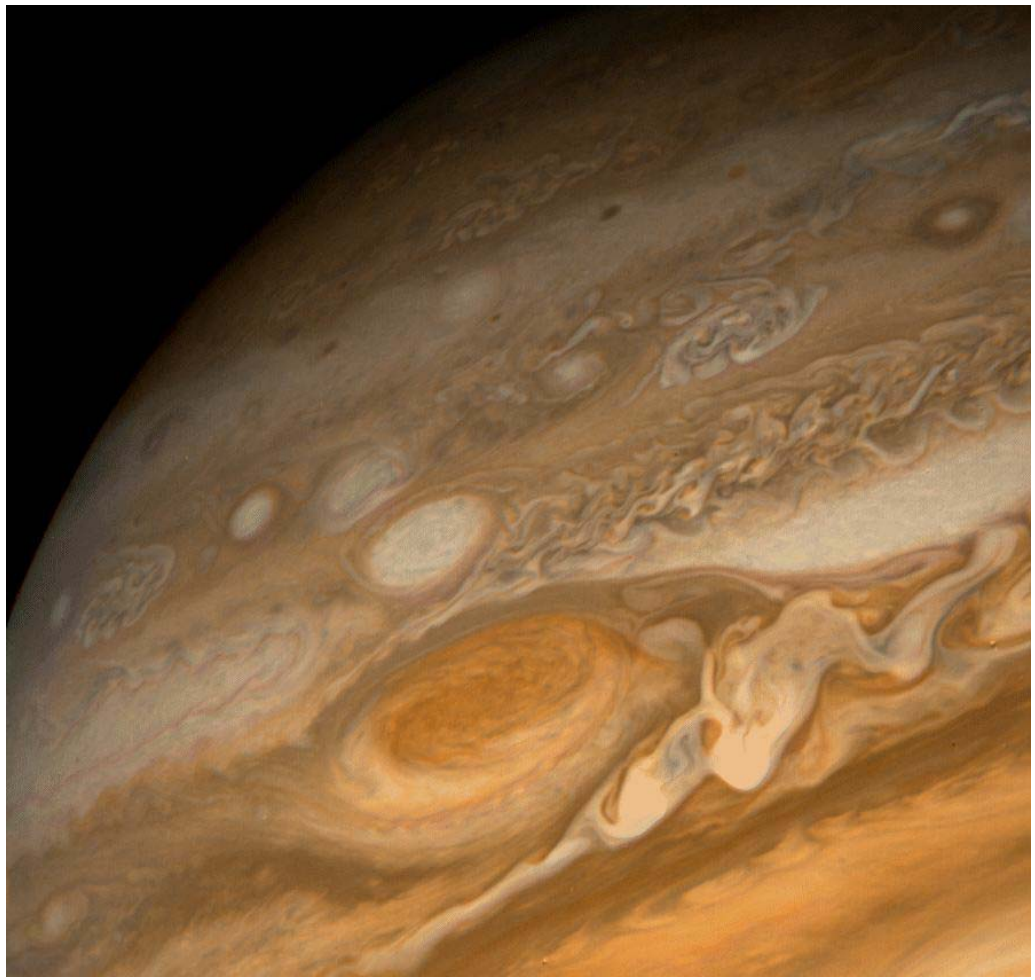
⌘ Edward Kush, Consultant	Ramjet Propulsion
⌘ Hans Ludewig, BNL	Nuclear Physics
⌘ George Maise, Plus Ultra Tech.	Principal Investigator
⌘ John Paniagua, Plus Ultra Tech.	Mission Analysis
⌘ James Powell, Plus Ultra Tech.	Inventor of Concept
⌘ Sven Roosild, Consultant	Radiation Hardening
⌘ Pasquale Sforza, U. Florida	Flight Vehicle Aerodynamics

