Europa Explorer: 2008 Study Approach

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NASA APL JPL

Agenda

- Science and TMC Panels Comments
- 2008 Study Ground Rules
- Approach for Meeting New Ground Rules

Science Panel Feedback - (1)

Europa Explorer

- Science rating: Very Good - Excellent
- 6 major strengths, 1 minor strength
  - Comprehensive, compelling, mature and responsive to decadal survey
  - Geological, and geophysical objectives are comprehensive
  - Instruments potentially provide revolutionary windows into understanding Europa
  - Clear descopes
  - Tour offers important advance in comparative planetology
  - Campaign operations plan strategy is well formulated

Science Panel Feedback - (2)

- No major weaknesses, 3 minor weaknesses
  - Chemistry objective was not as comprehensively addressed
  - Tie between actual measurements, expected results and science objectives not always well described
  - Descopes required for the floor mission severely degrades possible Jovian tour science

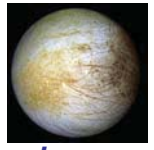
TMC Panel Feedback - (1)

- Form B (Instrument) – Medium Risk
- 2 major strengths, 3 minor strengths
  - Science traceability and cumulative science value over time
  - Well thought out science and data acquisition plan
  - Approximate 2 years of Jupiter system science followed by 92 days of intense Europa science, then 9 months of expected lifetime for follow-up investigations
  - Descope plan well thought-out and articulated

TMC Panel Feedback - (1)

- 1 major weaknesses, 4 minor weaknesses
  - Radiation-induced effects on measurement quality require further analysis and continuous mitigation strategies
  - Specific chosen instrument implementations questioned relative to the science objectives and other implementation choices
  - Chemistry goal not well supported by instrumentation

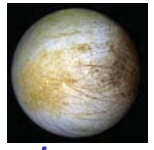
TMC Panel Feedback - (1)



Europa Explorer

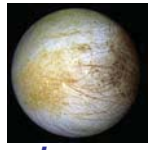
- Form C (TMC) – Medium Risk (2017), High Risk (2015)
- 4 major strengths, 13 minor strengths
  - Operations planning provides confidence in design
  - Instrument accommodation very thorough and gives confidence
  - Excellent technology assessment and development approach
  - Risk management approach shows good grasp of major challenges and offers effective mitigation
  - Planetary Protection approach reflects thoughtful consideration of issues
  - Systems engineering and management of radiation design ensures appropriate attention and consideration in design

TMC Panel Feedback - (1)



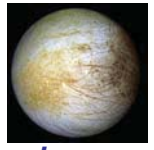
- 3 major weaknesses, 21 minor weaknesses
  - Significant risk remains in radiation mitigation for instrument development
  - Phase A too short for a proposed 2015 launch
  - Cost and schedule uncertainty significant due to radiation and planetary protection issues
  - Specific instrument implementation choice issues
  - Mass and power margins too low
  - Concern for lack of flight-qualification for solid state recorder memory
  - Potential dose-rate effects not addressed
  - NICM (plus radiation and PP factors) as the cost model for instruments questioned

Unique and Relevant JSO TMC Feedback



Europa Explorer

- Strengths (not comprehensive listing)
  - Unique opportunity for science for all 4 Jovian Satellites as well as nearly continuous Io monitoring
  - Synoptic Jupiter atmosphere measurements
  - Very capable payload
  - Innovative orbit at ganymede
- Weaknesses (not comprehensive listing)
  - Specific science themes were not well addressed, or instrument was not shown to adequately make measurement to support science objectives
  - Most flybys on night side of Jupiter
  - Pointing and stability requirements are challenging to meet instrument requirements
  - Large volume data recorder may be problematic



