EE-584
Spacecraft Design & Systems Engineering

Lecture 0 - Welcome

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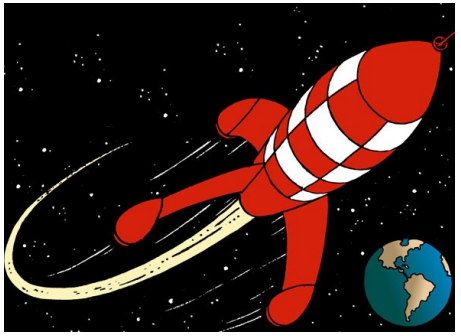
Space is hard!

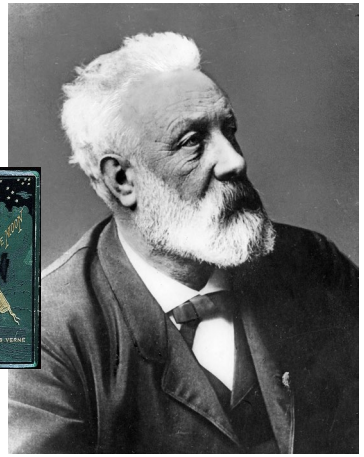
Source: U.S. Space Force Public Affairs

Why Space? The Old and the New

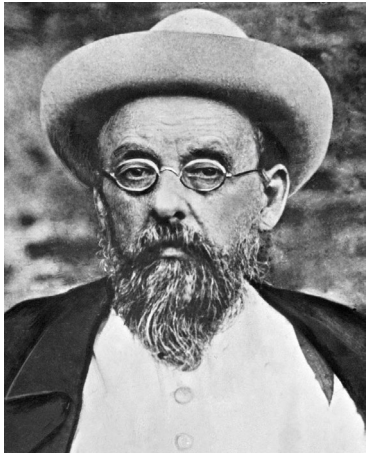


Why Space?

- A fundamental question without a concrete, (much less so a) concise answer: science, knowledge, exploration, power, inspiration, wonder…

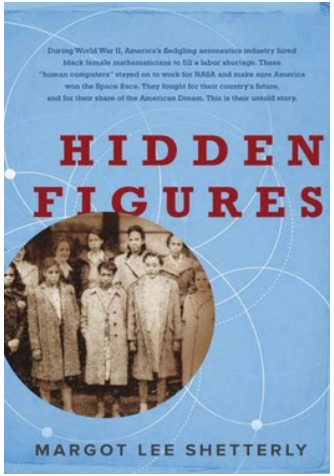


Jules Verne
(1828-1905)

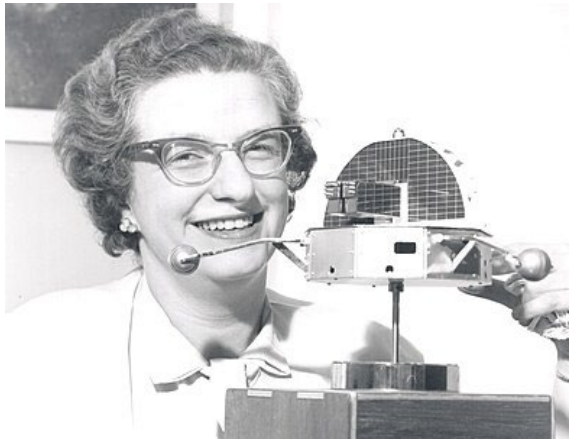


Konstantin E. Tsiolkovsky
(1857-1935)

Elon Musk
(1971-present)



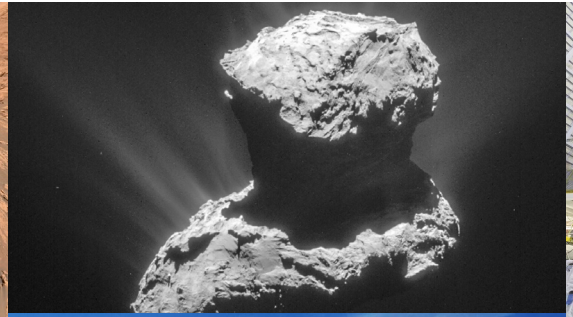
Margaret Hamilton qui a conçu les logiciels pour Apollo 11 (1936)

