The Europa Initiative for ESA's M5 mission

Report to OPAG

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August 11th, 2016

EI WORKING SCHEME
for an ESA contribution to
the Europa Lander mission

Europa M5
Initiative

Cubesat?

Orbiter

Penetrator
or…

Contribution to
NASA lander

Science themes dimension

GLOBAL GEOPHYSICS

CHARACTERIZE EUROPA AS A COMPLEX DYNAMICAL SYSTEM OF COUPLED LAYERS

FROM CORE TO PLASMA ENVELOPE THROUGH OCEAN AND CRYOSPHERE

RESPONDING TO JUPITER SYSTEM FORCING: TIDAL, MAGNETOSPHERIC

ASTROBIOLOGY

CONTRIBUTE TO NASA's LANDER SCIENCE

AND PROVIDE AN ADDITIONAL ELEMENT (AWL)

As resources permit

« Spacecraft » dimension

EI contribution to EUROPA Lander : Submitted LOI's

Joint Europa Mission (Blanc/Prieto-Ballesteros)

- **Baseline: Carrier-Orbiter + lander joint NASA/ESA mission:**
  - P1a: Carrier-Orbiter provided by ESA, operated by NASA;
  - P1b: Alternative option: Carrier-Orbiter provided and operated by NASA; science platform (+ sub-systems?) provided by ESA
  - Science platform open to both ESA member states and NASA
- Option 1: Augmented surface science: Astrobiology Wet Laboratory (AWL) provided by ESA + Member States to enhance landing site exploration.
- Option 2: Augmented orbital science - cubesat released from carrier.

AKON (Jones/Martins)

- Akon penetrator mission – contributes to a multi-site investigation of Europa's surface/subsurface as a complement to the baseline soft-lander mission.

Europa Small Orbiter (André/Iess)

- Small satellite mission : global study of Europa as a geophysical object. Synergistic science between orbiter and lander. Same orbiter science as JEM but more focused.

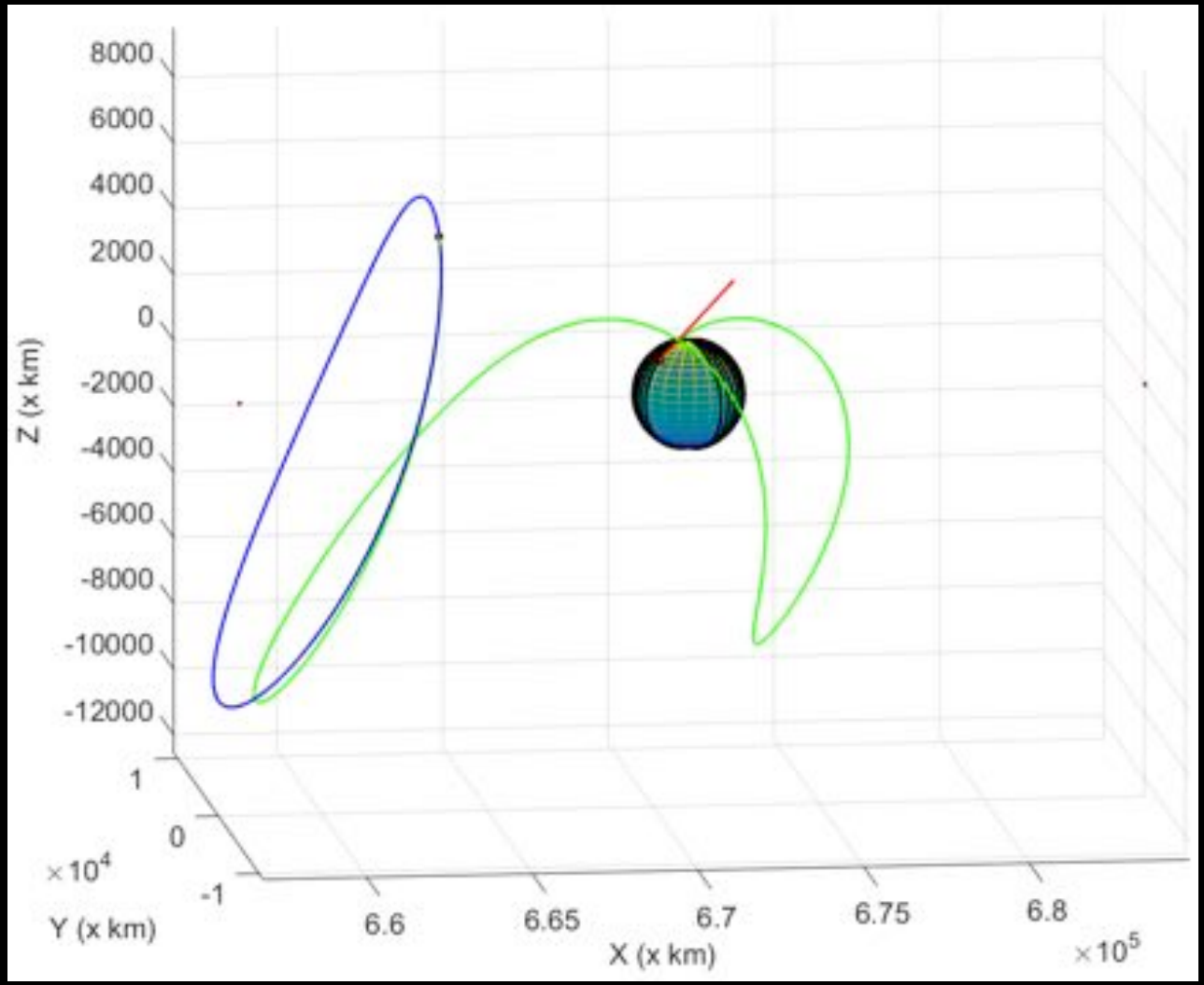
REFERENCE MISSION PROFILE
Joint Europa Mission (JEM)

