EJSM Jupiter Ganymede Orbiter Science

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Image credit: John Spencer, SwRI

Joint Jupiter Science Definition Team

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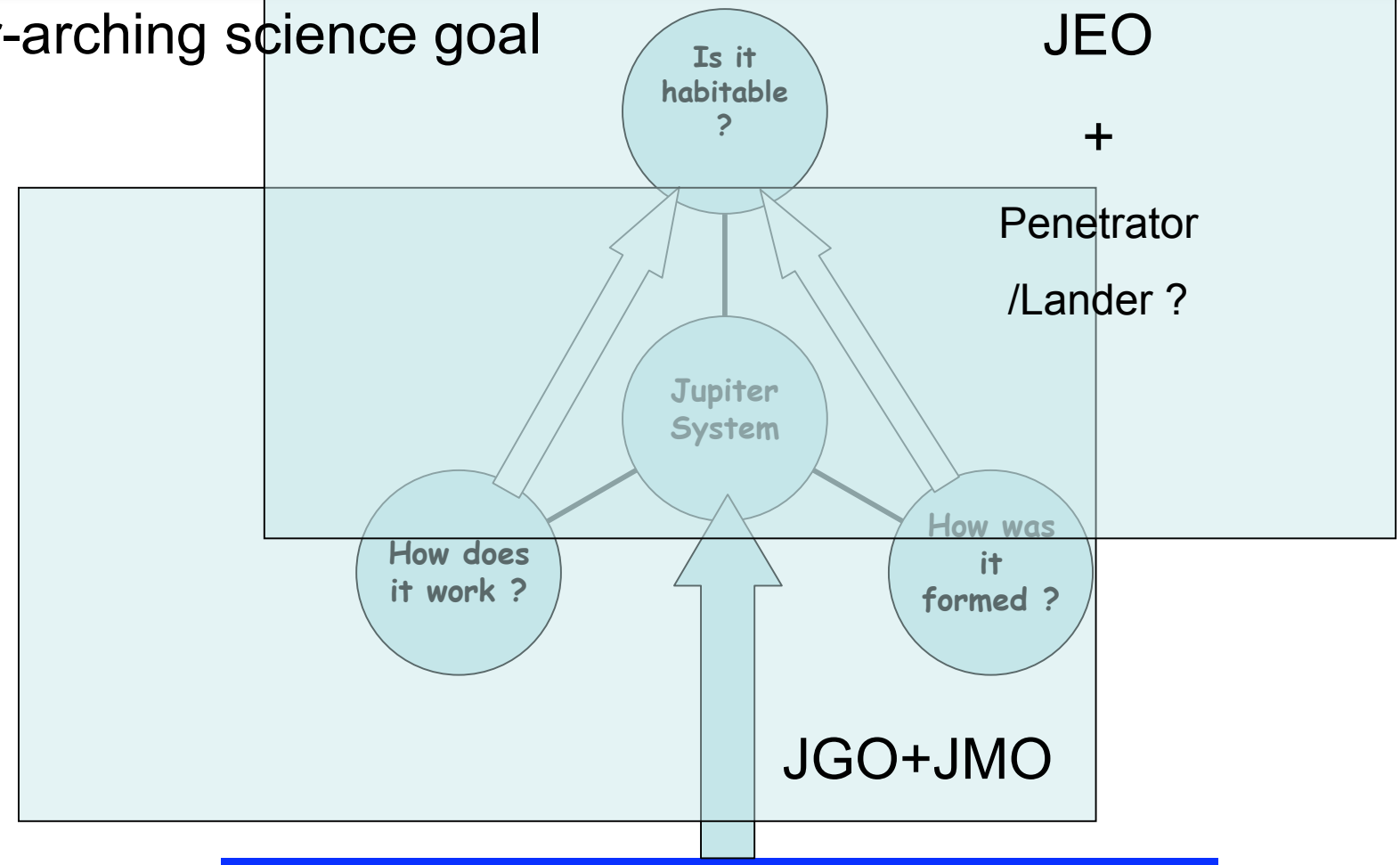
Plus members of the following groups:

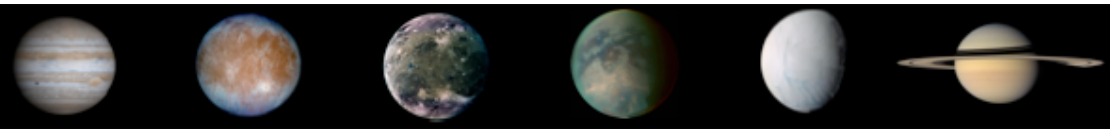
- US JJSDT
- EU JJSDT
- EU Cross-Disciplinary SDT
- Japan JJSDT
- US Technical
- US Administrative
- EU Technical
- EU Administrative
- Japan Technical
- Russia Technical

Over-arching science goal



« The emergence of habitable worlds around gas giants »

EJSM/JGO: ESA's Cosmic Vision assessment study phase



The emergence of habitable worlds around gas giants

Science Goals

How does the sytem work? How was it formed?
Is it habitable?

