Europa Mission Planning and Status

Planetary Protection Advisory
Committee Meeting
July 27, 2005

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Europa Geophysical Explorer Mission Concept Study

Summary Report

June 27, 2005

The Next Step in Europa Exploration

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Not for distribution outside NASA; not cleared for external release

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The Next Step in Europa Exploration

Why study this now? What has changed?

- The Europa Geophysical Explorer 2005 would build on previous Europa Orbiter concepts:

✓ **Earth gravity assists (EGAs) are on the table (direction from NASA)**
  - Dramatic increase in delivered mass
  - Somewhat longer flight time is acceptable

✓ Advances in radiation-hardened components and subsystems
  - Results from considerable investments from X-2000 and JIMO

✓ Developments in radioisotope power systems (RPSs)
  - Technology development for the MMRTG, SRG, and upgraded MMRTG

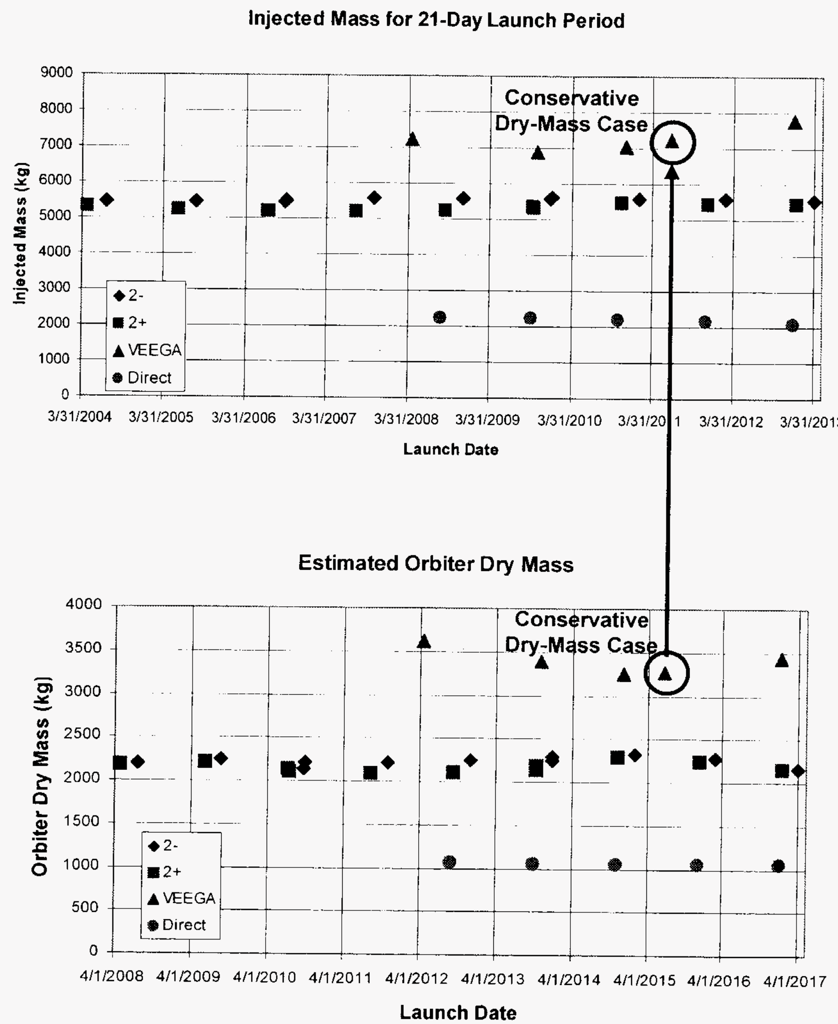
However, additional mass capability must be applied judiciously, without driving costs into an unaffordable range

Increased Mass Enabled by EGA

Earth gravity assists dramatically increase the delivered mass to Europa.

Some of this additional mass is unallocated and may be used to enhance spacecraft margins and science return.

Further detailed studies and design are needed to determine the use of this potentially available mass.



Potential Options for Unallocated Mass

- The potentially available mass could be used for
  - Additional spacecraft-growth margin needed due to challenges of a Europa mission
  - Additional instruments for enhanced orbital science
  - Extra radiation shielding that could result in a longer mission duration
  - A capable lander for surface operations (ref., Tibor Balint, Europa Surface Science Package Report, 09/2004)
  - Other purposes, still to be defined

Trade Studies

- Ten potential EGE mission options were explored within this study.
  - This trade space explored the system impacts of selecting different trajectory types, power systems, radiation shielding, launch vehicles, DSN architectures, and science payloads

