SAPIENZA
UNIVERSITÀ DI ROMA

Studiare alla Scuola di Ingegneria aerospaziale

Studying at the School of Aerospace Engineering

The School of Aerospace Engineering at Sapienza University of Rome is one of the oldest academic institutions worldwide in the field of aerospace engineering. It was founded in 1926 as School of Aeronautical Engineering for promoting progress in aeronautical science and art.
Since then, peculiar features of the School have been multidisciplinary approach and close connection between research and teaching; in fact, besides standard technical subjects, the study program soon included aeronautical biology and medicine; moreover, intense lab activity has constantly led to close connections between teaching, research and technological progress.
Soon after the School's foundation, its faculty could use large laboratories located at Guidonia near Rome where they achieved very important results in aeronautical design, in development of seaplanes, and in studies on hypersonic aerodynamics.
Starting from the 1960's the School's activities began focusing mainly on astronautics, and in 1963 the School's name changed into School of Aerospace Engineering. Professors and technicians of the School designed and manufactured the satellites of the San Marco series. Thanks to the launch of the first satellite of the series, in 1964 Italy became the third nation in the world, after USA and USSR, to inject its own satellite in orbit.
In 1962 the School set-up a launch platform near Malindi, Kenya that has been used without any launch failure till 1988.
In 1997 the School started an educational program called UniSat, which consisted in having students design and manufacture satellites; each UniSat satellite was launched into space by a Russian-Ukrainian rocket called Dnepr every two years that corresponds to the length of the study program offered by the School. Thanks to the UniSat series and to other later satellites made at the School, called Edusat, Lares, and TigriSat, the School launched into space eight satellites in the last fifteen years, and has become a worldwide flagship institution in astronautics.

Special Master of Aerospace Engineering

The School offers the Special Master of Aerospace Engineering, which is for students having a university degree in any engineering discipline. It is a two-year program; however, it reduces to a one-year program for students with a master degree (or an equivalent degree) in the area of aerospace engineering. The whole special Master is taught in English. The educational project of the Special Master of Aerospace Engineering pushes students towards practical projects. Each year a board composed by School's professors, staff of the Italian Ministry of Defense, and staff from aerospace companies proposes practical projects to students in fields such as manufacturing of nano and micro satellites, space robotics, space science and biological experiments, space guidance, navigation and control and advanced space materials. Students can follow the curriculum below or suggest a motivated alternate according to their interests. A thesis must be submitted at the end of the study program and defended in front of a committee made of faculty members, aerospace professionals, and industry representatives.

The first semester will start during the second half of September 2022 and will end in December. The second semester will start on March and will end half of June 2023.

For further info please visit the "Applications 2022-2023" section at the website https://web.uniroma1.it/scuolaingegneriaaerospaziale/en

Academic year 2022-2023 - Suggested Curriculum

(other choices matching students' interest and background could be also considered by the Board)

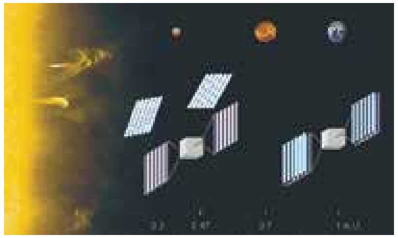
First year	Credits
Astrodynamics (ING-IND/03)	9
Satellites remote sensing: acquisition system and data processing methods (ING-IND/03)	9
Design of space vehicles (ING-IND/05)	9
Navigation (ING-IND/05)	6
Attitude Dynamics, Determination and Control (ING-IND/05)	6
Choose three out of the following seven courses – Dynamics and control of space structures (ING-IND/04) – Numerical modeling of space structures (ING-IND/04) – Orbit determination (ING-IND/05) – Fundamentals of electronics (ING-INF/01) – Spacecraft control (ING-INF/04) – Electrical power systems for space exploration (ING-INF/01) – Electronics for space telecommunication systems (ING-INF/03)	18
Total cfu	**57**