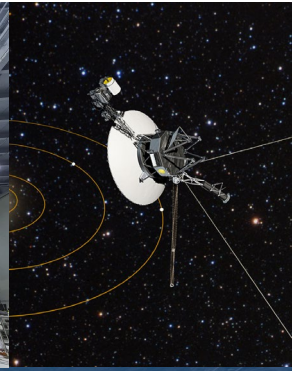


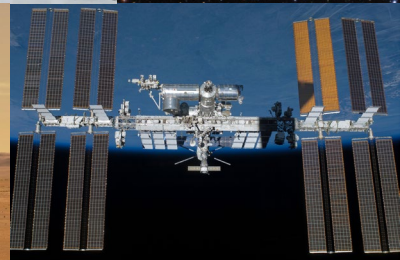
Nancy Grace Roman, à l'origine de Hubble (1925-2018)

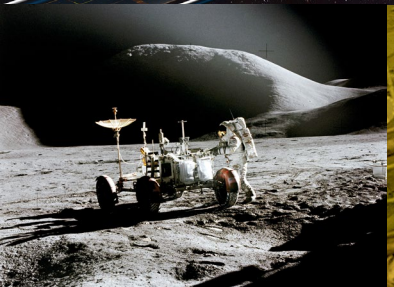
Peggy Whitson, astronaute américaine avec le plus long temps cumulé dans l'espace