Mission targets

- 1 - Europa
- 2 - satellites
- 3 Magneto-sphere
- 4 - Jupiter
- 5 - Ganymede

Jovian orbit

- Jupiter Europa Orbiter
- Jupiter Ganymede Orbiter
- JMO

Satellite orbits

- Europa Orbiter
- Ganymede Orbiter

Surface

- Surface element ? (SE)

1 - Habitability in the Jupiter system

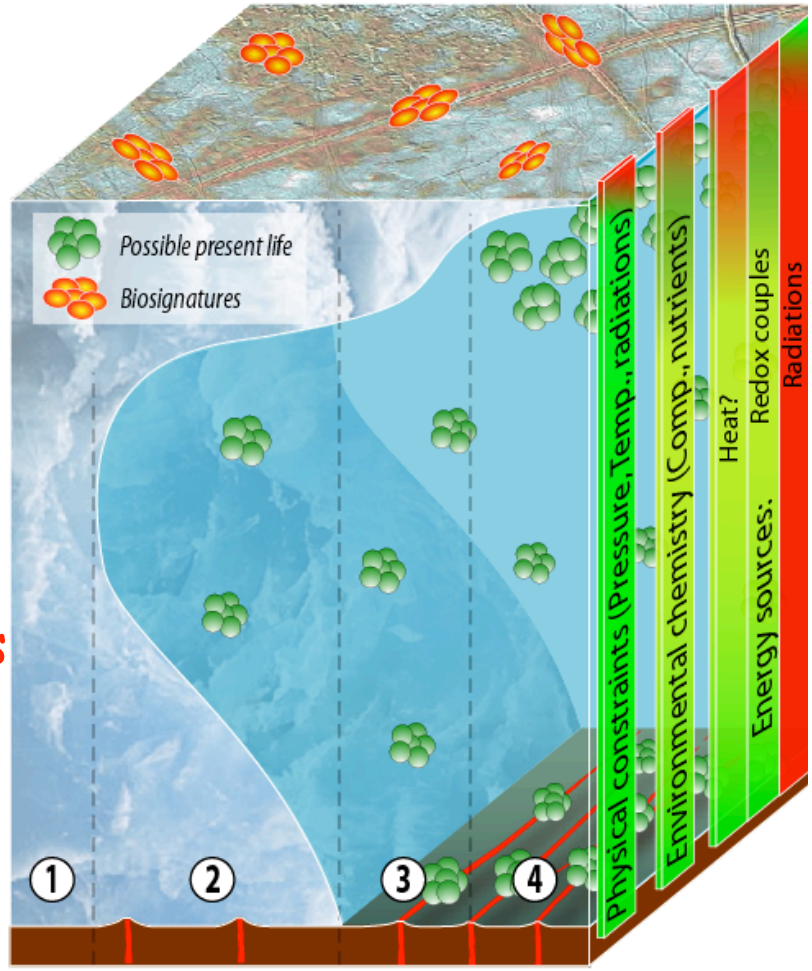
Establish and characterize Europa's habitability: JEO

- Existence of a sub-surface ocean
- Characterization of ice shell and subsurface water
- Surface composition & chemistry
- Characterize surface features, geomorphology and candidate sites for future in situ exploration
- Search for astrobiological signatures