Second year	Credits
Advanced topics in aerospace engineering (ING-IND/05)	9
Design of electronic systems for space: reliability engineering (ING-INF/01)	6
Design of electronic systems for space: hardware and software design techniques (ING-INF/01)	6
Stages	6
Choose one out of the following four courses: – Advanced control of space vehicles (ING-IND/03) – Optimal control and game theory in flight mechanics (ING-IND/03) – Robotics and Artificial Intelligence in Space Engineering (ING-IND/05) – Space technology (ING-IND/04)	6
Choose one out of the following twelve courses: – Modelling of flexible space launchers (ING-IND/04) – Fundamentals of nuclear engineering for astronautics (ING-IND/19) – Hybrid propulsion and new launch systems (ING-IND/07) – Flight mechanics of launch and reentry systems (ING-IND/03) – Law in space activities (IUS/13) – Life support systems for planetary exploration (ING-IND/05) – Radar systems for astronautics (ING-INF/05) – Space debris detection and removal (ING-IND/03) – Aerodynamics of continuous and rarefied flows (ING-IND/06) – Thermal control and thermomechanical interactions in space vehicles (ING-IND/05) – Theory and operations of formation flying (ING-IND/05) – Low thrust propulsion (ING-IND/07)	6
Final dissertation	24
Total cfu	**63**

Laboratories

The courses and projects include activities carried on
at the following laboratories:

In addition, the School's facilities include:



AerosPower Lab

AerosPower (Aerospace Power) is a laboratory of electronics mainly committed to investigate and produce power systems for aerospace vehicles. Advanced and original solutions are developed for applications in launchers, spacecrafts, rovers, and aircraft. The research and development activities are carried out at different levels:

- **System** The activities at a system level are intended to develop leading-edge configurations for generation and management of on-board power in specific missions and particular types of vehicle. Recent noteworthy applications include: space tug, rover for moon exploration, spacecraft with electric propulsion for the inner Solar System, propulsion by electro-dynamic tether;
- **Subsystem** Subsystems are developed for on-board power management and distribution. Recent achievements comprise: solar Arrays and complete power conversion management units per rovers, micro- and nano- satellite as well as hybrid power sources for pulsed loads in launchers and power units for aircrafts. Systems for wireless power transfer are investigated too;
- **Circuit** At a circuit level the activities are intended to study leading-edge design techniques for power converters, for their controllers as well as for protection devices, suitable for the typical harsh requirements in terms of reliability, efficiency, lightness and compactness, as well as for electro magnetic compatibility.

Arca Lab

The Laboratory of Automation, Robotics and Controls for Aerospace - ARCAlab of the School of Aerospace Engineering, conducts its research and experimentation activities in the fields of robotic aerospace systems and control of space vehicles. ARCAlab has collaboration with Asi, Esa and national and international aerospace companies and research institutes. The students are involved in the laboratory activities in the framework of research projects.
The laboratory has a facility with a simulated lunar surface and a moving frame to test algorithms for the autonomous landing of interplanetary probes and the rendez-vous and docking maneuvers. Moreover, the experimentation activities involve the guidance, navigation and control of mobile robots for the planetary exploration, and the developing of prototypes of sensors and actuators for the control of space vehicles.

Eosial Lab

The Eosial - Earth Observation Satellite Images Application Lab is a lab of satellite remote sensing images dedicated to develop innovative applications through the use of optical data (multi- and hyper-spectral) and SAR, integrated with GIS analysis. The fields of interest include: the monitoring of fires, monitoring of volcanic eruptions, the detection of oil spills, monitoring and mapping of agricultural areas, crop early warning, detection of pests and diseases, the development of applications related to safety issues (borders permeability, monitoring of refugee camps) and disaster management (dust storm, damage assessment, early warning, etc.).
The activities of the laboratory is oriented, in particular, to the development of monitoring applications performed automatically and in real time or near-real-time. The laboratory is equipped with the software and hardware tools necessary for satellite images processing and an extensive archive of satellite images including images in low, high and very high spatial resolution, optical and radar.