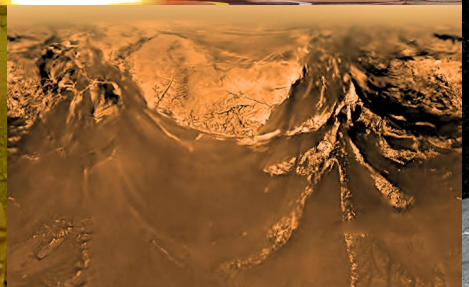
Why Space? The Old and the New



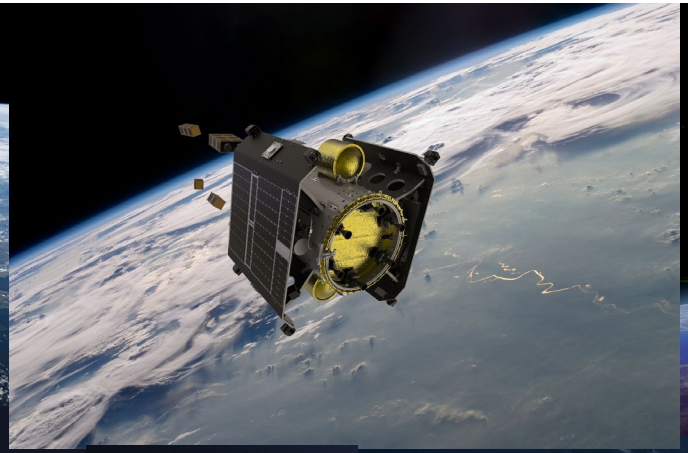


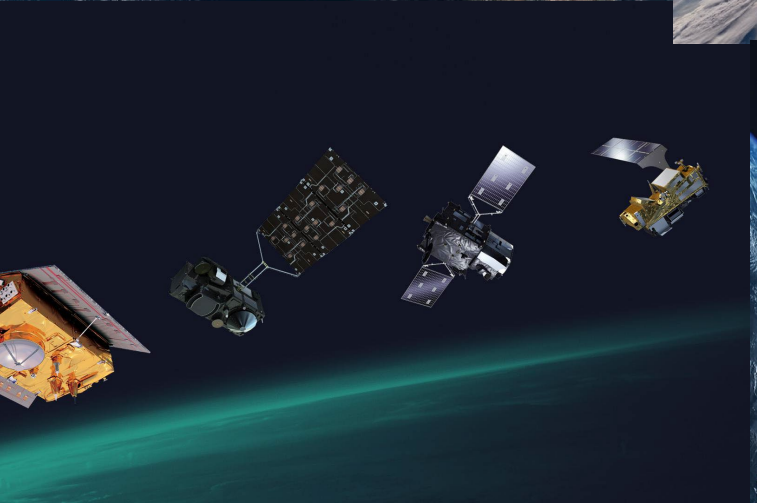






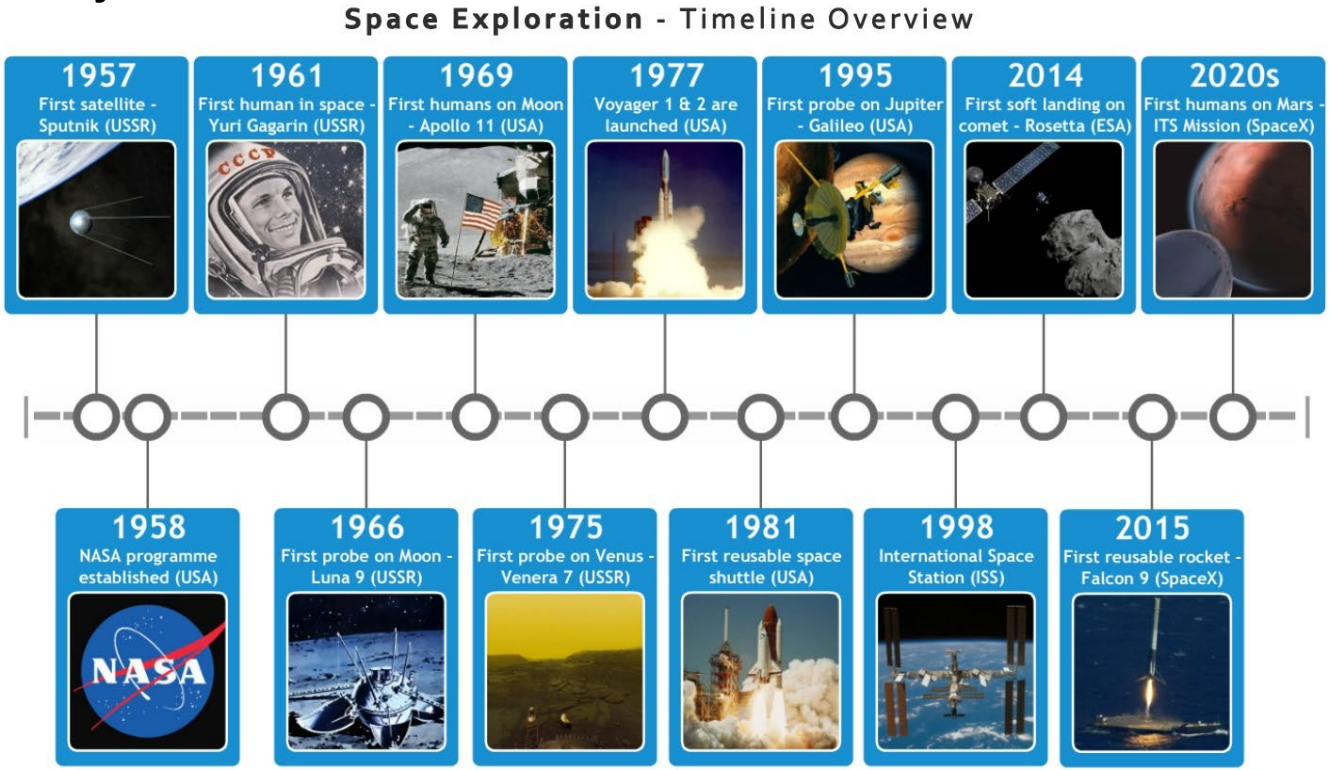
Why Space? But also for your daily life





Why Space? The Old and the New

Space: a story of firsts…



Why Space? The Old and the New

Why Space?

The Scientific Imperative (Knowledge)

Where did we come from?
What will happen to us in the future?
Are we alone in the universe?

The Cultural Imperative (Exploration)

“Earth is the cradle of humankind, but one cannot live in the cradle forever”
Are we connected to the cosmos?, if so, how?

The Political Imperative (Unity & Prosperity)

Fight or flight applied to modern geopolitics
Compete or cooperate?
Expand or confine?

Huntress et al., *The next steps in exploring deep space—A cosmic study by the IAA*, Acta Astronautica, 58(6-7), 304-377, 2006

Who we are…

InstructorS

Emmanuelle David

Mathieu Udriot

Marnix Verkammen

Gilles Feusier

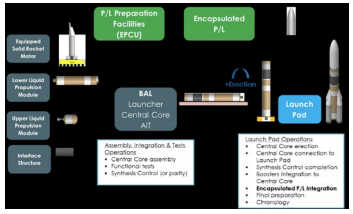
Volker Gass

and two teaching assistants…

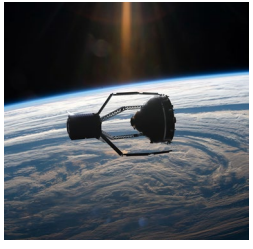
Ramon Heeb

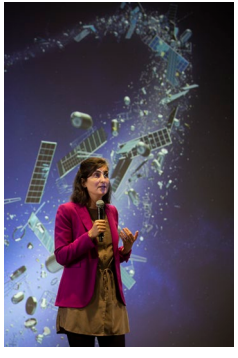
Samuel Wahba

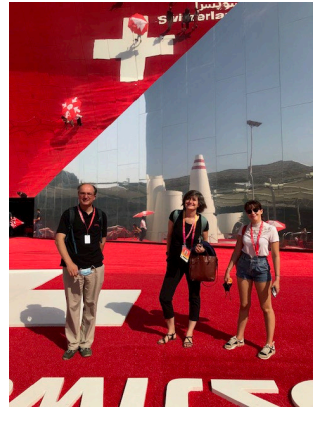
Who are we?



