EE-584
Spacecraft Design & Systems Engineering

Lecture 0 - Welcome

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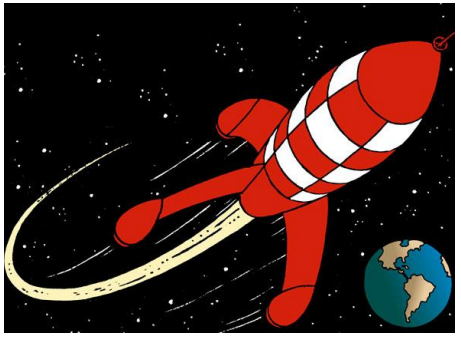
Space is hard!

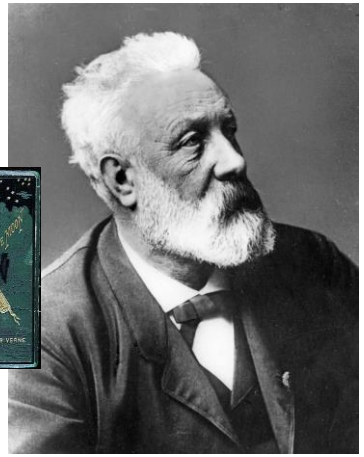
Source: U.S. Space Force Public Affairs

Why Space? The Old and the New



Why Space?

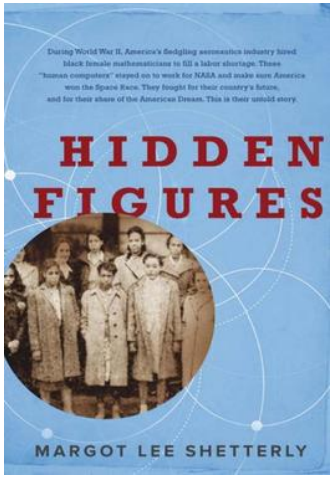
- A fundamental question without a concrete, (much less so a) concise answer: science, knowledge, exploration, power, inspiration, wonder…



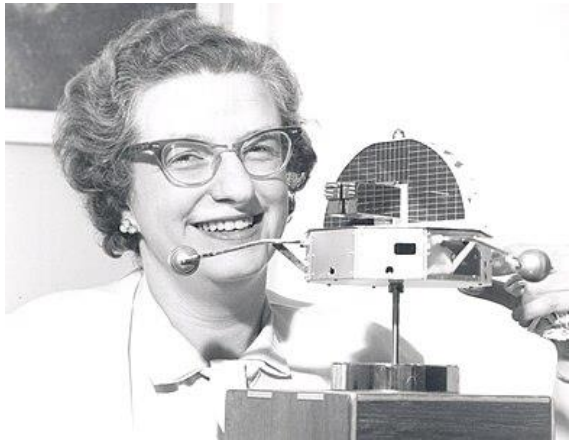
Jules Verne
(1828-1905)

Konstantin E. Tsiolkovsky
(1857-1935)

Elon Musk
(1971-present)



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

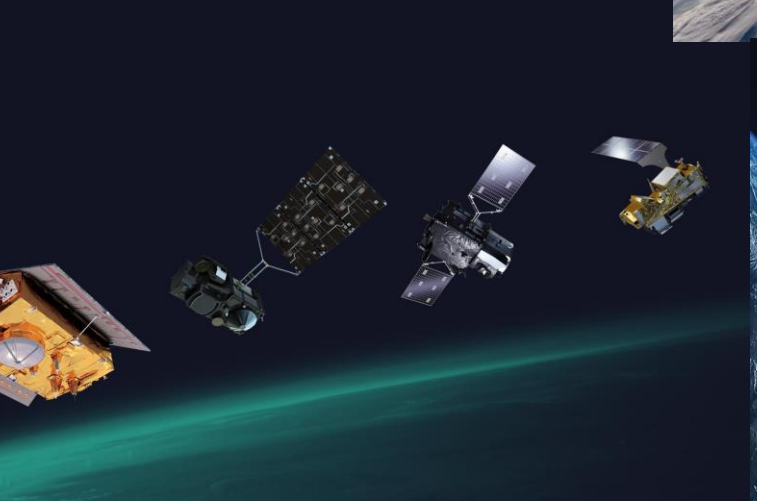


Nancy Grace Roman, à l’origine de Hubble (1925-2018)