The hardware equipment includes:

- acquisition system of the SEVIRI sensor on board the geostationary satellite of the MSG (Meteosat Second Generation) series; the system also acquires resampled images within 1 km of the MODIS sensors, AVHRR and GOES geostationary satellites (USA) and HIMAWARI (Japan).
- FLIR thermocamera;
- C LAI 2200 Plant Canopy Analyzer (LI-COR 2012) and Dualex 4 - A Force for estimating LAI (Leaf Area Index) and the content of chlorophyll and polyphenols in the leaves;
- drone esarotors (SAPR SF6) equipped with a multispectral camera MicaSense with 5 channels.

Eosial Instruments

Eosial Satellite Image Acquisition

Flight Mechanics Lab

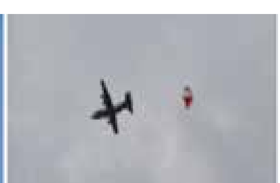
Flight Mechanics Lab is dedicated to Prof. Michele Dicran Sirinian and is devoted to the design, manufacturing and testing of scaled models of aerospace vehicles (https://web.uniroma1.it/scuolaingegneriaaerospaziale/flight-mechanics-lab)

Scaled aircraft design and testing Scaled models are designed, manufactured and able to flight. From the flight data recorded on-board (gyros, accelerometers, altimeters, pitot tubes, magnetometers) the aerodynamic properties (stability derivatives) of the vehicles are derived. The following scaled modes are in the Flight Mechanics Lab:

- Dicran aircraft (original design), a 1/5 scaled model of an aircraft able to flight over Mars;
- Cessna (accurate reproduction of a 1/5 scaled model);
- C130 J (accurate reproduction of a 1/10 scaled model).

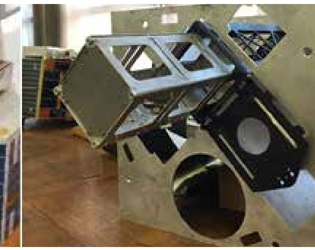
Airlaunch design and testing Flight test of separation between the C130 J and a 1/10 scaled model of a rocket able to inject a microsatellite in orbit, are performed to test the numerical models of airdrop, parachute extraction and stabilization, and evasion maneuvers.

Scaled rocket design and testing Rocket design, manufacturing and launch is a part of the course "Flight Mechanics of Launch and Reentry Systems". Many scaled rockets have been designed through the years and several units are available in the Flight Mechanics Lab, with apogee capability ranging from 200 to 2000 meters of altitude. All rockets are endowed with navigation



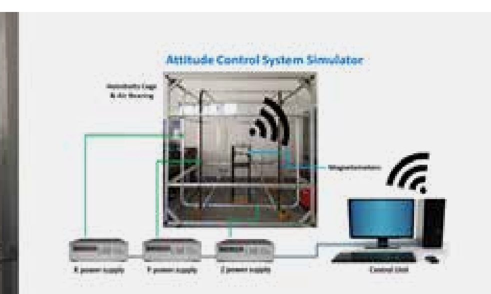
and attitude sensors (gyros, pitot tubes, altimeters, accelerometers, magnetic sensors, GPS antenna, microcamera). The rocket propellant is produced in-house and tested outdoor (watch http://youtu.be/fCUPcT8BGYI)