ESA- A6 Team







Who are we?

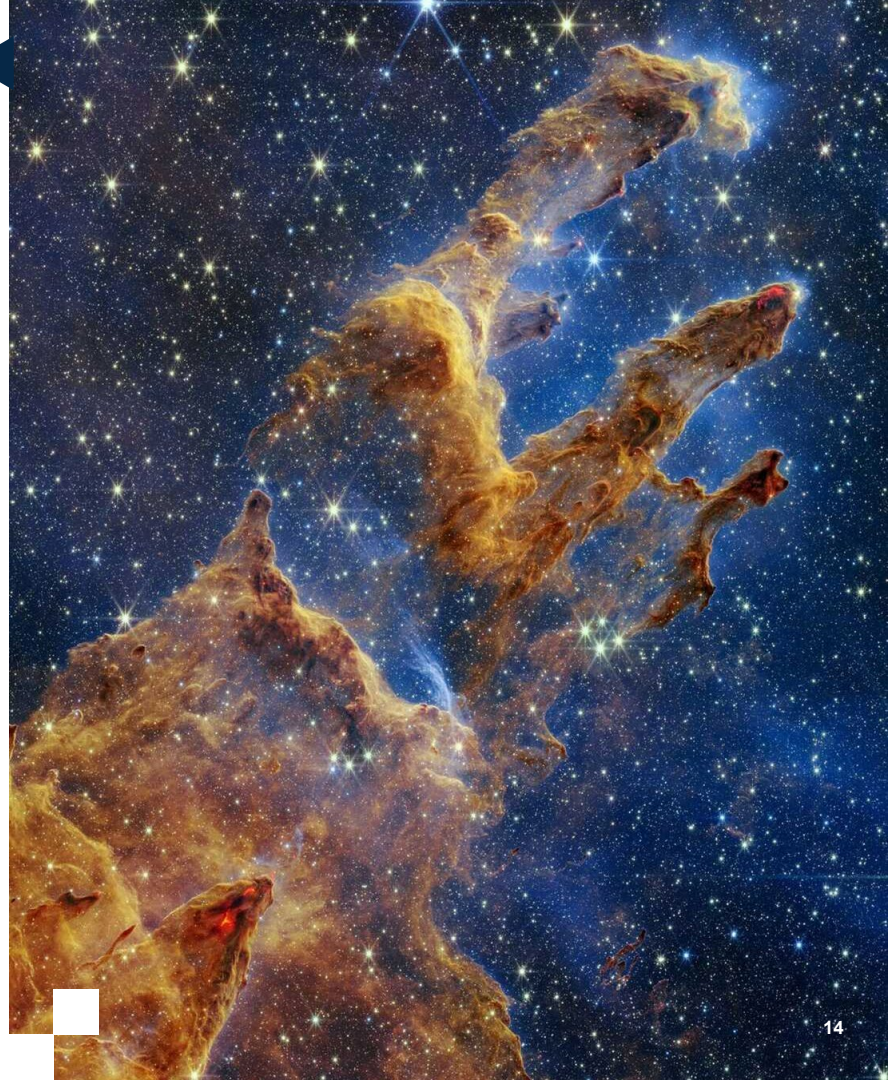
The people of EPFL SPACE Center

Learning Outcomes

By the end of this lecture you should be familiar with…

Course Logistics

- Goals and anti-goals of EE584
- Course structure
- Requirements & pre-reqs
- Assignments & grading
- Reading recommendations



Source: NASA/JWST

Goals and Anti-goals

Goal(s)

To apply in a **practical setting** the fundamentals of spacecraft & space systems engineering.

This is an **overview** course that requires some prior knowledge. Each lecture could be a course on its own. Familiarity with best practices, concepts, and approaches for how to ideate, design, plan, and execute successful space missions is our aim.

This is a **hands-on, project-based** course. You will design your own space mission and the spacecraft needed for it.