MISSION SEQUENCES

- Phase 1: Interplanetary cruise w. cruise science (tbd)
- Phase 2: JOI + optimized tour of Galilean satellites to first Europan working orbit w. Jupiter science
- Phase 3: First Europa orbit sequence for Lander delivery
- Phase 4: Halo-Europa orbit sequence for Lander relay and lander + orbiter science
- Phase 5: Circularization to low, polar, circular orbit
- Phase 6: Main orbiter science sequence: 1 to 3 months.
- Phase 7: De-orbit and descent science
- End of mission.

Yellow: under NASA control – Red: under ESA control – blue: science sequences

MISSION SEQUENCES: Phases 4 to 6

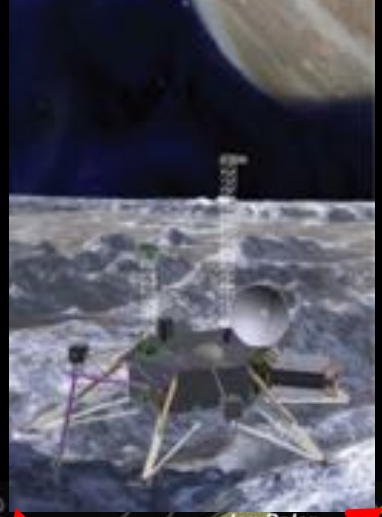


Two-burn, two-day transfer from phases 4 to 6 – Delta V cost = 452 m/s
Final orbit: altitude 121.7 km, inclination 94.7°

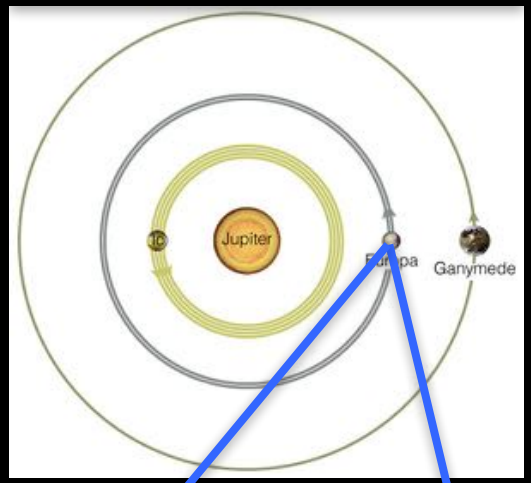
Credits: William DESPRATS, Ryan RUSSELL, Julien LAURENT-VARIN