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

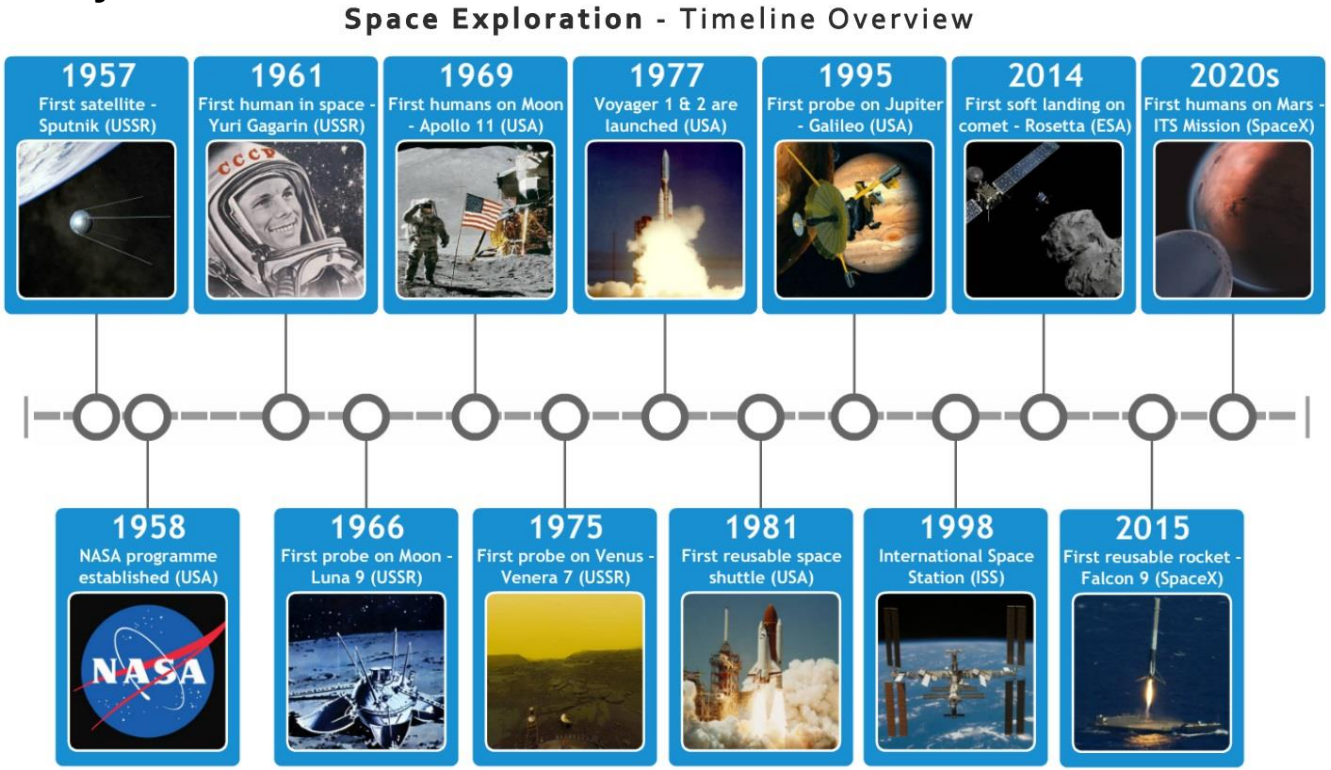
Why Space? The Old and the New

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…

Instructor

Emmanuelle David

Mathieu Udriot

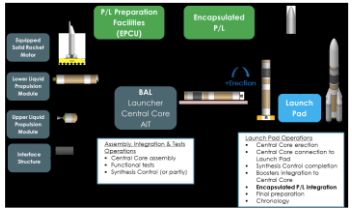
Marnix Verkammen

Course Admin

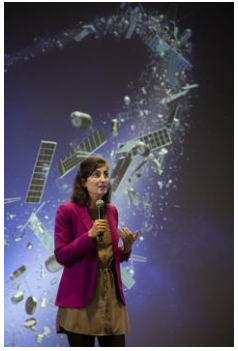
Candice Norhadian

and more to be confirmed…

Who are we?



ESA- A6 Team

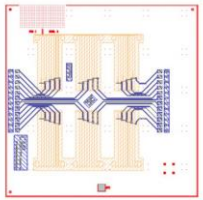


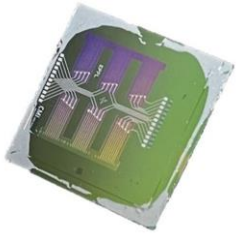
Who are we ?

