The LIFE space mission: characterizing atmospheres of terrestrial exoplanets and searching for habitable worlds and biosignatures

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"Therefore, launching a large mission enabling the **characterisation of the atmosphere of temperate exoplanets in the mid-infrared** should be a top priority for ESA within the Voyage 2050 timeframe."

ESA Senior Committee Report

LIFE SUMMARY

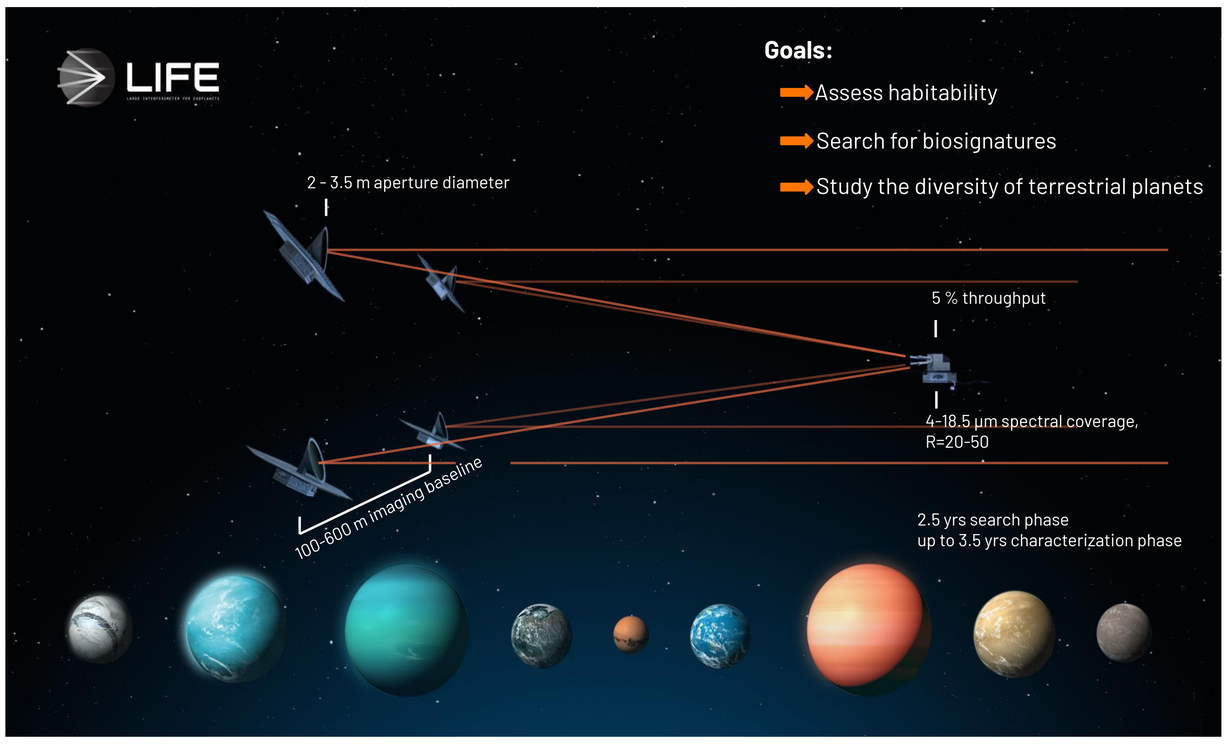


Figure 1. *Artist Impression of LIFE. Key parameter summary.*

The Large Interferometer For Exoplanets (LIFE) is an ambitious space mission with unparalleled scientific capabilities optimized for the **direct detection and atmospheric characterization of hundreds of exoplanets**. Dozens of these will be terrestrial, temperate, and possibly hospitable to life as we know it.

As a **formation-flying mid-infrared (nulling) interferometer**, LIFE is located in L2 and consists of 4 collector spacecrafts with 2-3.5 m apertures and a combiner spacecraft.

The observing wavelength range is 4-17.5 µm (requirement) / **3-20 µm** (goal) and the required **spectral resolution** is 35 (req.) / **50** (goal).