OUR SCIENTIFIC PROJECT

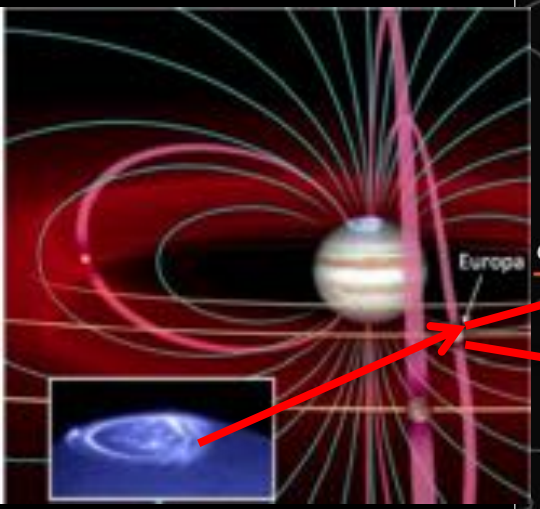
Search for
Europan life…

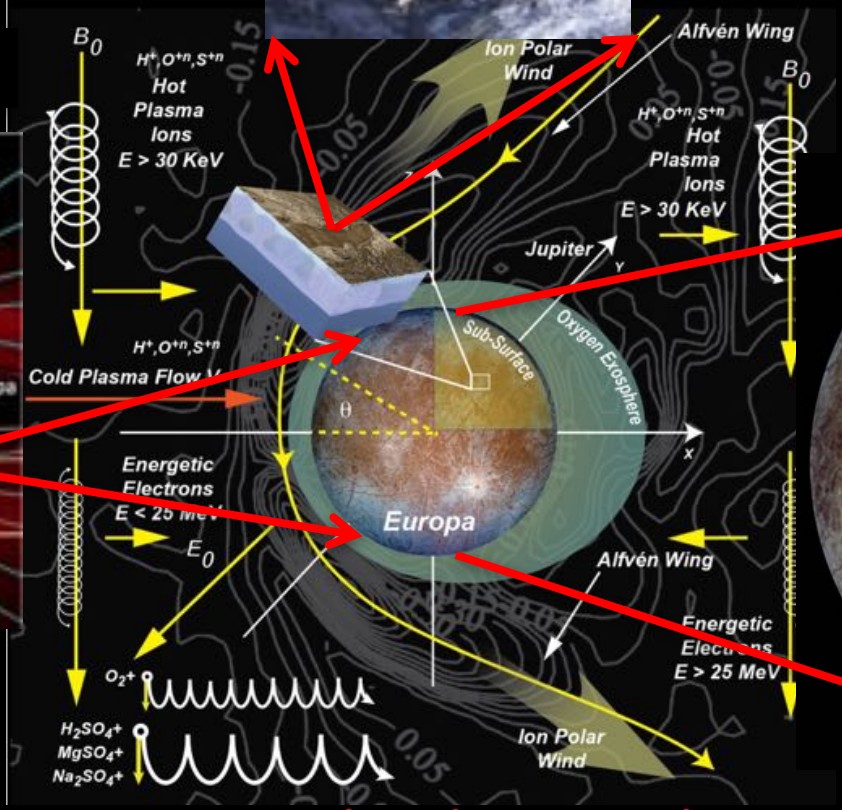


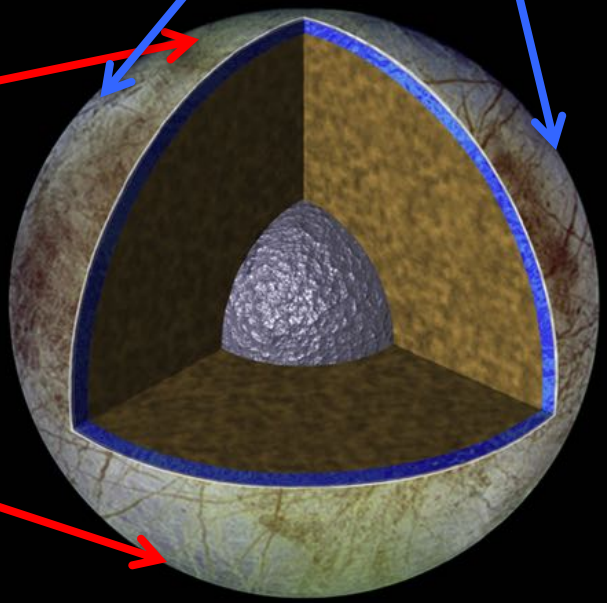
TIDAL FORCING



MAGNETOSPHERIC FORCING





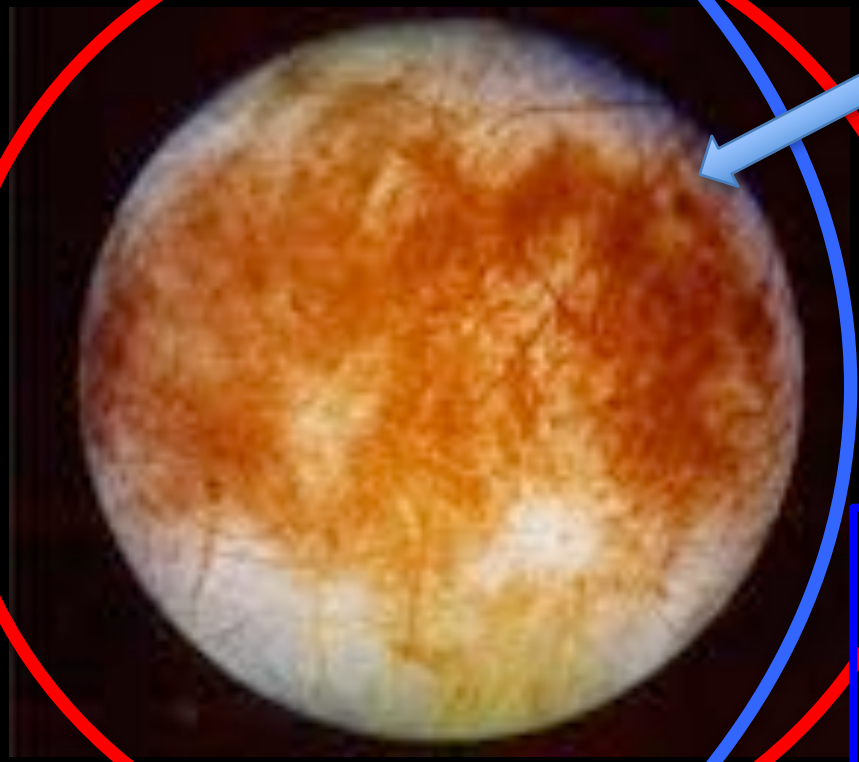


… and study Europa as a complex dynamical system of coupled layers, from