2008 Study Ground Rules

2008 General Statement of Work

Europa Explorer

- Conduct Pre-Phase A studies to support down-select (~Fall 2008) to next OP mission.
  - Build upon 2007 study results
  - Respond to findings from TMC and Science panels
  - Redesign the mission in accordance with Ground Rules
  - Undergo independent TMC & Science panel reviews
- Deliverables
  - Prelim and Draft Project Information Package (PIP) for AO
  - Prelim approved parts and materials list/report
  - Final Report to NASA HQ and public version

Management Tasks - Programmatic

Europa Explorer

- Support HQ in planning and formulation of AO for Science Investigations
- Coordinate effort to draft PIP for each study
- Initiate workshops to prepare science and instrument community for AO release
- Prepare TAAs to enable foreign interaction
- Coordinate interactions with foreign partners
- Engage NEPA/LA Office for launch of Nuclear materials
- Capture Cassini lessons learned (particularly Phase E cost drivers and operations)
- Fund travel expenses for SDT members and scientists selected to support ESA Cosmic Vision studies.

Tasks Common to Both Studies

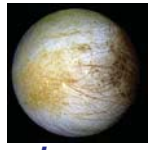
Europa Explorer

- Redesign the 2007 study mission concept per Requirements and Ground Rules
- Respond to feedback from TMC and Science panels
- Refine science goals, objectives and measurements to meet Requirements and Ground Rules
- Update cost, schedule and risk assessment from 2007 study; WBS to level 2 and Critical Path
- Better define measurements supporting science investigations
- Support required briefings and reviews (30d, 90d, independent review and informal briefings)

EE Specific Tasks

- Science floor limited to no more than 60 days in orbit around Europa
  - Extended mission separate
  - Characterize sensitivity of design point
- Jovian System science is Level 1 requirement
- Refine chemistry objective, especially relative to habitability
- Analyze rad-induced effects on measurement quality and identify mitigation strategies
- Identify/investigate international contribution within $1B limit, including deploying and supporting a msn. element independent of Europa orbiter and adjusting tour design
- Refine the radiation plan described in the 2007 report and endorsed by the TMC panel in response to the radiation findings on Forms B and C;
- Begin executing the revised radiation plan, including
  - Establish a radiation related lifetime and performance parameter methodology for the electronic parts database,
  - Begin identifying and testing (if necessary) representative parts, including detectors, to determine parameters as described above
- Draft an Approved Parts and Materials List for all hardware which includes parameters and a procedure for evaluation and acceptance of non-conforming parts (only highly justified and well mitigated exceptions permitted).

Requirements and Ground Rules – (1)



Europa Explorer

- Produce a NASA-only baseline concept cost capped at $2.1B (FY07$)
  - 33% reserves on dev cost less LV
- Produce an enhanced mission concept with an additional $1B of international contributions
  - Must provide capability above US mission science floor and cannot impinge on NASA's ability to fly a complete mission for $2.1B

Science content is considered the free parameter

Requirements and Ground Rules – (2)

Europa Explorer

- Assume use of MMRTGs or solar or both
- Assume same PP guidelines as 2007
- Use 33% margins in all areas
- Assume same LV as 2007 with addition of Ares V (at same cost as Delta IVH)
- Only one significant new technology
- Proposed launch date between 2015 and 2018; earlier date and flight times < 7 yrs preferred
- Assume Ka-band, 34 meter aperture, 100 Mbps throughput for DSN
- E/PO at 0.5% – 1.0% of LCC
- Phase E approach that results in reduced relative to Cassini

Key Milestones

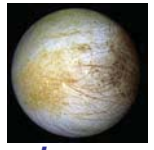
Europa Explorer

- Develop detailed study plan
  - Planning initiated……..….Jan 23, 2008
  - Budgetary plans completed……..……...Feb 7, 2008
- Science Definition Team
  - SDT community leads identified……..….Jan 17, 2008
  - SDT JPL co leads identified……..……..……...Feb 11, 2008
  - SDT selection telecon……..……Feb 15, 2008
  - First Europa SDT meeting……..…..Feb 27-29
  - First Titan SDT meeting (tentative)……..…Feb 21-22
- NASA study reporting
  - Formal study start……..…Feb 11, 2008
  - 60 day report to Alan Stern……..….*Apr 8, 2008
  - 120 day report to Alan Stern……*Jun 9, 2008
  - Preliminary Final Report for independent review…..……*Aug 7, 2008
  - Final Report……*Oct 28, 2008

