Europa Geophysical Explorer Mission Concept Studies

AGU Presentation

December 9, 2005

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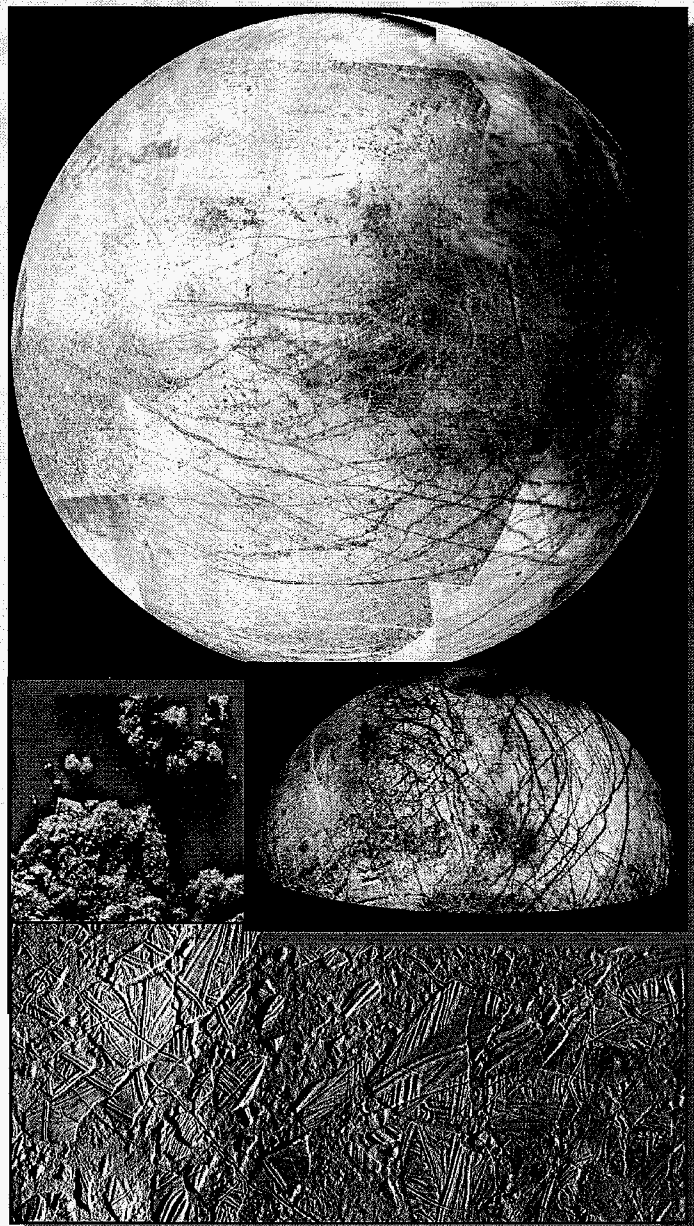
Objectives of this Study

- The Strategic Road Map for Solar System Exploration recommended in May 2005 that NASA implement the Europa Geophysical Explorer (EGE) mission as a Flagship mission early in the next decade. This supported the recommendations of the Solar System Decadal Survey and the priorities of the Outer Planets Assessment Group (OPAG).
- **NASA Headquarters Solar System Division initiated a 45-day study of the mission in early May 2005 in order to**
  - Understand new Europa mission possibilities that have emerged since the Europa Orbiter mission was cancelled
  - Define technology and advanced-development needs to support a launch early in the next decade
- **The study was supported by:**
  - Radioisotope Power System Program: Ajay Misra
  - Solar System Chief Technologist: Jim Robinson
  - Science: Curt Niebur



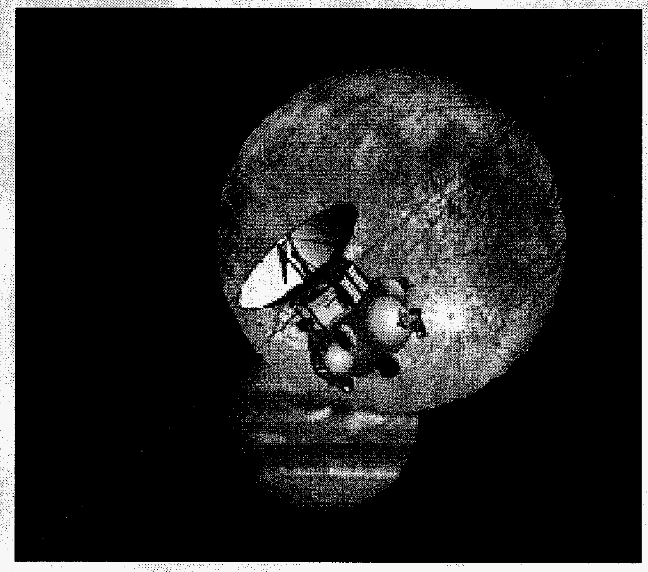
Why do this Study Now? What has Changed?