core to plasma envelope, responding to Jupiter system forcing

Joint Europa Mission Science
I- GLOBAL GEOPHYSICS
(also covered by ESO)

Based on synergistic geophysical measurements between orbiter and lander

Geophysics observing System



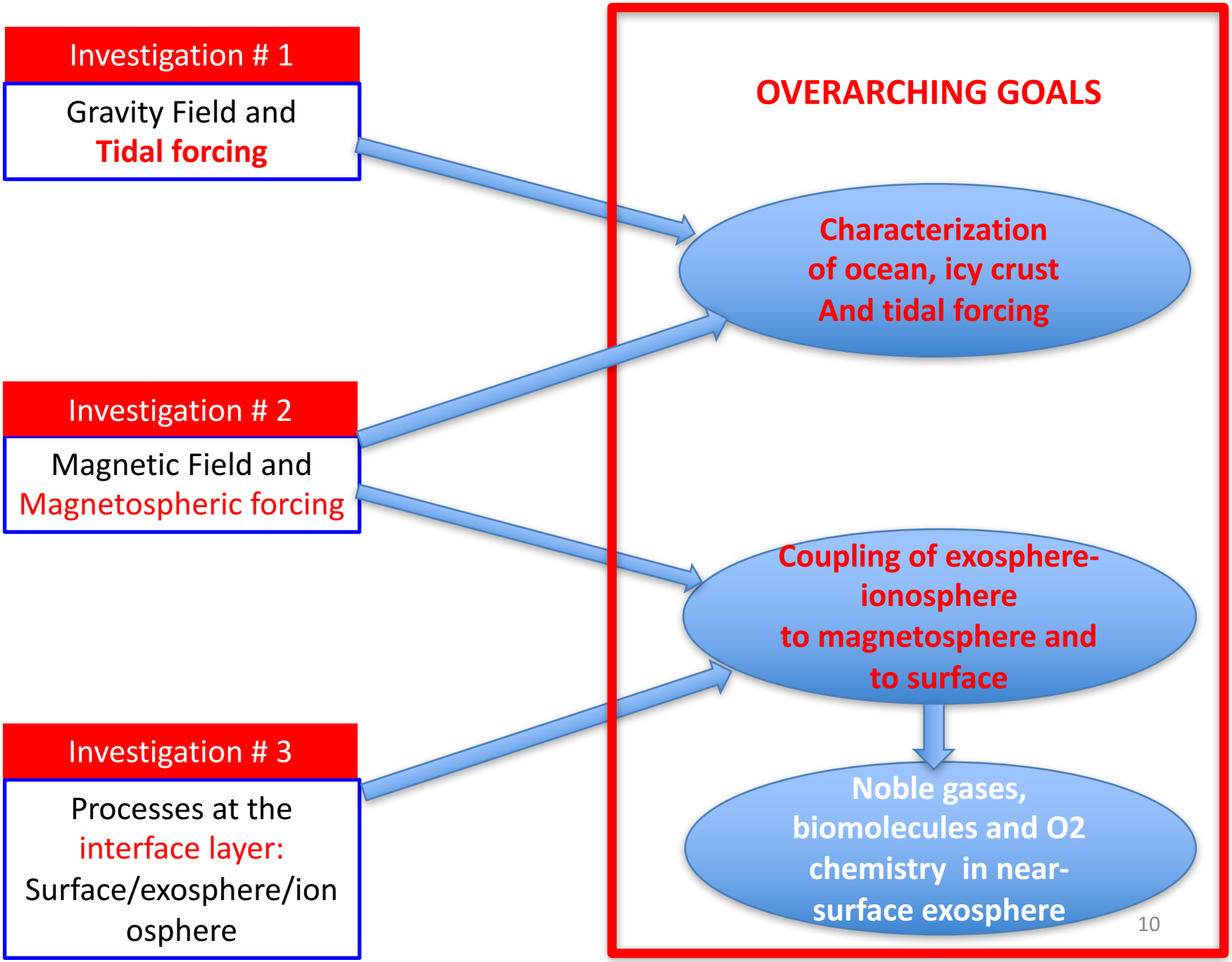
Lander provides a fixed geophysical station

