EE-582 **Lessons learned from the space exploration**

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Cursus	Sem.	Type
Electrical and Electronical Engineering	MA2, MA4	Opt.
Space technologies minor	E	Opt.

Language of teaching	English
Credits	2
Session	Summer
Semester	Spring
Exam	During the semester
Workload	60h
Weeks	14
Hours	**2 weekly**
Lecture	2 weekly
Number of positions	

Summary

The objective of the course is to present with different viewpoints, the lessons learned which lead to the decisions in the space exploration and their consequences today and for the decades to come. A semester continuous evaluation is done through a conceptual study of a space project (see below).

Content

1. Introduction The first 15 years:
The geopolitical impact of the second World War. The start of the space conquest in the Cold-War context. The origin of the early Soviet successes, their working methodology, way of doing and designing, the technological limits. The American political, technological and industrial reactions, the Moon race (Apollo). The reasons for the first space disasters and the Soviet failure in the Moon race. The end of the Apollo programme. The early conception and design of human-rated space vehicles and the associated risks.
2. Soviet and American Low Earth Orbit human occupancy:
The origin of the Soviet space stations programmes: Almaz, Salyut and Mir. The initial goals, the operational and human difficulties, the achieved results, the military hidden aspects. The US programmes: MOL, Skylab. The Space Shuttle Transportation System achievements, weakness and failures. The consequences of the Cold-War end on Soviet / Russian and American space activities and cooperation. The start of the International Space Station (ISS) programme and a new worldwide-cooperation between the different Partners, despite major geopolitical conflicts.
3. The Chinese Space programmes:
The early Soviet / China cooperation and technology transfer. The Long March launchers families and missions. The Chinese ambitions: the human space programme and space stations activities and achievements; the present and future Moon and Mars exploration missions. The start of a new geopolitical space strategy at the dawn of a new Moon race. The roles and ambitions of new space start-ups.
4. The Launchers in the World:
Review and panorama of the launchers in the World with their associated technological choices: Soviet / Russian, American, Japanese, Indian and others. SpaceX recovery and reusability of Falcon 9 launcher elements. From Europa to Ariane, the national and European projects. The successes of Ariane 1 to 5 and the start of the Ariane 6 launcher. The launchers family with Vega / Vega-C at the CSG (European Spaceport). The start and end of Soyuz launches from French Guyana.
5. The automated probes and future human exploration programmes:
Review and panorama of the automated probes exploration missions towards Moon, Venus and Mars. The Artemis and Starship programmes. Return to and stay on the Moon missions, in the next decades. Why and when Mars missions? The NASA human Mars exploration programme study (DRA). Strategies and potential roles of the main Space agencies. The New Space actors roles and influences.
6. The next 50 years:
What can be expected in the next decades with respect to Space tourism, Solar Power Stations, Moon resources exploitation, the build-up of space colonies and a new vision for exploring, exploiting the solar system resources.

Keywords

Cold-War, Sputnik, Luna, Vostok, Voskhod, Mercury, Gemini, Apollo, Soyuz, Salyut, Space Shuttle, Mir, ISS, Shenzhou,

Tiangong, Chang'E, Moon race, Space cooperation, Space barter, Artemis, Starship, Launch service provider, Recovery and re-use of space elements, Space tourism, Space resources exploitation.

Learning Prerequisites

Required courses

Recommended courses

EE-585 Space mission design and operations, ENG-510 Space Propulsion, EE-584 Spacecraft Design and Systems Engineering

Learning Outcomes

By the end of the course, the student must be able to:

- Conduct a trade-off assessment of a space project conceptual design
- Assess / Evaluate competing space ideas, concepts and early designs
- Identify the different roles that are involved in well-functioning teams and assume different roles, including leadership
- Take into consideration that learning from past space missions conception, design and experiences can greatly help to conceive and realize new space projects.
- Realize the importance of being aware of and follow the geopolitical space environment and evolution in which they will make their professional space carrier.

Transversal skills

- Plan and carry out activities in a way which makes optimal use of available time and other resources.
- Use a work methodology appropriate to the task.
- Keep appropriate documentation for group meetings.
- Negotiate effectively within the group.
- Demonstrate a capacity for creativity.
- Access and evaluate appropriate sources of information.

Teaching methods

Ex cathedra, in English or French. Lecturing (4 hours) every second week at EPFL during the Spring semester, or through Zoom conferences, if required.

Expected student activities

- Quick build-up of Project groups (4 to 6 students max), within 2 weeks after semester start
- Active participation in the project groups
- Participation during the lectures

Assessment methods

Semester continuous evaluation through a project
During the semester, a short Space project has to be performed. It is requested to set-up stand-alone independent groups (4 to 6 students max) to perform a space project conceptual design at system level, with trade-off assessments of three missions ideas issued from the group think-tank process. An easy-to-use System trade-off method, as applied in the frame of preliminary conceptual design phases (pre-Phase A), is introduced and shall be used in the evaluation process. It requires definition of evaluation criteria, their weighting and application to the 3 mission concepts. A project follow-up and guidance is provided during the semester. A draft mid-term report is requested. It will be reviewed with

each group individually through Zoom or in-person meetings, when possible. The project final report closes the activity at the end of the semester.

Supervision

Office hours	No
Assistants	No
Forum	No
Others	Available for each group to answer questions on the project conduct, the mornings of the lecturing day, or by mail and/or Zoom meetings.

Resources

Virtual desktop infrastructure (VDI)

No

Notes/Handbook

Lectures' syllabus delivered prior to each course in PDF format

Websites

- https://www.esa.int
- http://www.nasa.gov
- https://global.jaxa.jp
- http://en.roscosmos.ru
- https://cnes.fr/en
- https://www.dlr.de/EN/Home/home_node.html
- https://global.jaxa.jp
- https://www.isro.gov.in
- http://www.cnsa.gov.cn/english/index.html

Videos

- https://www.esa.int/ESA_Multimedia/Videos/2013/07/Faces_of_ESA_Marc_Toussaint