NASA Final selection of mission target ~ Oct 30, 2008

***Subject to change**

OPF Organization



Europa Explorer

NASA Outer Planets Program

Europa Mission Study
K Clark - Manager
R Pappalardo - Study Scientist

Europa Study Team
(JPL/APL)

- Programmatics-Clark
- Mission Design-Ludwinski
- System Engineering
  - Flight/Ground Systems-Tan-Wang
  - Operations Scenarios - Lock
- Cost- Jorgenson
- Report Generation - Ludwinski

Jupiter SDT
(NASA/ESA/JAXA/RosCosMos Combined)

- NASA Co-lead - R Greeley
- ESA Co-lead – J-P Lebreton
- JPL Study Scientist
- Science members
- Engineering support (from EE Study Team)

Saturn SDT (NASA/ESA Combined)

- NASA Co-lead - J Lunine
- ESA Co-lead -J Lebreton
- JPL Study Scientist
- Science members
- Engineering support (from TE Study Team)

Titan Mission Study
K Reh - Manager
D Matson - Study Scientist

Titan Study Team
(JPL/APL)

- Programmatics-Reh
- Msn Des-Strange/Spilker
- System Engrg-Elliott
  - Flt/Gnd Sys-Elliott/Welz
  - Ops Scenarios-Lock
  - Project I&T-TBD
- Cost-Jorgensen
- Report Generation-TBD

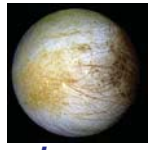
Outer Planets Flagship Missions Support Studies (i.e. working groups)
(JPL/APL)

- Radiation Analysis
- Radiation Parts Testing
- Planetary Protection Analysis
- Instrument Dev Studies
- Instrument AO/PIP Preparation
- Mission Operations Analysis

Deliverables

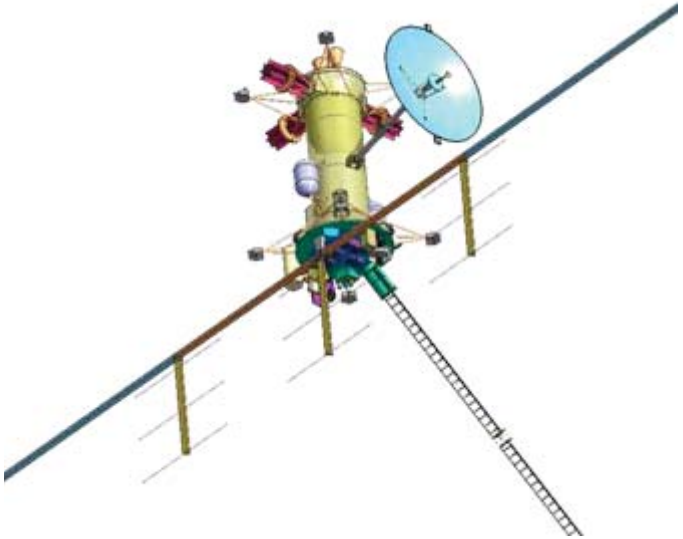
- Preliminary Radiation and Planetary Protection Design Guidelines
- Preliminary Approved Parts and Materials List
- Radiation Test Reports
- Draft Project Information Package for AO
- Draft Report to NASA HQ for independent review
- Final Report to NASA HQ
- Public version of Final Report