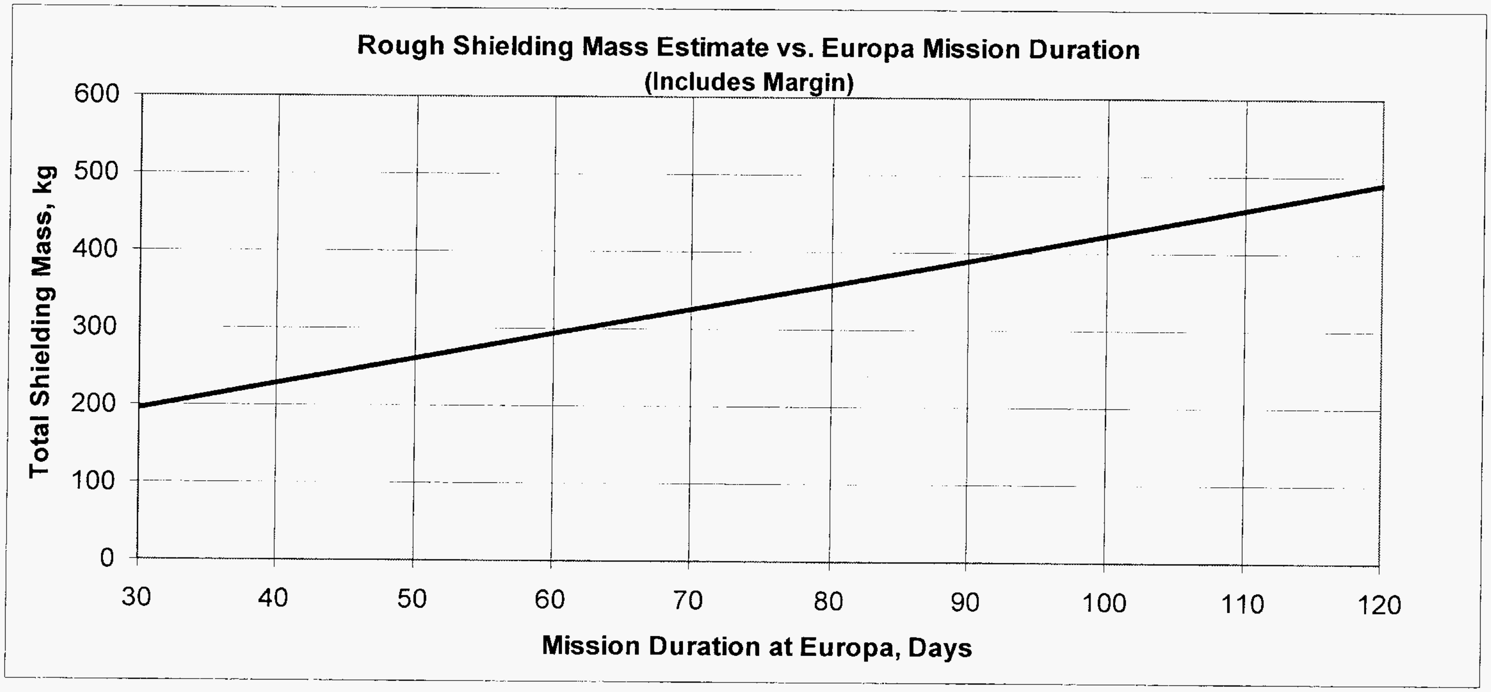
- Preliminary Trade studies and comparisons performed included:

  - Trajectory Type
    - VEEGA cf. ΔV-EGA
  - RPS Type
    - MMRTG cf. SRG cf. Upgraded MMRTG
  - Launch Vehicle Type
    - Delta 4050 cf. Atlas 551
  - Deep Space Network
    - Existing cf. Upgraded
  - Mission Duration at Europa
    - Shielding Mass cf. Mission Duration
  - Science Instrument Payload
    - Example suite cf. Augmented Orbiter Suite
  - Communications System
    - EGE cf. EO 2001
  - Lander Allocations
    - Options have mass margin ≥ 500 kg
  - Total Mission Risk
  - Preliminary Cost

Trade Study: Mission Duration at Europa (Example 4)

Longer duration mission provides opportunity for greater science return.

