Planetary Exploration, Horizon 2061:

Some proposed next steps for Giant Planets Systems exploration

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HORIZON 2061 APPROACH : DESIGN THE TRACEABILITY MATRIX OF AN

« INTEGRATED SPACE SCIENCE MISSION » TO THE SOLAR SYSTEM

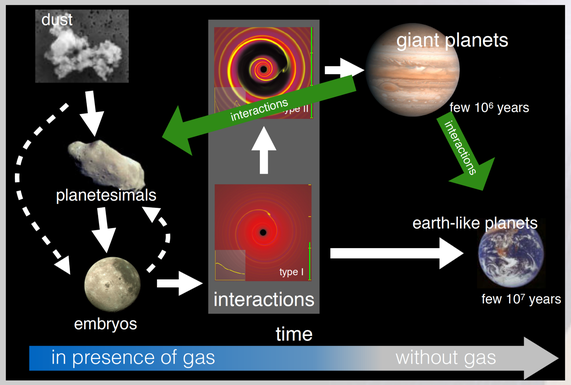
OVERARCHING GOAL

Study the formation and evolution processes leading to the growth of complexity, and ultimately to the possible emergence of life, through the diversity of planetary systems:
(1) the growth of molecular complexity, from the Interstellar medium (ISM) to planetary and moons environments
(2) the growth of planetary environments complexity , and the conditions under which their evolutionary paths may lead them to become “habitable”

(a) Origin of planetary systems

Key measurements:
- **Primitive grains in ISD, small bodies and meteorites: crystalline phases, volatiles, organics,… elemental and isotopic composition**
- **Connect the small body and meteorite records**
- **Giant planets’ atmospheres elemental and isotopic composition**

Mission types: sample return (in situ analysis when impossible) and giant planets entry probes.



(b) Formation and diversity of planetary systems architectures

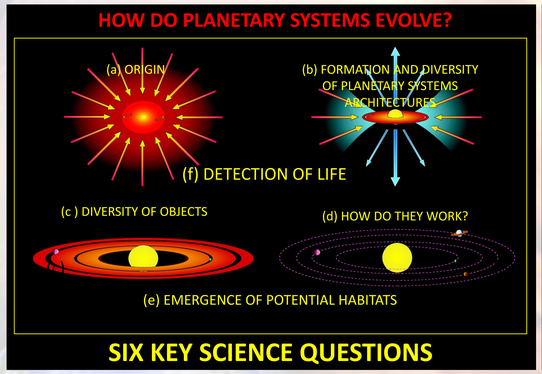
Key measurements:
- **Composition of ices and clathrates (with their different phases), rare gases and heavy elements (via H2O, NH3, CH4…)**
- **Cratering record throughout the Solar System**

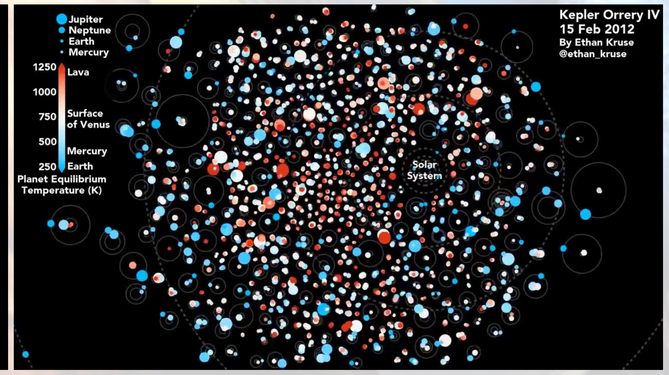
Mission types: sample return of each object class (in situ analysis when impossible), orbiter and entry probes for giant planets and orbiter and landers for icy satellites.