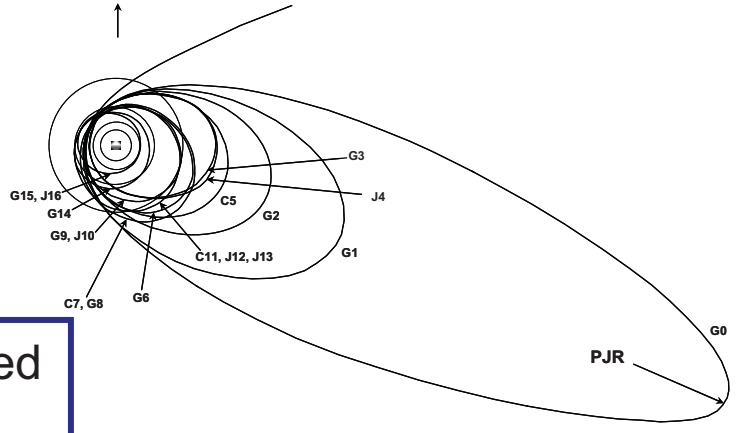
Notional Europa Explorer Floor Mission Concept



Europa Explorer

- Concept: Europa orbiter with Galilean Tour
- Launch Vehicle: Atlas 531
- Power Source: 5 ASRGs
- Mission Timeline:
  - Launch: ~6/2015 (VEEGA)
  - Jupiter arrival: ~7/2021
  - Galilean satellite tour science: ~2 yr
    - Targeted and non-targeted observations of Jupiter, Calllisto, Europa, Ganymede and Io possible
    - Tour data volume returned: ~0.6 Tb - Floor
  - Europa orbital science: ~ 6 months
    - 70m stations for 92 days 24/7, then single pass/day
  - Spacecraft operates until loss of control; final disposition: Europa surface Impact
- Instruments: 8 ; 77 kg, 106 W
- Cost: $2.4B

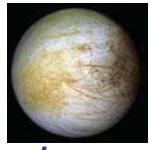




Representative Tour Trajectory

Floor mission concept from 2007 was updated for concrete changes from Ground Rules

Notional Europa Explorer 2008 Mission Concept



Europa Explorer

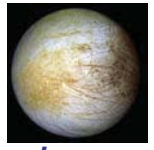
New Starting Point

- Concept: Europa orbiter with Galilean Tour
- Launch Vehicle: Atlas **551**
- Power Source: **5 MMRTGs**
- Mission Timeline:
  - Launch: ~6/2015 (VEEGA)
  - Jupiter arrival: ~7/2021
  - Galilean satellite tour science: ~2 yr
    - Targeted and non-targeted observations of Jupiter, Calllisto, Europa, Ganymede and Io possible
    - Tour data volume returned: ~0.6 Tb - Floor
  - Europa orbital science: ~ **60 days**
    - **34 m stations, no arraying, 24/7**
  - Spacecraft operates until loss of control; final disposition: Europa surface Impact
- Instruments: 8 ; 77 kg, 106 W
- **Modified reserves base**
- Cost: **$2.45B**

Drivers

- Time:
  - Shorter flight time – less cost
  - Earlier launch – less infrastructure cost
- Cost:
  - $2.10B
  - Fewer MMRTGs
    - Lower power
- Plutonium:
  - Fewer MMRTGs
    - Lower power

Notional EE Mission Concept Comparison



Europa Explorer

Parameter	*Floor EE Configuration*	*Updated Guidelines*
# Instruments	8	TBD
Mission Duration in Europa Orbit	6 Months	60 Days
Payload Mass (CBE)	77 kg	tbd kg
Payload 2-Oribit Average Power (CBE)	58 W	tbd W
Trajectory Type	VEEGA	Desire shorter flight time (<7yrs to Europa)
Launch Vehicle Type	Atlas V 531	Desire Atlas 551 to have mass capability
LV Injected Mass Capability	4030 kg	tbd kg
Flight System Dry Mass (CBE)	1069 kg	tbd kg
RPSs (# and Type)	5 ASRGs	tbd MMRTGs
Gravity Science Technique	X-band only	tbd
Ultra Stable Oscillator (USO)	None	None
Data Volume	7 Gb/day	tbd
DSN Station	70m, 24/7 for 92 days	34m, 24/7
System Mass Margin (Per JPL)	34%	33%
System Power Margin (Per JPL)	35%	33%
Cost	$2.4B	$2.1B

