EE-587
Space sustainability, a multidisciplinary approach

Lecture 1 - Introduction

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EPFL Space Center

Education

Agenda for today

1. General introduction
2. Start “fresque” brainstorm

   Break
3. Summary / conclusion of the exercice
4. Space sustainability
5. Course information (how)
   a. Semester planning
   b. Group work and grading

Teachers

Emmanuelle David
(ESC)

Mathieu Udriot
(ESC)

Marnix Verkammen
(ESC)

Stephan Hellmich
(LASTRO, ESC)

+ several external experts (from ESA, ITU, PSI, SpaceTalk, WaysEhead, etc.)

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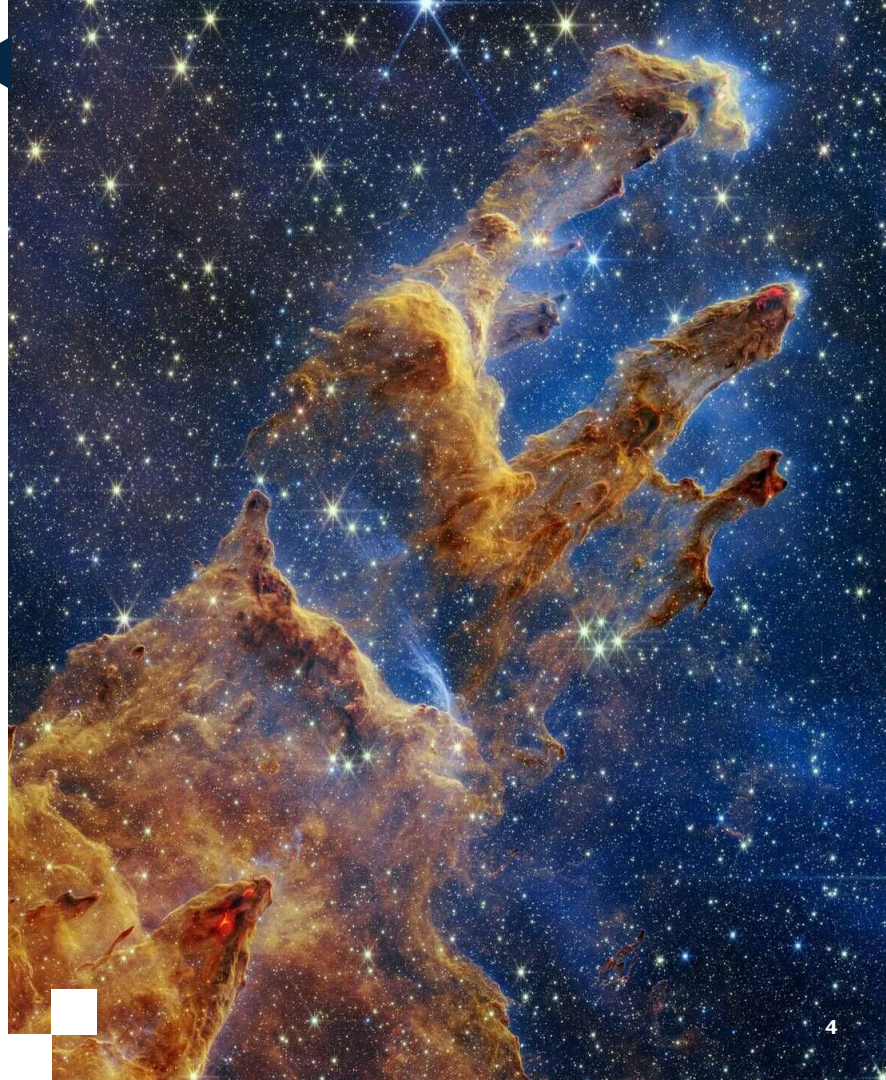
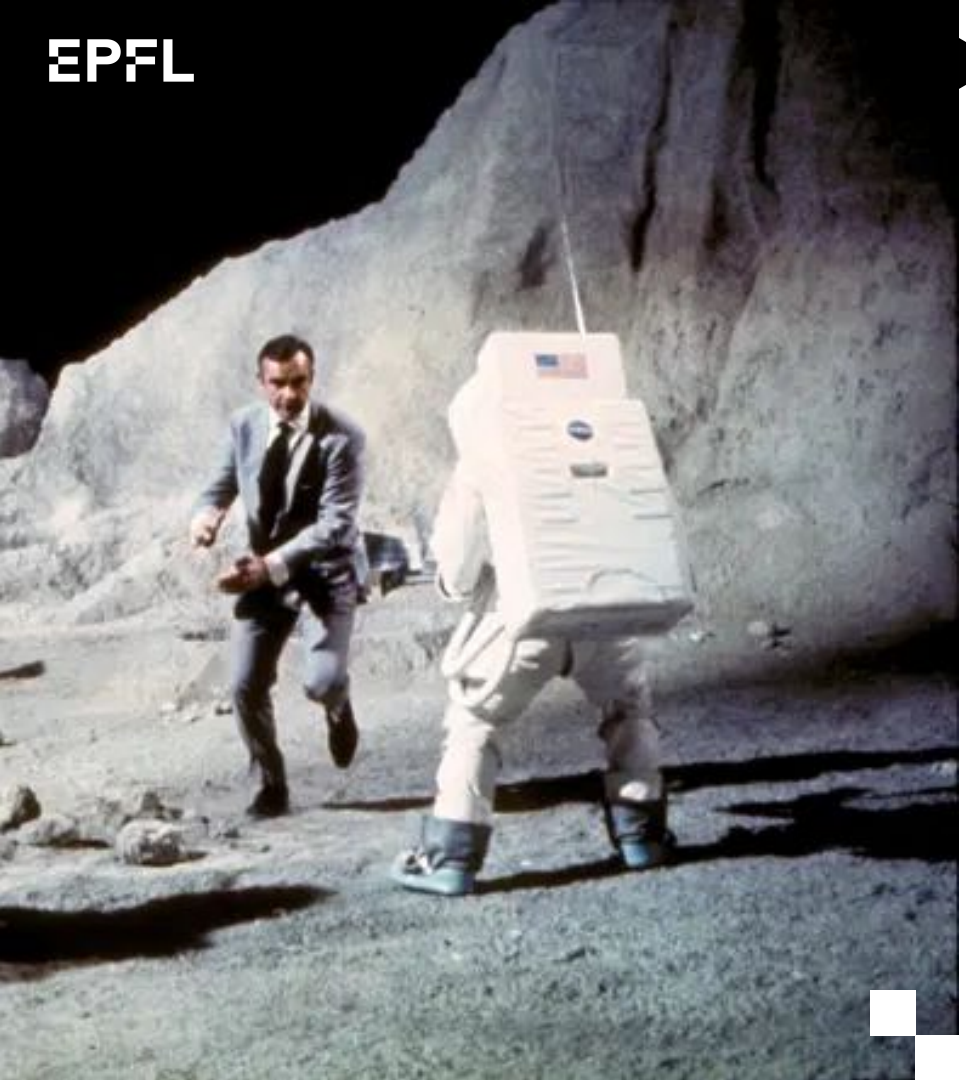
Welcome