This course is for you if…

- You'd like to **learn about space** and potentially **work in the space industry** in the future,
- You like to understand **how things work** and **how they are built**,
- You like to learn about how to apply **system-level thinking** to your projects ,
- You like **ideation** and **conceptual design**,
- You dislike theory and complex math, ,
- You'd like to earn **5 ECTS** without taking an exam.

Goals and Anti-goals

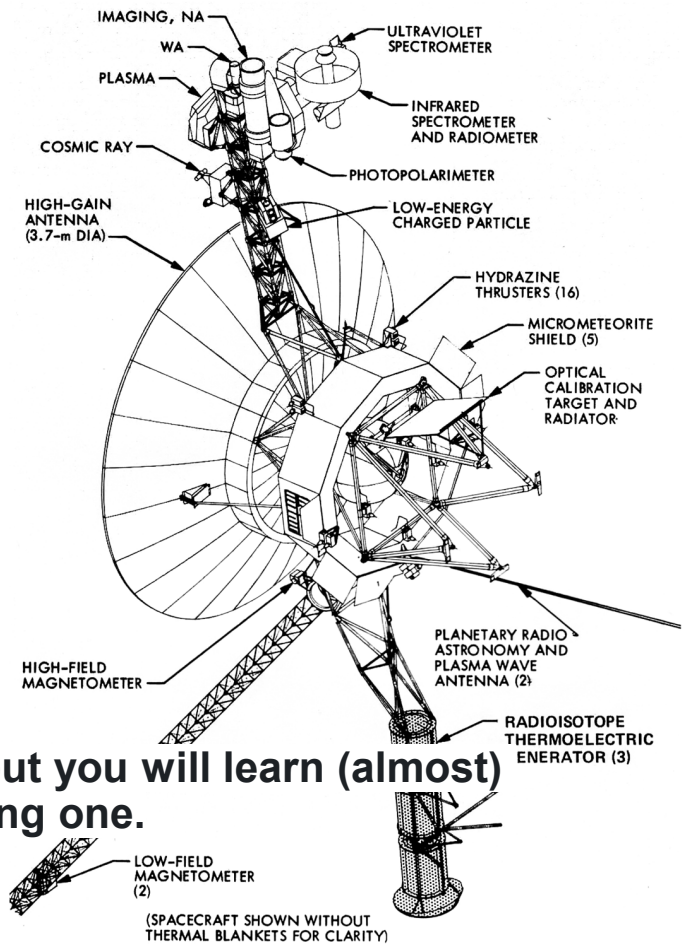
Anti-goals

To become an expert on any specific spacecraft subsystem.

To use complex simulation and computer-aided tools.

To memorize theoretical principles and prepare for exams.

To face problems alone.



Unfortunately, we won't be building a spacecraft but you will learn (almost) everything there is behind building one.

Course Structure

Course Structure

How ?

Lectures every Monday from 14:00 - 16:00 in **Room DIA005 (on-site only, unless otherwise announced)**

- 2* 45 min of basic concepts

Practical work with TAs every Monday from 16:00 - 18:00 in **Room DIA005**

- Time for you to work on your mission with your group. Make good use of it!!
- Not mandatory but hilghly recommended
- **Pratical work in the Lab- Kitsat, Cleanroom and ground station**