Orbiter provides global and continuous coverage

… and EMFM provides information on farther and closer Europan environment

A « classical » geophysical ground-space observing system

GEOPHYSICS SCIENCE SUMMARY



Investigation # 1

Gravity Field and Tidal forcing

- 1. Static g and internal structure:
  - Lateral variations, C_{lm} S_{lm} to degree 20+
  - Improvement in vertical structure retrieval

Major step forward in ice shell characterization Including its tidal interactions with Jupiter !

- 2. Tidal response characterisation:
  - g tides (k_2)
  - Surface tidal deformation (h_2) – Altimeter!
  - Global tidal heating (of ice shell)

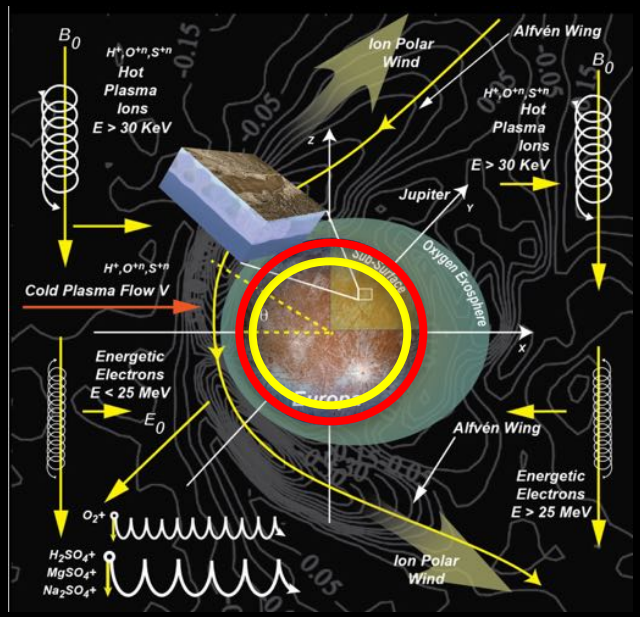
- 3. Rotation-libration (gravimetry + positioning)

ORBITER	LANDER
Gravity science	Seismometer or geophone
Altimeter	Optical corner
PRIDE-E (Astrometry by VLBI)	Tlltmeter?

Investigation # 2

Magnetic Field and Magnetospheric forcing

STUDY THE 2-OBSTACLE EUROPAN MAGNETOSPHERIC INTERACTION



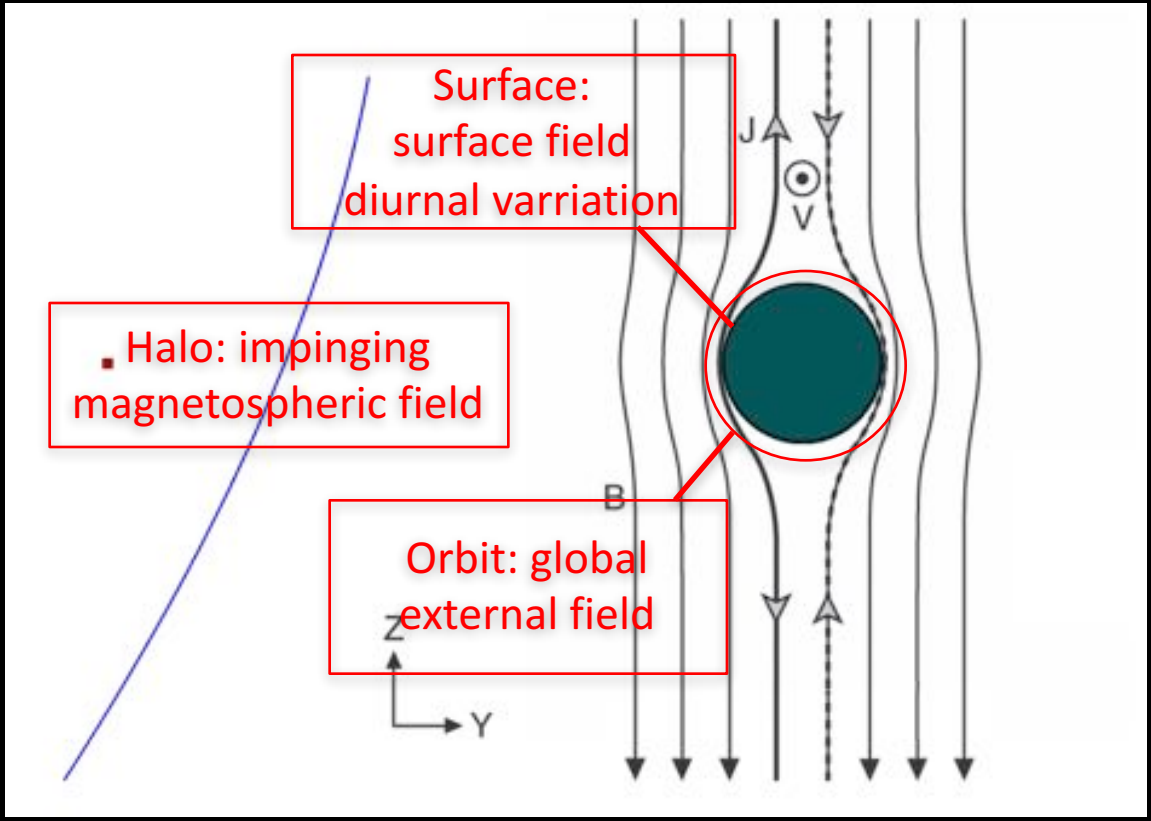
- 1. Mag flux interaction with conducting ocean
  -> separation of the 4 contributions to B field:
  - Impinging magnetospheric field (about 450 nT)
  - Ocean- induced currents (about 50 nT)
  - Plasma currents: ionosphere, Alfven waves
  - Permanent core field? (small and unknown)

