



SAPIENZA
UNIVERSITÀ DI ROMA

Dipartimento di Ingegneria Meccanica e Aerospaziale (DIMA)

Director: Prof. Marcello ONOFRI

Scientific Coordinator: Prof. Mauro VALORANI



Lox/Methane Propulsion for Satellite and Spacecraft Manoeuvring



EUROPEAN PROFESSIONAL MASTER FOR GRADUATE STUDENTS IN
"SPACE TRANSPORTATION SYSTEMS"
SPACE LAUNCHERS AND RE-ENTRY VEHICLES

December 9, 2015

THE ITALIAN ACTIVITY ON SPACE HAS STRONG LINKS TO THE SPACE ACTIVITY AT SAPIENZA UNIVERSITY

- ON 1964 THE ITALIAN SPACE ACTIVITY STARTED WITH THE **FIRST LAUNCH** OF A EUROPEAN SCIENTIFIC SATELLITE FULLY DESIGNED, BUILT AND MANAGED BY A TEAM OF SAPIENZA UNIVERSITY.
- THE TEAM LED BY PROF. **LUIGI BROGLIO** PERFORMED **FIVE SUCCESSFUL LAUNCHES** AND BECAME WORLD FAMOUS TO BE THE THIRD, AFTER URSS AND USA, TO SHOW A CAPACITY TO HANDLE LAUNCH ACTIVITY, AND PUT SCIENTIFIC SATELLITES IN ORBIT.
- SINCE THAT TIME, SAPIENZA UNIVERSITY HAS BEEN PROVIDING MANY CONTRIBUTIONS TO INTERNATIONAL PROGRAMS, WITH STRONG LINKS TO ITALIAN INDUSTRY AND THE SUCCESSFUL PARTICIPATION TO INTERNATIONAL PROJECTS LIKE CASSINI, MARS EXPRESS, COSMO-SKYMED, VEGA...



EDUCATION Activity in Space Engineering

Motivated by the need to offer support to the VEGA Project with well trained engineers, the Sapienza University of Rome started in 2002 a post-graduate course devoted to Launchers and Re-entry Vehicles.

The STS Master Course is a Professional Master Course of second level, for graduate students conceived as a service for industry. Indeed, Industries have a major role in making the selection of the applicant students, and guarantee to cover the fee and six months of stage in their premises.

There are no other similar courses in Europe and in fact it has gained a firm reputation at international level: it is sponsored by **ESA, CNES, ASI** and the most important **Italian and European Space Industries**. Since 2006 **ArianeSpace** hosted the Master trainees to visit the Kourou Base and attend to the launch of one of the EU Launchers.

Many students who attended the course are now the responsables of major industrial activity related to VEGA.



Sponsorship

Agencies

- ASI •CNES •ESA •DLR

Industries

- AERO SEKUR •ARIANESPACE
- ASTRIUM •AVIO •ELV
- OHB CGS
- THALES ALENIA SPACE
- VITROCISSET

Universities and organizations

- Sapienza Università di Roma
- Politecnico di Milano - Università di Pisa
- ESA–HQ •ESA–ESRIN
- ESA–ESTEC
- CIRA •NASA •ONERA



Jean-Jacques Dordain Chose Sapienza University

Nominated Honorary Research Fellow

- On last July he left the position of DG ESA, after 12 years of activity, in which he become one of the most renowned person in the space sector.
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- After that he received a large number of requests of collaboration from Industries and Universities.
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- On September he decided to accept our invitation and he is now Honorary Research Fellow at the Sapienza University and member of the SSAS (School for Advanced Studies) and of the CRAS (Center for Aerospace Research).

Training Programme

The II°Level University Master's degree in "Space Transportation Systems" (STS) has a duration of 12 months, and it awards 60 ECTS credits.

It is carried out in English language and consists in an activity of **1.500 hours**, organized in 3 phases, scheduled as follows:

- 1) **Theoretical education.** Frontal lectures, experimental activities, work projects, exercises, middle-term tests (500 hours – first 5 months).
- 2) **Intensive programme.** Training weeks in some of the best Research Centers in Europe; VKI–Bruxelles; ISAE/Toulouse.
- 3) **Paid internships** in European Aerospace Centers and EU space industries, with the possibility of practically implementing the skills learned during the theoretical course. During this phase a Master's thesis is carried out by the students which will be evaluated as a final exam (800 hours – 6 months).