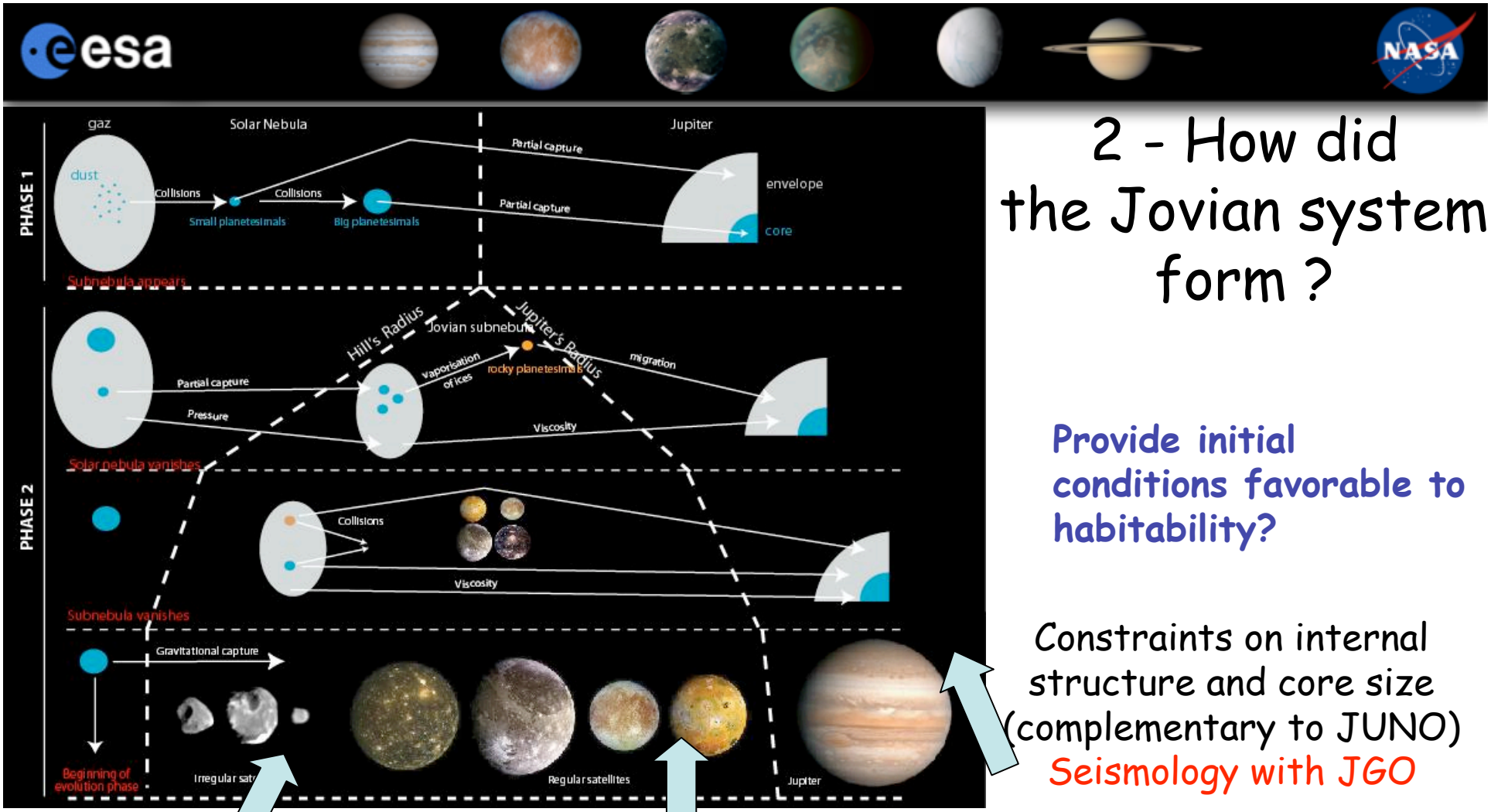
Comparative study of habitability conditions at the "sister moon" Ganymede: JGO

- Existence of an ocean
- Surface characterization
- Deep interior and B field generation
- Magnetosphere

Comparison with a (likely) undifferentiated body, Callisto: JGO (+ JEO?)



2 - How did the Jovian system form ?



Provide initial conditions favorable to habitability?

Constraints on internal structure and core size (complementary to JUNO)
Seismology with JGO

Constraints on early evolution of system from cratering records of irregular& regular satellites

JGO+JEO

Constraints on proto-jovian nebula from chemical and isotopic abundances of atmosphere and regular satellites

