M.Sc. Space Systems

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Department for Earth and Planetary Science
www.master-space.ethz.ch

ETH zürich | SPACE

Why us?

ETH Zurich: our ambition regarding Space

Make major contributions to **large** international science **missions**

Be part of **major international cooperations**, incl. ESA, NASA, JAXA, Middle-East

Cooperate more with industry and other academic institutions

Lead small technology demonstration **missions**

Science (driver)

Technology (enabler)

ETH zurich | SPACE

Cross-disciplinary cooperations via vibrant ETH Zurich and Swiss Space community

Education (fuel)

Offer one of the **world-leading** interdisciplinary and cross-disciplinary **Space MSc programs**

Lead small **educational missions**

Foster more **space-related entrepreneurship**

Space is more than human spaceflight!

Three pillars of New Space

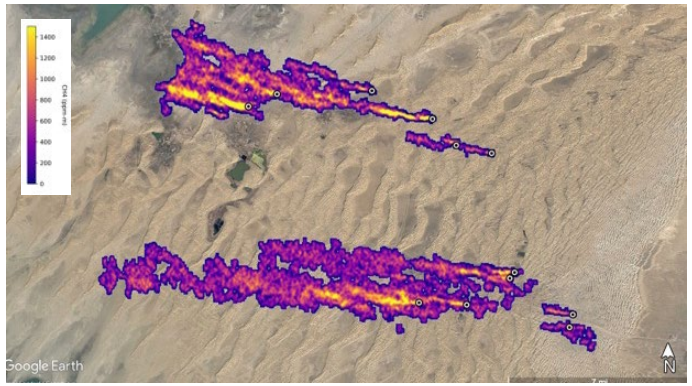
Systems

- Focus on system engineering
- Industry is desperately looking for system engineers on the European market
- Combined with deep knowledge in one specialization

Data

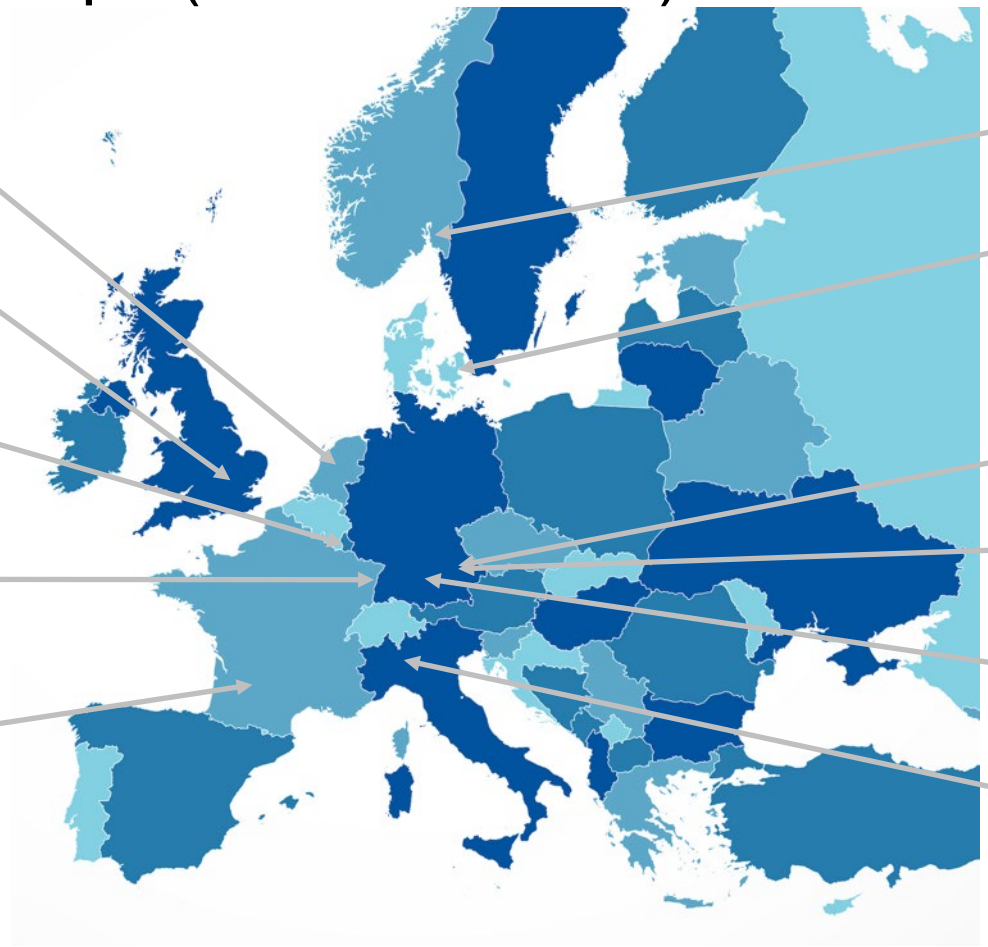
- Data makes the difference
  - In iterative design
  - In downstream science
- Teach data formats and analysis techniques
- Help from domain experts from ETH and industry

