IMAGINE TOGETHER THE FUTURE OF PLANETARY EXPLORATION

WHY HORIZON 2061?

2061 will be the centennial of the first human space flight…

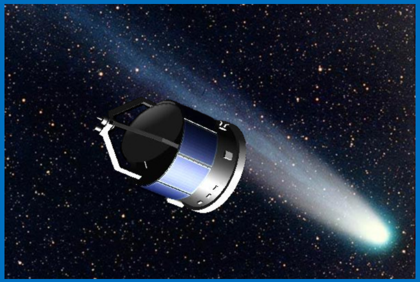
… and of President Kennedy's Moon address to Congress

2061 will see the return of comet P/Halley in the inner solar system, reminding us of the international fleet of spacecraft which flew by it in 1986!

THUS, 2061 IS A SYMBOLIC DATE CHOICE
WHICH ALLOWS US TO CONNECT ROBOTIC AND MANNED EXPLORATION
IN THE SAME, SINGLE PERSPECTIVE!

HORIZON 2061

MOTIVATIONS AND OBJECTIVES



1. HORIZON 2061 IS **NOT A ROAD-MAP BUILDING ACTIVITY** ! (No selection of priority themes, no selection of a « short list » of missions.

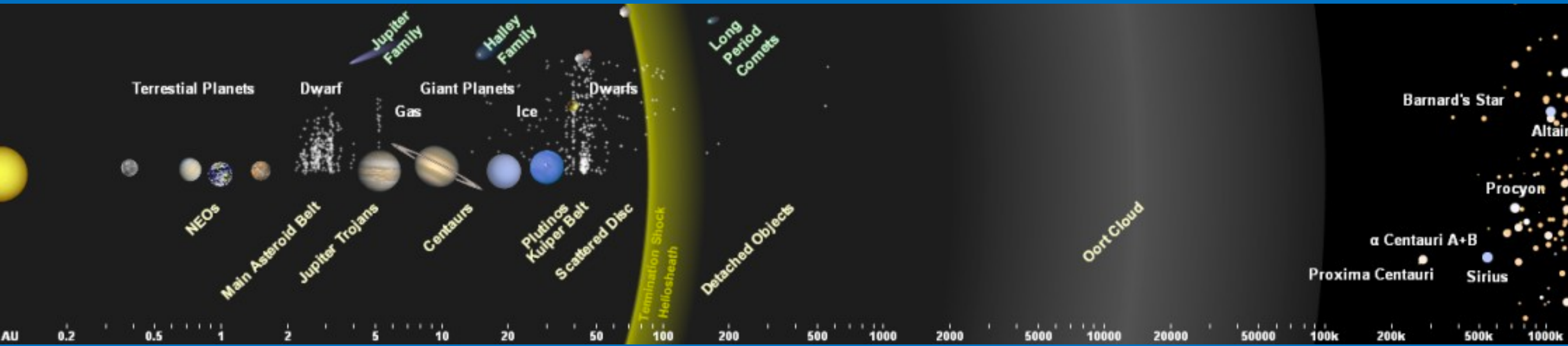
2. HORIZON 2061 IS AN INTELLECTUAL EXERCISE, LED BY THE COMMUNITIES OF PLANETARY SCIENCE AND EXPLORATION AND FED BY THEIR FREE IMAGINATIONS, WHICH AIMS AT **ELABORATING AN « INTEGRATIVE » (NON-SELECTIVE) MULTI-DECADAL SCIENCE-DRIVEN VISION OF THE FOUR PILLARS OF PLANETARY EXPLORATION, BUILDING UPON THE UNIFYING PARADYGM OF « PLANETARY SYSTEMS »**

