



# Overview of space activities at ETH Zurich

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Image cover: NASA-GSFC, Adriana M. Gutierrez (CI Lab)

# Introduction

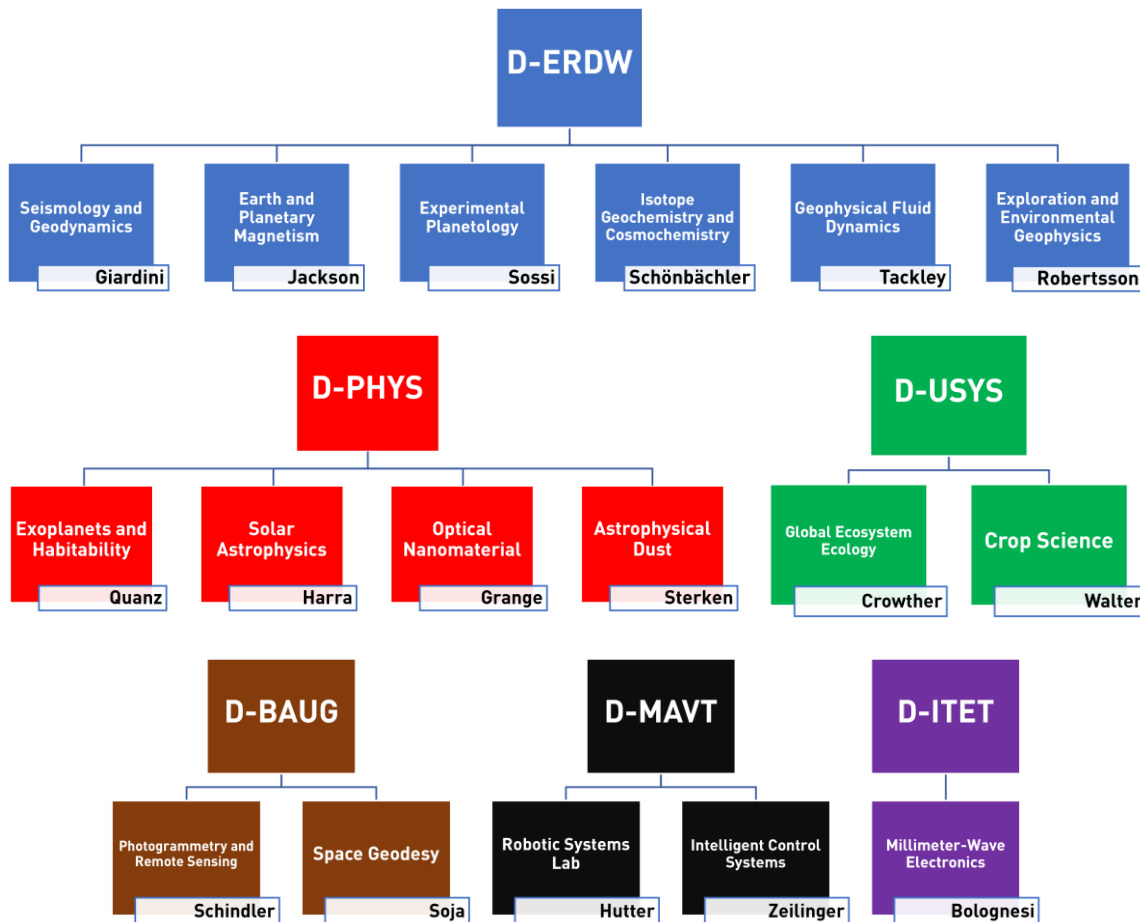
This document gives an overview of past, present, and some future activities related to space at ETH Zürich, as well as the active research groups in this field. The different activities are separated in the three main categories, namely science, technology, and education. Larger activities are provided with more details.

Please note: The overview is not exhaustive and might not cover all space-related activities at ETH Zurich.