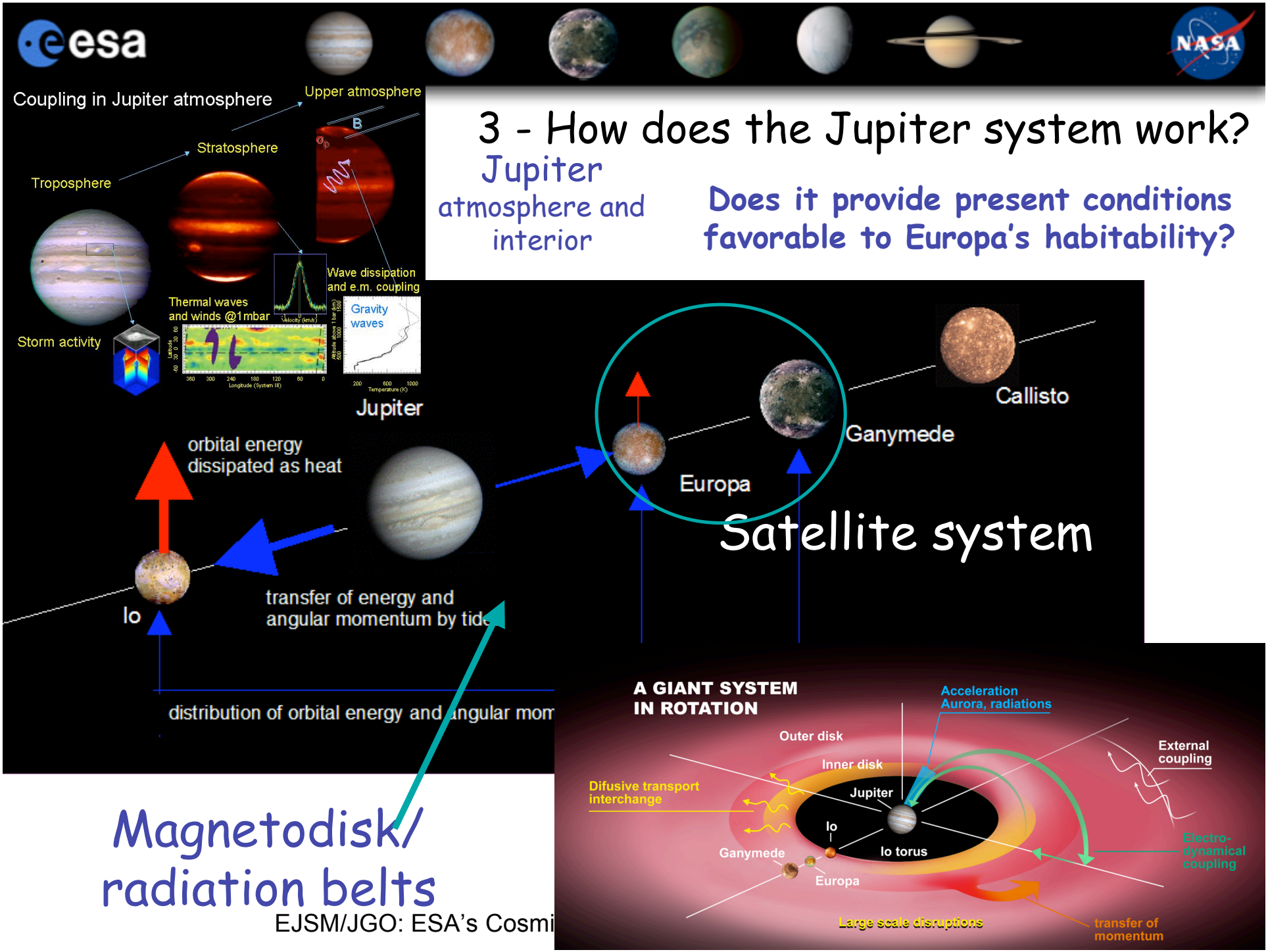
JGO (incl. Callisto)+JEO

EJSM/JGO: ESA's Cosmic Vision assessment study phase

3 - How does the Jupiter system work?

Jupiter atmosphere and interior

Does it provide present conditions favorable to Europa's habitability?



Magnetodisk/ radiation belts

EJSM/JGO: ESA's Cosmi

1 - The Galilean satellite system

ORBITERS

In-depth comparative science

MULTIPLE FLY-BY's

MULTIPLE FLY-BY's

Io **Europa** **Ganymede** **Callisto**

JEO JGO

EJSM/JGO: ESA's Cosmic Vision assessment study phase

2 – Magnetosphere, magnetodisk, radiation belts

JGO:

-Middle and outer magnetosphere, magnetodisk,

-Transport regions for plasma and angular momentum,

- Ganymede's magnetosphere

JEO:

-Source regions (iogenic and europagenic plasma),

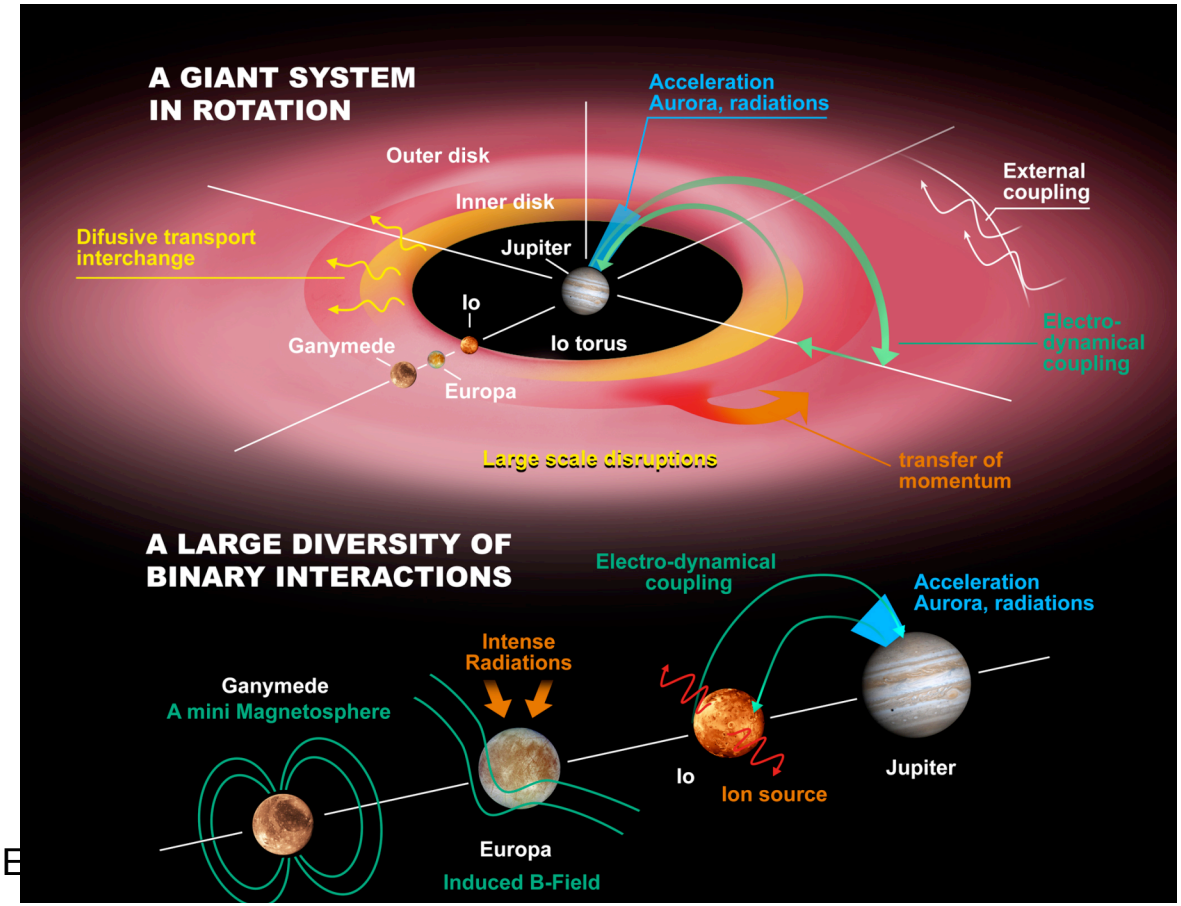
-Io and torus

-Radiation belts

JMO:

- In-depth characterisation of plasma populations and plasma processes (dedicated p/f payload + orbit)

-Overall integration of the system: Jupiter as a giant particle accelerator and radiosource, how does it work ?



3 - Jupiter's atmosphere

JGO:

-Thermal structure and dynamics (tropo/strato/thermosphere)

- Stratospheric composition

- Vertical coupling (from interior to ionsphere)