Goals

- To learn the history and geopolitical challenges of space sustainability.
- To apply different tools and methods to measure, understand and act for space sustainability
- To evaluate the technical, economical, governance and geopolitical aspects of space sustainability in a group work.



Source: NASA/JWST



Welcome

Learning outcomes

1. Define space sustainability
2. Analyze impacts of space missions on the space and earth's environment
3. Quantify environmental impact
4. Integrate space sustainability in system trade-off
5. Contextualise technical requirements within a geopolitical and legal context

\+ Transversal skills

Sources: Allstar/UNITED ARTISTS

Michka Mélo

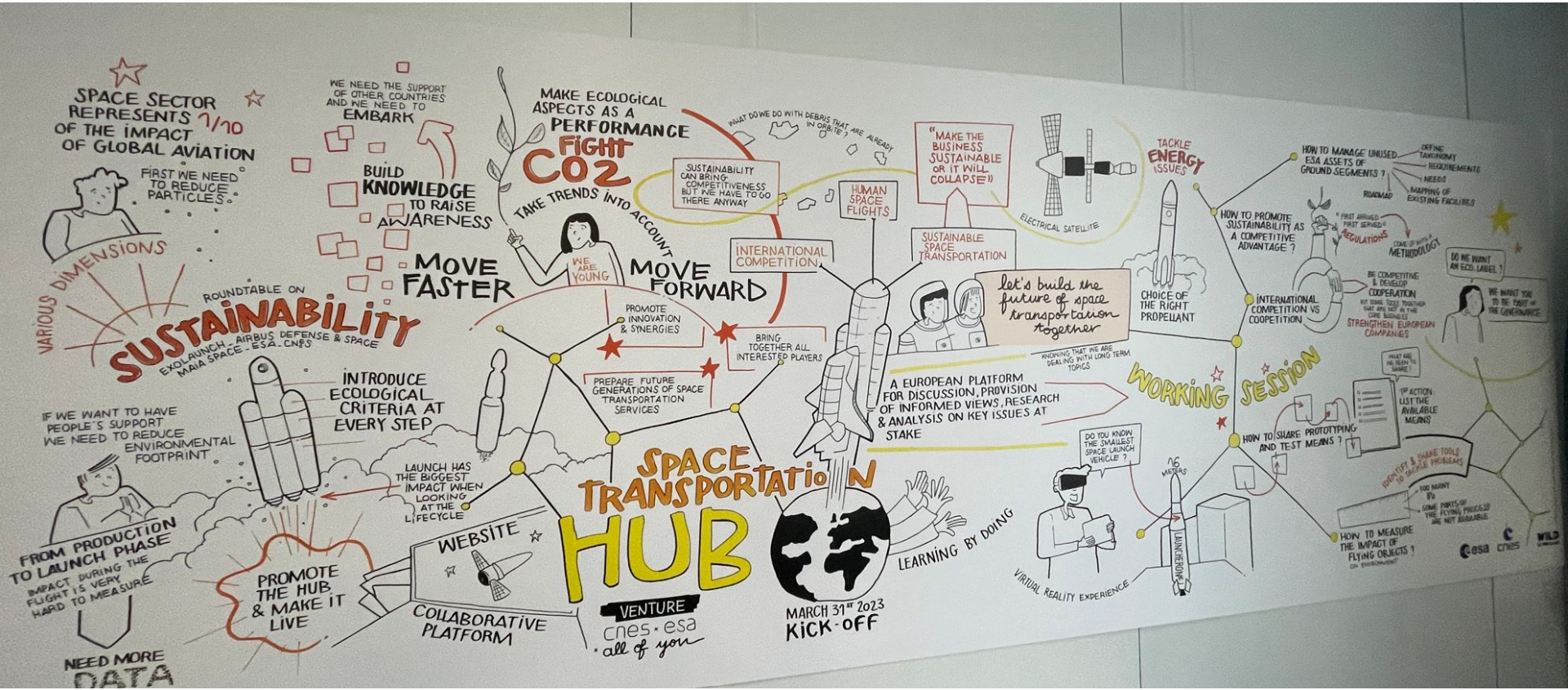
Coach en durabilité

michka.melo@epfl.ch

Space sustainability fresque
Using MURAL

7'	Individual visioning
25'	Subgroup visioning
15'	Break
10'	Plenary debrief

→ go.epfl.ch/space2070



Courtesy of Margaux Duperrey (ESA FLPP)

Definition(s) - safety and sustainability

Space sustainability (by the UN)

The long-term sustainability of outer space activities is defined as the ability to **maintain the conduct of space activities indefinitely into the future** in a manner that realizes the objectives of equitable access to the benefits of the exploration and use of outer space for **peaceful** purposes, in order to meet the **needs of the present generations while preserving the outer space environment for future generations**.