Jovian Clouds



Motivation for Studying Jupiter

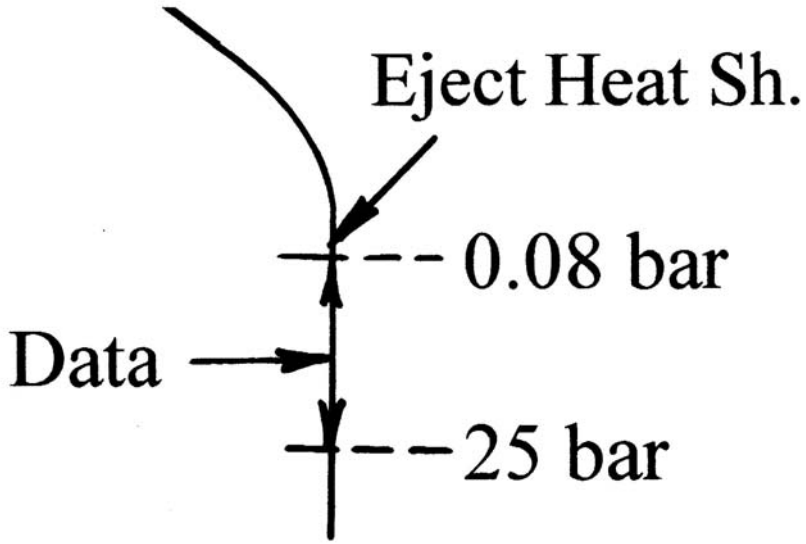
- Jupiter's atmosphere has has many puzzling features.
- Understanding Jupiter is the central to exploration of Solar System.
- Jupiter is prototype for Saturn, Uranus and Neptune.
- Jupiter is extremely common planet type. It is likely that most solar systems have a gas giant at ~5 AU.

Galileo Probe

To date, only direct measurement of Jovian atmospheric properties.

Launched: 1989
Entered Jovian Atmosphere: December 7, 1995

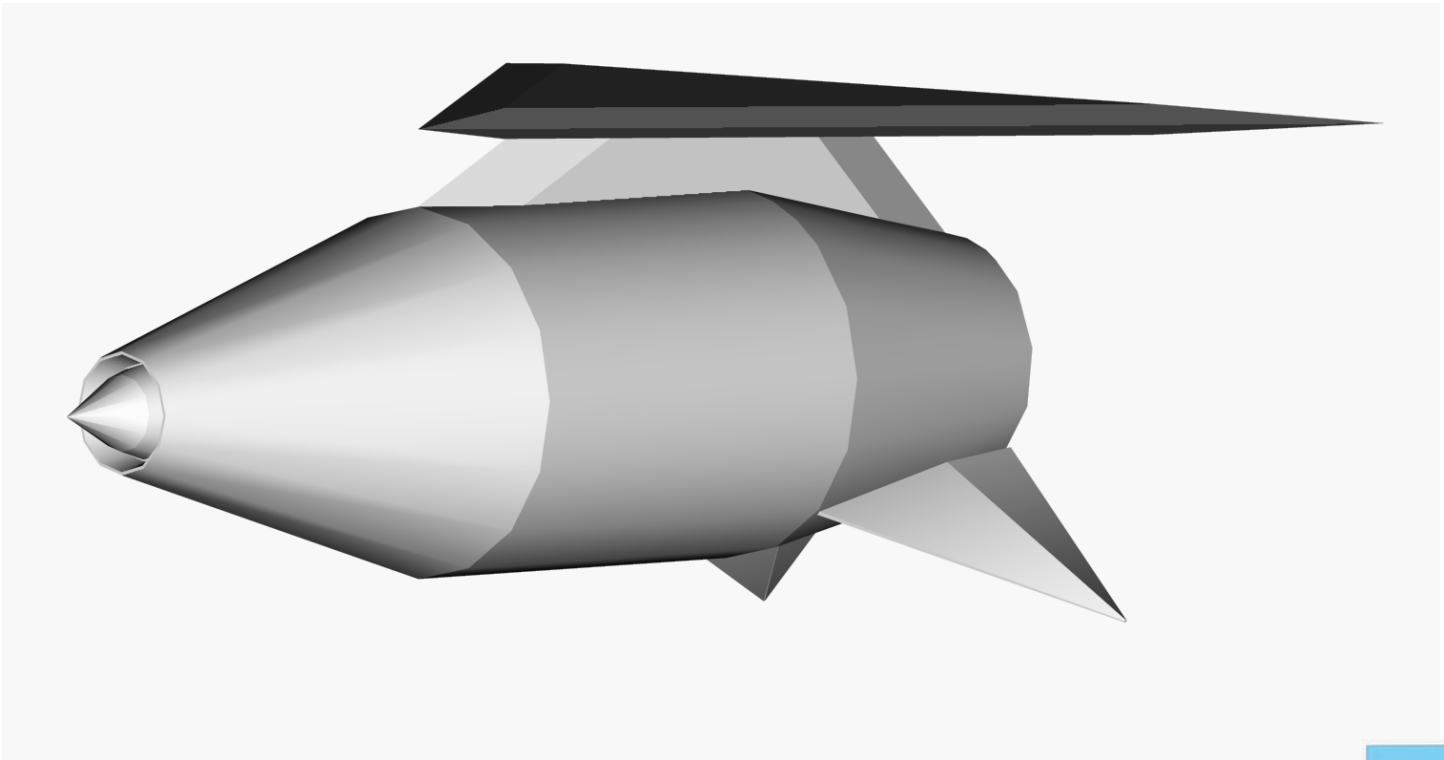
$V = 47.4$ km/s
$T_o = 15{,}000\,^{\circ}C$
Decel. = 230g