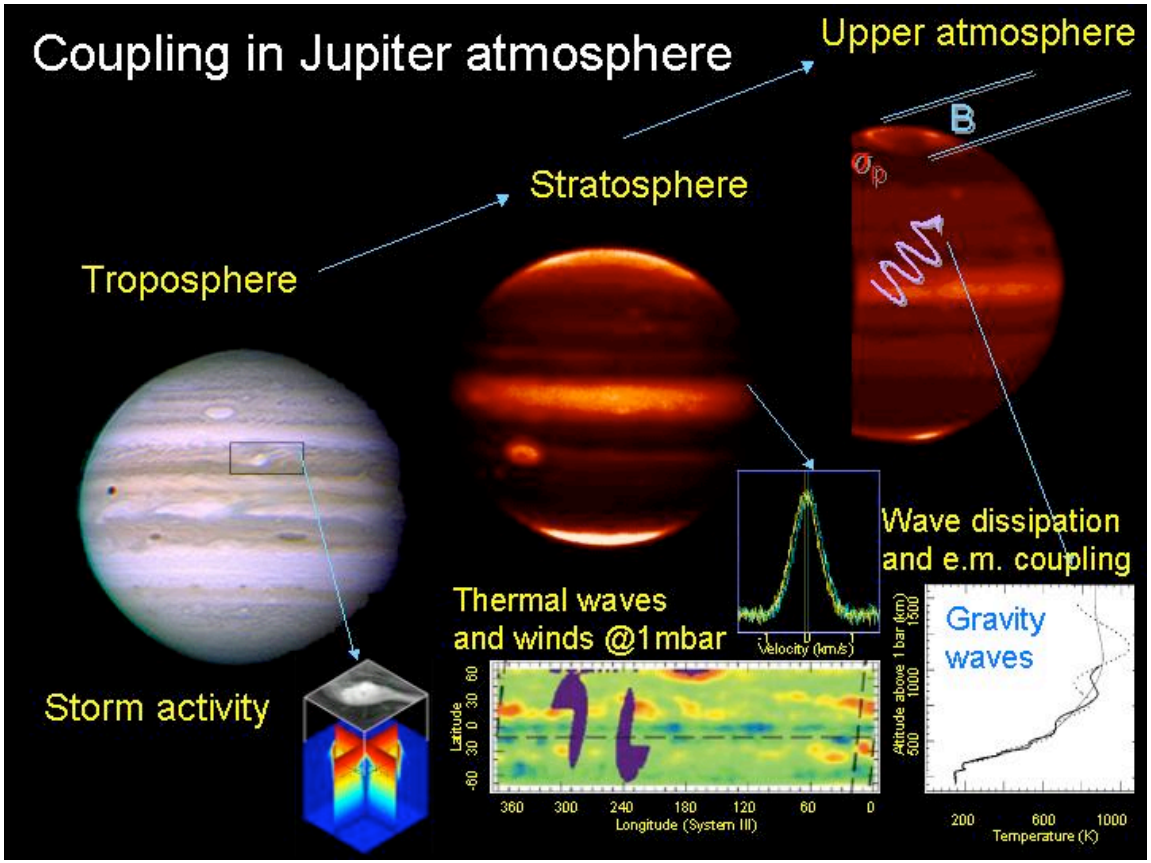
- Thermospheric heating

JEO + JGO:

-Tropospheric composition

-High resolution dynamics

-Compmentarity between two s/c



EJSM/JGO: ESA's Cosmic Vision assessment study phase

- The « fundamental equation » of EJSM:

  EJSM science>> JEO science +
  JGO science +JMO science

- Better overall payload if we select in coordinated way as part of ONE EJSM programme
  - NASA AO for JEO
  - ESA AO for JGO
  - JAXA AO for JMO

- EJSM payload selection should be highly coordinated between the three agencies for optimisation of the EJSM programme payload

For more information

- http://jupiter-europa.cesr.fr

LAPLACE proposal site (contact ej@cesr.fr)

- http://sci.esa.int/science-e/www/area/index.cfm?fareaid=100

ESA's Cosmic Vision web page

- http://opfm.jpl.nasa.gov

Outer planet flagship mission website

JGO Model Payload

First Analysis of Traceability Matrix

Model payload as discussed at JSDT meeting in Monrovia (28-20 May) and proposed updates as of Monday 2 June by MB, J-PL, OG

EJSM TM (1/3)

EJSM TRACEABILITY MATRIX

Goal	Science Objective		Science Investigation	Spacec
HOW DID THE JUPITER SYSTEM FORM?	A. Jupiter	Formation of Jupiter	Investigate the internal structure of Jupiter	JGO
				JEO
			Determination of the chemical, isotopic & elemental composition of Jupiter's atmosphere	JGO
				JEO
	B. Galilean satellites	Constrain formation scenarios of the Galilean Satellite System (Io and Europa mainly for JEO and Callisto and Ganymede mainly for JGO)	Composition and physical characteristics of the satellites' surfaces	JGO
				JEO
			Surface geology	JGO
				JEO
			Satellites' secular accelerations to constrain evolution and formation scenarios	JGO
				JEO
			Degree of differentiation of the Galilean satellites	JGO
				JEO
	C. Small bodies	Characteristics of undifferentiated bodies	Physico-chemistry of the small bodies from the ring to the outer system	JGO
				JEO
			Improve our understanding of the irregular satellites	JGO
				JEO
			Investigate the inner region of the Jupiter system	JGO
				JEO
WORK?	A. Jupiter	Explore the internal structure and dynamics of Jupiter	Thermal structure and dynamics of the Jovian atmosphere (troposphere/stratosphere/io	JGO
			Composition of the stratosphere	JGO
			Coupling in the Jovian atmosphere (interior/troposphere/stratosphere/ionosphere)	JGO
			Modeling the thermospheric heating	JGO
			Composition of the troposphere	JGO
				JEO
	Ganymede	Understand the evolution of Ganymede by investigating its surface, interior and environment	Investigate the presence and location of water within Ganymede	JGO
				JEO
			Magnetosphere of Ganymede	JGO
				JEO
			Surface geology	JGO

EJSM TRACEABILITY MATRIX (2/3)

HOW DOES THE JUPITER SYSTEM WORK?	A. Jupiter	Explore the internal structure and dynamics of Jupiter	Thermal structure and dynamics of the Jovian atmosphere (troposphere/stratosphere/io	JGO
			Composition of the stratosphere	JGO
			Coupling in the Jovian atmosphere (interior/troposphere/stratosphere/ionosphere)	JGO
			Modeling the thermospheric heating	JGO
			Composition of the troposphere	JGO
				JEO
	B. Ganymede	Understand the evolution of Ganymede by investigating its surface, interior and environment	Investigate the presence and location of water within Ganymede	JGO
				JEO
			Magnetosphere of Ganymede	JGO
				JEO
			Surface geology	JGO
				JEO
			Investigate the deep interior of Ganymede	JGO
				JEO
	C. magnetodisk / magnetosphere	Study the Jovian magnetodisk / magnetosphere considering Jupiter as a fast magnetic rotator and giant particle accelerator.	Characterization of the 3D properties of the magnetodisk	JGO
				JMO
			Investigate the plasma sources, mass loading variability, composition, transport modes, and loss processes in the magnetosphere	JGO
				JEO
				JMO
			Characterization of the Magnetosphere/Ionosphere/thermosphere coupling processes	JGO
			Morphology & modulation of the auroral/radio emissions and modulation of charged particles	JGO
			Magnetospheric mapping of auroral/radio features	JGO
				JEO
				JMO
			Magnetospheric response to solar wind variability (Jovian space weather)	JGO
				JEO
				JMO
			Characterization of high-energy particle properties, acceleration processes, losses	JGO
				JMO
			Analysis of high-energy electrons synchrotron emissions	JGO
				JMO
	D. Satellites (not including Ganymede and Europa)	Investigate surface characteristics, internal structure, and interactions of the moons in the jovian system	Study the internal structure (including the putative ocean) and dynamics of Callisto	JGO
				JEO
			Magnetic interactions in the jovian system	JGO
				JEO
				JMO
			Investigate the significance of tides for the long-term evolution of the Galilean Satellite	JGO
				JEO