If you are an ETH researcher with activities in this field and would like to be featured in this document, feel free to get in touch with us at [info.space@ethz.ch](mailto:info.space@ethz.ch).

## Overview ETH groups

This scheme gives an overview of some of the groups at ETH which are doing research activities related to space. The leading professors/ doctors are also listed.





# Science

## ESA LISA & LISA Pathfinder

### LISA - Laser Interferometer Space Antenna

#### Goal:

- LISA Pathfinder: Test components and technology required for future LISA mission.
- LISA: Deploy the first space observatory to detect gravitational waves.

#### Status:

- LISA Pathfinder: Completed. Launched in 2015 and successfully tested relevant technologies with results exceeding expectations.
- LISA: In development. Should be launched in 2034.

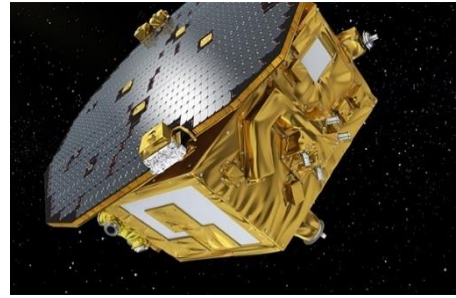


Image: ESA, LISA Pathfinder

**ETH contribution:** Design of control electronics and drive mechanism, data acquisition, noise mitigation and signal identification.

**ETH groups:** D-ERDW, Seismology and Geodynamics Group ([Prof. Dr. Domenico Giardini](#))

#### Links:

- [ETH Seismology and Geodynamics Group](#)
- [ETH - LISA Pathfinder factsheet \(PDF\)](#)
- [LISA Pathfinder \(ESA website\)](#)

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## NASA InSight

### InSight - Interior Exploration using Seismic Investigations, Geodesy and Heat Transport

**Goal:** InSight, a robotic lander designed to study the deep interior of Mars. Primary scientific instrument onboard was SEIS, the Seismic Experiment for Interior Structure.

**Status:** Completed

Landed on Mars in 2018, it ceased operations in December 2022 after detecting a total of 1319 marsquakes.

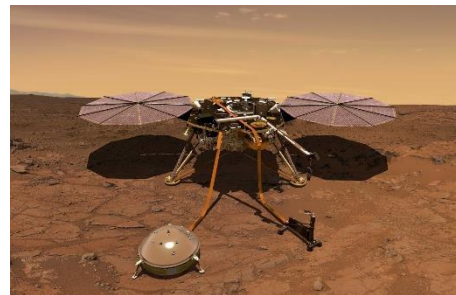


Image: NASA, InSight

**ETH contribution:** Data analysis and interpretation by Seismology and Geodynamics Group, as well as data acquisition of SEIS by Aerospace Electronic and Instrument Laboratory (part of SEG).

#### ETH groups:

- D-ERDW, Seismology and Geodynamics Group ([Prof. Dr. Domenico Giardini](#))
- D-ERDW, Exploration and Environmental Geophysics ([Prof. Dr. Johan Robertsson](#))

#### Links:

- [ETH Exploration and Environmental Geophysics Group](#)
- [ETH – InSight Mission Website](#)
- [NASA MARS InSight Mission \(NASA website\)](#)



# NASA/ ESA James Webb Space Telescope

## JWST- The largest optical telescope in space

**Goal:** Equipped with high-resolution instruments for infrared astronomy, it enables observation of the first stars, the formation of the first galaxies, and detailed atmospheric characterization of potentially habitable exoplanets.

**Status:** Ongoing

Launched in December 2021, and entered service in July 2022. Currently in orbit around the Sun- Earth L2 point.



Image: NASA, JWST MIRI

**ETH contribution:** MIRI (mid-infrared range measuring instrument) was developed by the Institute for Particle Physics and Astrophysics as part of a consortium.