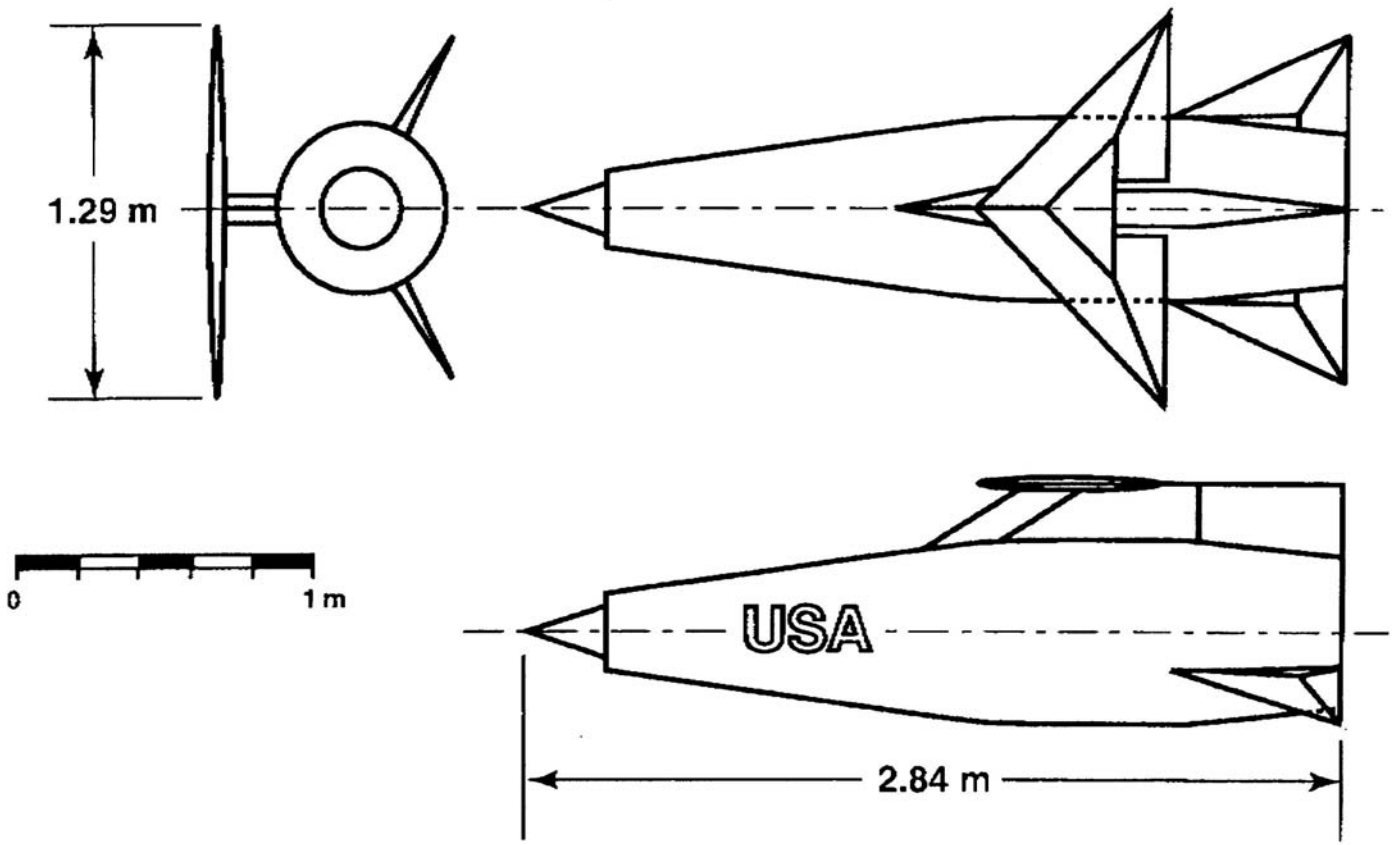
Characteristics of Nuclear Ramjet Flyer

- Jovian atmosphere is an unlimited source of propellant.
- MITEE compact nuclear reactor is (nearly) unlimited source of heat.
- With few moving parts, mechanical wear should be minimal.

