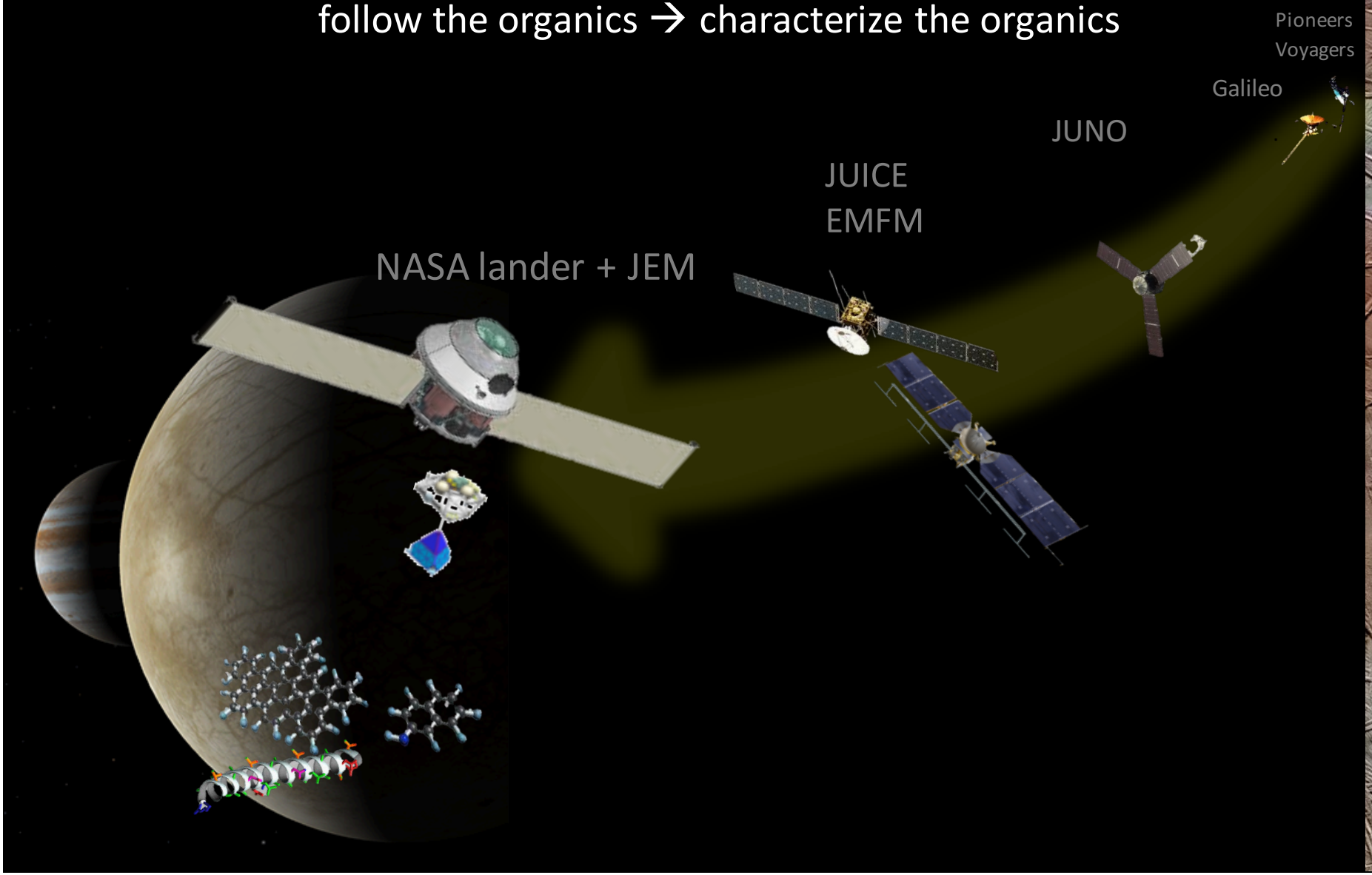

THE PLACE OF EUROPA IN ESA, NASA AND OTHER STRATEGIC DOCUMENTS AND THE EUROPA INITIATIVE
-Astrobiology issues

ASTROBIOLOGY LEIVMOTIV

EXPLORATION → HABITABILITY CHARACTERIZATION → SEEK SIGNS OF LIFE

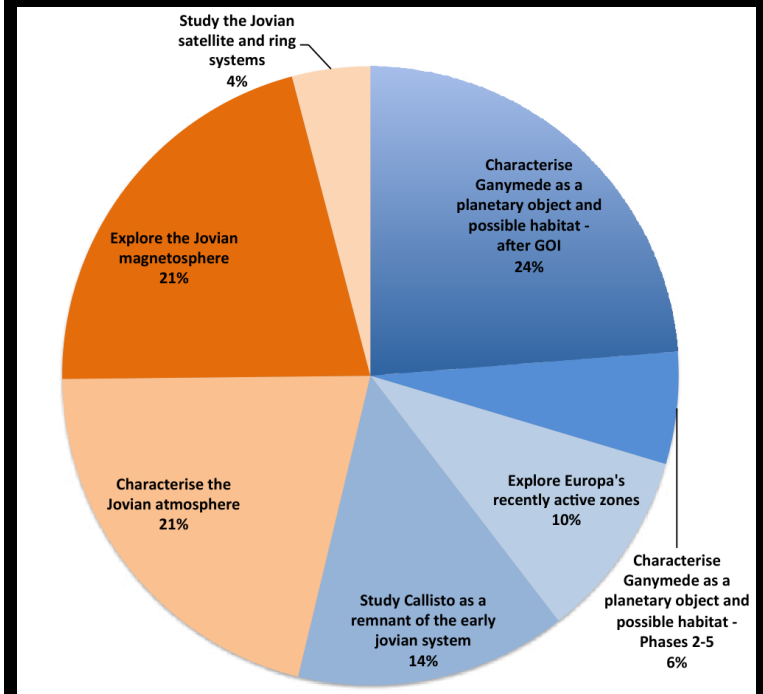
follow the organics → characterize the organics



ASTROBIOLOGY AT JUICE

JUICE Science Themes

- *Emergence of habitable worlds around gas giants*
- *Jupiter system as an archetype for gas giants*



ICY MOONS (54%) – JUPITER SYSTEM (46%)

Ganymede as a planetary object and possible habitat
- Largest satellite in the solar system
- Ocean between icy layers
- Internal dynamo
- Richest crater morphologies
- Archetype of waterworlds

Europa's recently active zones
- An active world?
- Ocean in contact with silicates

Callisto as a remnant of the early Jovian system
- Impactor history
- Enigmatic differentiation
- Witness of early ages

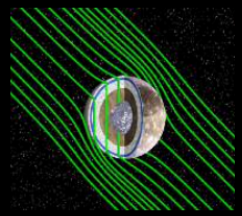
ASTROBIOLOGY AT JUICE

JUICE objective: Explore Europa recently active zones

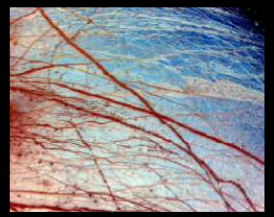
Flyby strategy:

- In-situ observations
- Imaging
- Infrared observations
- Ice penetrating radar
- Altimetry

Will result in :