- **The next step in Europa exploration, EGE 2005 would build on previous Europa Orbiter concepts, plus some changes, such as:**
  - ✓ **Earth Gravity Assists (EGA) are on the table (direction from NASA), with safety still of highest priority**
    - Result in a dramatic increase in delivered mass
    - The somewhat longer flight time is deemed acceptable
  - ✓ **Better understanding of the radiation environment**
    - Radiation modeling from Galileo data indicates a smaller total radiation dose
  - ✓ **Advances in radiation-hardened components and subsystems**
    - Results from considerable investments from X-2000 and JIMO
  - ✓ **Developments in radioisotope power systems (RPS)**
    - Technology development for the MMRTG, SRG, and upgraded MMRTG

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

Draft Level One Requirements for the EGE Study

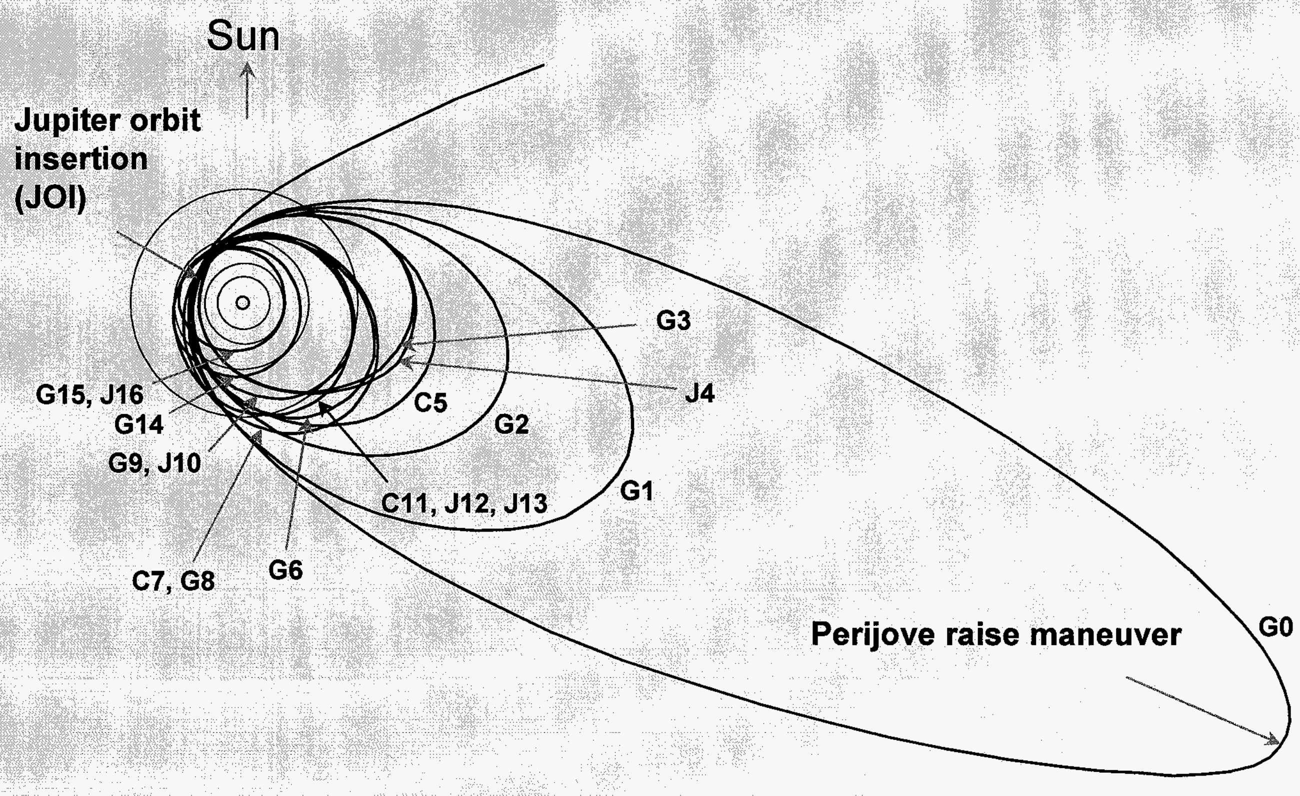
- **Earliest Launch: 2012**
- **Launch vehicle: Delta IV Heavy or Atlas V**
- **Primary Propulsion: Chemical**
- **Power Generation: Radioisotope Power System (RPS)**
- **Orbital Mission: 30 days minimum to meet orbital science objectives**
- **Earth Gravity Assists: Allowed**