(c) Diversity of objects

Key measurements:
- **Compare the internal structures and bulk compositions of all classes of differentiated objects and try to connect them to their exoplanet counterparts**
- **Full inventory of the different types of small bodies within each reservoir and of small irregular satellites of giant planets**
- **Connect planets, satellites, small bodies and meteorites**

Mission types: orbital and multiple flyby missions for each type of object





MISSION TYPES AND TARGETS

		Moon-Earth system	Mars	Venus	Mercury	A	C	Planet	Moons	Planet	Moons	T	KBO	HP Boun daries	Oort cloud objects	Proxima Centauri
		Terrestrial planets				Small bodies		Gas giants		Ice giants		Small bodies		Heliopause and beyond		
Human exploration		?	?	-	-	-	-	-	-	-	-	-	-	-	-	-
Utilisation of in situ ressources		?	?	-	-	-	-	-	-	-	-	-	-	-	-	-
Sample Return		Moon sample return	Mars and Phobos sample return	-	-	Yes, all types	Comet sample return	-	Europa, Enceladus sample return	-	-	Trojan sample return	-	-	-	-
Available meteorites		Yes	Yes	?	?	Yes	?	-	-	-	-	-	-	-	-	-
In situ exploration	Network	Yes	Yes	-	-	-	-	-	-	-	-	-	-		-	-
	Mobile	isotopes	Isotopes, biomarkers	Balloons	-	Yes	Yes	-	Isotopes biomarkers	-	Yes	-	-		-	-
	Station	-	-	Yes	Yes	-	-	-	Isotopes biomarkers	-	Yes	-	-		-	-
	impactor	-	-	-	-	-	-	-	Yes	-	Yes	-	-		-	-
	Atm. probe	-	-	Yes	-	-	-	Yes	-	Yes	-	-	-		-	-
Orbital observation	Swarm	-	Mars Satellite swarm atm.	Venus satellite swarm atm.	-	Yes	-	Yes	-	-	-	-	-		-	-
	Small sat.	Yes	Yes	Yes	-	-	-	-	-	-	-	-	-		-	-
	Orbiter	Yes	Yes	Yes	-	Yes	Yes	Yes	Yes	Yes	Yes	-	-		-	-
Fly-by		-	-	-	-	Spectro-scopic survey	Yes	-	Yes	-	Yes	Spectro -scopic survey	Yes	Yes	Fast mission to fresh comet	-
Earth-based observation		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Kepler ?; Planck ?	Yes

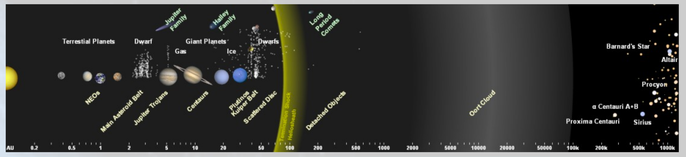
MISSIONS FLOWN OR DECIDED

MISSIONS ADDRESSING THE KEY SCIENCE QUESTIONS

(d) Planetary systems coupling mechanisms at 4 scales

Key measurements:
1. **Global characterization of the different envelopes of each planet and its moons**
2. **Global structure and dynamics of each system (SS, giant planets systems): gravitational dynamics, electrodynamics**
3. **Interactions of LISM with heliosphere**
4. **KBO, Oort cloud …**
5. **… Proxima Centauri b (closest exoplanet)**

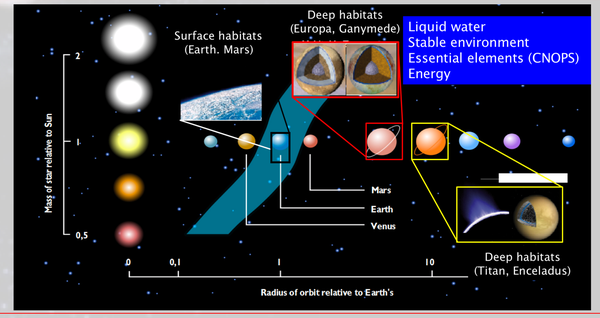
Mission types: orbiters and surface networks, multipoint missions for magnetospheric interactions. Missions to outer solar system: KBO, Heliopause, Proxima Centauri



(e) Emergence of potential habitats

Key measurements:
Study habitability of surface habitats and deep habitats

Mission types:
- **Global orbital monitoring… combined with plumes measurements by subsatellites;**
- **Characterization of habitability at one or several sites: fixed station, penetrator, rover…**
- **Sample return: Moon, Mars, Venus or icy satellites**



(f) Detection of life

Key measurements:
- **Develop sensors to try and detect signs of life across the full spectrum of complexity (biomarkers and biomolecules) at surface, sub-surface, atmospheres/exospheres (plumes), oceans and lakes**

Mission types:
- **plumes measurements by subsatellites;**
- **Surface or subsurface measurements by fixed station; penetrator, rover…**
- **Sample return: Moon, Mars, Venus or icy satellites**