ERT
EPFL ROCKET TEAM

PROJECT BELLA LUI
EPFL ROCKET TEAM

EUROC
EUROPEAN ROCKETRY CHALLENGE





EPFL

DTU

eSpace

EPFL Space Center

SPACE GENERATION ADVISORY COUNCIL

Sustainable Space Hub

Who are we ?

TU Delft **Impact Contest**

Launch your start-up idea

TU Delft

Aerospace Engineering
BSc + MSc

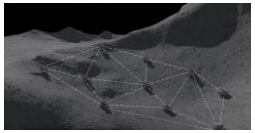
EPFL Space Center

eSpace

LUNAR ZEBRO

www.zebro.space

https://www.youtube.com/watch?v=w_BUfLucM8g



Who are we?

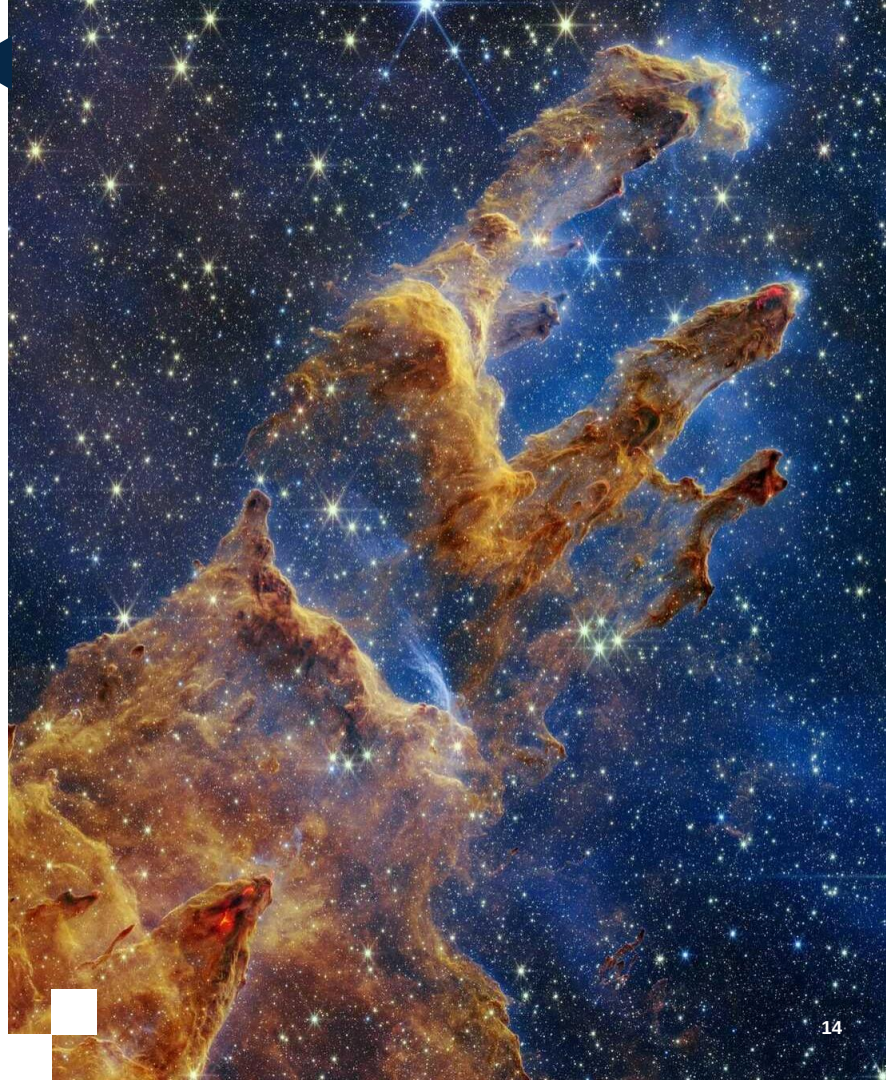
The people of EPFL SPACE Center

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

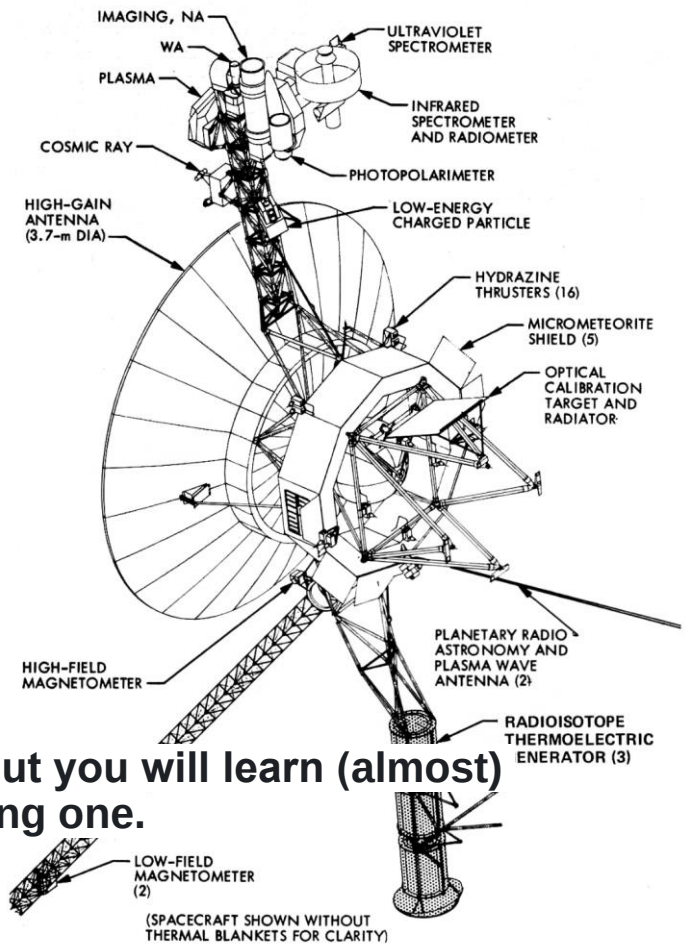
Anti-goals

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

How ?

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

- 45 min of basic concepts + 45 min of case studies/exercises/guest speaker presentations

Pratical work in the Lab- Kitsat, Cleanroom and ground station

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

- Time for you to work on your mission. Make good use of it!!
- But use it as you see fit.

Questions to be asked on Moodle on the forum

Check Moodle for instructions.

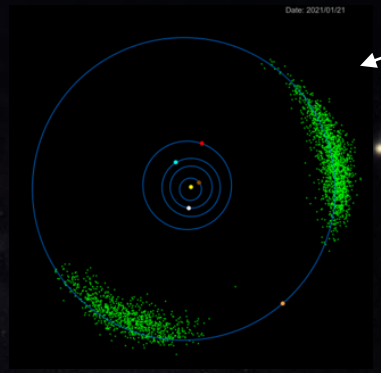
Lecture slides and (possibly) notes will become available on Moodle before each class.

Tentative schedule (subject to changes- Check Moodle)!

Lecture	Title	Date
L01	Welcome: Mission Design & Spacecraft Systems Engineering	09.09.2024
L02	System level thinking intro, conceptual design and trade-offs	23.09.2024