EJSM TRACEABILITY MATRIX (3/3)

DOES THE JUPITER SYSTEM HARBOUR A HABITABLE WORLD? LOOKING INTO EUROPA	A. Ocean	Characterize the extent of the ocean and its relation to the deeper interior.	Determine the amplitude and phase of the gravitational tides.	JEO
			Characterize the magnetic environment (including plasma), to determine the induction response from the ocean, over multiple frequencies.	JGO JEO JMO
			Characterize surface motion over the tidal cycle.	JEO
			Determine the satellite's dynamical rotation state.	JGO JEO
			Investigate the core, rocky mantle, and rock-ocean interface.	JEO
	B. Ice	Characterize the ice shell and any subsurface water, including their heterogeneity, and the nature of surface-ice-ocean exchange.	Characterize the distribution of any shallow subsurface water.	JEO
			Search for an ice-ocean interface.	JEO
			Correlate surface features and subsurface structure to investigate processes governing communication among the surface, ice shell, and ocean.	JEO
			Characterize regional and global heat flow variations.	JGO JEO
	C. Chemistry	Determine global surface compositions and chemistry, especially as related to habitability.	Characterize surface organic and inorganic chemistry, including abundances and distributions of materials, with emphasis on indicators of habitability.	JGO JEO
			Relate compositions to geological processes, especially communication with the interior.	JEO
			Characterize the global radiation environment and the effects of radiation on surface composition, atmospheric composition, albedo, sputtering, sublimation, and redox chemistry.	JGO JEO JMO
			Characterize the nature of exogenic materials.	JGO JEO JMO
	D. Geology	Understand the formation of surface features, including sites of recent or current activity, and identify and characterize candidate sites for future *in situ* exploration.	Determine the formation history and three-dimenstional characteristics of magmatic, tectonic, and impact landforms.	JGO JEO
			Determine sites of most recent geological activity, and evaluate future landing sites.	JEO
			Investigate processes of erosion and deposition and their effects on the physical properties of the surface debris.	JEO

LEGEND:	
Origins	
Evolution	
Processes	
Habitability	
Life	

EJSM/JGO: ESA's Cosmic Vision assessment study phase

JGO 2008: Goal, Objectives, Investigations (1/2)

	Priority	Science Investigation
Jupiter	**P0**	Thermal structure and dynamics of the Jovian atmosphere (troposphere/ stratosphere/ ionosphere)
		Composition of the stratosphere
		Coupling in the Jovian atmosphere (interior/troposphere/ stratosphere/ ionosphere)
		Investigate the internal structure of Jupiter
		Modeling the thermospheric heating
		Composition of the troposphere
Ganymede	**P0**	Investigate the presence and location of water within Ganymede
		Magnetosphere of Ganymede
		Surface geology
		Surface composition and physical properties
		Investigate the deep interior of Ganymede
Magnetosphere	**P1**	Characterization of the 3D properties of the magnetodisk
		Investigate the plasma sources, mass loading variability, composition, transport modes, and loss processes in the magnetosphere
		Characterization of the Magnetosphere/Ionosphere/thermosphere coupling processes
		Morphology & modulation of the auroral/radio emissions and modulation of charged particles
		Magnetospheric mapping of auroral/radio features
		Magnetospheric response to solar wind variability (Jovian space weather)
		Characterization of high-energy particle properties, acceleration processes, losses
		Analysis of high-energy electrons synchrotron emissions

JGO Themes:

Origins	Evolution	Processes	Habitability	Life

JGO 2008: Goal, Objectives, Investigations (2/2)

Satellite system	**P1**	Study the internal structure (including the putative ocean) and dynamics of Callisto
		Surface composition and physical properties of Callisto
		Surface geology of the satellites: Composition and physical characteristics of the surface; interaction with Jovian environment Targets will depend on the chosen mission profile but Callisto is a specific goal for JGO
		Magnetic interactions in the jovian system
		Investigate the significance of tides for the long-term evolution of the Galilean Satellites
		Physico-chemistry of the small bodies from the ring to the outer system
		Improve our understanding of the irregular satellites
		Investigate the inner region of the Jupiter system
Europa	**P2**	Characterize the extent of the ocean and its relation to the deeper interior.
		Characterize the ice shell and any subsurface water, including their heterogeneity, and the nature of surface-ice-ocean exchange.
		Determine global surface compositions and chemistry, especially as related to habitability.
		Understand the formation of surface features, including sites of recent or current activity, and identify and characterize candidate sites for future *in situ* exploration.