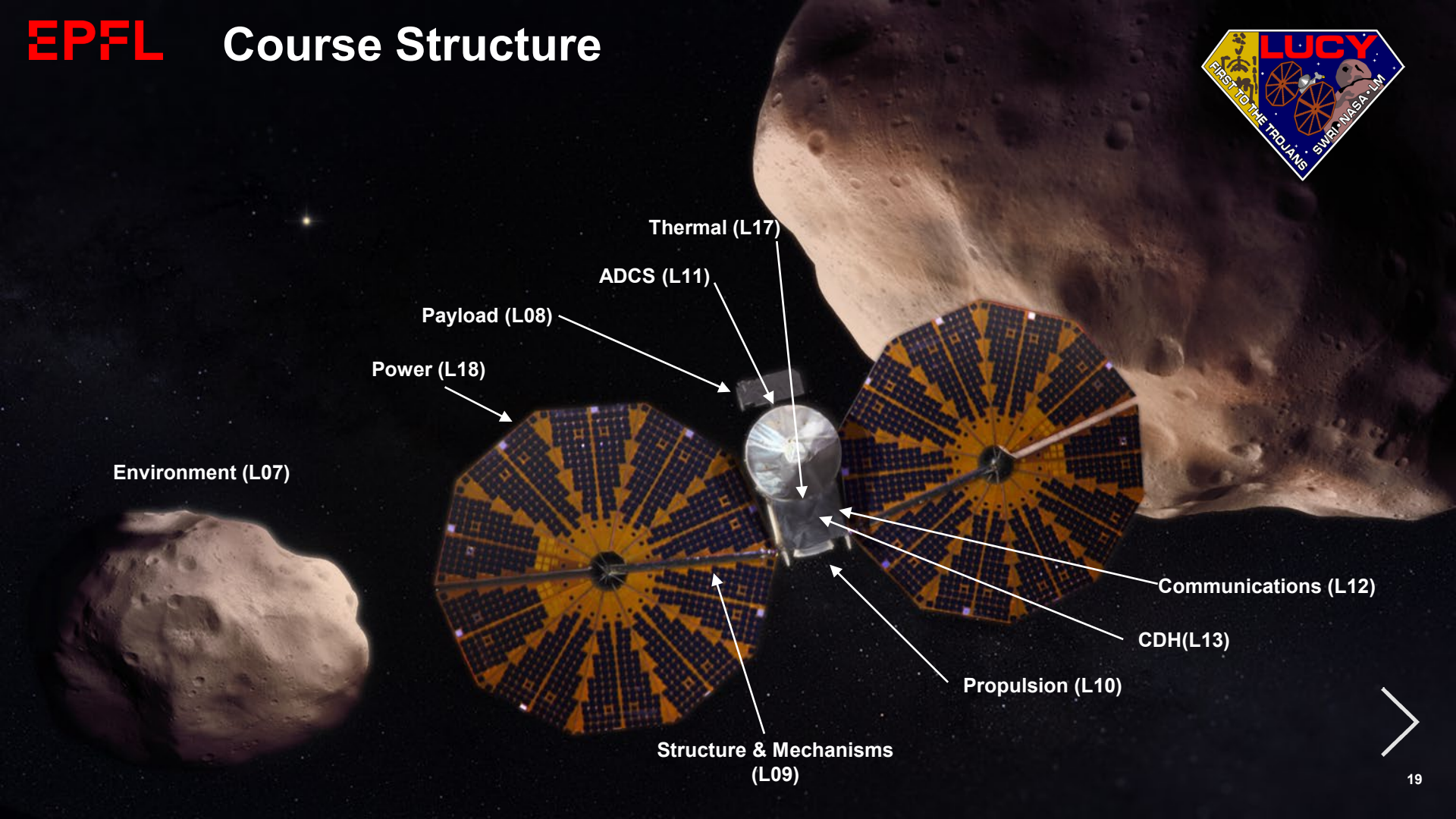
Questions to be asked on Moodle on the forum

Check Moodle for instructions.

Lecture slides and (possibly) notes will become available on Moodle before each class.

24 h of lectures
24 h of assisted practical work
64h of independent work

Course Structure



Date		Title
08.09.2025	L00	Welcome + admin
	L01	Introduction to Space Project Management, and V model
	L02	Stakeholder Value analysis --> High level requirement
		Time to work**individually and or in group**
15.09.2025		Group formation-
	L03	SE- V model, requirement, concept
	L04	SE, architecture, design to map to functions
		Time to work**individually on small SE project**
22.09.2025		Jeûne Fédéral
29.09.2025	L05	SE
	L06	SE
		Time to work**individually on small SE project**
		Time to work**individually on small SE project**
06.10.2025	L07	**Reminder**space env + orbital mechanic
	L08	Space science (payload)
		Time to work**individually on small SE project**
		Time to work**individually on small SE project**
13.10.2025	L09	Space sust intro
		Space sust intro
		midterm (**ndividual**? about SE stuff ? e.g. short text about SE example)

	20.10.2025		Holidays
L06	27.10.2025	L10	Propulsion system selection and sizing process
		L11	AOCS
			Time to work **in groups**
			Time to work **in groups**
L07	03.11.2025	L12	Telecom, ground station,
		L13	telemetry command and data handling
			Time to work **in groups**
			Time to work **in groups**
L08	10.11.2025	L14	Avionics & on board processing
		L15	Ground segment- operations
			Time to work **in groups**
			Time to work **in groups**
L09	17.11.2025	L16	Struct and mechanism
			Struct and mechanism
			Time to work **in groups**
			Time to work **in groups**
L10	24.11.2025	L17	Spacecraft Thermal Design & Control
		L18	Electrical Power System
			Optional practical session I (4:15pm-6pm)
			Time to work **in groups**
L11	01.12.2025	L19	SSA/SST
		L20	Launch vehicles and launch operations
			Optional practical session II (4:15pm-6pm)
			Time to work **in groups**
L12	08.12.2025	L21	AIT
		L22	Roadmap and future missions
			Time to work in groups
			Time to work in groups
MDR	15.12.2025		final presentation (by group)

Practical Work

- Session in Clean Room
- Session with Test Facilities

Course Structure

How

No additional exercises or homework to complete but I encourage you to use the class time.