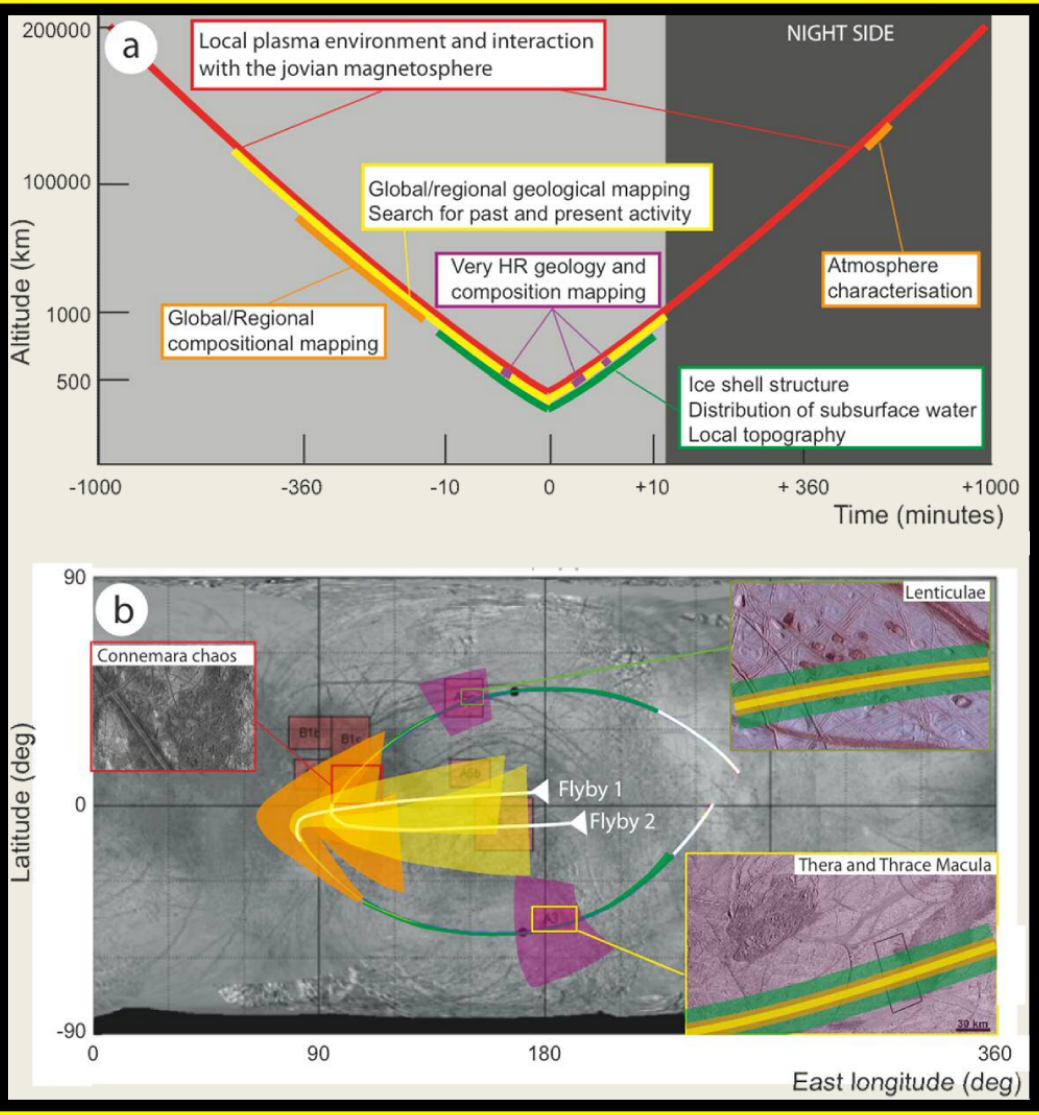


Characterisation of induced field



Composition and geology of areas of high interest

Subsurface exploration of recently active regions



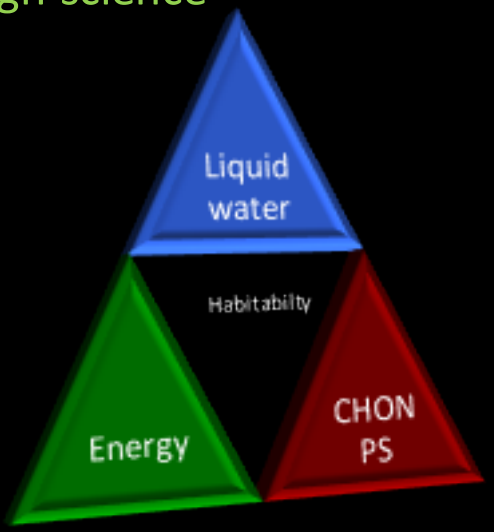
Europa				
Year	2030	2031	2032	2033

Goal	Objective	Investigation	Model Instrument
Explore recently active zones	Composition: Determine the composition of the non-ice material, especially as related to habitability	Characterize the composition and chemistry of Europa's surface	JANUS, PEP, MAJIS
		Identify biologically essential elements and search for biosignatures	
		Provide a consistent picture of the surface chemistry and separate the relative contributions of endogenic subsurface chemistry and exogenic magnetosphere-driven radiolysis and sputtering	
		Constrain the origin and evolution of the volatile inventories, and reveal information about the sources and sinks of their thin atmospheres	
	Liquid water: Search for liquid water under the most active sites	Search for pockets of liquid water in the shallow sub-surface of Europa	JANUS, GALA, RIME
		Unveil places where the exchange processes between surface and subsurface liquid reservoirs have been more intense	
	Processes: Study the recently active processes	Study of at least two of the most active sites with high spatial resolution to unveil their geology and composition	JANUS, MAJIS, UVS, J-MAG, RP-WI, PEP, GALA, RIME
		Study remotely and in-situ current activity on Europa (geysers, plumes etc.)	

ASTROBIOLOGY AT EMFM

EXPLORE EUROPA TO INVESTIGATE ITS HABITABILITY

- **Ice Shell and ocean:** Characterize the ice shell and any subsurface water, including their heterogeneity, ocean properties, and the nature of surface-ice-ocean exchange
- **Composition:** Understand the habitability of Europa's ocean through composition and chemistry
- **Geology:** Understand the formation of surface features, including sites of recent or current activity, and characterize high science interest localities