Sustainability



- The space revolution will affect Earth's and planets' ecosystems
- Space provides new ways to collect environmental data
- Orbital debris needs to be mitigated
- We want to help define sustainability metrics and policy solutions

Competitors in Europe (M.Sc. Courses)



TU Delft
Engineering – Space Flight

Open University
Space Systems and Science

U Luxembourg
Interdiscipl. Space Master

Strasbourg
Space Studies

ISAE SUPAERO
Aerospace Engineering

University of Oslo
Space Systems and Science

Denmark TU
Earth and Space Physics and Engineering

TU München
Aerospace Engineering

TU München
ESPACE

Stuttgart
Luft- und Raumfahrttechnik

Milano
Ingegneria Spaziale

ETH unique strengths:
Growing startup economy; Outstanding robotics and engineering; Excellent teacher-student ratio;
World leading research in Physics and Earth Sciences (1st in QS worldwide);
400 space-related researchers

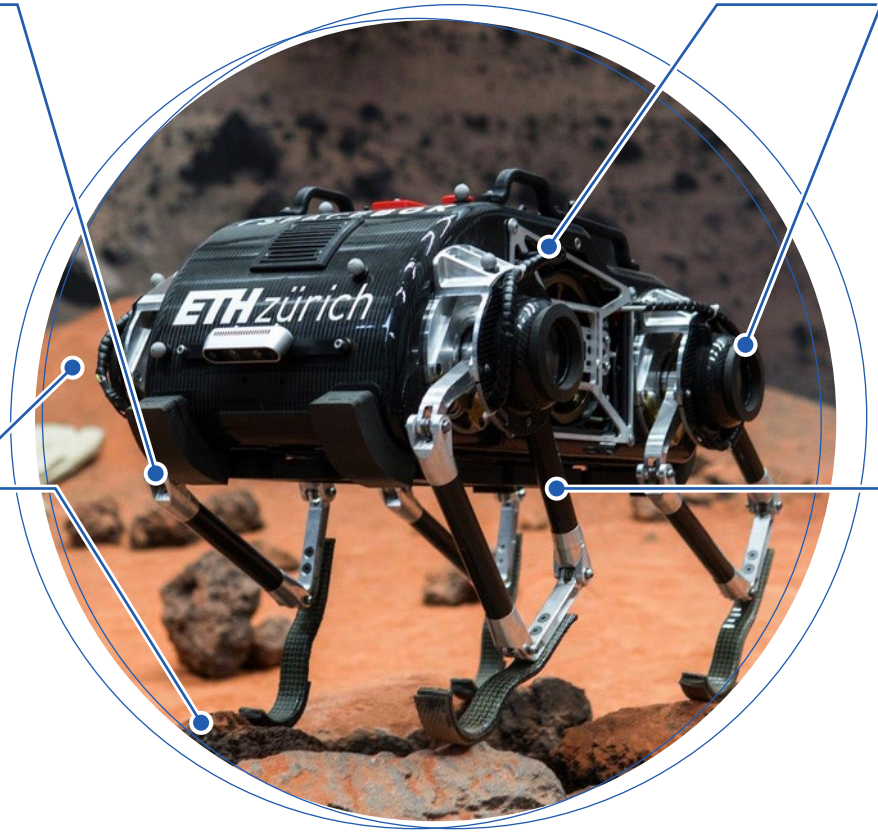
Example space system – an interdisciplinary approach