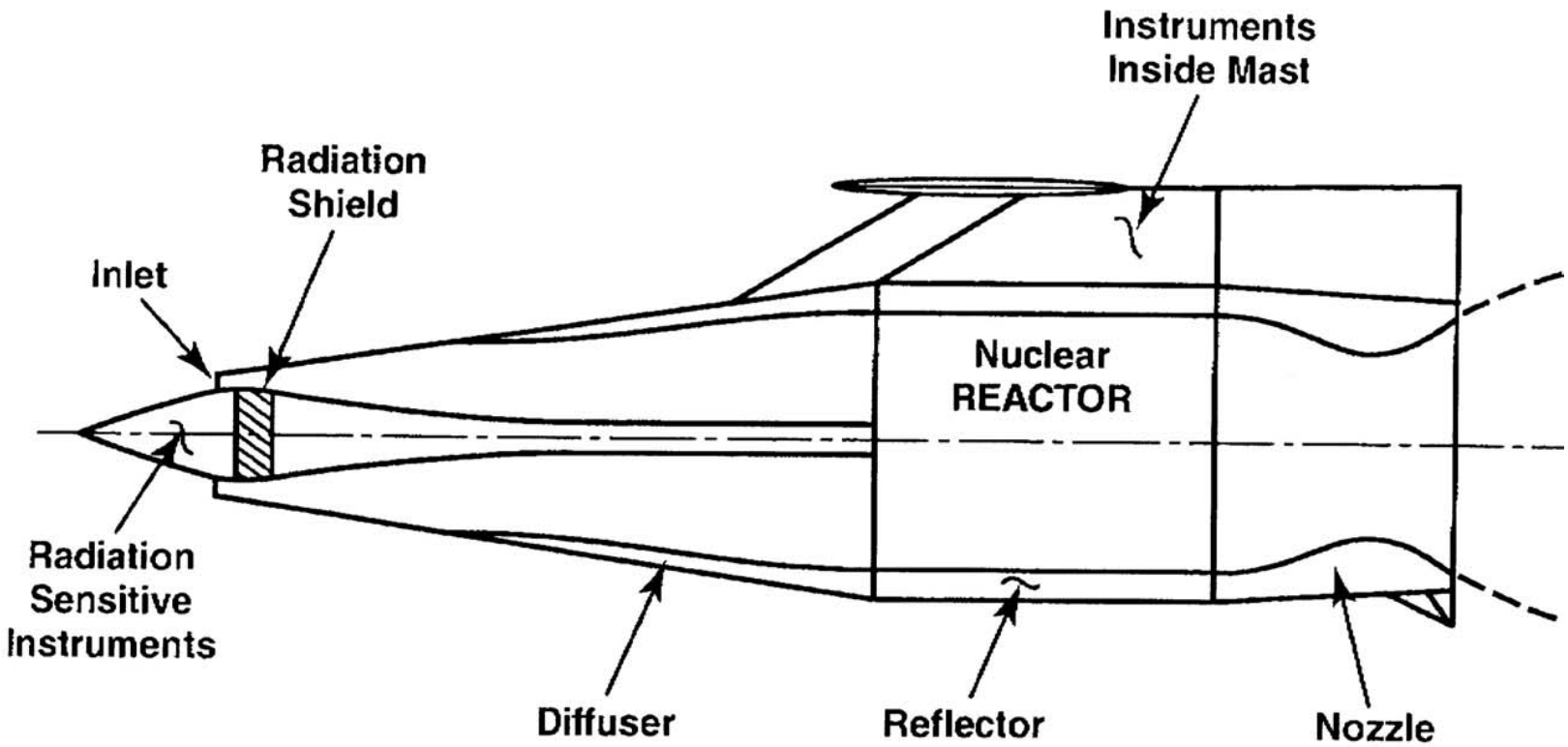
Nuclear Ramjet Flyer



Ramjet Flyer (3 Views)



