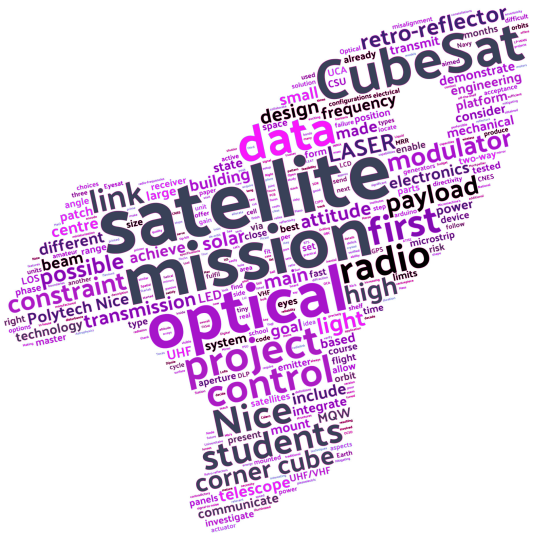
Smallsats



SUMMARY.
Have you ever thought of building an artificial satellite yourself? It is now more than 60 years that the first artificial satellite, Sputnik, was set into orbit around the Earth. This satellite served as an inspiration for generations of researchers and engineers to develop the technologies of aeronautics and space, which are nowadays very commonly found in everyday life (telecommunications, localisation, computers, digital cameras, materials, etc.). The recent development of the so-called 'NewSpace' offers opportunities to set new frontiers in space exploration.
This METEOR aims at giving a glimpse of spacecraft physics and bringing space technologies notions to the hands of students in the form of short courses, and a direct contribution to the Nice Cube project, the nanosatellite project of Université Côte d'Azur, which will demonstrate a laser link between the ground and the satellite.

OBJECTIVES

Today, it is possible to test and validate scientific ideas and new technologies in space on small timescales (typically 5 years). This can be done aboard tiny satellites called "CubeSat". These are standardized satellite plat- forms made of cubes of 10 cm side and 1 W of available electrical power (1U format). Several cubes can be combined (2U, 3U, etc.). Such a platform enables motivated students to learn on a hands-on project the technologies, project management, and all the space- related competences. In this METEOR, the student will first follow lectures on space technologies. They will learn how to read a scientific or technical article, and then they will work on a hands-on project related to the mission in development in Nice, called Nice Cube.

What you will acquire:

- you will be aware of nanosatellites space missions particularities and know where to find relevant information on a space mission development.
- You will know how to read a scientific or technical article and extract its main information to raise your understanding level of a topic.
- You will have a first experience on a real mission, Nice Cube.
- You will acquire basic knowledge of the physics of space- crafts (positioning, orbits, orientation).
- You will also learn the essentials of space project management, that you will practice on one focused aspect of space missions.

PREREQUISITES

- ✗ S1. Numerical methods
- ✗ S2. Gravity & relativity
- ✗ S2. Dynamics & Planetology
- ✗ S2. General mechanics

THEORY

by F. Millour

Introduction to optical communications. Using light to transmit a message has been done for ages. The same principle is nowadays used to improve inter-satellite communications. Principles of free space optics, light propagation in different media, issues and solution for free space optical communications will be reviewed in this course.

by G. Metris

Orbital dynamics notions - impact on orbits choice. The Keplerian model for a setallite's orbit is not a valid approximation in the complex Earth environment. The main orbit perturbations will be reviewed, and their impact on the orbital dynamics. We will deduce from that the criteria to use in order to choose a best-suited orbit for a satellite mission.

by L. Dell'Elce

Satellite Attitude Determination and Control System (ADCS). This course is an introduction to the fundamental concepts that are necessary to design an attitude control system, which aims at orienting the satellite in a pre-defined position. After a brief glance at the most-commonly used hardware for ADCS, a mathematical approach on the control problem will be developed.

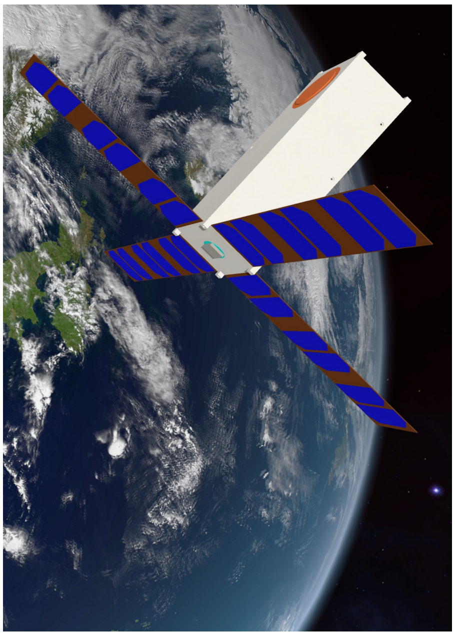
by L. Rolland

Global Navigation Satellite Systems (GNSS). GNSS such as GPS, GLONASS, Galileo are key components of modern terrestrial space missions. This course first reviews the basics con- cepts of GNSS precise positioning. A more practical session covers the main steps of the GNSS processing chain: from data acquisition with a GNSS de- vice to the final position. We finally dis- cuss the limitations of GNSS navigation in terms of precision and accuracy.

APPLICATIONS

by F. Millour, L. Dell'Elce, L. Rolland, G. Metris

The students will work on a short project during 1 month (4 weeks). This assignment will be directly related to the Nice Cube mission being developed at Université Côte d'Azur. These mini-projects contain a theoretical part and a practical part, and depend on the needs of the Nice Cube project. Example projects titles are: "Space mechanics", "Optical communications", "Precise Orbit positioning with GPS/GNSS", "On-board image compression and data transfer".



The Nice Cube nanosatellite project as envisionned in 2025.

MAIN PROGRESSION STEPS

For instance:

- **Week 1-2**: theoretical courses (5 topics) and bibliographic study with presentation of a paper.
- **Week 3-6**: mini-project related to the Nice Cube mission.
- **Week 7**: preparation of the final oral presentation.

EVALUATION

The evaluation of the nanosatellite METEOR is distributed as follows:

- **Theory grade [30%]**
  - Written exercise (50%): two articles summaries
  - Presentation of two articles (50%): critical spirit
- **Practice grade [30%]**
  - mid-course report on the mini-project (50%).
  - end report on the mini-project (50%).
  - The behavior during the mini-project (oral reporting of the weekly work, attitude, motivation) will be positively evaluated.
- **Defense grade [40%]**
  - Oral and slides quality
  - Context
  - Project / Personal work
  - Answers to questions

BIBLIOGRAPHY & RESOURCES

- Article on the Nice Cube project
- CSU website

CONTACT

☎ +33.4.89.15.03.59
✉ fmillour@oca.eu