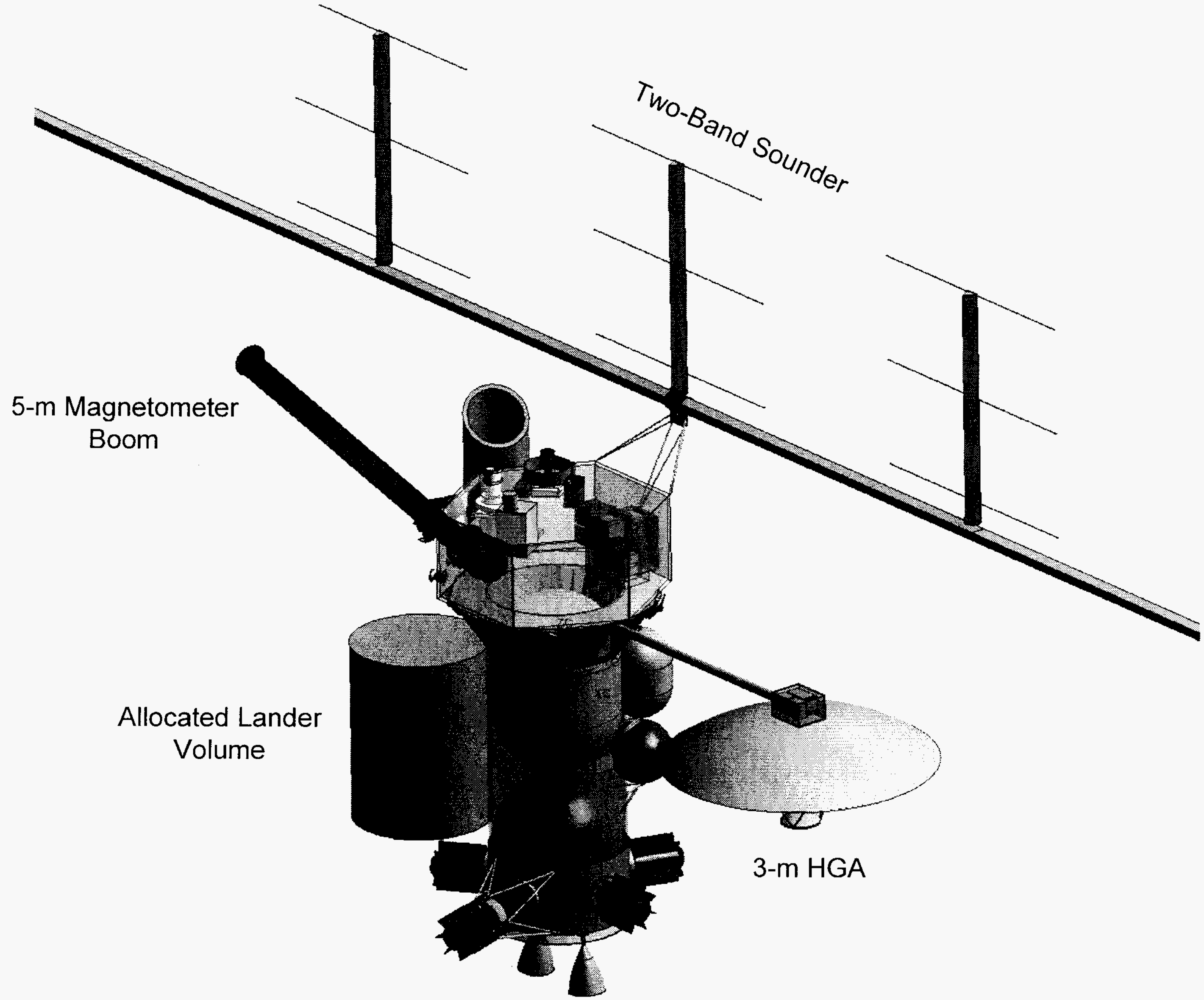
- Preliminary estimates were made of the shielding required for a ≥ 30 day Europa mission.
- Each month at Europa exposes the spacecraft to ~900 krads (behind 100 mils of aluminum).
- Need to increase the shield thickness and mass by ~50% for a 30 day mission extension (i.e., 60 days in orbit around Europa).