(Source: NASA HQ, Curt Niebur)

EGE Representative Jovian Tour

Jovian Tour provides significantly enhanced science return from the Jovian environment and flybys of Ganymede, Callisto, and Europa before EOI.

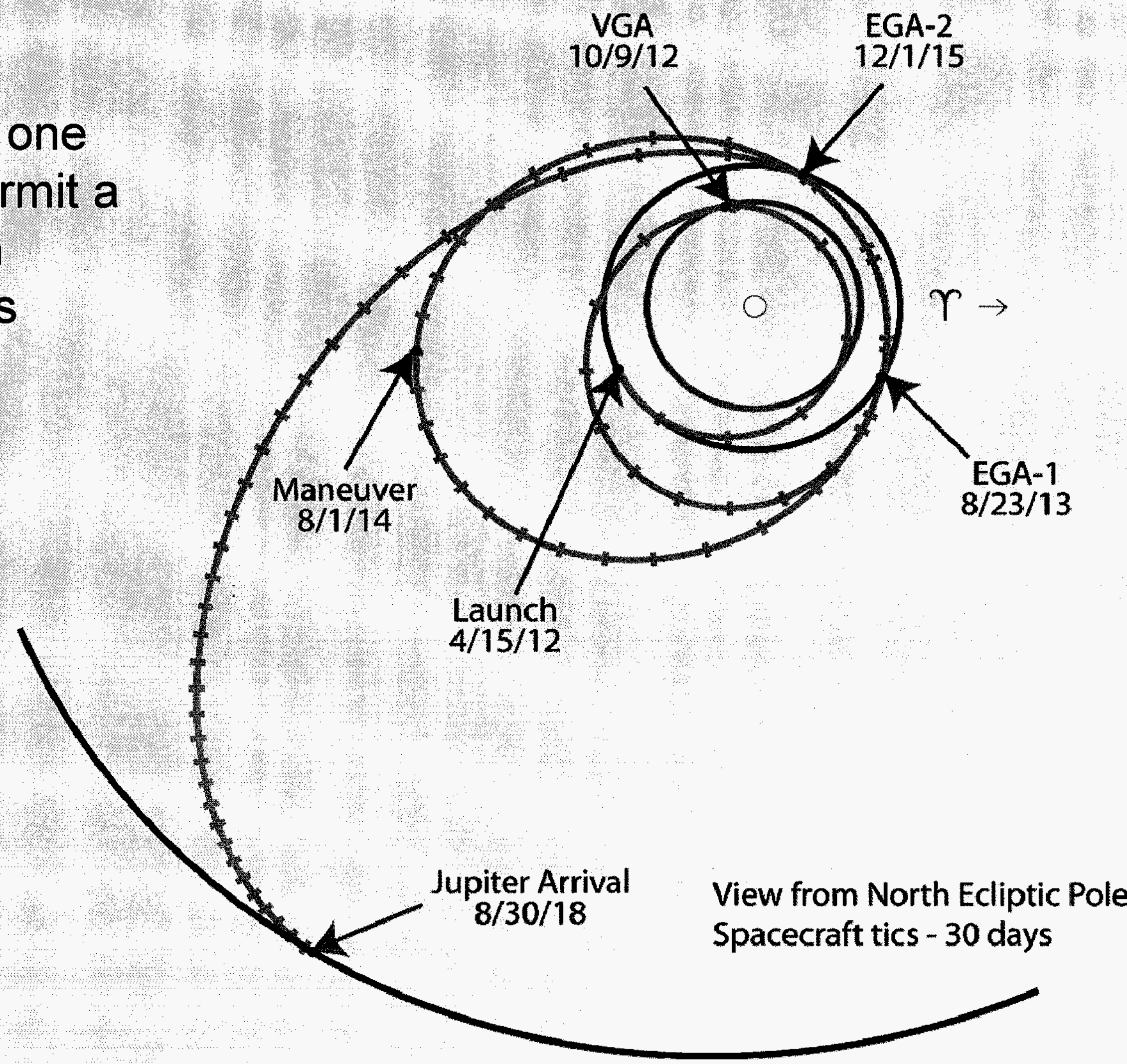


Sun–Jupiter Fixed View

J = Jupiter
C = Callisto
G = Ganymede

EGE 2012 VEEGA Trajectory Concept

Two Earth flybys and one Venus flyby would permit a significant increase in science payload mass



Science Objectives: Development

The EGE Study Team worked closely with the Europa Sub-Group (ESG) of the OPAG, to develop the science objectives and science instrument payloads for EGE

OPAG ESG Membership

- Greeley, Ron: planetary geoscience, lead
- Bagenal, Fran: fields & particles
- Campbell, Bruce: 3D terrain modeling
- Cooper, John: Jupiter system science
- Johnson, Torrence: JIMO SDT
- Khurana, Krishan: magnetic field
- Makris, Nick: ocean seismology
- McKay, Chris: astrobiology
- Moore, Bill: ocean, gravity science
- Pappalardo, Bob: Jovian satellites
- Prockter, Louise: surface geology
- Waite, Hunter: composition

OPAG ESG Objectives

A. Confirm the presence of a subsurface ocean

B. Characterize the three-dimensional configuration of the icy crust, including possible zones of liquid

C. Map organic and inorganic surface compositions, especially as related to astrobiology

D. Characterize surface features and identify candidate sites for future exploration