2. Charged particles interaction with surface.

- > Global picture of Europan magnetospheric interaction with Jupiter for comparison with:
  - Ganymede interaction (Europa-JUICE synergy)
  - Other types of planetary/satellite interactions

ORBITER	LANDER
Magnetometer	Magnetometer
Plasma instrument (IMS/ELS)	Radiation monitor
NIMS?	

OUR EUROPAN « MAGNETIC OBSERVATORY »



The geometry of a halo relay orbit facilitates the separation of the 4 contributions to the B-field
(figure from Kivelson et al., 2009)

Investigation # 3

Processes at the interface layer: surface/exosphere/ionosphere

1. Charged particles interaction with surface:

- surface-exosphere-ionosphere coupling
- Astrobiological consequences incl. production of oxydizers and desorption of molecules of astrobiological interest

- ## 2. Global understanding of Europan exosphere-ionosphere envionment:
  - endogenic (Europa) vs exogenic (Io-Jupiter)

ORBITER – DESCENT SCIENCE	LANDER
Plasma instrument (IMS/ELS)	Radiation monitor
NIMS?	

JEM GLOBAL GEOPHYSICS
Payload for discussion

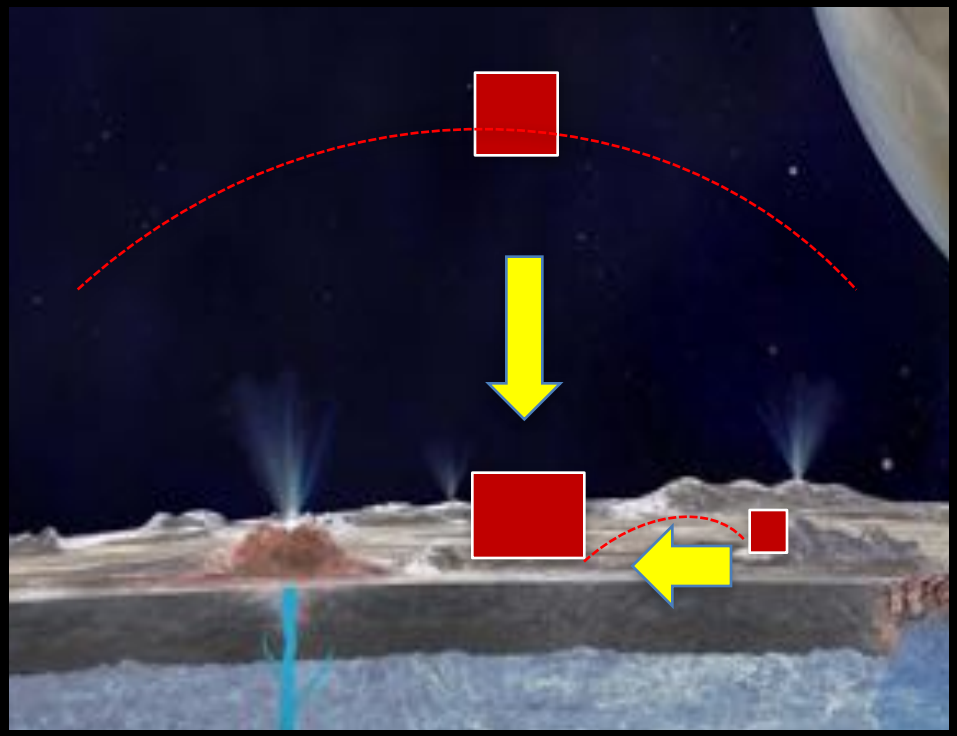
ORBITER	LANDER
Gravity science	Seismometer or geophone
Magnetometer	Magnetometer
Plasma instrument (IMS/ELS)	Radiation monitor
Altimeter	
NIMS?	Tlltmeter?
PRIDE-E (Astrometry by VLBI)	