Conditions of life, geochemical gradients, signs of life

Goal	Objective		Investigation	Model Instrument
Explore Europa to investigate its habitability	IO. Ice Shell and Ocean	Characterize the ice shell and any subsurface water, including their heterogeneity, ocean properties and the nature of surface-ice-ocean exchange	IO.1 Characterize the distribution of any shallow subsurface water and the structure of the icy shell	EIS, REASON
			IO.2 Determine ocean salinity and thickness	ICEMAG, MISE, PIMS, SUDA
			IO.3 Constrain the regional and global thickness, heat-flow, and dynamics of the ice shell	ETHEMIS, EIS, Gravity, ICEMAG, PIMS, REASON
			IO.4 Investigate processes governing material exchange among the ocean, ice shell, surface, and atmosphere	EIS, ICEMAG; MASPEX, MISE, REASON. SUDA
	C. Composition	Understand the habitability of Europa's ocean through composition and chemistry	C.1 Characterize the composition and chemistry of endogenic materials on the surface and in the atmosphere, **including potential plumes**	EIS, UVS, ICEMAG, MASMEG, MISE, REASON, SUDA
			C.2 Determine the role of the radiation and plasma environment in creating and processing the atmosphere and surface materials	EIS, UVS, MASPEX, MISE, PIMS, Radiation, REASON, SUDA
			C.3 Characterize the chemical and compositional pathways in the ocean	EIS, ICEMAG, MASPEX, SUDA, MISE
	G. Geology	Understand the formation of surface features, including sites of recent or current activity, and characterize high science interest localities	G.1 Determine sites of most recent geological activity, including potential plumes, and characterize localities of high science interest and potential landing sites	ETHEMIS, EIS; UVS, MASPEX, MISE, PIMS, REASON, SUDA
			G.2 Determine the formation and three-dimensional characteristics of magmatic, tectonic, and impact landforms	EIS, REASON
			G.3 Investigate processes of erosion and deposition and their effects on the physical properties of the surface	ETHEMIS, EIS, UVS, PIMS, REASON, SUDA