- Passage from a phase to the following occurs after Verification Tests

TRAINING MODULES

Lecture given by well known European experts

	MODULES
Unit 1	Introduction
Unit 2	Overview of Launcher Systems
Unit 3	Space Program Management & Quality Certification
Unit 4	Mission Analysis
Unit 5	Combustion Modeling
Unit 6	LRE Thrust Chamber
Unit 7	Pump-fed Systems
Unit 8	Rocket Nozzles
Unit 9	Aero-thermo-dynamics of launchers and re-entry vehicles
Unit 10	Solid Rocket Motors
Unit 11	Launcher Design
Unit 12	Structures
Unit 13	Ground Segment
Unit 14	Launcher System Management



A unique training in European Centers

Residential weeks spent in European Research Centers offer the trainees a valuable opportunity to experience studying and working in an international context, and become acquainted with the capabilities of some of the main European Space Labs/Centers:

- **CIRA** for High Enthalpy flows
- **DLR** Lampoldshausen for Combustion and Engine validation tests,
- **CNES** and Ecole Supérieure des Mines in Paris for GNC
- **ONERA** Meudon for High speed flows / **ONERA** Palaiseau for Combustion
- **VON KARMAN INSTITUTE** for Aero-thermo-dynamics
- **ESA-ESTEC** for applications of Concurrent Engineering Design
- **ISAE-Toulouse** for Structural Dynamics in Space

**A SPECIFIC CONTRIBUTION BY ESA and ASI COVERS THE COST OF THE TRAINEES
MOBILITY DURING THESE RESIDENTIAL WEEKS**



MASTER STS

International Steering Board

Coordinator: Marcello Onofri

UNIVERSITIES

Aachen UNIV
Barcelona UPC
Brussels VKI
TU Delft
Lausanne EPFL
Liege UNIV.
TU Munich
Arts et Métiers ParisTech
Mines Paris Tech
CNAM Paris
Rome SAPIENZA
Stuttgart UNIV
Toulouse ISAE

Warsaw UNIV.

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RESEARCH CENTERS / AGENCIES

ASI Arturo De Lillis
CIRA Salvatore Borrelli
CNES Christophe Bonnal
DLR Wolfgang Koschel
ESTEC Franco Ongaro
ONERA Philippe Reijasse



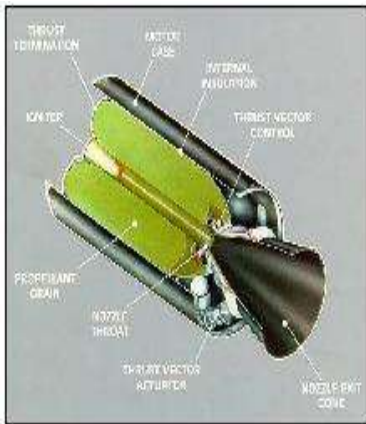
USING MODEL ROCKETS TO PROMOTE EDUCATION IN SPACE ENGINEERING

- The design, build and launch of a **model rocket** is a great opportunity for students to get a first insight into rocketry activities
- Model rocketry is a relatively **safe and inexpensive** way for students to learn and be inspired by space technology
- The low cost of implementation, short preparation time and simplicity of design make of this concept an excellent **practical opportunity** for students



- The workshop, supported by **AVIO Spa**, is organized into theoretical lectures, short-courses and practical classes
- Students are responsible for the design of the rocket, operation verification, launch preparation, data analysis and team organization