L03	Spacecraft Environment & Astrodynamics	30.09.2024
L04	Space Science & Instrumentation (objectives)	07.10.2024
L05	Propulsion & Attitude Control	14.10.2024
L06	Space Sustainability (EOL management) & Life-Cycle Assessment	28.10.2024
MCR	Mission Concept Review (presentation)	
L07	Telecommunications & Ground Stations & operations	04.11.2024
	Telemetry, Command, & Data Handling, Avionics	
L08	Intro to Spacecraft Operations (Clearspace)	11.11.2024
	Avionics	
L09	Spacecraft Structures & Mechanisms	18.11.2024
L10	Spacecraft Thermal Design & Control	25.11.2024
	Electrical Power System	
L11	Spacecraft Configuration Engineering	02.12.2024
L12	Launch vehicles and launch operations	09.12.2024
MDR	Mission Design Review	16.12.2024

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

Course Structure



Astrodynamics (L02)

Thermal (10)

ADCS (L08)

Payload (04)

Power (L06)

Environment (L02)

Communications (07)

CDH(L08)

Propulsion (L03)

Structure & Mechanisms (L09)

Practical Work

- Session in Clean Room
- Session with Test Facilities
- Ground station visit

Course Structure

How

No additional exercises or homework to complete.

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

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 **individually** 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).

You will present it in **multiple reviews** where your mission will be evaluated by a panel of experts.