Committee on the Peaceful Uses of Outer Space, Vienna, 20–29 June 2018

“Space sustainabilities” ?

Sustainability **from space**

“ Using space as a platform to directly or indirectly address global problems. ”

- Getting space data from earth observation (EO) satellites
- Using space assets for problems on Earth (GNSS)

Sustainability **in space**

“ Viewing space as a natural resource for preservation, exploitation and exploration. ”

- Risk mitigation and management of space debris,
- Preservation of Dark & Quiet Skies

Sustainability **for space**

“ Protecting the terrestrial environment from the impacts of space activities. ”

- Assessing the impacts using Life Cycle (Sustainability) Assessment
- Mitigating impacts using ecodesign

Sustainability **of space**

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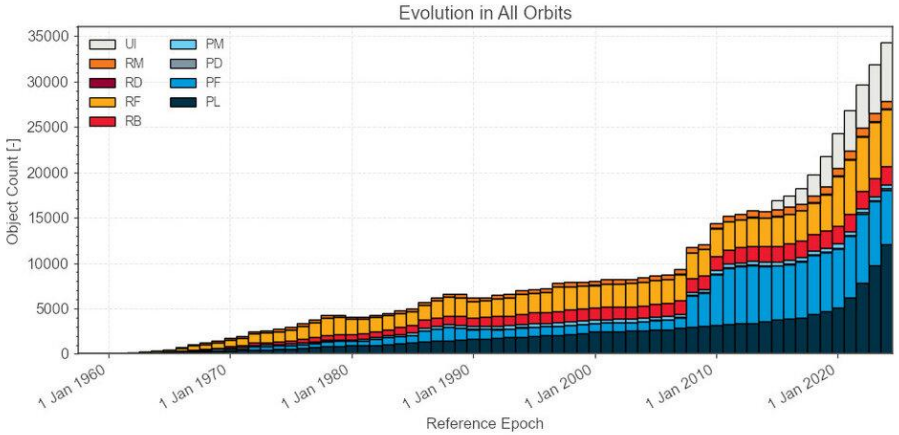
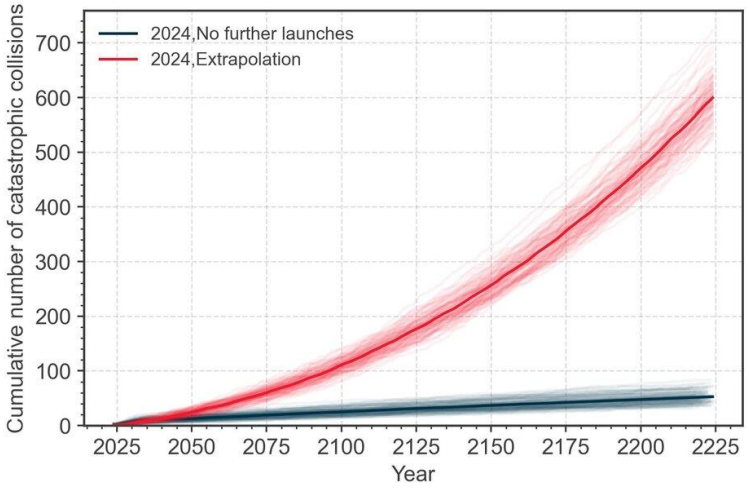
Cited from: Wilson, A. R., & Vasile, M. (2023). The space sustainability paradox. Journal of Cleaner Production. DOI: 10.1016/j.jclepro.2023.138869

In space: The debris situation



ESA Space Environment 2024 - Number of tracked objects in Earth orbit over time



ESA Space Environment 2024 - The future number catastrophic collisions in Earth orbit

STARLINK

- 6'411 (Feb 25) operational sats in orbit
- Permission for 12,000
- Approval pending for 30,000 more

OneWeb

- 648 satellites in orbit
- 220 to be launched

amazon | project kuiper

- 3276 satellites to be launched

And more !