**ETH groups:** D-PHYS, Exoplanets and Habitability Group ([Prof. Dr. Sascha P. Quanz](#))

### Links:

- [ETH Exoplanets and Habitability group - JWST](#)
- [ESA JWST MIRI \(ESA website\)](#)
- [NASA JWST \(NASA website\)](#)

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## LIFE - Large Interferometer for Exoplanets

**Goal:** Concept mission candidate for a future L-class mission in ESA's Science Programme to investigate atmospheric properties of exoplanets and search for life.

**Status:** Concept started in 2018. Ongoing/ future.

**ETH contribution:** Led by ETH Exoplanets and Habitability Group, currently in the conceptual phase of the proposed mid-infrared space telescope interferometer.



Image: LIFE

**ETH groups:** D-PHYS, Exoplanets and Habitability Group ([Prof. Dr. Sascha P. Quanz](#))

### Links:

- [ETH Exoplanets and Habitability group](#)
- [LIFE Space Mission Website](#)

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## COPL - Centre for Origin and Prevalence of Life

- Interdisciplinary research center supported by >40 professorships to investigate life on earth and beyond. Ongoing. Directed by Prof. D. Queloz.
- D-PHYS, Exoplanets and Habitability Group ([Prof. Quanz](#))
- [ETH Centre for Origin and Prevalence of Life](#)

# ESA/ NASA Solar Orbiter

## Taking the closest ever images of the Sun

**Goal:** To study the sun up close and from high latitudes, providing the first images of the sun's poles and investigating the heliosphere, solar winds, and solar flares.

**Status:** Ongoing

Launched in February 2020, and began routine science operations in November 2021.



Image: ESA, Solar Orbiter

**ETH contribution:** Prof. Harra was co-principal investigator of the Extreme Ultraviolet Imager (EUI), an important instrument aboard the spacecraft.

### ETH groups:

D-PHYS, Solar Astrophysics Group (PMOD/ WRC, [Prof. Dr. Louise Harra](#))

### Links:

- [ETH Solar Astrophysics Group](#)
- [ETH News – Solar Orbiter Launched](#)
- [PMOD / WRC Website](#)

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## JAXA Solar-C

- Development of the Solar Spectral Irradiance Monitor (SOSPIM) by PMOD/ WRC. In development, launch planned in 2026.
- D-PHYS, Solar Astrophysics Group (PMOD/ WRC, [Prof. Harra](#))
- [PMOD/ WRC Website](#)

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## ESA Truths

- CSAR (Cryogenic Solar Absolute Radiometer) instrument aboard ESA Truths mission, setting the reference for climate measurements. Launch planned in 2030.
- D-PHYS, Solar Astrophysics Group (PMOD/ WRC, [Prof. Harra](#))
- [ESA TRUTHS Mission \(ESA website\)](#)

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## Cosmic dust

- Computer simulations, data analysis, instrument calibration, and mission concept design for the study of cosmic dust in the solar system and beyond. Involvement in missions like Destiny+, and mission concepts, e.g., Interstellar Probe, DOLPHIN, and SunCHASER.
- D-PHYS, Astrophysical Dust Group ([Dr. Sterken](#))
- [ETH – Astrophysical Dust Group](#)

## ESA EnVision

- Contribution to the VenSpec – H instrument, designed to study the composition of Venus. Launch planned in the 2030s.
  - D-ERDW, Geophysical Fluid Dynamics Group ([Prof. Tackley](#))
  - [ESA EnVision Website](#)
- 

## Sample return missions

- Asteroids analysis as well as of samples currently deposited by the Perseverance rover.
  - D-ERDW, Isotope Geochemistry and Cosmochemistry ([Prof. Schönbacher](#))
  - [ETH News - Asteroid samples reveal early Solar System history](#)
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## ESA SWARM

- Mission to study earth's magnetism, launched in 2013.
  - D-ERDW, Earth and Planetary Magnetism ([Prof. Jackson](#))
  - [ETH News - ESA SWARM](#)
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## Crowther Lab

Global Ecosystem Ecology Group at D-USYS

Crowther Lab studies global ecosystems, generating knowledge to protect biodiversity and address climate change.