Each 30-day mission extension requires ~100 kg of additional shielding.

*Analysis assumed that, to first order, shielding thickness and mass were linearly related to radiation dose. Detailed radiation and spacecraft accommodation analyses need to be performed to generate a more accurate shield-mass estimate.

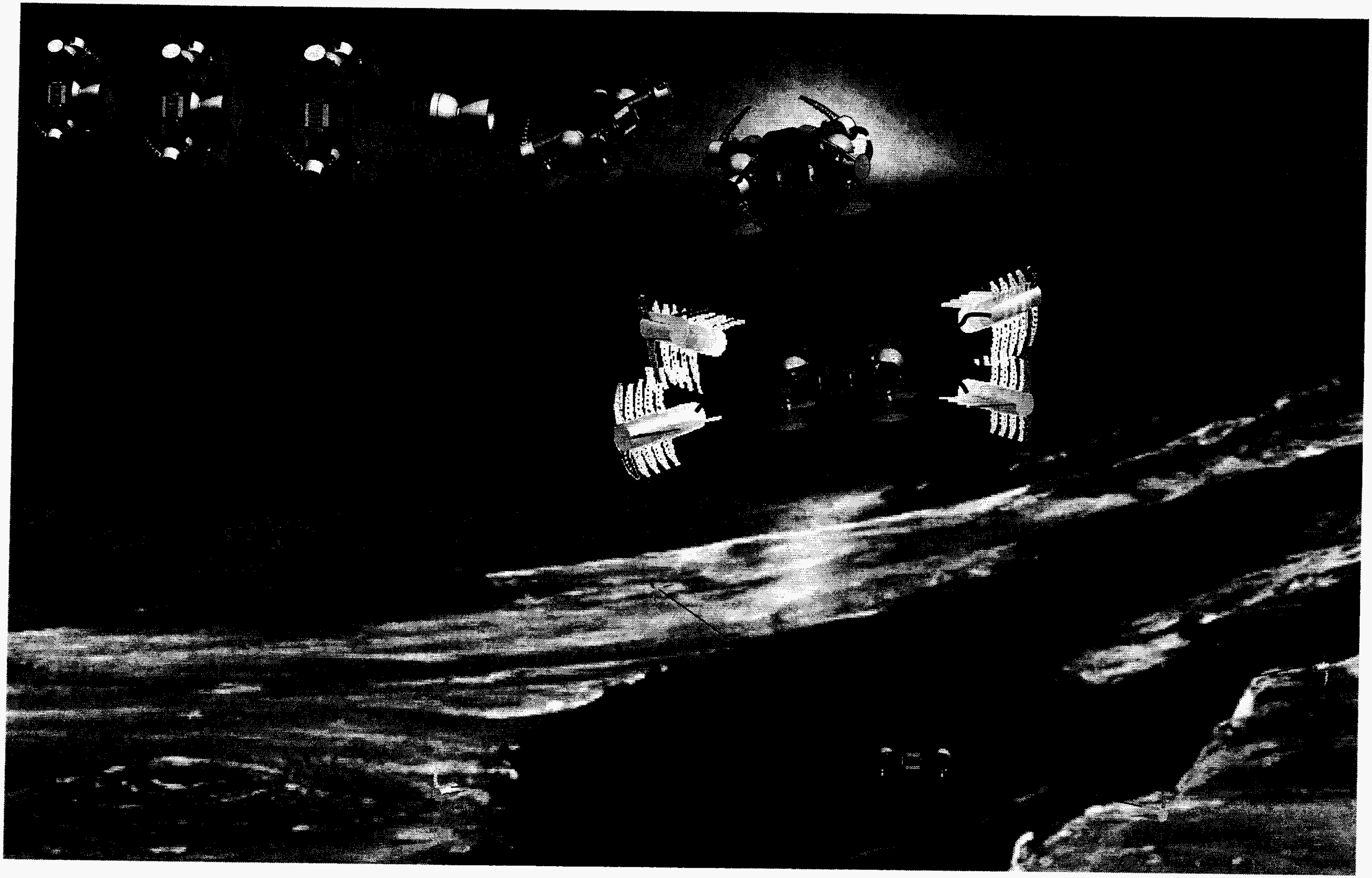
Example Drawing: EGE Spacecraft—Deployed Configuration