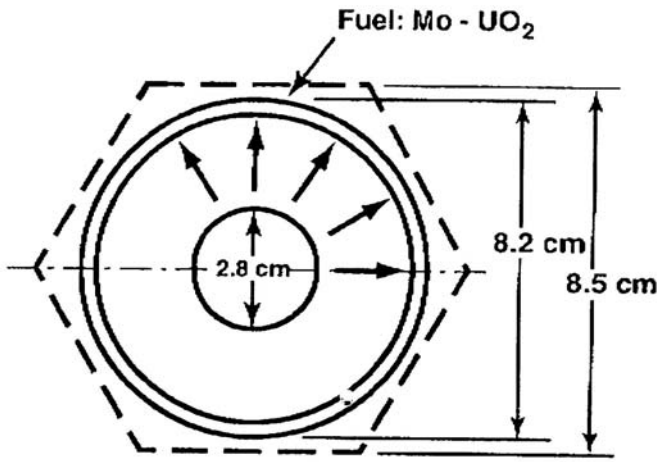
Cut-Away View of Flyer

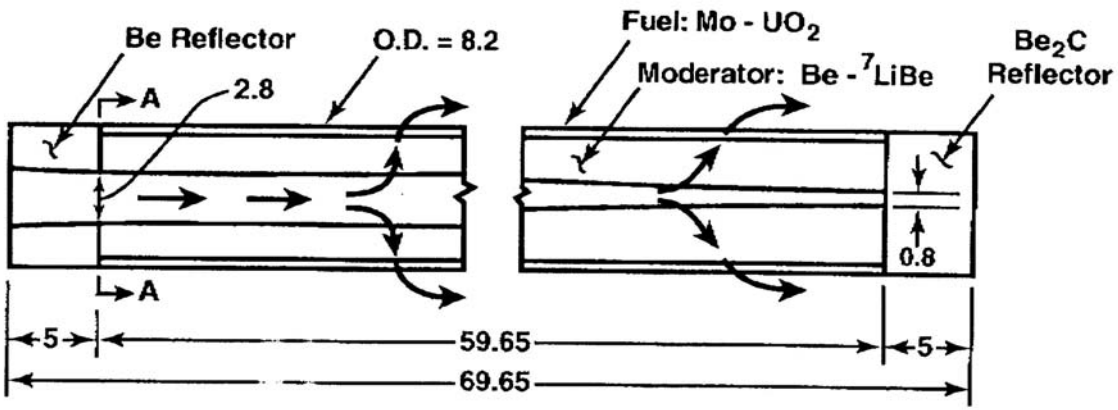


MITEE Nuclear Engine (Rocket Version)

- MITEE (**MI**niature Reac**T**or **E**ngin**E**);
  Ref.: *Acta Astronautica*, Vol. 44, No.2-4, 1999)
- Derivative of Ultra-Light Particle Bed Reactor (PBR) developed for SDIO (1985-1993; ~ $200M)
- MITEE is lighter and more compact then PBR.
- MITEE can be adapted for ramjet application:
  - Replace H_2 by ambient atmosphere from inlet
  - Reduce outlet temperature from 3000 K to 1500 K
  - Reduce power density from 10 to 2 MW/liter
  - Increase operating life from ~1 hour to months

Fuel Element of MITEE Nuclear Engine (Ramjet Version)





Radiation Safety

- Before reactor startup nuclear fuel is not hazardous.
- Reactor will start operation only after Jovian entry.
- During launch (from Earth) safety systems prevent criticality for all conceivable accidents.

Mission Characteristics

- Payload of 900 kg, comprised of
  - Ramjet Flyer 300 kg
  - Thermal Shield 300 kg
  - Companion Orbiter 200 kg
- Launch into LEO w. chemical rocket (e.g., Atlas IIAS).
- From LEO, fly to Jupiter using:
  - Chemical rocker with GA's: ~6 years
  - Nuclear Thermal Rocket (NTR): ~2 years

Mission Characteristics (Cont.)

- Upon arrival at Jupiter:
  - Companion Satellite separates from Entry Capsule
  - Companion Satellite enters Jovian orbit
  - Capsule enters Jovian atmosphere
- When Entry Capsule has slowed to Mach 3, Flyer separates from thermal shield.
- Nuclear engine starts.
- Flyer commences atmospheric mapping.

Atmospheric Data Collected

- Pressure
- Temperature
- Chemical Composition
- Wind Velocity
- Cloud Particles and Size Distribution
- Lightning Frequency and Energy
- Energy Flux from Sunlight
- Energy Flux for Deep Interior
- 3-D Images of Cloud Formations

Scientific Instruments

- Atmospheric Structure Instrument (ASI)
- Gas Chromatograph/Mass Spectrometer (GCMS)
- Clear-Air Turbulence Scanner (CAT)
- Lightning/Energetic Particle Detector (LEP)
- Nephelometer
- Magnetometer
- Stereo Imaging System (SIS)
- Dropsondes (6; allow 3 kg)

Conclusions

- Ramjet Flyer is a practical system for mapping in great detail characteristics of Jovian atmosphere.
- Understanding Jupiter is central to exploration of our Solar System (and other solar systems).
- The MITEE nuclear engine, if developed for the Ramjet Flyer, has multiple other applications for Solar System and for near interstellar exploration.