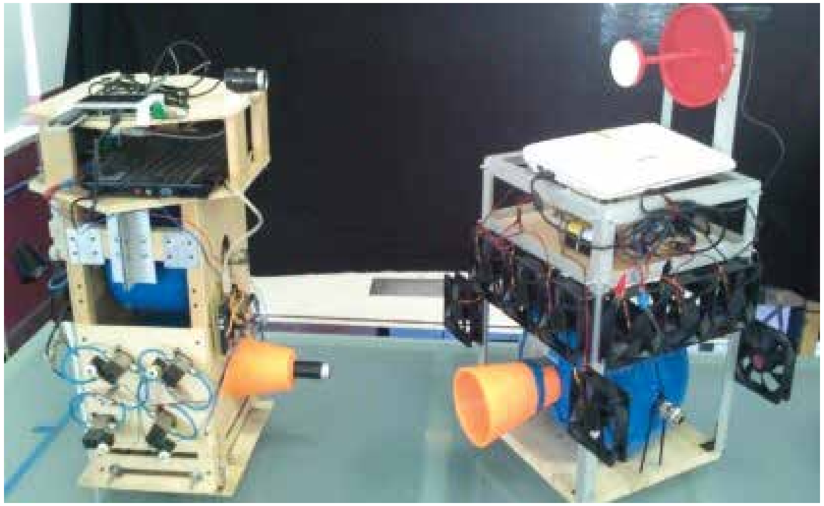
Satellite design and manufacturing Structure and mechanical components of Cubesat, PocketQube and microsatellites are produced in the Flight Mechanics Lab by the available 3D printer and CNC machine.
An integration room is available for Cubesat satellites integration (e.g. Tigrisat and STECCO, launched in 2014 and 2021).



Experimental testing of attitude determination and control systems
Attitude determination and control systems are tested using a 3x3x3 m3 Helmotz cage, that allows recreating the Earth magnetic field experienced by the satellite during its orbital motion, and a spherical airbearing which allows simulating zero-gravity rotation.

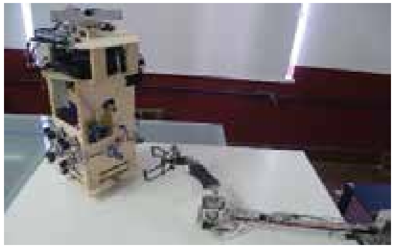
Maritime launch design and testing Experimental testing of a 1/10 scaled model for a microlauncher ejection system to be used for maritime launch. The ejection system can operate using pressurized air or ballistic charges.





Guidance and Navigation Lab

Research at the lab deals with the different aspects of the Guidance, Navigation and Control loop which is instrumental to all modern aerospace ventures. Applications of current activities include rendezvous and docking between spacecraft, grasping and deorbiting of space debris, command of rovers. Significant heritage on formation flying, large and deployable space systems and structures and swarm-like, behavioral controlled systems, Global Navigation Satellite Systems (GPS, Galileo), inertial and optical navigation is present.
The lab stresses, whenever possible, real world testing with the available experimental setups. Students from different degree levels are deeply involved in research activities.



Nanosatellite Electronics Lab

The Nanosatellites Electronics Lab is equipped with instrumentation for the design, simulation, test and prototyping of analog, digital and mixed signal electronic circuits for space applications. The activities carried out in the laboratory include the development of the flight software for the ABACUS on-board computer and the test of payload electronics developed at the School of Aerospace Engineering.
The lab is also used for the didactic activities oriented to familiarize the students with the satellite electronics as well as with the lab instrumentation and procedures. The equipment of the lab includes a soldering workstation with ESD protection, low noise power supplies, waveform signal generators, oscilloscopes, spectrum analyzer, logic analyzer, programming tools for digital embedded systems and ESD protected working area.

Thermo-vacuum and Optics lab

The thermo-vacuum and optics lab is one of the three main installations of the LARES-lab. The other two are the ISTARC center and the optical fiber lab described later in the document. All the labs are used both for research and educational purposes. The students will have the opportunities during the courses to see and operate the facilities. During the thesis more advanced activities and research will be performed by the students.