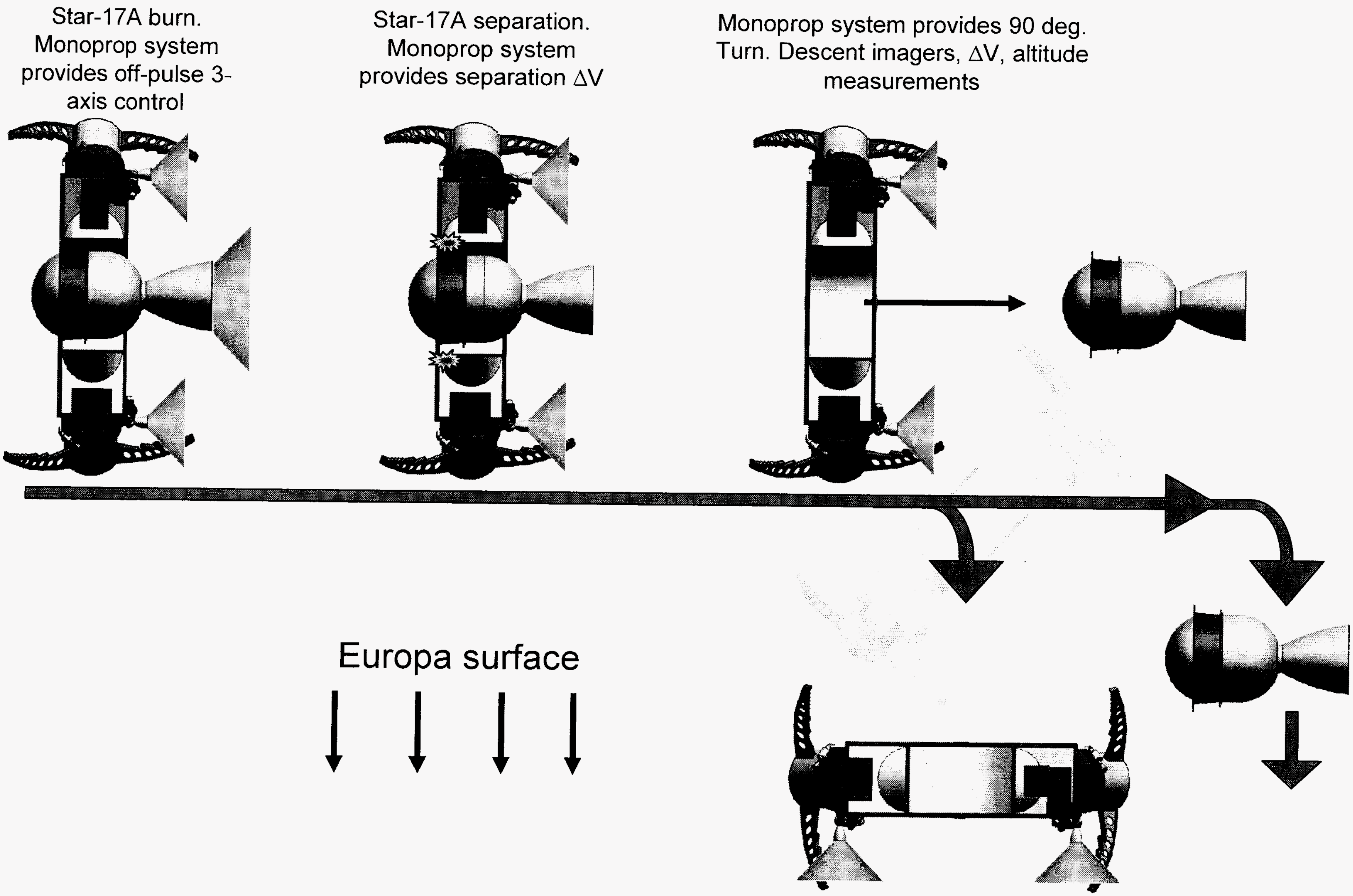
This is a design concept

Prometheus Project

Notional Europa Lander Concept

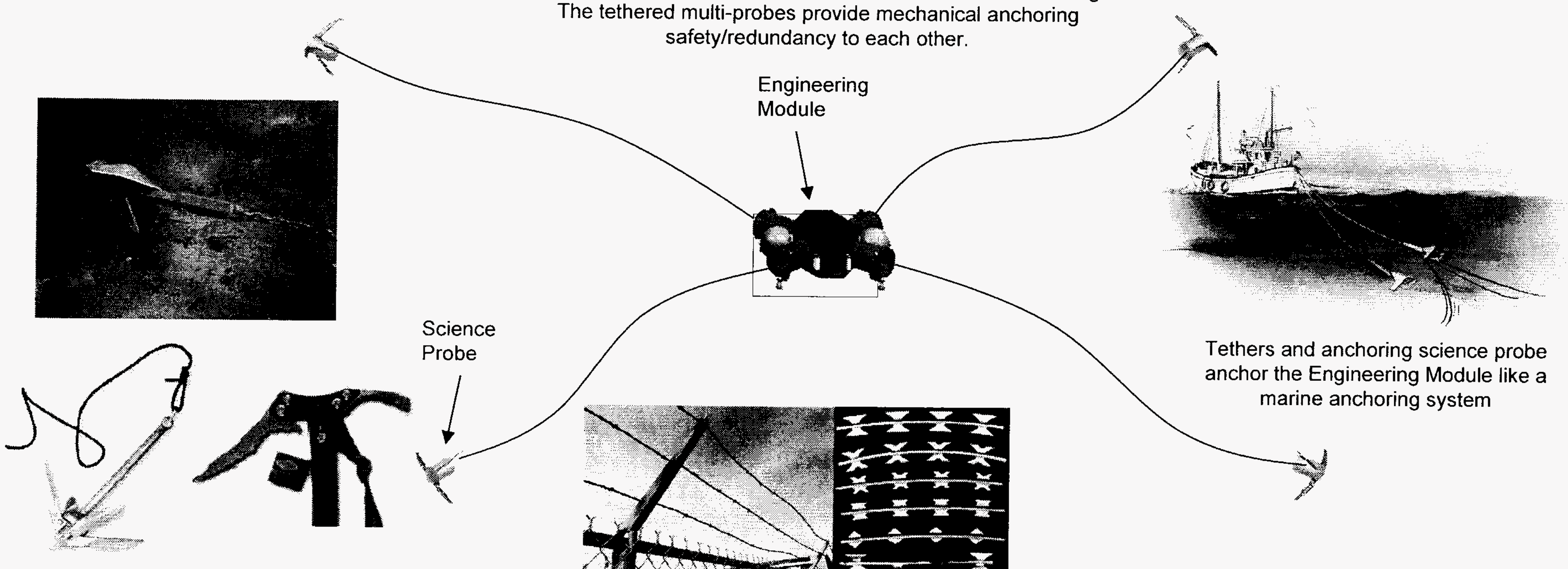


Star-17A Separation Scenario



Tethered Multi-Probes for Extreme Terrain

Inspired by mountaineering rope teams and Marine anchoring. The tethered multi-probes provide mechanical anchoring safety/redundancy to each other.