One individual mid term exam

No final written nor oral exam. (note!!)

Personal Work During the first half of the semester in understanding systems engineering

You will be working primarily on your **final project.** At the end of every lecture you should apply the learned concepts to progressively design your own mission.

Final Project

Goal – To conceptually design a space mission

and its associated spacecraft based on the **stated directive**

Each of you will work **in group** to select a mission type, define mission goals, give it a name and and an acronym, design a patch, select a launcher, define its mission profile, orbits and final trajectory, and conceptually design primary and (potentially) secondary spacecraft (e.g., rover).

2025- Mission Directive

A debris-free mission tackling at least one of the following challenges:

Challenge 1:

Aerospace Lab Lunar Orbiter Mission

Challenge 2 :

Beyond Gravity Very Low Earth Orbit Mission

Challenge 3:

X-Ray Servicing

Group work

After each lessons there will a short assignement each weeks to do in class. We will ask a short summary on the moodle starting week 4 (week from 29.08)

Assignments & Grading

Personal Report [30 Oct 2024]

Short Report on one system engineering case studies

MCR constitutes **20% of your final grade**.

Presentations shall be submitted on Moodle on by **27 Oct 2024, 23:59 CET** (check instructions)

Mission Definition Review (MDR) [16 Dec 2024]

Final presentation.

Each of you has **2-5 minutes** to expose your mission and design of your spacecraft followed by 2.5 minutes of Q&A.

MDR constitutes **30% of your final grade**.

Presentations shall be submitted on Moodle on by **15 Dec 2024, 23:59 CET** (check instructions)

Assignments & Grading

Final Report

Detailed description of your mission and spacecraft design.

Supplement the info presented at the MDR.

Final reports must be submitted in the form of an **academic paper**.

Must follow the **International Astronautical Congress template**

- Template and additional instructions available on Moodle.

Final reports are limited to a **max. 10 double-column pages**, including abstract, figures, references, and annexes.

- It is not about quantity, it's about clarity.
- Feel free to use any tools at your disposal (yes, I'm talking about NLPs). But remember, value is in your ideas being founded on solid principles. Use of the wrong principles will be penalized.
- Numerical analyses need to be disclosed.
- Trade-offs should be described and chosen options properly justified.

Final report constitutes **50% of your final grade**.

First version of your final report should be submitted by **16 Dec 2024, 23:59 CET**.

Camera-ready version of your report must be submitted by **14 January 2024, 23:59 CET**.

…but wait there's more!

Paper Competition

The **best presentation and report** will be chosen by the evaluation panel among of all those submitted.

This mission will inspire the selected target mission during the intensive (ENG-411) **Concurrent Engineering of Space Missions course** (Spring Semester)

All students will be given a chance to submit an **abstract**, with the support of instructors and TAs, about her/his mission to the **5th Symposium on Space Educational Activities in April 2026 in Munich.**

We have secured on presentation slot, the selected student will be invited to submit a **paper** (“final report”) to the Conference and her/his attendance will be **sponsored for the group.**

Assignments & Grading

Grade >= 4 → Pass
5ECTS

Recap

[20%] Mid-term exam [13 Oct 2025]

[30%] Final presentation --> Mission Definition Review (MDR) [15 Dec 2025]

[50%] Final report [15 Dec 2024 & 12 Jan 2025]

No oral or written exam during exam period!

Grading rubrics will be made available for your reference on Moodle.

Deliverables: MDR presentation slides, and final report.

Best report will be given the honor to be selected as basis for ENG411 and a chance to attend the 5th Symposium on Space Educational Activities.

All details and further instructions available on Moodle.

Questions so far?...

Requirements & Prerequisites

This course it's not meant for students on the 1st semester of their MSc.

We are going to cover A LOT of ground → some prior knowledge on **systems engineering** and **space mission design** is highly recommended.