2024- Mission Directive

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

Challenge 1:

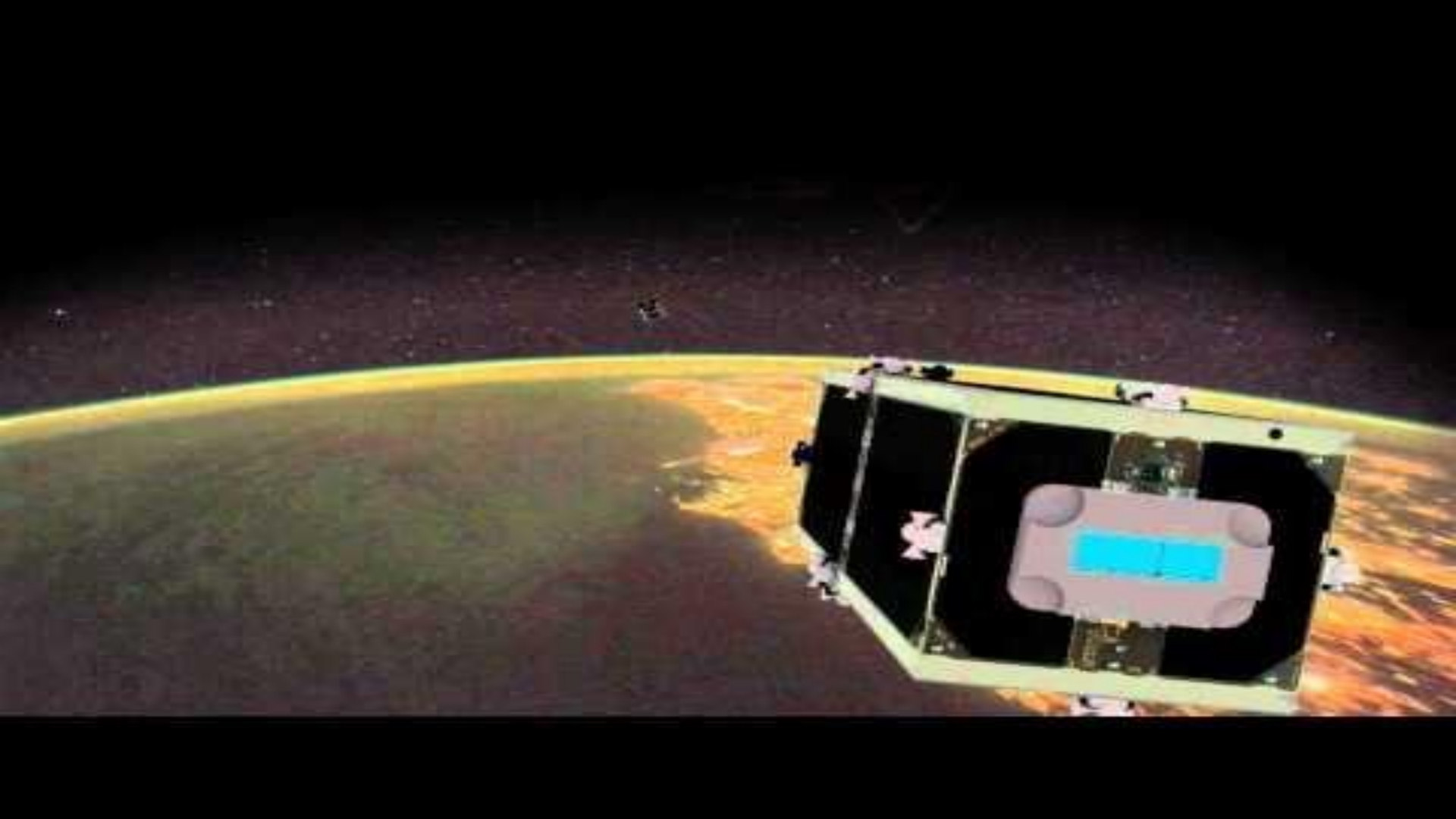
GNSS/telecom constellation satellites around the Moon (example : ESA Moonlight)

Challenge 2 :

Space Weather mission (L4 or L5)

Challenge 3:

Mission to recover Swiss cube (like ReMoVE PoliMi, rediscover Cleanspace)



Assignments & Grading

Mission Concept Review (MCR) [30 Oct 2024]

Mid-term elevator pitch.

Each of you has **5 minutes** to convince the evaluation panel of the value and impact of your mission.

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 **European Conference on Aerospace Science**

- 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 MDR 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)

The selected student will be given a chance to submit an **abstract**, with the support of instructors and TAs, about her/his mission to the follow-up **EUCASS Conference in Rome in Summer 2025 (29th of June to July the 5th)**.