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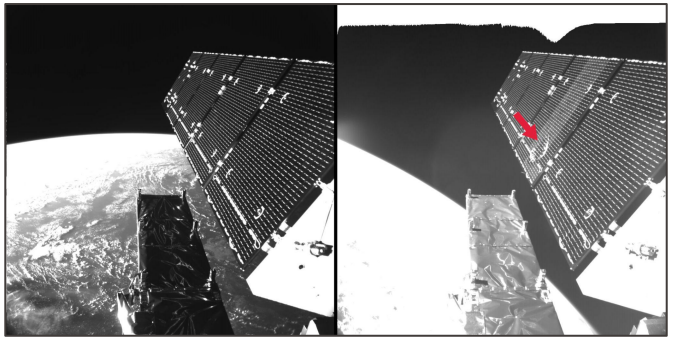
… a threat to safe operations

Kinetic events
(catastrophic or not)

→ Kessler syndrome

1 cm object ~= hand grenade



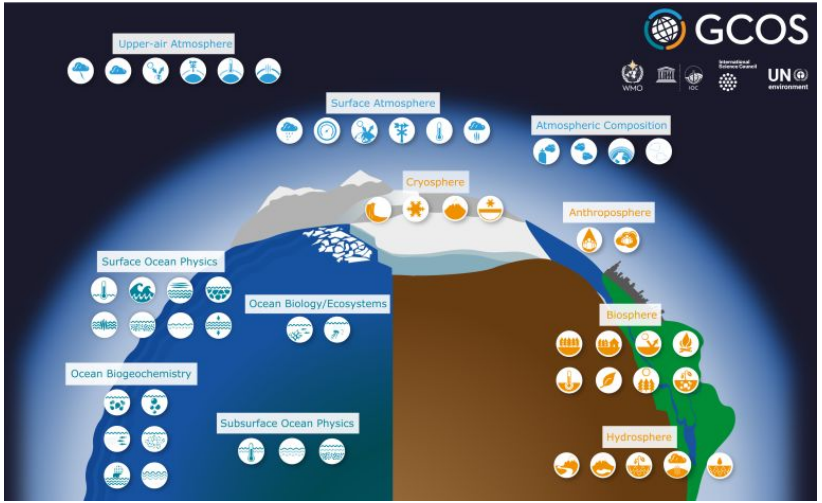
https://www.esa.int/Space_Safety/Space_Debris/Hypervelocity_impacts_and_protecting_spacecraft

Daily collision-avoidance maneuvers (costly) ⟶ Example: Starlink satellites now maneuver **275** times per day to avoid space objects.

https://www.space.com/spacex-starlink-50000-collision-avoidance-maneuvers-space-safety

If we continue business as usual, the orbit around Earth may become inaccessible within the next few decades.

Special orbits for special benefits → data from space



Essential Climate Variables
for science, climat monitoring

- Relevant
- Feasible
- Cost-effective

https://gcos.wmo.int/site/global-climate-observing-system-gcos/essential-climate-variables/about-essential-climate-variables

Global Navigation Satellite Systems (GNSS)
→ Indirect benefits (farming, weather forecast, …)

Social benefits (→ lecture on space4SDGs)