Fig. 1 Overview of the chamber

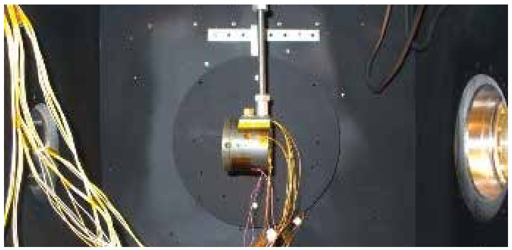


Fig. 2 LARES specimen inside the chamber

Thermovacuum chamber It is small cubic thermo-vacuum chamber of 60x60x60 cm internal size, realized specifically for testing the cube corner reflectors of LARES satellite (Figure 1). It is capable of reaching very high vacuum conditions and it is suitable also for testing nanosatellites and small payloads in simulated space environment.
The chamber simulates radiation thermal exchanges toward deep space with nitrogen cooled shrouds and solar radiation with a Sun simulator lamp. Several tests of payloads and nanosatellites have been already performed in the LARES-lab, including the qualification tests of the LARES (LAser RElativity Satellite), CHAMP and GRACE laser retro-reflectors and the components of TIGRISat (the first Iraqi satellite) and EduSat. A high optical quality window allows to perform also tests of optical components in the simulated space environment. Several thermal sensors can be attached on the specimen as well as resistive heaters to control the specimen temperature (Figure 2).
An optical circuit is available at the side of the chamber for testing components in air or under space simulated condition inside the thermo-vacuum chamber. A remote control of the thermovacuum chamber is in progress for allowing the students to control the tests in the thermovacuum chamber from home.

ISTARC - International Space Time Analysis Research Centre
ISTARC Lab was born for supporting LARES mission whose objective is to test frame-dragging predicted by the theory of general relativity. The Earth rotation drags spacetime and the orbital plane of satellites with it. The orbit determination of the LARES and LAGEOS satellites and the accurate estimation of the classical perturbations acting on the satellites will allow to measure the node shift, produced by general relativity (Figure 3). ISTARC is also credited by NASA for providing the position of the LARES satellite to the International Laser Ranging Service (ILRS) for tracking the satellite. Since lasers have a very narrow light beam the target position need to be determined very accurately. Therefore the predictions (more technically known as Consolidated Prediction File or briefly CPF) have to be much more precise than the predictions, calculated using two-line elements, used for tracking satellites with radars. In Figure 4 are reported, as an example, the differences in meters between the predicted and the actual positions of LARES satellite in January 2015.

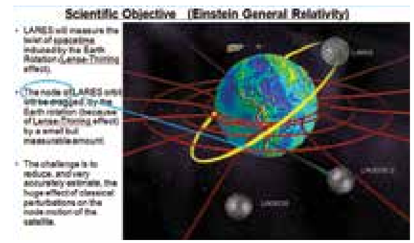


Fig. 3 LARES mission. The mission requires data from the three satellites plus the accurate determination of the Earth gravitational field obtained from the two GRACE satellites shown at center top of the figure in the left

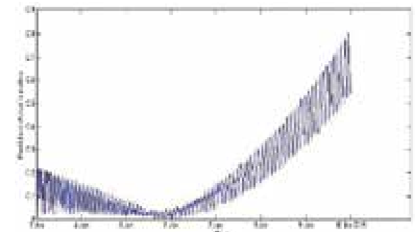


Fig. 4 Comparison between predicted and real position of LARES sat

Optical Fiber Strain Gauges The use of fiber optic sensors and specifically of the so-called Fiber Bragg Gratings (FBGs) for structural health monitoring, are studied in the lab. Several applications have been performed on test items such as a sailing boat mast and a drop keel, with many sensors for acquiring deformation and shape in real time.
Students have the opportunity to operate the mast and the keel installations during the courses at the School of Aerospace Engineering.
The interrogation system is a 4 channell interrogator with a wide band (1510–1590 nm) and 1 kHz data acquisition frequency.