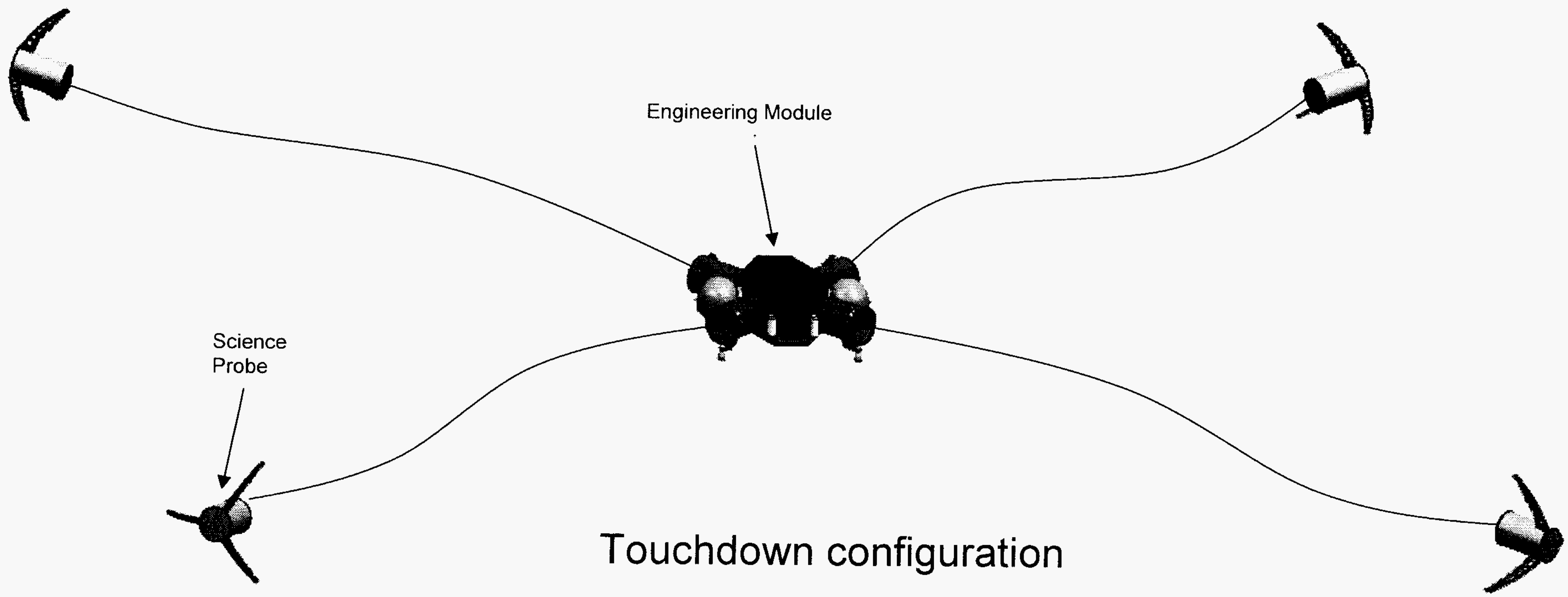


Tethers and anchoring science probe anchor the Engineering Module like a marine anchoring system

Geometry of science probes serves as an anchoring and sample acquisition device

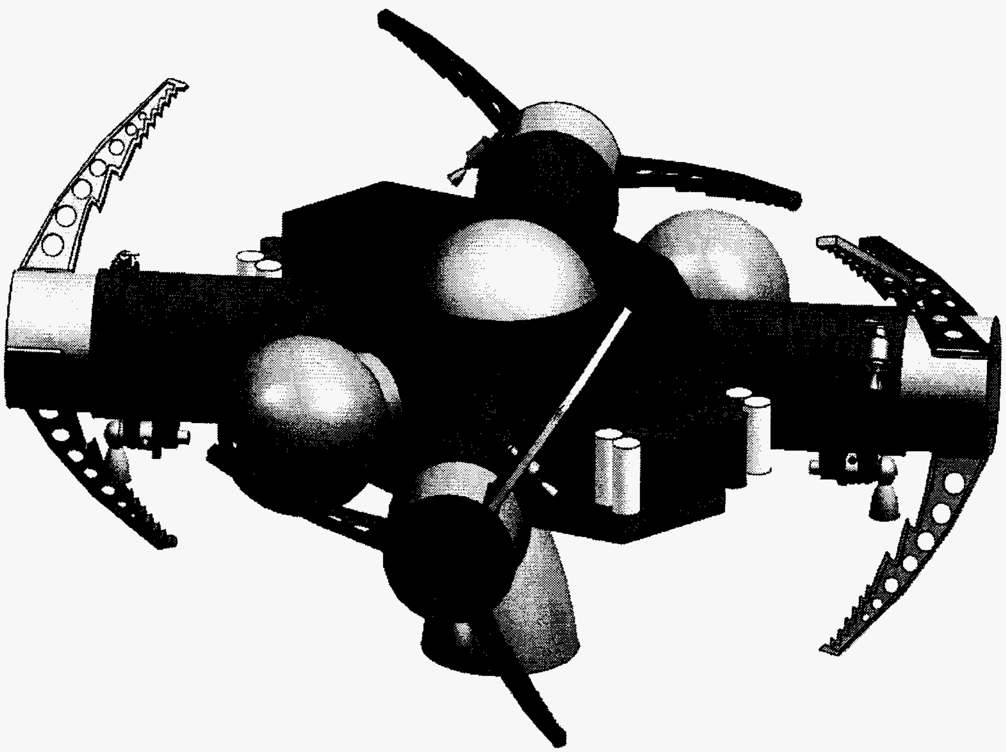
Barbed tethers act as continuous anchors which prevent the Engineering Module from slipping