Required courses

- Space mission design and operations (EE-585) with Thibaut Kuntzer (already taken or have registered for it)
- If you did not follow that course or have not signed up this semester, you can sign up to the followin MOOC

https://www.edx.org/learn/space/ecole-polytechnique-federale-de-lausanne-space-mission-design-and-operations

Resources

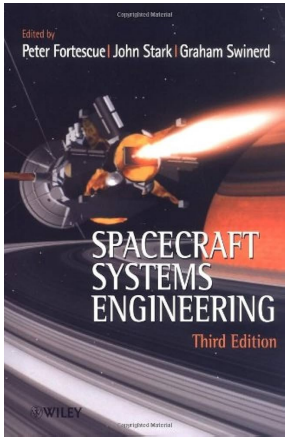
Bibliography used during the course

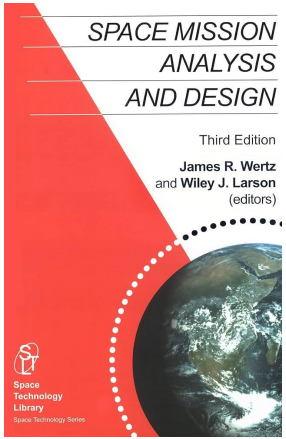
The course is primarily based on two textbooks →

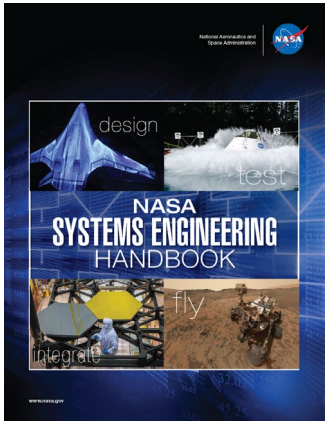
These are recommended, but not required- available

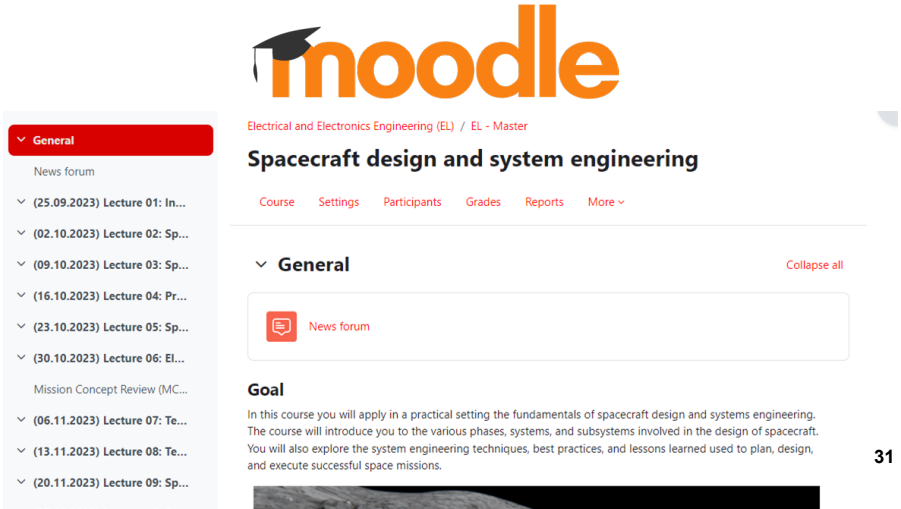
At the Library- please provide feedback .

References to specific chapters in these books and other resources will be provided in each lecture.









MINOR IN SPACE TECHNOLOGIES

PIZZA PARTY

INFO SESSION

eSpace

Sept. 16th

17h00

BC 420

Registration Mandatory

With talks by:
Claude Nicollier
Emmanuelle David
and more!


NASA
SPACE APPS
LUZERN

About the Event

The NASA International Space Apps Challenge is a global hackathon for coders, scientists, designers, storytellers, makers, builders, technologists, and space enthusiasts. In Lucerne, we'll be developing tech-driven apps focused on climate studies, space flight, and research conducted on the ISS.

We will be integrating and leveraging Machine Learning and AI into our apps, keeping technology at the forefront of what we do.

LOCATION: Technopark, Lucerne
EVENT DATES: Oct. 4-5, 2025

Parting thoughts

This version of the course is given at EPFL for the second time. There will be things to improve and polish. Bear with us.

We need your feedback! You can help us make the course better for future students. Share openly what you think we can improve.

We are here to help YOU learn. Anything you may need help with, do not hesitate to let us know.

Contact: emmanuelle.david@epfl.ch
Samuel.wahba@epfl.ch

Ramon.heeb@epfl.ch