It is an interdisciplinary research group, harnessing big data, machine learning and satellite imagery, to build global ecosystem models.

Prof. T. Crowther then founded Restor.eco, the largest network of restoration and conservation sites across the globe.

**ETH groups:** D-USYS, Crowther Lab ([Prof. Dr. Tom Crowther](#))

### Links:

- [ETH – Crowther Lab](#)
  - [Restor.eco Website](#)
- 

## ESA Solumscire

- New quality of soil data for precision farming.
- D-USYS, Crop Science ([Prof. Walter](#))
- [ETH – Crop Science Group](#)
- [ESA Business - Solumscire](#)



Image: Crowther Lab



## Extreme weather

- ESA contract on “Advancing the Study of Extreme Weather Events with Data, Deep Learning Methods and Climate Analysis”.
  - D-BAUG, Photogrammetry and Remote Sensing ([Prof. Schindler](#))
  - [ETH – Photogrammetry and Remote Sensing Group](#)
  - [ESA – EO Science for Society – Project Details](#)
- 

## Crop monitoring

- Development of an automatic system for large-scale crop classification based on Sentinel-2 satellite images, but also yield predictions and high-carbon stock estimates, etc.
  - D-BAUG, Photogrammetry and Remote Sensing ([Prof. Schindler](#))
  - [ETH – Photogrammetry and Remote Sensing – Large crop monitoring](#)
- 

## Humanitarian monitoring

- Leveraging Copernicus satellite-images to obtain much better estimates of population densities, essential to make humanitarian missions more effective.
  - D-BAUG, Photogrammetry and Remote Sensing ([Prof. Schindler](#))
  - [ETH News - Researchers deliver science for humanitarian action](#)
- 

## Earth canopy height model and deforestation

- Using satellite data to model and track the earth canopy height (height of trees with respect to the ground), and tracking of deforestations.
  - D-BAUG, Photogrammetry and Remote Sensing ([Prof. Schindler](#))
  - [Nature - Cocoa plantations are associated with deforestation in Côte d'Ivoire and Ghana](#)
  - [Github – A high-resolution canopy height model of the earth](#)
- 

## Snow depth estimation

- Using satellite data to estimate snow depth with at high spatial resolutions, important for hydrology, energy planning, ecology, and safety evaluation of winter activities.
  - D-BAUG, Photogrammetry and Remote Sensing ([Prof. Schindler](#))
  - [ScienceDirect – Snow depth estimation at country-scale](#)
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## EOdal – Earth Observation Data Analysis Library

- Open-source Python package for an easy-to-learn framework enabling reproducible and scalable EO research.
- Developed during PhD studies, further development during [Pioneer Fellowship](#).
- D-USYS, Crop Science ([Prof. Walter](#)) and Agroscope
- [EOdal github repository](#) and [tutorials](#)

# Technology

## Robots for space exploration



Image, left: ESA, SpaceBok/ right: GLIMPSE

A series of quadruped robots to research locomotion for space exploration.

- **SpaceBok** (2017-2019): Started as D-MAVT focus project, was further developed, and ultimately tested at ESA ESTEC in the Netherlands.
- **SpaceHopper** (2021-ongoing): Started as D-MAVT focus project, was selected in February 2023 for the first ESA Academy PETRI cycle.
- **GLIMPSE/ ARISE** (2021-2023): Developed as part of a consortium together with FZI – Forschungszentrum Informatik, University of Zurich, University of Basel, University of Bern, and HSLU. It won the ESA/ ESRIC Space Resources Challenge.