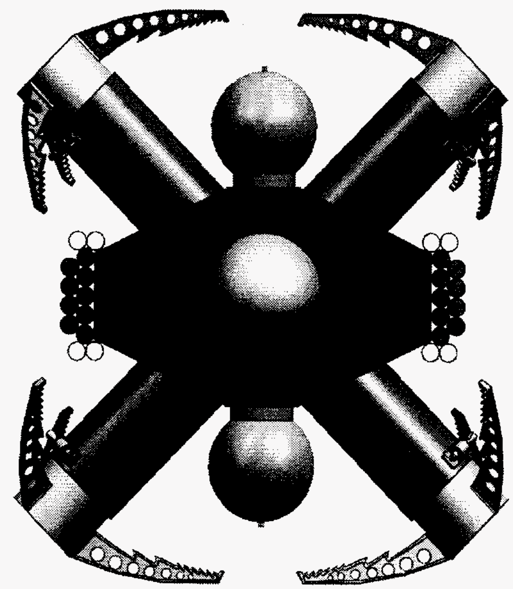
Touchdown Lander Configuration

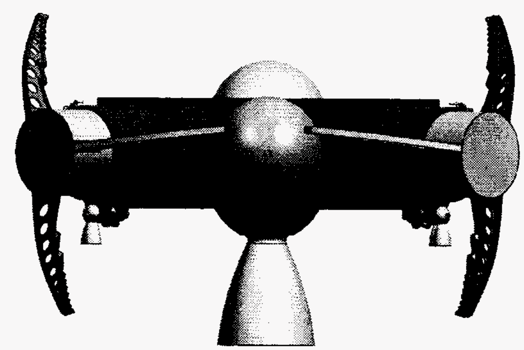


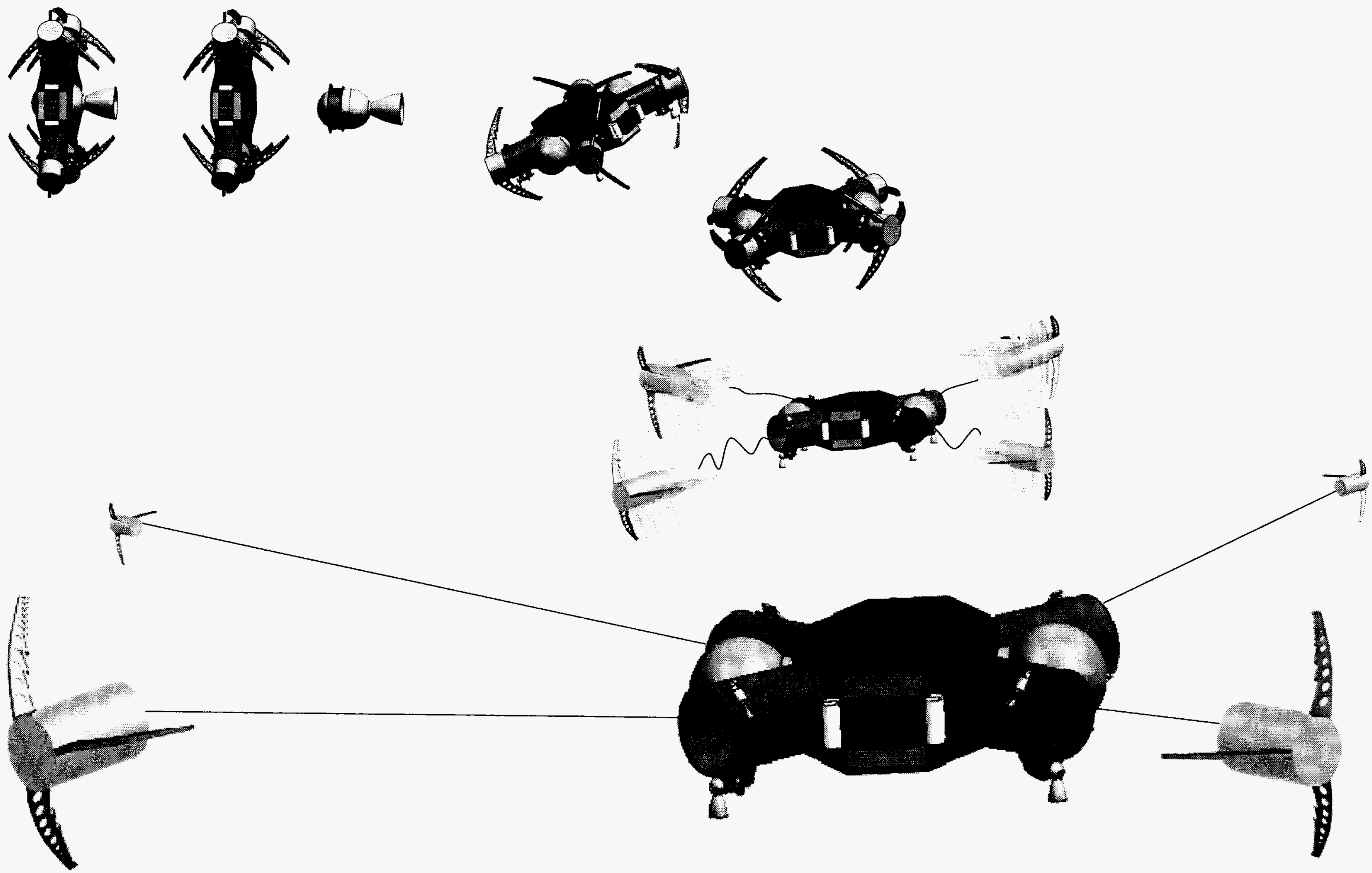
Touchdown configuration

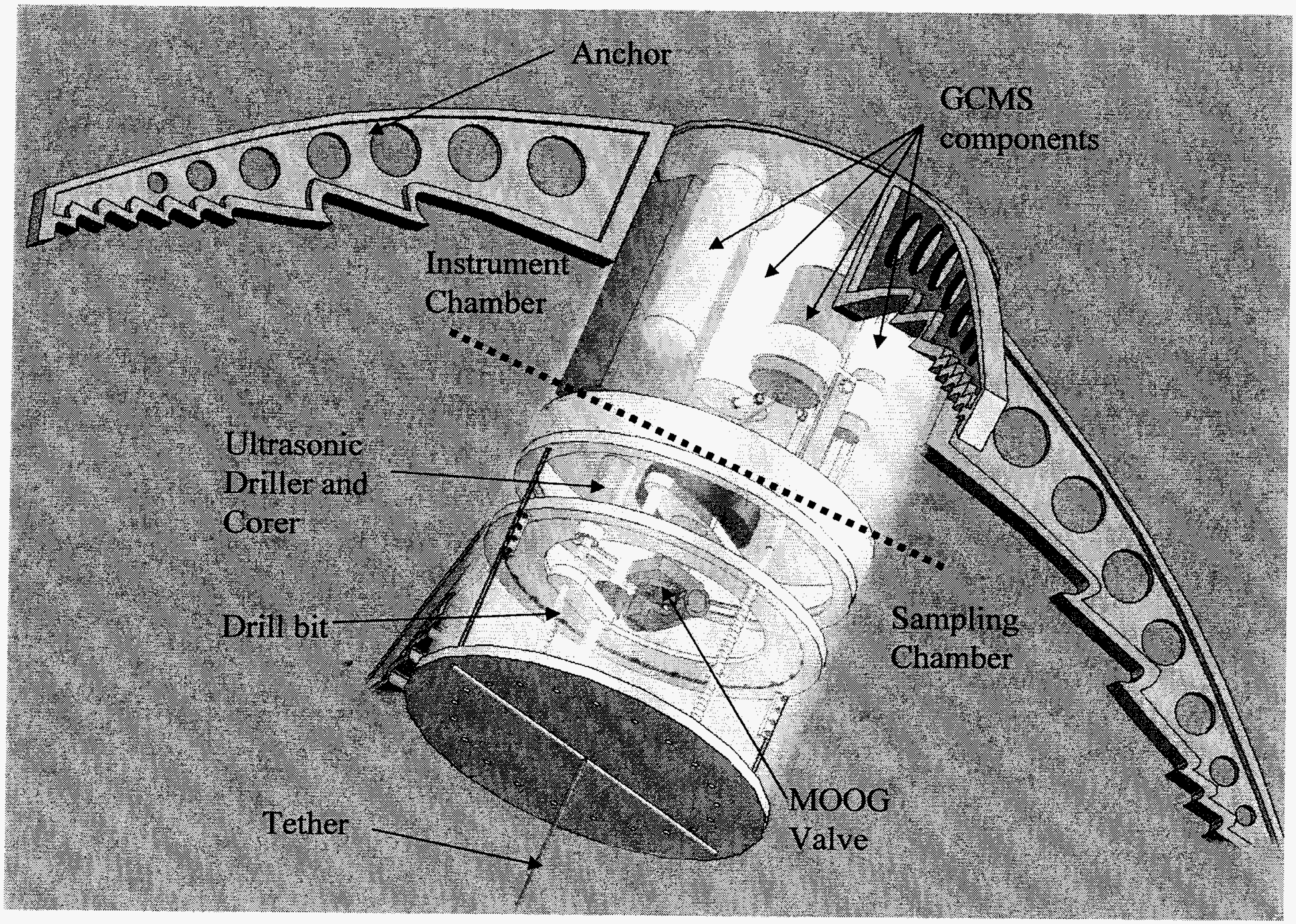
Touchdown Lander Configuration











Anchor
GCMS components
Instrument Chamber
Ultrasonic Driller and Corer
Drill bit
Sampling Chamber
MOOG Valve
Tether

Stability of Europan Orbits

JIMO Mission Design
Team

Jet Propulsion Laboratory

8 July 2005

Updated 18 July 2005

Europa Orbit Stability Summary

- All orbits not near Europa's equatorial plane (of any altitude) are unstable over the period of days to months. High altitude orbits will generally evolve to escape while low altitude orbits will evolve to impact