Joint Europa Mission Science II – CONTRIBUTION TO SURFACE ASTROBIOLOGY

Based on
astrobiology investigations on the NASA lander
+ an «Astrobiology Wet Laboratory »
To be proposed by ESA + member states

JEM Surface Astrobiology Objectives

Focus on 2 specific points



#1 Understand the exchange processes between the aqueous interior environments and the surface

#2 Search for signs of extant life

EI Astrobiology OVERARCHING GOALS

EI Surface Astrobiology TM

Goal A	Objective		Investigation	Requirement	Instrument
SEARCH FOR EXTANT EUROPAN LIFE	Understand the exchange processes between the aqueous interior environments and the surface	Characterize the hydrochemistry of endogenic fluids	Physical chemistry: Acidity, redox, conductivity and temperature of samples in liquid state	pH (to 1 unit) redox (TBC) conductivity (TBC) temperature (0.1 K)	Multiparametric electrode sensor
			Volatiles in ice	O2, CH4 (TBC)	Multiparametric electrode sensor
		Determine the physical state of the icy context	Texture of the regolith (Porosity, grain size, ice contaminants)	TBC	Microscope
			Radialon dose	TBC	Radiometer
			Magnetometry on surface	TBC	Magnetometer
	Search for signs of life	Detect biosignatures	Potential biomolecules	D/L aromatic aa PAHs Short peptides Antifreezing peptides and sugars EPS from psycrophile microbes Cold shock proteins (<10ppb)	Multiarray immunoassay detector

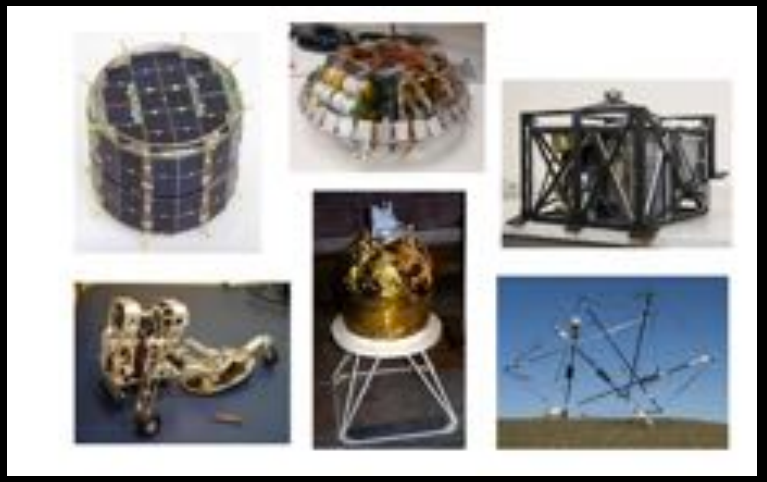
Main lander payload: potential European contributions

NASA soft lander platform	**European institutes interested to contribute/collaborate**	**Relevant national agencies**
GCMS*	LATMOS-CNES, University of Bern, Max Plank Institute	NASA, France, Switzerland, Germany
Raman spectroscopy*	IRAP, INTA/CSIC-UVA	NASA, France, Spain
PanCam/microscope *	DLR, MSSL/UCL, Space Exploration Institute, CNRS	NASA, Germany, UK, Switzerland, France
Geophone*	Imperial College London, IPG-Paris-CNES-ISAE	NASA, UK, France
Additional payload (to be considered)		
Microarray immunoassay detector	CAB-CSIC-INTA	Spain
Wet chemistry lab	CAB-CSIC-INTA	Spain
m-thermogravimeter	IAPS	Italy
Ice properties package (gravimeter, tiltmeter, radio transponder, heat sensors)	Univ. Roma La Sapienza	Italy
Magnetometer	Imperial College London	UK
Radiometer	DLR	Germany

OPTIONAL EUROPEAN ADDITION: ASTROBIOLOGY WET LABORATORY (AWL)

Concept options:

- High/medium/no mobility.
- Independent of the lander, except for communications.
- AWL separates from lander (e.g. by soft ejection) and lands between 5 to 10 meters away.
- Limited mobility capability (100 - 1000 cm) will also be explored.
- Baseline instrumentation: wet chemistry on shallow surface samples
- AWL has its own independent power unit, computer unit, communications units, thermal control and mobility systems.