The protected orbital regions

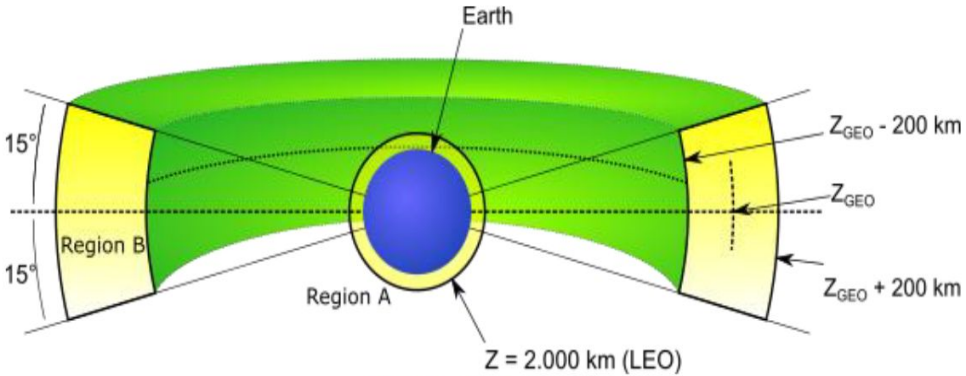


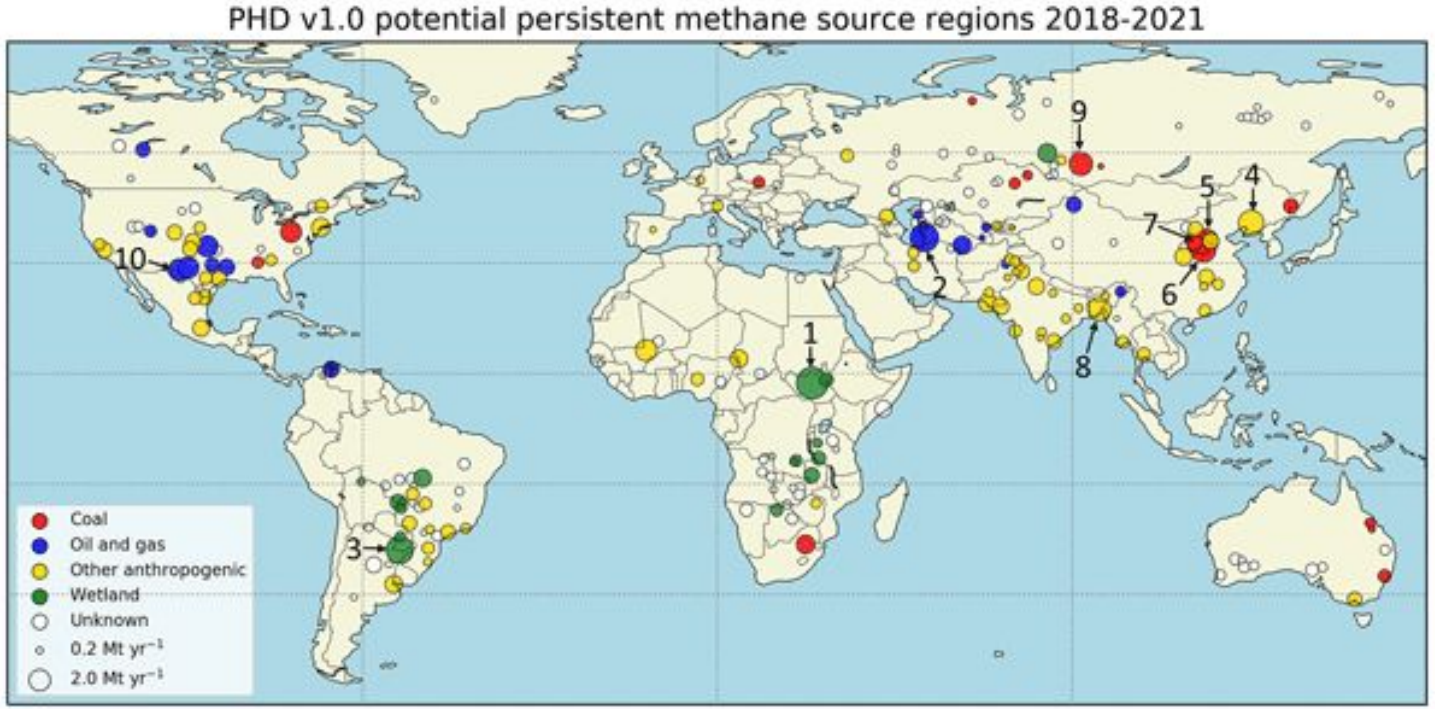
Figure 1 - Protected regions

https://www.iadc-home.org/documents_public/view/id/172#u

- LEO- Low- earth orbit
- GEO- Geostationary orbits
- MEO- Middle Earth orbits

→ Specific guidelines and norms for space debris risk management

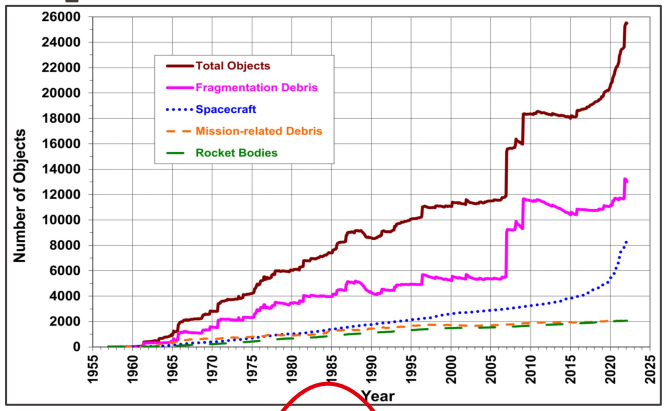
Sustainability from space

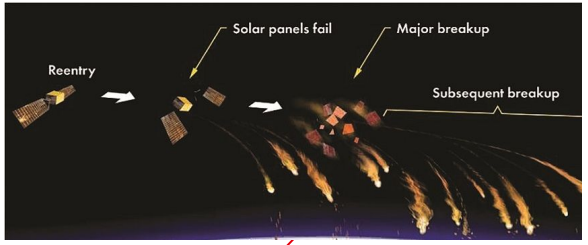


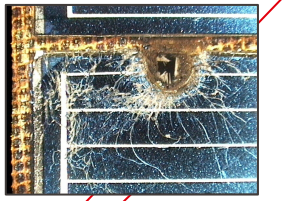
https://acp.copernicus.org/articles/24/10441/2024/