USING MODEL ROCKETS TO PROMOTE EDUCATION IN SPACE ENGINEERING



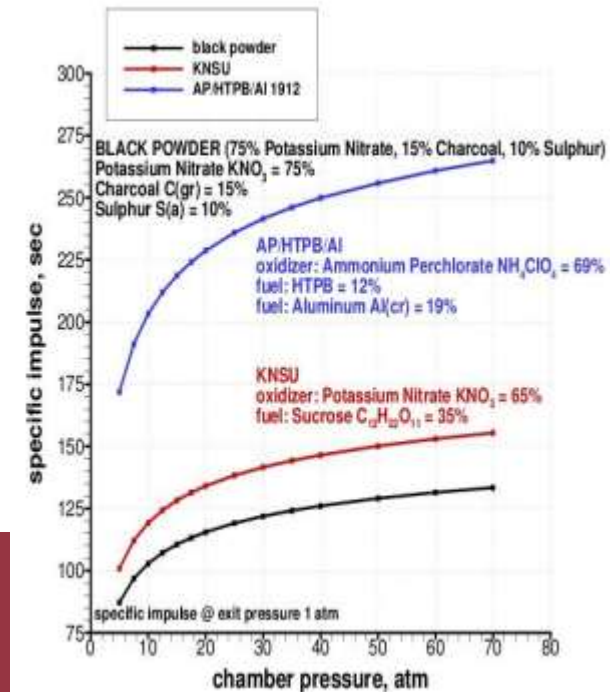
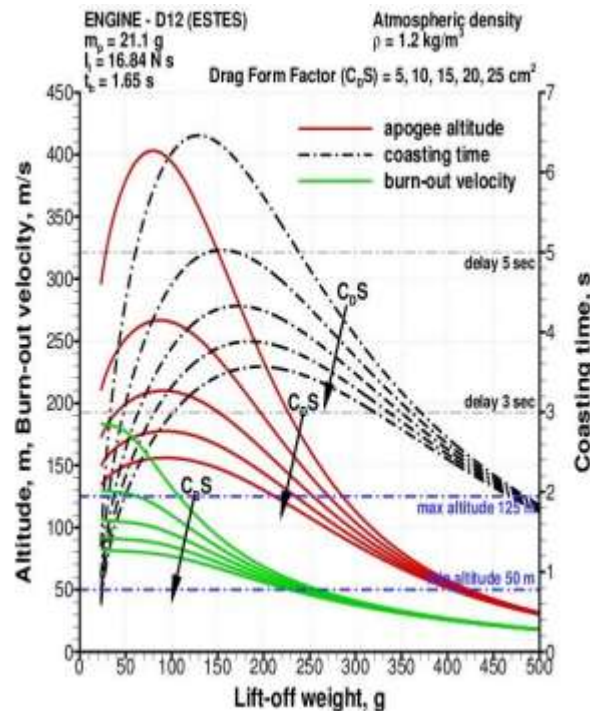
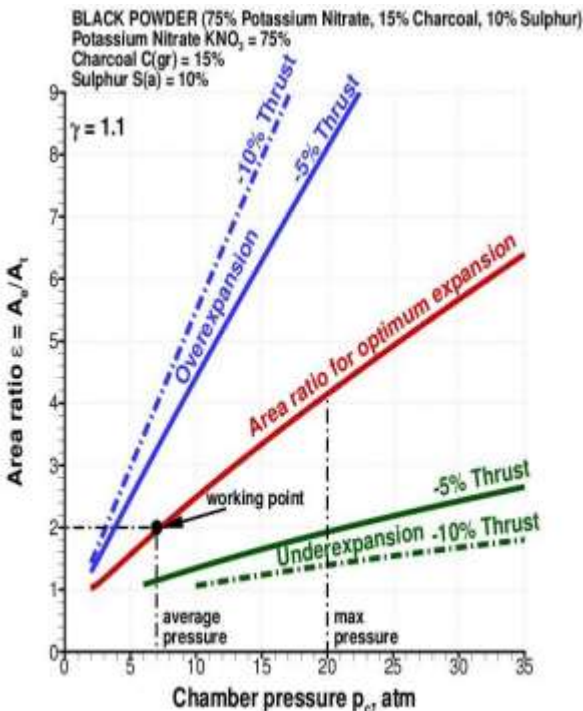
nozzle