### ETH groups:

D-MAVT, Robotics Systems Lab, ([Prof. Dr. Marco Hutter](#))

### Links:

- [ETH SpaceBok](#)
- [ETH SpaceHopper](#)
- [ETH News – GLIMPSE Robot](#)
- [ETH News – ARISE wins](#)

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## HEMTs for ESA Rosetta

- For ESA Rosetta mission: Development of high-electron-mobility transistors (HEMTs) for amplification of weak data-carrying signals. Mission completed.
- D-ITET, Millimeter-Wave Electronics Laboratory ([Prof. Bolognesi](#))
- [ETH HEMT - ESA Collaboration](#)

## Spectrometers for space

- Development of superlattice wideband waveguide spectrometers, which are much lighter than common mirror spectrometers.
- D-PHYS, Optical Nanomaterial Group ([Prof. Grange](#))

- [ETH – Optical Nanomaterial Group](#)
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## Electro-optic devices for space lasers

- Research on integrated electro-optic devices for in-space laser transmitters, now also commercialized by ETH spin-Off Versics.
  - D-PHYS, Optical Nanomaterial Group ([Prof. Grange](#))
  - [ETH Spin-Off Versics – Website](#)
- 

## Machine learning for space geodesy

- Application of machine learning technology: GNSS IoT data fusion (ESA NAVISP contract), improving gravimetry models, geodetic network for LEO satellite constellations, etc.
  - D-BAUG, Space Geodesy Group ([Prof. Soja](#))
  - [ETH – Space Geodesy Group](#)
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## Millimeter precise positioning

- Applications for GNSS/GPS, in-orbit positioning, atomic clocks, meteorology, etc.
  - D-BAUG, past chair of Mathematical and Physical Geodesy (Prof. Rothacher – retired)
  - ETH spin-off Fixposition, developing systems for real time precise global positioning through deep sensor fusion. Founder won ESA special prize and Swiss regional winner of European Satellite Navigation Competition 2015.
  - [Fixposition - Website](#)
- 

## In-orbit guidance

- ESA study on “Guidance and control of autonomous in-orbit operation”.
- D-MAVT, Intelligent Control System ([Prof. Zeilinger](#))
- [ETH – Research Zeilinger](#)

# Education

## ARIS



Image: ARIS

ARIS (Akademische Raumfahrt Initiative Schweiz) is a student initiative founded at ETH Zurich in 2017. It gives students the possibility to combine inspiration for space exploration, hands-on project work and personal development. During its history, it won several awards at the Spaceport America Cup and at the European Rocketry Competition.

### Current projects:

- SAGE: ARIS' first CubeSat project, planned to be launched in space in 2025.
- NAUTILUS: Unmanned underwater vehicle to explore Jupiter's oceans and Saturn's icy moons
- ODYSSEY: Rocket designed to cross the border of space, the Kármán line, by 2027.
- BERNOULLI: Rocket to win the European Rocketry Competition 2023.
- PROMETHEUS: Advancing ARIS' propulsion systems with the first bi-liquid cryogenic engine.

### ETH contribution:

- ETH working spaces at Innovationspark Zurich, Dübendorf
- Supervision of D-MAVT Focus projects:
  - 2019-2022: Institute Dynamic Systems and Control, Prof. Guzzella and [Prof. Zeilinger](#)
  - 2022-present: Advanced Manufacturing Lab, [Prof. Bambach](#)
- Support in development of project SAGE by Center for Project-Based Learning D-ITET

### Links:

- [ARIS – Space to grow – Website](#)

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## Lecture series: Space research and exploration

- Some of the speakers in 2022: Thomas Reiter (ESA Astronaut), Claude Nicollier (ESA Astronaut), Didier Queloz (ETH), Sascha Quanz (ETH), Louise Harra (ETH, PMOD/WRC), ...
- Hosted by D-PHYS, Exoplanets and Habitability Group ([Prof. Quanz](#))
- [ETH – Course Catalogue – Lecture Series: Space Research and Exploration](#)

ETH Zürich

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