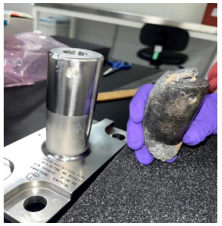
→ Not the focus on this course in terms of content (but interesting to think about)

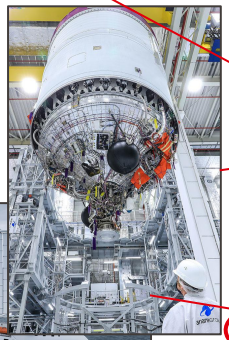
Impacts of space activities

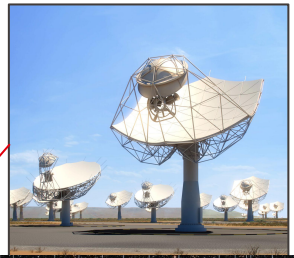












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More broadly: Planetary protection / defense

Planetary protection goes **both ways**:
1967 Outer Space Treaty Article 9, Sentence 2 Harmful contamination

“States Parties to the Treaty shall pursue studies of outer space, including the Moon and other celestial bodies, and conduct exploration of them so as to **avoid their harmful contamination** and also **adverse changes** in the environment of the Earth **resulting from the introduction of extra-terrestrial matter** [...]”

- See also Committee on Space Research (COSPAR) Policy on Planetary Protection (PPP)

Planetary defense

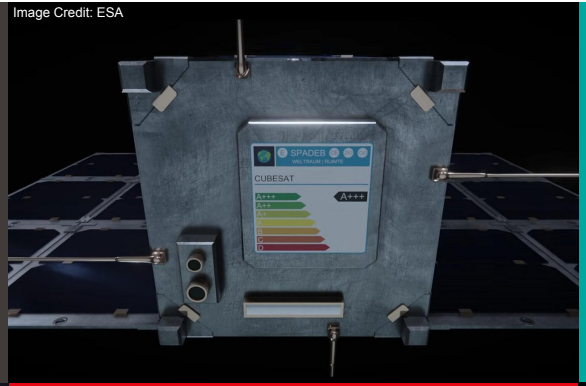
- Near Earth objects detection
- Torino Impact Hazard Scale
- Object deflection missions (DART, Hera, …)

→ Not the focus on this course

Other references:
https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Exploration/ExoMars/Planetary_protection
https://planetaryprotection.jpl.nasa.gov/
https://www.heramission.space/
https://science.nasa.gov/planetary-defense/

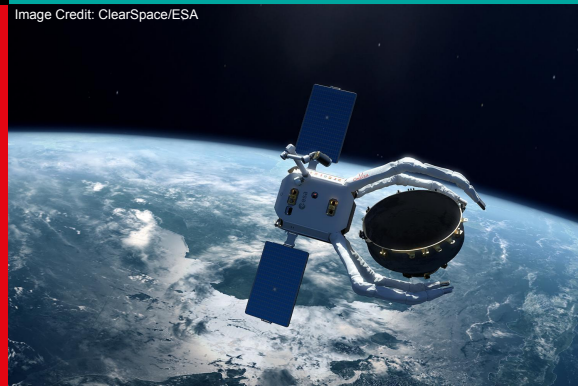
What can we do ?

Stop Launching



Remediation (like Active Debris Removal)

Increase Space Sustainability



Sustainable Space Hub

How can we foster space activities while sustaining the use of outer space in the long term?

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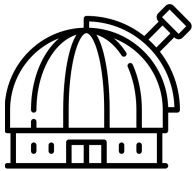
Sustainable Space Hub

EPFL's competence group for new technologies and services to secure the long-term usability of space

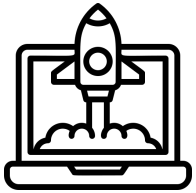
Sustainable Space Hub

1. **Measure**



Filling the knowledge gaps about space objects, emissions, etc.

2. **Understand**



Analyse and quantify environmental risks and impacts of missions

3. **Act**

Include assessments in space mission design since the early phase

https://www.flaticon.com

Course information (how)

EE-587

Space sustainability, a multidisciplinary approach

This class

Structure →

2 ECTS

In room **INM 11**

From 2:15 pm to 4pm, on Mondays

Mid-study presentation with experts

Final presentation (oral exam) with experts

Space Center staff available for questions

Lecture	Title	Date	Time
L01	Logistics of the course, and the group work	17.02.2024	1415
	Introduction to (space) sustainability (measure, understand, Act)		1515
L02	Geopolitics and regulations of Space Sustainability and Earth-Space Sustainability	24.02.2025	1415
	Space Policy Game		1515
L03	Space Situational Awareness	03.03.2025	1415
			1515
L04	The Space sustainability Rating	10.03.2025	1415
			1515
L05	Technologies for Space sustainability- ADR and OOS	17.03.2025	1415
	Time for project		1515
L06	The ESA Tools- Master and Drama	24.03.2025	1415
	Time for project		1515
L07	Mid term- Group work presentation	31.03.2025	1415
			1515
L08	LCA and Eco-Design- LCA expert testimony	07.04.2025	1415
			1515
L09	LCA and Eco-Design- LCA expert testimony	14.04.2025	1415
	Time for project		1515
	Holiday	21.4.2025	
L10	LCA and Eco-Design- LCA expert testimony	28.04.2025	1415
	Time for project		1515
L11	What is ESG and CSR and how does it apply to Space companies?	05.05.2025	1415
	Time for project		1515
L12	Space and the SDGs	12.05.2025	1415
	Time for project		1515
L13	ITU and Space Sustainability	19.05.2025	1415
	Time for project		1515
L14	Question about the course	26.05.2025	1415
			1515