3. IT IS BUILT ACROSS SCIENTIFIC AND TECHNICAL BOUNDARIES:
   - BETWEEN SOLAR SYSTEM AND EXTRASOLAR PLANETARY SYSTEMS SCIENCES
   - ACROSS THE LIMITATIONS OF THE DIFFERENT OBSERVATION TECHNIQUES (IN SITU VS. REMOTE SENSING)
   - ACROSS SCIENTIFIC AND TECHNICAL DISCIPLINES
   - BETWEEN SCIENTISTS, ENGINEERS AND MANAGERS
   - CONNECTING THE PUBLIC AND PRIVATE SPHERES

   TO **STIMULATE INTERDISCIPLINARY SYNERGIES FOR THE BENEFIT OF THE PROGRESS OF SCIENTIFIC KNOWLEDGE AND TECHNOLOGICAL CAPACITIES**

4. **THE REPORT OF THE HORIZON 2061 EXERCISE WILL BE PUBLISHED AS A MULTI-AUTHORS, MULTI-CHAPTERS BOOK BY ELSEVIER. EACH INDIVIDUAL CHAPTER WILL BE PEER-REVIEWED AND PUBLISHED ELECTRONICALLY ON-LINE AS A ScienceDirect article. IT WILL BE PRESENTED TO THE GENERAL ASSEMBLY OF COSPAR IN SYDNEY IN AUGUST 2020.**

Horizon 2061 perspective of Solar System Exploration, today and tomorrow



ROBOTIC EXPLORATION

DETAILED COVERAGE BY SPACE-BASED TELESCOPES

SAMPLE RETURN

HUMAN EXPLORATION

H2061 METHOD

DESIGN AN

« INTEGRATED SPACE SCIENCE MISSION TO PLANETARY SYSTEMS »

BY BUILDING ITS TRACEABILITY MATRIX, WE WILL BUILD OUR « FOUR PILLARS »

OVERARCHING GOALS KEY SCIENCE QUESTIONS	MAJOR SCIENTIFIC QUESTIONS — PILLAR 1
KEY MEASUREMENT OBJECTIVES MISSION TYPES AND TARGETS	REPRESENTATIVE MISSIONS — PILLAR 2
TECHNOLOGY AND INFRASTRUCTURE NEEDS	INFRASTRUCTURE — PILLAR 4 TECHNOLOGY — PILLAR 3

METHOD

Produce a 50-year foresight of

Planetary Systems Exploration (Solar System)

through a projection of its four « pillars »:

- **(1) major scientific questions**

(2) representative planetary missions

Bern, Sept. 2016

- **(3) enabling technologies**

(4) supporting infrastructures

Lausanne, April 2018

SYNTHESIS Toulouse, SEPT. 11-13, 2019

Confront our long-term « science dreams » with a projection of our technical capacities

FROM KEY SCIENCE QUESTIONS TO KEY MEASUREMENTS AND TO MISSION TYPES

1 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) of all types of pristine material and giant planets entry probes

2 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.

3 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

4 PLANETARY SYSTEMS COUPLING MECHANISMS AT 4 SCALES

Key measurements

- Global characterization of the different envelopes of each planet and its moons
- Global structure and dynamics of each system (solar system, giant planets systems) e.g. in particular gravitational/tidal interactions
- Electrodynamic and other interactions between satellites, planets and their magnetospheres, heliosphere, Very Local Interstellar Medium (VLISM), Galaxy…

Mission types

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

5 EMERGENCE OF POTENTIAL HABITATS

Key measurements

Study habitability of surface habitats and deep habitats

Mission types

- Global orbital monitoring of possibly habitable planets and moons
- In situ analysis of plumes related to cryovolcanic activity
- Characterization of habitablilty conditions at surfaces/subsurfaces of planets and moons: fixed stations (incl. penetrators), rovers…

6 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, atmos-pheres/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

Pillar (2)

Representative space missions

Tentative contents

1. Future Giant Space Observatories
2. The Earth-Moon System
3. Terrestrial planets
4. Giant planets and their systems
5. Small bodies
6. Heliosphere, Solar System, ISM and beyond

FROM

KEY MEASUREMENTS

AND

MISSION TYPES

TO

CRITICAL

TECHNOLOGIES