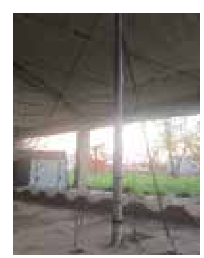


Fig. 5 Sailing Mast and drop keel used for real time monitoring with FBG sensors

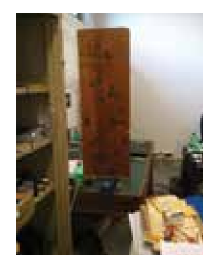


Fig. 6 Fiber optic gauges on a blade

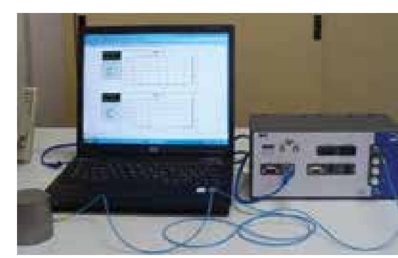
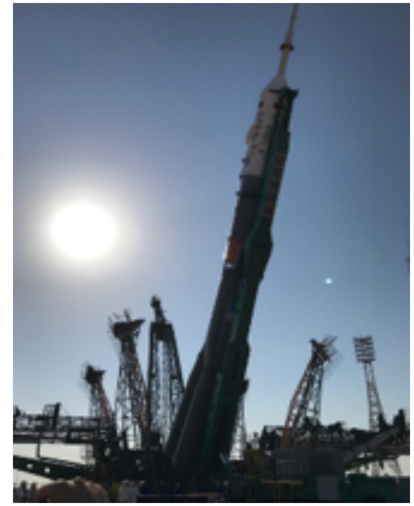


Fig. 7 Fiber optic sensors interrogation system

Pleiades

The Pleiades - Prototyping Lab for Evaluation and Integration of Analytical Devices with Embedded Sensors is devoted to the design, fabrication and test of microfluidic lab-on-chip systems with integrated thin-film electronic components for biological and biochemical research in space. Target applications include astronauts' health monitoring devices and instruments for the search for extinct or extant life traces in the solar system.
The lab is a fully equipped clean room supporting all the activities that go from the preparation of the experiments to the implementation of bioanalytical protocols in a controlled environment for the assessment of the performances of the micro-analytical devices and of the dedicated control and readout electronics.



Human Factor Lab

This Lab deals with the impact that the physiological and psychological issues have on the space systems. Researches were developed in the field of human space missions, long permanence onboard the International Space Station, human missions on Marsas well as confinement experiments on Earth (such as Mars 500 and Antartica) and future suborbital flights.
Among the topics condered are: crew resource management: effective communication, leadership, team management, stress management, time management, decision making, situation awareness, threat and error management, risk assessment and risk management.
Particular attention is given to impact that these topics have on the design of the missions and of the space systems.
The lab also provides advice in the field of Aeronautical Psychology to Civil Aviation Authorities of various Countries and to Commercial Airlines that show great interest in Knowing how some topics of Aeronautical Psychology are being dealt with in the Aerospace Environment.

SiaSpacePropulsionLab

For years, the Sapienza Space Propulsion Lab offers the possibility for Aerospace Engineering students to design, implement and launch mini-rockets! Through materials easily available, a black powder engine and calculation tools, such as Matlab and Open Rocket, we have created mini-rockets and participated in a competition completing the mission: to ensure that the rocket landed in conditions to safeguard the precious payload: in our case, a hard-boiled egg.
In addition to entertainment, the activities we do give us the opportunity to replicate in very small-scale systems of common use in the aerospace sector, to design and test platforms that can find useful applications in various sectors, in particular the science and testing of technologies and of materials in conditions that are not easily replicable.

The ground station

All the satellites developed by the School are tracked by the SIA Ground Station that provides the RF communication with the spacecraft.
The SIA Ground Station ensures the uplink of telecommands both in VHF and UHF bands and the collection of telemetry and low bit-rate payload data in the same bands while, for higher data rates, an S-band section is available.
The Ground Station hardware includes a Yagi Uda UHF-VHF antenna system with low noise preamplifier, an S-band antenna with a 4-meter dish, an ICOM910 radio, a SYMEK TNC and a YAESU G232B rotor controller.
The Ground Station is currently actively used to operate the Tigrisat satellite which is the last satellite launched by the School in June 2014.
The ground station equipment is also used for testing the satellite communication subsystems on ground.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Location and telephone numbers of facilities and secretariat offices are reported on the website of the School
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