How - group project

Group project

- 4-5 students per group → register for next week

- Use cases from industries (see next slide and backup)
  - Data packs on Moodle

- Project is **transversal** to all topics covered during the semester
  - Geopolitics and regulation aspects related to your mission
  - Space Situational Awareness
  - Compute the Space Sustainability Rating (SSR) of your mission
  - Using ESA tools, estimate debris risks, reentry, ground casualty risks
  - Propose active debris removal, in-orbit servicing elements in the ConOps
  - Compute a simple LCA of the constellation satellites, propose eco-design solutions
  - Find and analyse the ESG and CSR strategies of the companies in your use case
  - Understand impacts of your mission on the SDGs

→ More detailed expectations for the project will be provided at the end of each lecture

3 missions to choose from (real cases from industries)

Choose 1 mission from:

1. PlantB mission by Spring institute
2. *Mission TBC* by Airbus Defense and Space
3. PhotSat by IEEC
4. One of your own missions (can be from the course E-584, CHESS…)

→ more info in backup slides

Choose a mission in group for next week (indicate 1st and 2nd choice, we would like to cover at least the 3 ones proposed by industry)

How - Examination method

Levels
Great contribution
Small contribution
No contribution
Negative behaviour

- Presence and participation in class [**10%**] → we want it to be interactive

- Intermediate presentation: Week 7 [**40 %**]
  - Focus on first part of the semester
  - 15 min presentation per group
  - 5 min Q&A (with everyone)

- Final presentation: Date *TBD* during exam session [**50 %**]
  - Duration *TBD*
  - Focus on second part of the semester

Rules:

- Clearly show who did what (individual contribution to the group)
- Mention clearly the use of AI

Resources

- ESA space environment statistics https://sdup.esoc.esa.int/discosweb/statistics/
- ITU Space Sustainability Portal
- Secure World Foundation Handbook for New Actors in Space
- UNOOSA's Awareness-raising and capacity-building project on LTS Guidelines
- European Space Agency's Space Debris Charter and technical booklet
- **Info about space missions: https://www.eoportal.org**

Events in Spring 2025

March 2025

- Workshop **Space Sustainability: Bridging Initiatives and Perspectives (with SWF, FOGOS) – 27th-28th**
- Space sustainability course for professionals

April 2025

- ESA Space Debris Conference (1-4th April 2024)

Mai 2025

- Swiss Space Community days (Lausanne) - SXS
- Conference on Space Sustainability @Rolex (*TBC*)

June 2025

- EUCASS (Rome) - SUSTSP session

Chaired by E. David & Prof Columbo- Abstract deadline 15th of Feb

Any questions?

Parting thoughts

We are open to your feedback!

We are here to help you learn. Anything you may need help with or anything on your mind on how to make the course better, let us know.

Contact: emmanuelle.david@epfl.ch

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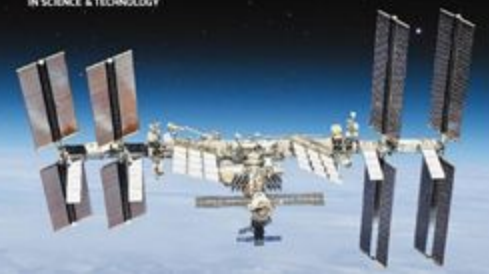
Space Sustainability WEEK MARCH 2025

Monday to Thursday- Space Sustainability course- How to design more sustainable missions

Thursday PM and Friday- **Space Sustainability: Bridging Initiatives and Perspectives with Secure World Foundation, EU- COST- FOGOS**



Updated definition and the sustainability paradox

"The long-term sustainability of outer space activities ***(on-ground and in-orbit)*** *is defined as the ability to maintain* ***and improve*** *the conduct of space activities indefinitely into the future in a manner that* ***ensures continued*** *access to the benefits of the exploration and use of space for peaceful purposes, in order to meet the needs of the present generations while preserving* ***both the Earth and*** *the outer space environment for future generations.*

Space sustainability also requires promoting the use and environmental benefits of space data and recognising the need for the launch and in-orbit activities to be carried out in an increasingly responsible and sustainable manner."