- Using a high precision numerical integration tool (DPTRAJ), a class of retrograde orbits has been shown to be apparently stable over a thousand years (see Figure 1) even in the presence of putative non-zero, higher order gravitational harmonics
- Example of orbit stability at moderate altitude/inclination, specifically 4,366 km at 146.5° was propagated for 1,000 years in DPTRAJ and was apparently well bounded (see Figure 2)
- There is significant dependency on orbit orientation which has not been well characterized
- Other classes of bounded orbits are likely to exist
- Transfer from low altitude, near polar science orbit to known stable orbits is very costly in radiation dose and/or propellant. For example in Figure 2, impulsive transfer cost would be ~0.7 km/s (m_p/m_0=0.56 – >0.66)

Figure 1

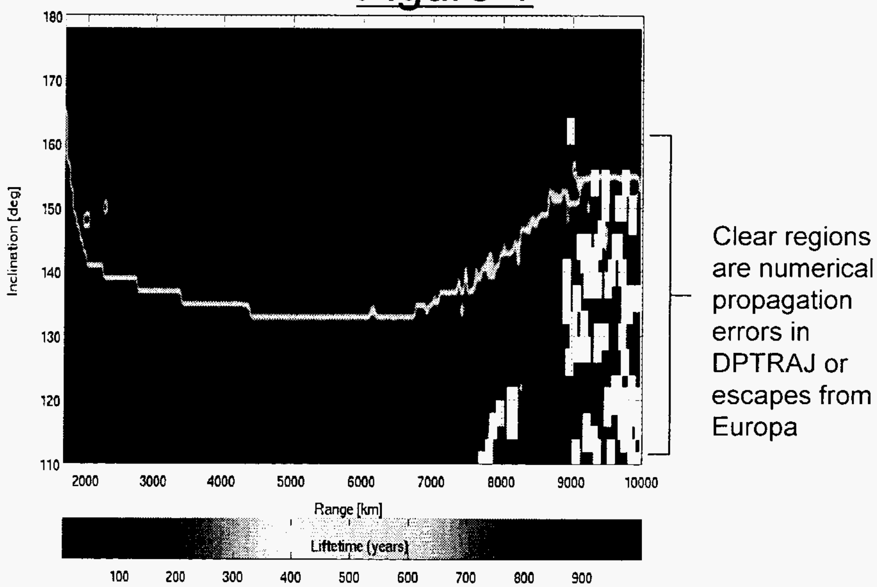


Figure 2