JGO Themes:

Origins	**Evolution**	**Processes**	**Habitability**	**Life**

JGO 2008: Two low mass Model payload options: ~ 44kg

Option 44.a - More Jupiter science

Name	Acronym	Mass
Radio Science	JRST+USO	4,5
Magnetometers	MAG	0,3
Doppler Spectro Imager	DSI	3,0
Camera package (multicolor?)	WAC+MRC	7,5
V/NIR Imaging spectrometer	VIRHIS	17,0
EUV-FUV spectrometer	UVIS	6,5
TIR spectrometer	TM	5

JGO Objectives: 54 %

Jupiter :	70 %
Ganymede:	55%
Magnetosphere:	18 %
Satellites:	55 %

Option 44.b - More Satellites/Magnetospheric science

Name	Acronym	Mass
Radio Science	JRST+USO	4,5
Magnetometers	MAG	0,3
Micro Laser altimeter	MLA	3,0
Camera package (multicolor?)	MRC	6,0
V/NIR Imaging spectrometer	VIRHIS	17,0
EUV-FUV spectrometer	UVIS	6,5
Reduced Plasma package	TBD	3,0
Langmuir Probe - Plasma wave	LP-PWI	2,6

JGO Objectives: 57 %

Jupiter :	54 %
Ganymede:	66 %
Magnetosphere:	45 %
Satellites:	59 %

JGO 2008: Two nominal model payload options: ~ 66 kg

Option 66.a - More Jupiter Science

Name	Acronym	Mass
Radio Science	JRST+USO	4,5
Magnetometers	MAG	0,3
Doppler Spectro Imager	DSI	3,0
Camera package (multicolor?)	WAC+MRC	7,5
V/NIR Imaging spectrometer	VIRHIS	17,0
TIR Imaging spectrometer	TM	5,0
Sub-mm wave sounder	SWI	9,7
EUV spectrometer	TBS	4,0
Solar Occultation Instrument	SOIR	5,0
Plasma Package	PLP	7,0
Langmuir Probe - Plasma wave	LP-PWI	2,6

JGO Objectives: 66 %

Jupiter : 89 %
Ganymede: 55 %
Magnetosphere: 52 %
Satellites: 55 %

Option 66.b - More Satellites Science

Name	Acronym	Mass
Radio Science	JRST+USO	4,5
Magnetometers	MAG	0,3
Micro Laser altimeter	MLA	3,0
Radar	SSR	12,0
Camera package (multicolor?)	WAC+MRC	7,5
V/NIR Imaging spectrometer	VIRHIS	17,0
EUV-FUV spectrometer	UVIS	6,5
NAC (Narrow Angle Camera)	HRC	10,0
Langmuir Probe - Plasma wave	LP-PWI	2,6
Reduced Plasma Package	TBS	3,0

JGO Objectives: 64 %

Jupiter : 55 %
Ganymede: 81 %
Magnetosphere: 45 %
Satellites: 70 %

JGO 2008: Comprehensive Model payload option: 88 kg

JGO Objectives: 80 %

Jupiter : 92 %
Ganymede: 85 %
Magnetosphere: 54 %
Satellites: 75 %

Name	Acronym	Mass
Radio Science	JRST+USO	4,5
Magnetometers	MAG	0,3
Micro Laser altimeter	MLA	3,0
Doppler Spectro Imager	DSI	3,0
Radar	SSR	12,0
Camera package (multicolor?)	WAC+MRC	7,5
V/NIR Imaging spectrometer	VIRHIS	17,0
TIR Imaging spectrometer	TM	5,0
Sub-mm wave sounder	SWI	9,7
EUV + FUV imaging spectrometer	UVIS	6,5
NAC (Narrow Angle Camera)	HRC	10,0
Plasma Package	PLP	7,0
Langmuir Probe - Plasma wave	LP-PWI	2,6

JMO 2008:

LAPLACE JMO Core Payload (Scenario 1)		
Name	**Acronym**	**Mass**
Magnetometers	MAG	0,3
Medium energetic particle detector	MEPA-i	7,5
Medium energetic particle detector	MEPA-e	2,5
Radio and Wave Instrument	???	8
Plasma Instrument	POPI-e	3,0
Plasma Instrument	POPI-i	7,0
		28,3