Wilson, Vasile (2023)

The spring institute

Mission : send a space terrarium in LEO

Type : In orbit demonstration

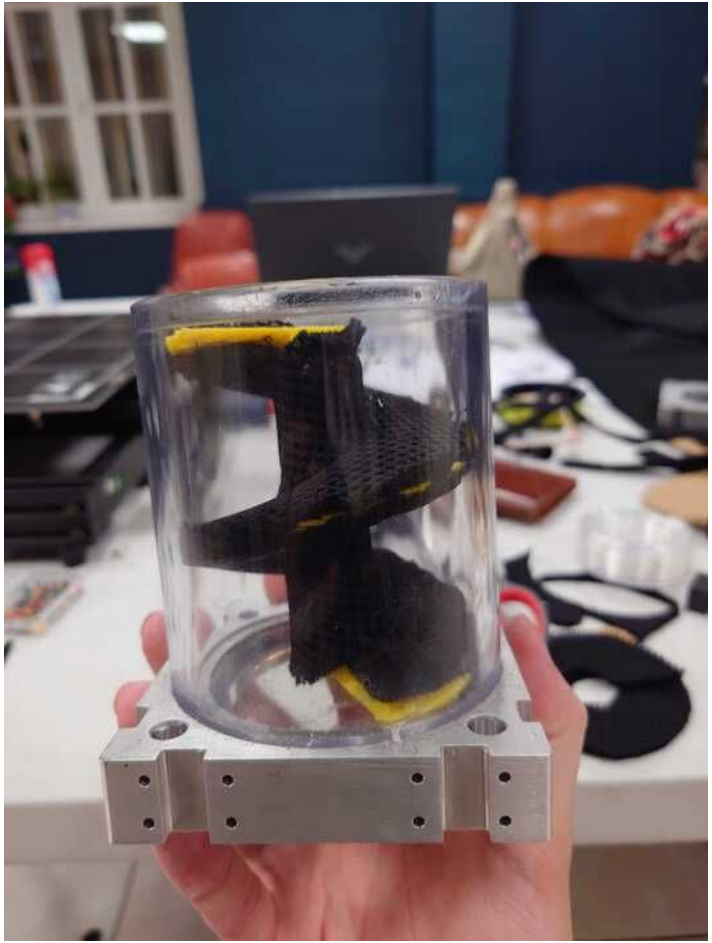
Level of : Phase 0

Customer : The spring institute (NGO)

Contact : louise@thespringinstitute.com

Partners:

- Brown University - payload structure
- Aberystwyth University - biological payload
- Université de Limoges - electronics
- ESTACA - first test on a stratospheric balloon
- Planète Sciences - balloon logistics
- Spring - Coordination



https://thespringinstitute.com/plant-b-cube-satellite-terrarium/

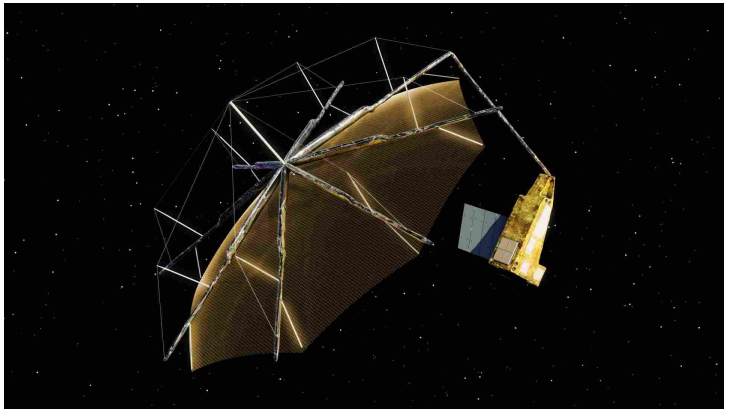
AIRBUS DS

Mission : Biomass evolution (TBC)
Type : Earth observation
Level of : Phase 0

Or

Mission: Debris Deflection or Collision avoidance with SpaceBorne Laser (TBC)
Type : In orbit demonstration
Level of: Phase 0

Customer : AIRBUS DS
Contact : mathieu.derrey@airbus.com



https://www.eoportal.org/satellite-missions/biomass#eop-quick-facts-section

PhotSat by IEEC

Mission: PhotSat

Type : astronomy

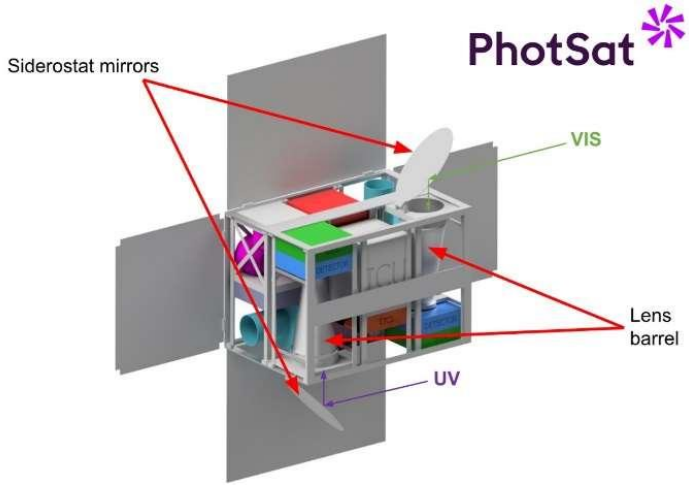
Level of: Phase 0/A

Customer: IEEC

Contact point : esteva@ieec.cat

Open cosmos article

https://www.ieec.cat/en/project/64/photsat/



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