D-PHYS

- Astronomy and Astrophysics
- Exoplanets
- Optical Sensors

D-ITET

- Communication
- Redundant design
- Embedded systems
- Sensors



D-EAPS

- Planetary Geology
- Geophysics
- Cosmochemistry
- Planetary Physics

D-MAVT

- Robotics
- Aerospace Engineering
- System Engineering

Contributions from researchers at multiple departments of ETHZ

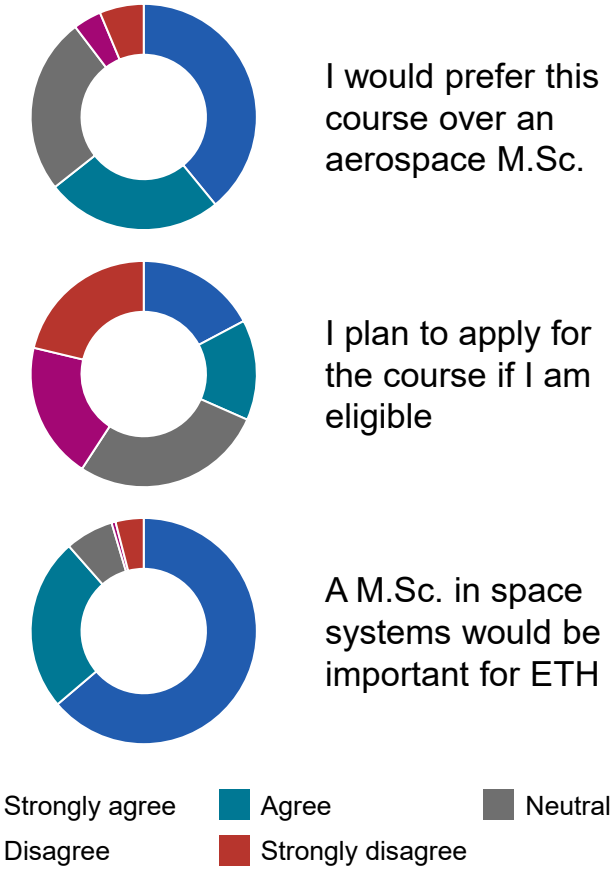
Feedback from student survey

A big impact might be achieved, if students will create innovative solutions (...). Thus, **spacecraft & mission design, but also downstream applications (e.g., data, GPS, and other signal processing) for Earth applications** should be taught, so the students have the baseline to develop specific solutions.
Student D-MAVT - mechanical engineering

An interdisciplinary approach to aerospace is valuable, **but it shouldn't remain superficial**. (…). It's essential to home in on a more specific area of focus.
Student D-ITET – electrical engineering

Aerospace engineering is already a well-represented field of study across the globe. **ETH should strive to provide a unique and special Space MSc. program;** in other words, something you can only find at ETH.
Student D-MAVT

Survey results among 174 students of D-EAPS*, D-ITET, D-MAVT, D-PHYS*



*) D-EAPS: earth and planetary sciences; D-PHYS: physics.

M.Sc. Space Systems is on its way

14.06.2023

First meeting of all stakeholders at ETH

12.12.2023:

Final department to vote in favour

23.01.2024

Publication of study regulations in “Rechts-sammlung ETH”

30.04.2024

> 80 student applications,
35 selected for 1st cohort

13.09.2024

Student welcome

Ongoing

Implementation of lectures, industry surveys

7 months!