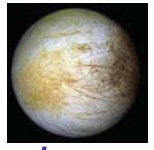
Approach to Meeting New Ground Rules

Background

Europa Explorer

- New ground rules significantly tighten the design box while introducing new requirements
- Existing floor design was focused on meeting the requirements of a flight system in a low altitude, circular orbit around Europa
  - Flight system was specifically not designed for distant monitoring or data acquisition from moon encounters
  - Elevated priority of Jupiter system science may indicate different trade space solutions

Architectural Approach – (1)

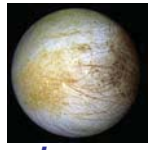


Europa Explorer

Issue/ Groundrule	Architectural Options	Consequence*	Key Questions for SDT
Launch to EOI ≤ 7 years	Higher energy trajectories, e.g. ΔV-EGA on Atlas V?	• Lower launch mass • Higher JOI ΔV • +$20M for largest Atlas V	-
	Higher energy trajectories, e.g. ΔV-EGA on Delta IV-H?	• Better performance than for Atlas V but +$300M	-
	Shorter jovian tour?	• Conflicts with achievment of Level 1 jovian system science	What are the key objectives to be achieved in the tour?
		• Possibly higher ΔV	-
	Ares V LV on direct trajectory?	• +>$300M but huge performance capability (12-16,000 kg)	What would be the emphasis given such a huge performance capability?
Launch date ≥2016	Delay launch from 2015	-	-

* Not all consequences apply to all sub-options

Architectural Approach - (2)

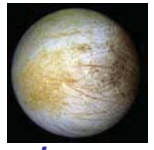


Europa Explorer

Issue/ Groundrule	Architectural Options	Consequence*	Key Questions for SDT
Jovian system science is Level 1	Single Io encounter on arrival orbit?	• ~50 krad/encounter (100 mils Al) • Similar ΔV to Ganymede first case • Possible DV savings for some added radiation cost	Should there be Io encounters?
	Io campaign?	• 4 encounter campaign is ~250 krad (100 mils Al) or roughly a month in Europa orbit • Possible DV savings for some added radiation cost	How many Io encounters and with what characteristics?
		• Spacecraft must be designed to operate in the higher dose rate environment of Io	Should the planning payload be impacted to accommodate Io science?
	Low-phase atmospheric vs. magnetotail science?	• Could affect arrival geometry thru choice of type 1 vs type 2 interplanetary trajectories	Which should be emphasized?
		• Constrains choice of tour targets to get desired orbit orientation	Can the objectives be quantified (e.g. duration below certain phase angle?)
	Number of targeted and non-targeteds encounters; Jupiter monitoring, distant Io occultations; Io monitoring; torus passages, wake, magnetic equator, alfven wing, and plasma sheet crossings; polar flybys?	• Higher tour ΔV • Longer tour • Greater tour design complexity • More capable instruments • Greater SSR storage capability	Can these be prioritized and paired with targets?
			How can cost be kept low?

* Not all consequences apply to all sub-options

Architectural Approach - (3)



Issue/ Groundrule	Architectural Options	Consequence*	Key Questions for SDT
60 day prime mission @ Europa	-	-	How do the 4 Europa Science campaigns get re-organized to fit into 60 days, e.g. altitude strategy and targeted observations?
34m only	X-up, Ka-down	• Re-design telecom system	-
		• Higher power	
		• Lower downlink availability due to weather	
Cost ≤ $2.1B	Start with floor		-
	Reduce power requirements?		
	Reduce mission duration?		

* Not all consequences apply to all sub-options

Request For SDT

Europa Explorer

- Need planning payload with priority
- Need mission design parameters with indication of requirements, goals and priority
- Need data volume requirements and goals