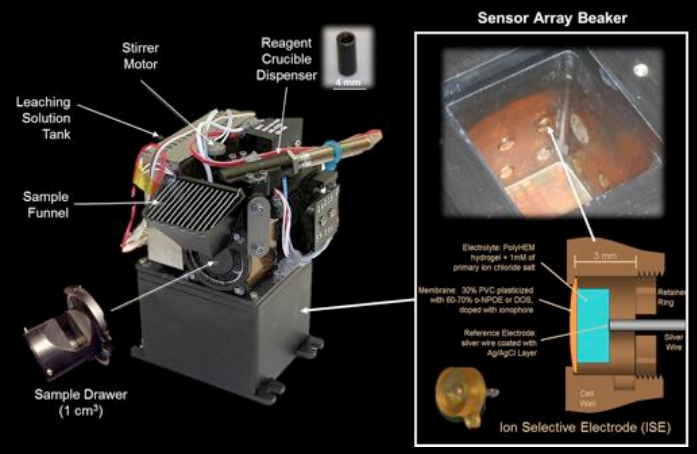
Heritage: MASCOT, MINERVA, CUBLI…)
Ref. Koeinig A. 2014 IEEE International Conference on Robotics & Automation (ICRA) Hong Kong Convention and Exhibition CenterMay 31 - June 7, 2014. Hong Kong, China

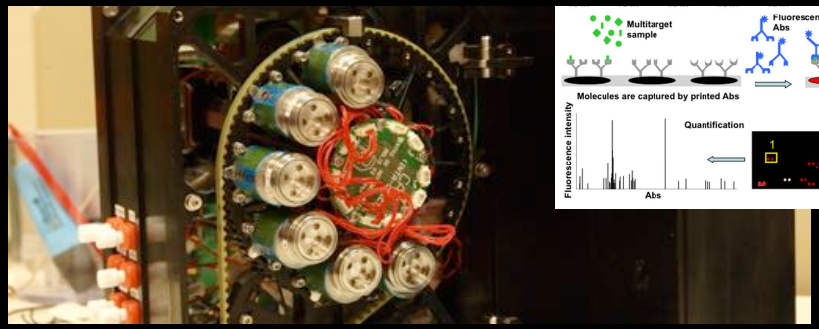
Information required for the design:

-Landing site main characteristics (e.g. morphology, radiation environment)
-Budgets (mass, power, dimensions) restrictions ** NASA Lander info required
-Communications with NASA Lander

AWL OPTION: reference payload

Mobile element (AWL)	Reference institute	National agency
Wet chemistry lab	CAB-CSIC-INTA	Spain
Microarray immunoassay detectors	CAB-CSIC.INTA	Spain
Camera/Microscope	Space Exploration Institute, CNRS	Switzerland, France
Radiometer	DLR	Germany
Magnetometer	Imperial College London	UK





WRAP-UP
M5 PROPOSAL(S) STRATEGY AND ACTION TIMELINE

POTENTIAL ESA CONTRIBUTIONS

- Carrier/relay/orbiter: 3 options
  - Full carrier bus (derived from JUICE elements) + p/l
  - Avionics + p/l (including all electronics, AOCS, power, ...): To be discussed with NASA
  - Accommodation of p/l on NASA bus

- Surface element:
  - AWL on NASA lander
  - Or AKON penetrator

- Total budget < 550 M€

PROPOSALS COMPLETION TIMELINE

- November ‘15 to this OPAG: building the science case
- This OPAG:
  - Presentation of science case and scenario
  - Community and NASA feed-back expected
- From OPAG to oct. 5 submissions:
  - A- Final consolidation of science case
  - B- Final identification of potential ESA contributions
  - C- Consolidating the mission scenario(s)
  - Discussion/validation of A, B, C at final team meeting: IRAP, Toulouse, sept. 7 to 9
  - Final draft (41 pages) submitted before oct. 5.

M5 PROPOSALS SELECTION/IMPLEMENTATION TIMELINE

- Proposals submission: oct. 5, 2016
- Letters of endorsement (national agencies): feb. 8, 2017
- Selection of (3?) missions for study: June 2017
- Phase 0 completed: November 2017
- Phase A kick-off: January 2018
- Mission selection: November 2019
- Mission adption: November 2021

THANK YOU
FOR YOUR FEED-BACK!

Europa Initiative wiki:

http://europa.sciencesconf.org/