E. Characterize the magnetic field and radiation environment

F. Understand the heat source(s) and time history of Europa's ocean

Science Objectives: Trace ESG Objectives to Example EGE Science Instruments

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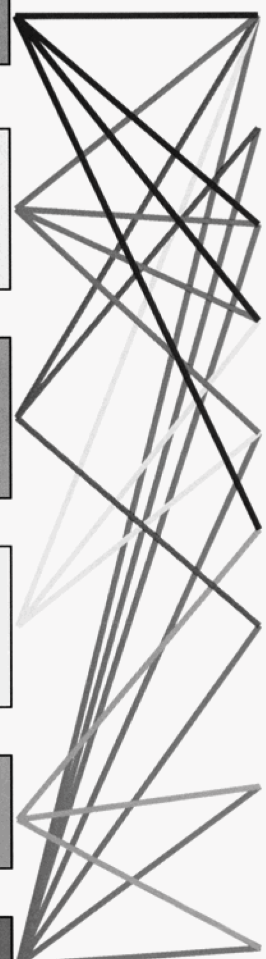


Example Science Instruments

(Objectives Met: A B C D E F)

- Visible imager A B C D F
- IR mapping spectrometer C F
- Precision tracking A B F
- Laser altimeter A B D
- Radar sounder B D F
- Magnetometer A E
- Ion & neutral mass spectrometer C F
- Low-energy charged particle spectrometer E F
- High-energy charged particle spectrometer E F

Payload Comparisons of Example Missions

Example Original Europa Orbiter	Example EGE Reference Mission	Example EGE Augmented Orbital Mission
30 kg, 30 W	~150 kg, ~150 W	~350 kg, ~350 W
Gravity/precision tracking	Gravity/precision tracking	Gravity/precision tracking
Narrow-angle camera (NAC)	Visible/NIR mapper, high resolution	Visible/NIR mapper, high resolution
Wide-angle camera (WAC), filters	WAC, filters	WAC, filters
IR mapper	Vis/MWIR spectrometer	MWIR spectrometer
Laser altimeter	Laser altimeter	Laser altimeter
Radar sounder	Two-band sounder	Two-band sounder
	Magnetometer	Magnetometer
	KeV ion spectrometer	KeV ion spectrometer
	MeV ion spectrometer	MeV ion spectrometer
	Ion and neutral spectrometer	Ion and neutral spectrometer
		Radiometer
		UV spectrometer
		NAC, filters
		TopoMapper
		Dust analyzer
		Plasma wave spectrometer