Target audience: students

Graduates from diverse backgrounds

- Mechanical and electrical engineers
- Computer scientists
- Earth and environmental scientists
- Physicists
- Mathematicians
- Other sciences

Target entry-level jobs

- Systems engineers in satellite or spacecraft design & development
- Space system architects
- Mission design engineers
- Production engineers
- Data analysts in industry and agencies
- Principal investigators in space missions or experiments (after PhD ;-))

How to get into the course?

Specialized Master

- No B.Sc. that guarantees entry
- All B.Sc. graduates (ETH, EPFL, universities, FHs) can apply

Formal requirements:

- 40 CP in mathematics (>18) / physics (>12)
- 40 CP in natural science or engineering courses

If you do not meet these requirements…

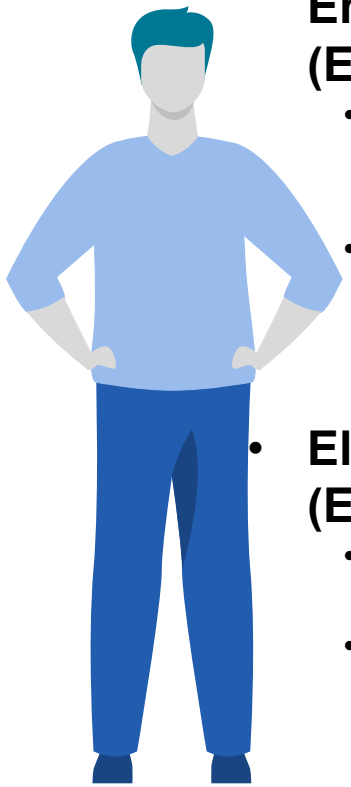
- Up to 30 CP of extra courses (Auflagen)
- 40-60 CP of extra courses *for students from universities of applied science*

Our requirement:

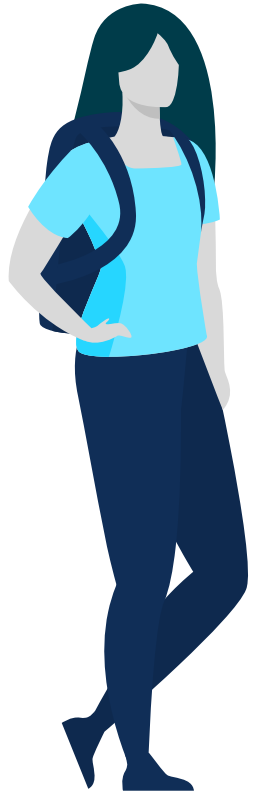
- Very good results
- Enthusiasm for space

What are good B.Sc. programs? (examples)

- **Earth and climate science (ETH):**
  - Motivation for space activities
  - Mathematical and geophysical background
- **Physics (ETH, EPFL, universities)**
  - Strong mathematical and physical background
  - Foundations of technology



- **Mechanical Engineering (ETH, EPFL):**
  - Background in mathematics and applied physics
  - Deep knowledge of processes and technical solutions
- **Electrical Engineering (ETH, EPFL):**
  - Strong mathematical and physical background
  - Knowledge of communications and electronics



- **Computer/Data Science:**
  - Background in mathematics
  - Deep knowledge of data handling and algorithms

Other

- If you want to combine field XYZ with space, go for it
- But: Bring a good grasp of maths and physics

Feedback from industry survey

Overall, high interest from industry in MSc Space Systems graduates, and interns

Space systems and data science are currently the main missing competencies

Most relevant deep tracks of the MSc curriculum for companies are:

1. Aerospace engineering
2. Space communication
3. Robotics
4. Earth observation | Space physics & astronomy

Industry involvement

Partners in student projects

- 1st semester: *develop a mission*
  - Development of mission concept based on scientific or business case
- 2nd semester: *analyse data from space*
  - Understand under-investigated industrial datasets
- 3rd and 4th semester: *build a commercial space product*
  - Industry projects leading to M.Sc. thesis
  - Project pitches from industry partners welcome

Internships

- Students of all M.Sc. Programs at ETH

Course development

- Analysis of employer requirements
- Support in teaching, e.g., via case studies

Course Layout

Semester 1	Semester 2	Semester 3
CC1: Space Systems (14 CP) 2 full days a week block courses	**CC2: Space Data (8 CP)** 4 × 1 month-long data classes	**CC3: Case Studies & Team Projects (8 CP)** Incl. review process
Scientific introductory courses (2 × 4 CP) • Earth / Planets • Earth observation • Space environment & astrophysics	**Deep Track (20 – 30 CP)** 1 (Aerospace) Engineering (D-MAVT) 2 Space communications (D-ITET) 3 Robotics (D-MAVT) 4 Earth observation (U Zürich, D-BAUG/USYS) 5 Planetary science (D-EAPS/PHYS, U Bern)	
Electives (>16 CP) Science in context (>2CP)		

Science & Eng. Science Engineering

M.Sc. thesis
individually or as group project, with industry, agency or ETH (30 CP)

Core Course 1: Class Overview: 2 full days a week

We	18.09.24	Space Environment	Simon Stähler (ETH)
Mo	23.09.24	System Engineering short course	Thomas Zurbuchen (ETH) Florian Kehl (ETH)
We	25.09.24		
Mo	30.09.24		
We	02.10.24	Spacecraft design overview	Thomas Zurbuchen (ETH)
Mo	07.10.24	Orbital Dynamics	Anna Kubik (ETH)
We	09.10.24		
Mo	14.10.24	Subsystem Comms & Power	Reto Muff (ETH)
We	16.10.24	Spacecraft Communications	Reto Muff (ETH)
Mo	21.10.24	Propulsion	Markus Jäger (Airbus)
We	23.10.24	Subsystem Controls & Computing	Thomas Zurbuchen (ETH)
Mo	28.10.24	Subsystem Structure & Thermal	Michael Gschweitl (ETH)
We	30.10.24	Sustainability	Emmanuelle David (EPFL)

Mo	04.11.24	Payload Design Overview	Florian Kehl, Simon Stähler (ETH)
We	06.11.24	Observational Payloads	Nick Thomas (U Bern)
Mo	11.11.24	Earth Observation Missions	Andrea Marconi (WSL)
We	13.11.24	Logistics, Integration, Testing	Thomas Zurbuchen (ETH)
Mo	18.11.24	Project presentations	
We	20.11.24	Human Spaceflight	Claude Nicollier (EPFL)
Mo	25.11.24	Project Management	Stefan Kögl (Industry)
We	27.11.24		
Mo	02.12.24		
We	04.12.24	Launch Vehicles	Simon Stähler (ETH)
Mo	09.12.24	Mission Operations	Thomas Zurbuchen (ETH)
We	11.12.24	Ground System Design	André Csillaghy (Industry)
Mo	16.12.24	Launch Operations	Deborah Müller (ETH)
We	18.12.24	End of Lecture	Simon and Florian

Thank you!

Let’s collaborate for the next generation of space leaders!

Core Course 1

Lecture

1. Space environment
2. System engineering
3. System engineering II
4. Orbital dynamics
5. Spacecraft subsystems
6. Subsystems II
7. Payloads
8. Payloads II
9. Communications
10. Logistics
11. Project management
12. Launch vehicles
13. Operations
14. End of lecture

Project

Build teams, define topic

Mission concept is reviewed

Teams have 8 weeks to finish project
Ending detailed concept study

Design Review

Hands on project (4 weeks)

2 full days per week

- 2 × 3 h lecture
- 2 × 4 h exercise
- Team project: mission design

Teachers from ETH

Industry experts