aerodynamics



propellant

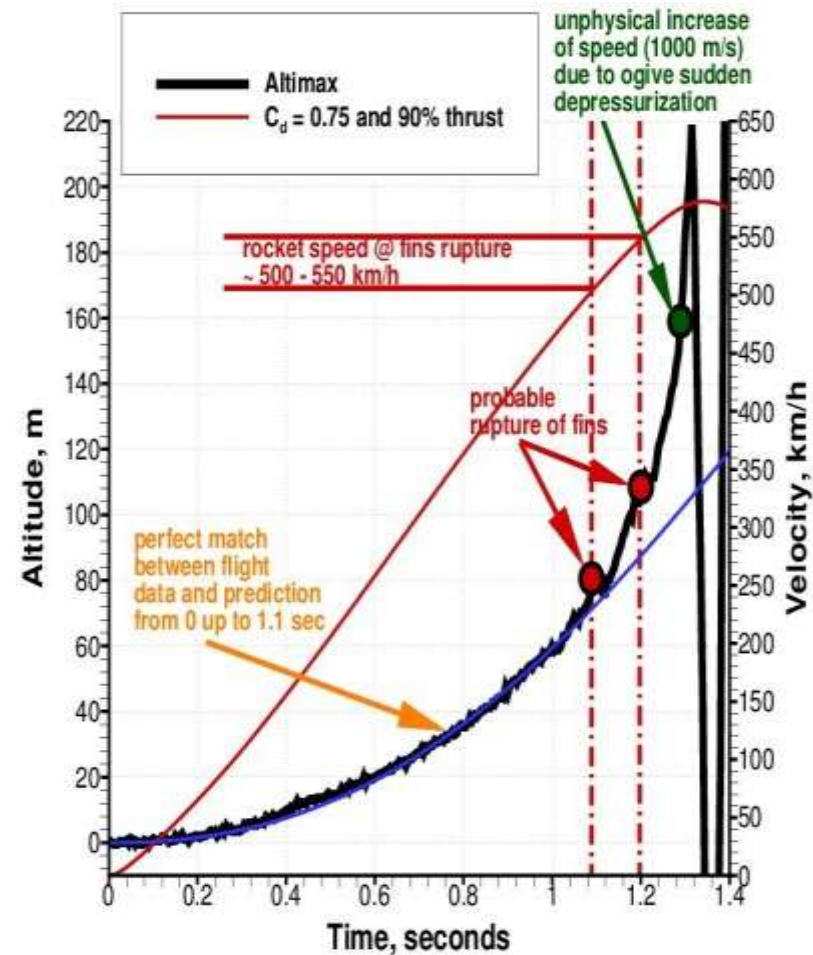
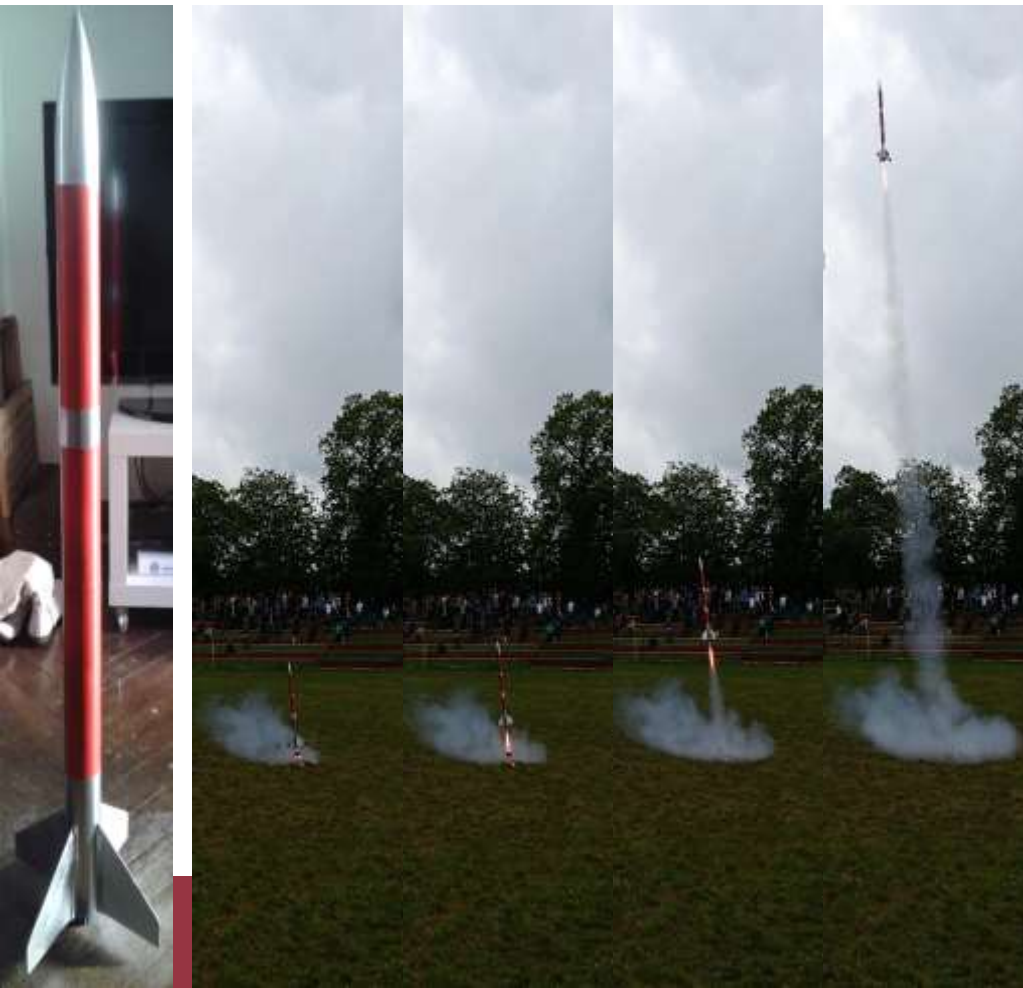


USING MODEL ROCKETS TO PROMOTE EDUCATION IN SPACE ENGINEERING

Post flight analysis

is a fundamental tool for the students to compare their prediction with flight data for "lessons learnt"

Model rockets with **electronic altimeters** can report and or record electronic data such as maximum speed, acceleration, and altitude. **Accelerometers** can be also installed



USING MODEL ROCKETS TO PROMOTE EDUCATION IN SPACE ENGINEERING

WE WOULD LIKE TO PROPOSE HERE A EUROPEAN COLLABORATION AMONG UNIVERSITIES TO ORGANIZE EU COMPETITIONS WITH INTERNATIONAL GROUPS OF STUDENTS IN BUILDING INNOVATIVE SMALL LAUNCHERS AND COMPONENTS

THE COMPETITIONS SHOULD BE SUPPORTED BY THE EU INDUSTRIES

THE AWARD TO THE WINNERS SHOULD BE A POSITION IN THE INDUSTRIAL ACTIVITY



**THANKS FOR THE
ATTENTION**