

# Report from Horizon 2061 Synthesis Workshop Pillar 1: From Science questions to representative space missions

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## Abstract

In our talk, we will present the context for and details from the presentations during the Horizon 2061 Synthesis Workshop, the third step of the "Planetary Exploration, Horizon 2061" exercise. We will focus on the results of the discussions and presentations concerning the science questions for Horizon 2061 and potential space missions that will address these questions.

## 1. Introduction

"Planetary Exploration, Horizon 2061" is a long-term foresight exercise initially proposed by the Air and Space Academy and led by scientists, engineers and technology experts heavily involved in planetary sciences and in the space exploration of the Solar System. This foresight exercise is opened to all scientists, engineers, technicians, journalists, industry and space agencies and people interested in the future of planetary exploration and the space adventure.

### 1.1. Ultimate objective

The Toulouse synthesis workshop ultimate objective is to look to the 2061 horizon (H2061) and develop a long-term picture of the four pillars of planetary exploration:

1. our major **scientific questions** on planetary systems;
2. the different types of **space missions** that we need to fly to address these questions;
3. the key **technologies** we need to master in order to make these missions flyable;
4. the ground-based and space-based **infrastructures** needed in support of these missions.

The year 2061 symbolically represents the intention to encompass both robotic and human exploration in the same perspective. Its distant horizon, located well beyond the usual horizons of the planning exercises of space agencies, avoids any possible confusion with them and is intended to "free the imagination". During the series of three Horizon 2061 workshops, planetary scientists have been invited to formulate what they think are the most relevant and important scientific questions independently of the *a priori* technical possibilities of answering them. Subsequently, engineers and technology experts have been invited to contribute to the exercise by looking for innovative technical solutions that will make it possible to fly the challenging space missions that will allow us to address these questions.

### 1.2. Main objectives

Four main objectives can be reached via this dialogue between scientists and engineers:

1. identify the technologies and infrastructures that will be needed to address our major scientific questions;
2. provide a broad spectrum of national space missions of diverse sizes and complexity levels all contributing to address these questions;
3. inspire coordination and collaborations between the different players of planetary exploration to better meet technology challenges and fly these missions; and
4. share with the public and public/private leaders the major scientific questions and technological challenges of planetary exploration.

### 1.3. Three successive steps

The "Horizon 2061" exercise involves three successive steps (workshops) designed to progressively build the three pillars. Its third step is

the "Horizon 2061 synthesis workshop", hosted by the Institut Aéronautique et Spatial (IAS) in Toulouse from September 11<sup>th</sup> to 13<sup>th</sup>, 2019. Its conclusions will be presented for discussions at the joint EPSC-DPS meeting in Geneva (September 15<sup>th</sup> to 20<sup>th</sup>, 2019), and later for discussion and final approval at the COSPAR General Assembly (Sydney, August 15<sup>th</sup> to 23<sup>rd</sup>, 2020). This presentation will focus on the first pillar of planetary exploration: science questions and appropriate space missions that will address these questions.

## **2. Studying planetary systems**

### **2.1. Overarching science goals**

Scientists want to 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 the environments of planets and moons; and
2. the growth of complexity in planetary environments, and the conditions under which their evolutionary paths may lead them to become "habitable".

### **2.2. Major scientific questions**

The major H2061 scientific questions addressed in Pillar 1 are:

1. Origins of planetary systems;
2. Formation and diversity of planetary system architectures;
3. Diversity of objects;
4. Planetary systems coupling mechanisms;
5. Emergence of potential habitats; and
6. Detection of life.

### **2.3. Talks**

The six talks planned for the Pillar 1 session at the Toulouse workshop are high-level science talks that will start from the different Horizons 2061 science questions and will connect these science questions to key measurements to be performed in the solar system to address these questions, and to an identification of the places/objects where to perform these measurements. The speakers will establish this connection throughout the solar system. The foreseen themes of the speakers are:

1. The exoplanet context
2. Origins and early evolution of the solar system
3. Diversity of objects
4. How does it work?
5. Emergence of potential habitats
6. Search for life

## **3. Summary and Conclusions**

During our presentation, we will explain the objectives of the Horizon 2061 Pillar 1 on science questions and future space missions that will address them. We will overview the content of the talks during the Horizon 2061 Synthesis Workshop, the third step of the "Planetary Exploration, Horizon 2061" exercise. We will further summarize the discussions that follow the talks and introduce the presently open questions.