5. Addressing the Ladder of Life: Rough Cut

Ladder Rung	Feature	Clipper	Target
Life (metabolism, growth, reproduction)			
Darwinian Evolution	changes in heritable traits in response to selective pressures	Monolith	
Growth and Reproduction	concurrent life stages or identifiable reproductive form [growth and reproduction]	???	Squid.
Metabolism	isotopes	MISE?, SUDA?, MASPEX	Plumes, Patches [caveat on sensitivity needed to conclude metabolic effect]
	co-located reductant and oxidant (e.g. persistant H2 +/- CH4 v. O2, nitrate, Fe3+, CO2) [Inferred Persistence]	UVS, MISE, SUDA, MASPEX [split into yellow and green based on plume]	Plumes, Patches, Surface [Green only with Plume!]
Suspicious biomaterials [not necessarily bio			
Functional Molecules	DNA		
	RNA		
	pigments	???	Patches,
	structural preferences in organic molecules [non random and enhancing function)	MASPEX, SUDA, MISE	Plumes, Patches
Potential Biomolecule Components	complex organics (peptides, PAH, nucleic acids, hopanes)	MASPEX, SUDA, MISE	Plumes, Patches
	amino acids (e.g. glycine, alanine)	MISE, SUDA, MASPEX	Patches, Plumes,
	lipids (fatty acids, esters, carboxylic acids)	MASPEX, SUDA, MISE	Plumes, Patches
General indicators	distribution of metals [e.g. vanadium in oil reserves or others like Fe, Ni, Mo/W, Co, S, Se, P]	MISE, UVS, SUDA, MASPEX	Patches, Plumes,
	patterns of complexity (organics)	MISE, SUDA, MASPEX	Patches, Plumes,
	chirality	MISE?	Patches,
Habitability			
	water, presence of building blocks for use, energy source, gradients	MASPEX, SUDA, PIMS, ICEMAG, UVS, EIS, MISE, E-THEMIS, REASON, Gravity	Plumes desirable, Surface, Patches, Sub-surface

First-order assessment by Europa Science Team, led by Habitability Working Group (Lunine, Hand co-chairs)

Colors refer to ability of Europa payload to address properties or materials cited in "Feature" column:

Blue: Payload provides a comprehensive investigation that fully addresses

Green: Two or more instruments can address

Yellow: Two or more instruments can probably address (more work required to confirm)

Red: cannot address or only one instrument can possibly address (more work required to confirm)

NASA LANDER STUDY 2012

Goal		Objective		Investigation	Model Instrument
Explore Europa to investigate its habitability	IO. Ice Shell and Ocean	Characterize local thickness, heterogeneity and dynamics of any ice and liquid water layers	IO.1	Constraint the thickness and salinity of Europa's ocean	MAG, MBS
			IO.2	Constraint the thickness of ice and the thickness of any water layer in the region	MAG, MBS
			IO.3	Search for local heterogeneity of the ice and any subsurface water	MBS
			IO.4	Characterize Europa's seismic activity and its variation over the tidal cycle	MBS
	C. Composition	Understand the habitability of Europa's ocean through composition and chemistry	C.1	Characterize surface and near surface chemistry, including complex organic chemistry to constrain ocean composition and understand the endogenic processes from which it evolves	MS, RS
			C.2	Characterize surface and near surface chemistry including complex organic chemistry to constrain the exogenic processes and material fluxes that affects ocean composition	MS, RS
			C.3	Characterize the context of compositional measurements	RI, SIS, MI
	G. Geology	Characterize a locality of high scientific interest to understand the formation and evolution of the surface at local scales	G.1	Constrain the processes that exchange material between the surface, near-surface, and subsurface	SIS, RI, MI
			G.2	Constrain the processes and rates by which the surface materials (regolith and bedrock) form and evolve over time	SIS, RI, MI
			G.3	Understand the regional and local context of the landing site	SIS, RI, MI
			G.4	Constrain the physical properties of the surface and near-surface at the landing site to provide context for the sample	SIS, RI, MI, Europa sampling system

ROADMAP ON OCEAN WORLDS

OVERARCHING GOAL OF ROW
Identify ocean worlds, evaluate their habitability, and search for life
Identify fundamental science questions
Support OW exploration program, including programs to develop instruments (PICASSO, MATISSE, COLDTech)

FOUR THEMES
-Identify ocean worlds in the solar system
-Characterize the oceans
-Characterize the habitability of ocean worlds (Earth and beyond)
-Understand how life might exist within ocean worlds and search for evidence of life within them

TARGET TEAMS
-Enceladus, **Europa**, Pluto&KBOs, Ceres&small bodies, Ganymede&Callisto, Triton, Titan, others