Well addressed: A
Partially addressed: D
Poorly addressed: C, B, E, F
Aggressive mass reduction
High instrument risk
High risk to objectives

Well addressed: A, B, D, E, F
Partially addressed: C
Poorly addressed: D 3[1]
New instruments required
Medium instrument risk
Almost all objectives met

Well addressed: A, B, C, D, E, F
Known instruments

See earlier pages on Science Objectives
for Key to lettered Objectives Addressed

Reference Mission Architecture Selection

Trade Element *(decision driver)*	Trade Study Investigations		
Launch Vehicle *(delivered mass)*	***Delta IV-H (4050H-19)***	Atlas V 521	
Trajectory Type *(delivered mass)*	2012 ΔV-EGA	***2012 VEEGA***	Direct
RPS Baseline Option *(delivered mass)*	SRG	***MMRTG***	Advanced MMRTG
Telecom Architecture *(infrastructure investment)*	***Current DSN***	Upgraded DSN Architecture	
Mission Duration at Europa *(reliability, mass)*	***30 days***	> 30 days	
Science Payload *(complexity)*	***Initial 150 Kg payload***	Augmented 350Kg payload	
Potential Lander Allocation *(complexity)*	<500 Kg	***None***	>500 Kg

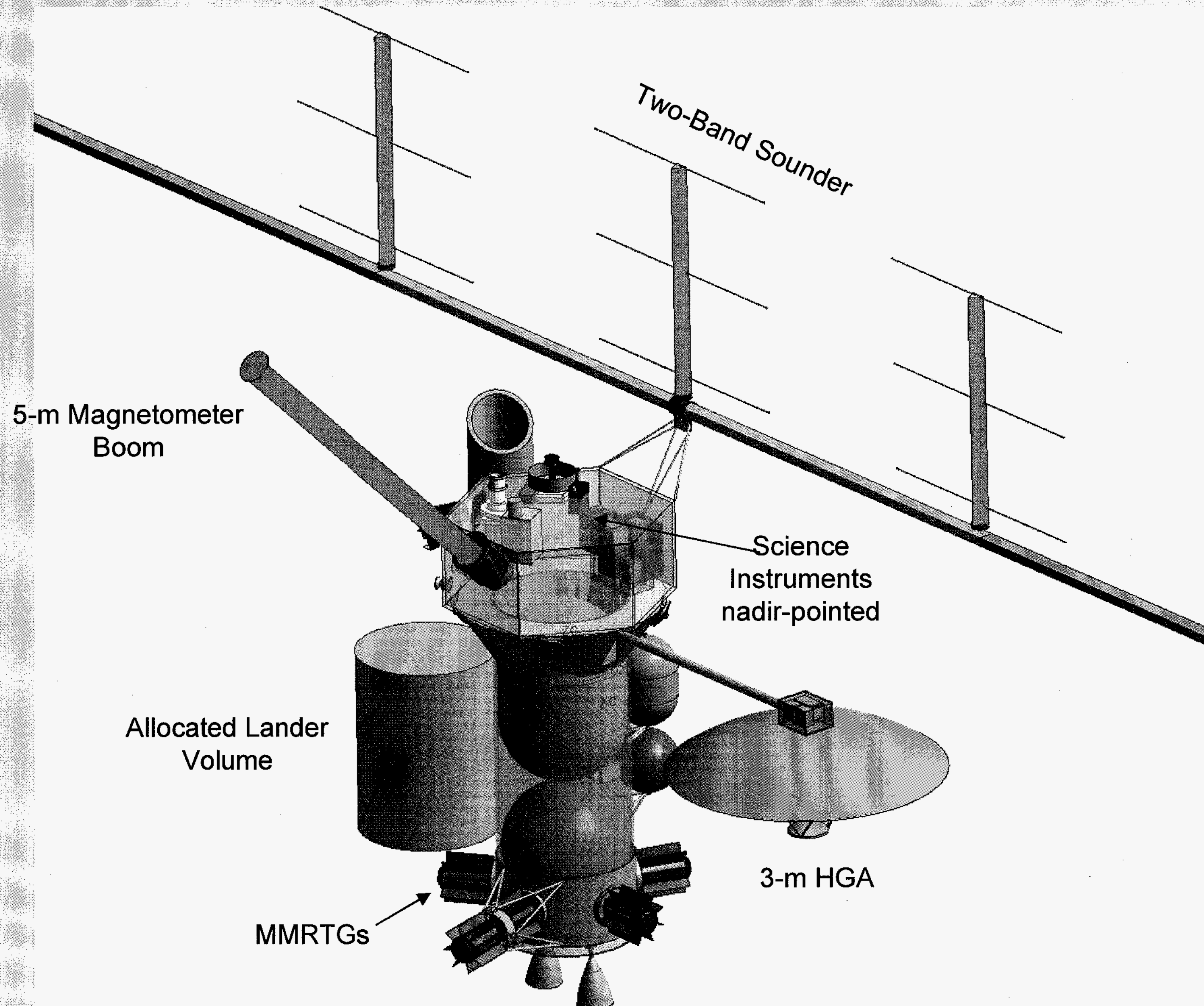
Key: ***Selected*** Not Selected

High-level Results from the Trade Studies

- **The comparisons show that many feasible mission options provide potentially available mass for enhanced spacecraft margins and science return, in addition to the assumed 150-kg orbiter payload mass**
- ***Recommendation:*** **analyze these and other cases more thoroughly, and develop integrated mission alternatives, to more rigorously define the capabilities of a Europa mission**

Category	Change from	Change to	Benefit	Issue
Trajectory	Direct	VEEGA	Dramatically increased delivered mass Increased potentially available mass	—
	VEEGA	ΔV-EGA	Shorter cruise	Decreased delivered mass
RPS	MMRTG	SRG	Decreased nuclear fuel requirement	Decreased potent. avail. mass
	MMRTG	Upgraded MMRTG	Increased potentially available mass	Choice of power level
Launch vehicle	Delta IV Heavy	Atlas 551	Increased launch vehicle flexibility	Decreased delivered mass
DSN architecture	Current DSN	Upgraded DSN	Increased downlink rate	Unfunded infrastructure