If the abstract is accepted for presentation, the selected student will be invited to submit a **paper** (“final report”) to EUCASS 2025 and her/his attendance will be **sponsored.**

Assignments & Grading

Grade >= 4 → Pass
5ECTS

Recap

[20%] Mid-term presentation --> Mission Concept Review (MCR) [30 Oct 2024]

[30%] Final presentation --> Mission Definition Review (MDR) [16 Dec 2024]

[50%] Final report [16 Dec 2024 & 14 Jan 2024]

No oral or written exam!

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

Deliverables: MCR presentation slides, 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 follow-up EUCASS 2025 in summer in ROME

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)

Resources

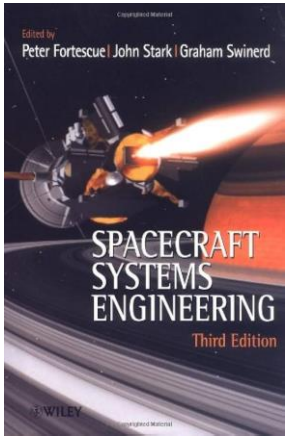
Bibliography used during the course

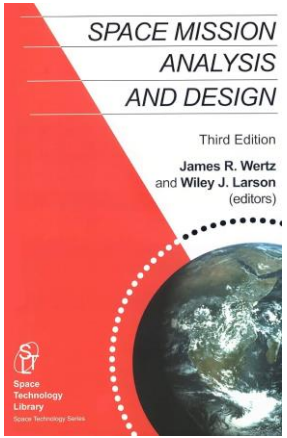
The course is primarily based on two textbooks →

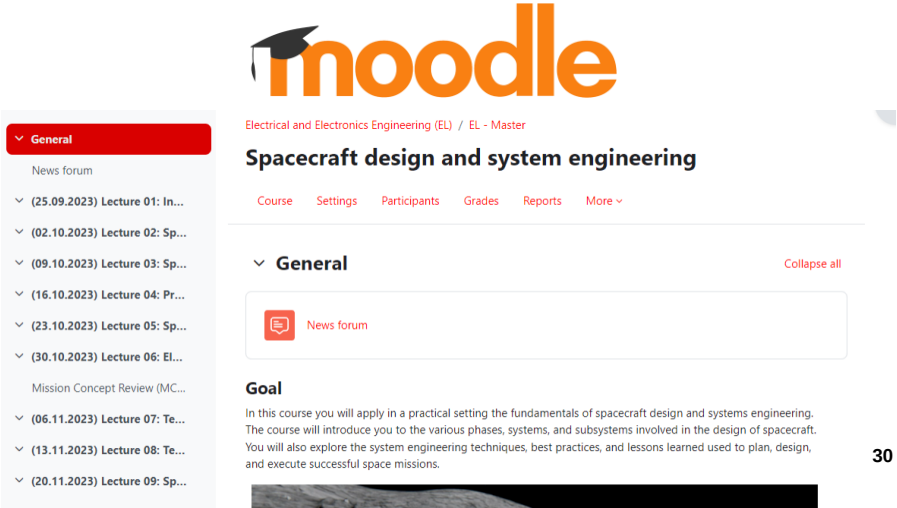
These are recommended, but not required- available

At the Library- please provide feedbachsk .

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







Announcement

ESA BIC Switzerland info event at EPFL

Wednesday, September 25, 2024
12:00 PM – 1:00 PM
Google Calendar · ICS

View Event →

Meet your Future Employer: ESA - European Space Agency In Lausanne

Thursday, September 26, 2024
12:15 PM – 2:15 PM
EPFL (map)
Google Calendar · ICS

View Event →

14 NOVEMBRE

EPFL - Forum Rolex | 12h15 - 14h00
Sur inscription, en français et en anglais

Space, Science & Technology

Evénement sur l'avenir du secteur spatial et de l'astronautique en Europe.
Découvrez comment l'exploration spatiale peut stimuler les partenariats public-privé dans les domaines de la science et de la technologie. Avec la présence de personnalités internationales de l'espace et des tables rondes réunissant des expert·es de l'industrie et de la recherche.

beyond gravity · LOCKHEED MARTIN · OMEGA · csem · SWISSMEM Space Technology · swiss space industries group

Parting thoughts

First time this version of the course is given at EPFL. 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
mathieu.udriot@epfl.ch

Marnix.verkammen@epfl.ch