The total **mission lifetime is 5-6 years** (requirement):

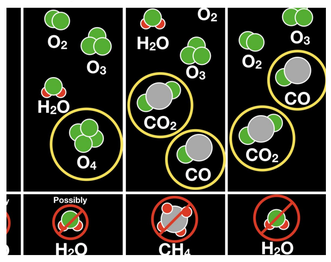
- **Search phase (2.5 years)**: detection of hundreds of planets
- **Characterization phase (up to 3.5 years)**: detailed investigation of atmospheric diversity and search for biosignatures
- Other science (up to 20%; tbc.)

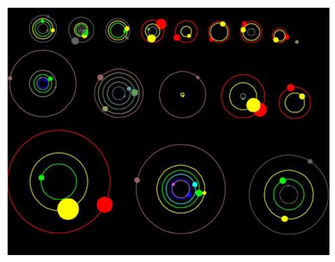
LIFE CONTEXT

The atmospheric characterization of a significant number of terrestrial planets, including the search for habitable and potentially inhabited planets, is one of the major goal of exoplanetary science. It is also one of the most challenging endeavours in 21st century astrophysics. However, despite being at the top of the agenda of all major space agencies and ground-based observatories, none of the currently planned projects or missions worldwide – neither in Europe, nor in the US, China or India – has the technical capabilities to achieve this goal. The LIFE initiative addresses this issue by investigating the scientific potential and technological challenges of an ambitious mission employing a formation-flying nulling interferometer in space working at mid-infrared wavelengths. As such, LIFE is grounded in the heritage of ESA's Darwin and NASA's TPF-I concepts from the early/mid 2000s. However, breakthroughs in our understanding of the exoplanet population as well as significant progress in relevant technologies justify the need, but also the feasibility for a future mission like LIFE to investigate one of the most fundamental questions of humankind: **Are we alone in the Universe?**

LIFE SCIENCE OBJECTIVES

Science Objective SO1.1:
LIFE shall detect 30-50 mature (3-6 Gyr) exoplanets with radii between 0.5 and 1.5 Earth radii and orbiting within the empirical habitable zone (eHZ) of nearby FGKM stars.
Science Objective SO1.2:
Based on objects detected in SO1.1, LIFE shall investigate (and if possible quantify) the fraction of exoplanets orbiting within the (empirical) HZ providing habitable conditions.
Science Objective SO2.1: For objects detected in SO1.1 LIFE shall assess if their atmospheres contain "classic" biosignature gases (with a specific focus on the O_3 / CH_4 pair) and gases associated with, or incompatible with, known false positives.
Science Objective SO2.2:
For objects detected in SO1.1 and temperate objects with radii up to 2 Earth radii detected in SO3.1, LIFE shall assess if their atmospheres contain signs other "non-classical" biosignatures (e.g. phosphine or isoprene, surface pigments, seasonal changes etc).
Science Objective SO3.1:
LIFE shall investigate the architectures of the regions out to ~1-2 AU of nearby planetary systems.
Science Objective SO3.2:
LIFE shall determine the variation of atmospheric composition as a function of planet size and orbital separation for these SO3.1 systems .

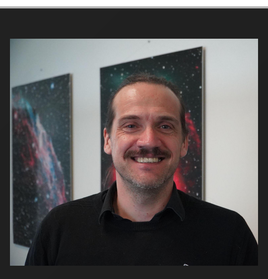




LIFE STATUS AND NEXT STEPS

After official kick-off in 2018, LIFE is currently in a first study phase. Activities include:

1. Formulating a first set of clear science objectives and science cases for the mission
2. Deriving a first set of major science requirements based on the science objectives
3. Assessing the current status and maturity of key technologies required for the mission
4. Drafting a technology development roadmap
5. Seeking funding opportunities for technical as well as scientific work related to LIFE
6. Community building by generating interest in the science and technology development and expanding the team of collaborators. **Please get in touch with us!**



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