Instrument payload	150 kg, 9 inst.	350 kg, augmented	Increased surface coverage and resolution	Increased complexity

EGE Spacecraft Example Concept Deployed Configuration



Conclusions

- **In this 45-day study, JPL explored some of the options for a Europa Geophysical Explorer. The use of Earth Gravity Assisted trajectories provides the possibility of a relatively mass-rich mission**
- **Next steps:**
  - Work with the science community to further refine science objectives and payload options
  - Identify and develop mitigation plans for RPS, radiation, planetary protection, and launch issues
  - Conduct detailed trade studies to optimize trajectories, spacecraft design, data return, and the ground system, to develop integrated mission alternatives
  - Conduct analyses to recommend project management strategies for controlling scope, risk, cost, and schedule

EGE Study Team Members

Core team

Jacklyn R. Green	Study Leader and Manager
Rob Abelson	Lead Systems Engineer
Pam Chadbourne	Program Systems Engineer
Peter Illsley	Configuration
Elizabeth Kolawa	Technologist
Jan Ludwinski	Mission Design
Lisa Priester	Documentation
Celeste Satter	Systems Engineer
Jim Shirley	Science Advisor
Bill Smythe	Instrument Lead Scientist/Engineer
Tom Spilker	Science Advisor

Radiation Assessment

E. Kolawa	Lead
R. Blue	Avionics (X2000)
G. Carr	PMAD (X2000, JIMO)
D. Gear	Avionics (X2000)
F. Deligiannis	Rad hard electronic components (JIMO)
K. Strauss	Memory technology (X2000, JIMO)
M. Mojarradi	PMAD, Radhard electronics
B. Pain	APS technology
J. Patel	Physics of devices
H. Garrett	Radiation environment

RPS Assessment

Team Members

- Rob Abelson Lead
- Kip Dodge
- Rich Ewell
- Bill Nesmith

Resources

- Jack Chan (Lockheed Martin)
- Bill Otting (Boeing)
- Bob Wiley (DOE)

Science Assessment and Compliance

Tom Spilker

Science Instruments Definition

Bill Smythe	Lead
Soren Madsen	Sounder, TopoMapper
Carl Bruce	Cameras and spectrometers
Daniel Winterhalter	Fields and Particles

Lander Options

Jim Shirley

Partnership Options

- Jacklyn R. Green Lead
- John McNamee
- Gregg Vane
- Claudia Alexander
- Rob Staehle