ESEO
European Student Earth Orbiter: ESA’s Educational Microsatellite Program

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• ALMAspace Presentation
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**ALMA Space** is a privately owned, R&D company based in Forlì, Italy, dedicated to the design, manufacture and operation of low-cost, high-quality space systems. The company was established at the end of 2007 as a spin-off of the Microsatellite Laboratory of the University of Bologna, to bring to the market the results of its research activity in the field of small space systems engineering.

**ALMA Space** products and activities range from microsatellite missions and subsystems to unmanned vehicles GNC systems, from planetary spacecraft radio tracking techniques to highly automated ground control systems. Due to its very recent establishment, **ALMA Space** previous experience was mainly gained through the research activity carried out by the spinning-off university laboratory.
The European Space Agency issued an Open Invitation to Tender (ITT) in February 2012.

“…The scope of the activity includes the hands-on training of university students on the development, assembly integration, test, verification and delivery of a complete satellite system, including the satellite subsystems, the payload elements, and the ground segment systems required to operate the spacecraft and its payload; in addition, the scope of the activity includes also the preparation and the conduct of the Launch Campaign and the Launch and Early Orbit Phase.”

“The primary objective of the ESEO project is to provide students with valuable and challenging hands-on space project experience across all disciplines and throughout the full project lifecycle in order to fully prepare a well-qualified space workforce for the future.”

“Commensurate with the education objectives of the project, and with the constraints deriving from re-utilising a pre-existing spacecraft, the ESEO system elements shall therefore be designed, developed, built, tested and operated, to the maximum possible extent, by European university students.”
After ESA’s evaluation, in Dec. 2012 a contract was awarded to the ALMASpace/UniBO team:
ALMASat-1

Launched in 2012

ALMASat-EO

Launch 2015 (TBC)

ESEO

Launch 2016 (TBC)
**ALMASat-1** microsatellite was entirely designed, manufactured and assembled in the Microsatellite Lab of University of Bologna in Forlì. **ALMASat-1** has been successfully launched onboard VEGA VV-01 on February 2012 part of the LARES payload under responsibility of the Italian Space Agency. The research program started in 2003 with the design and assembly of an simplified ground control station, now operational at VHF-UHF and S-bands since September 2003.
ALMA\textit{Sat-EO} is the first Earth Observation microsatellite entirely designed, manufactured and assembled by ALMA\textit{Space}.

The industrial research program started in 2007, after the Italian Ministry of University and Research (MiUR) approved ALMA\textit{Space}’s Project 16/6 “Piattaforma satellitare per l’osservazione della Terra”.

ALMA\textit{Sat-EO} microsatellite project has the main goal of designing a space platform for Earth observation, dedicated to several applications for the weather monitoring, land surveillance and monitoring of interesting events.
University of Bologna
*GPS Receiver and OD*

- **Denmark Univ. of Technology**
  - Microcamera

- **Hungarian Academy of Sciences**
  - Tritel Dosimeter

- **Wroclaw Univ. of Technology**
  - S-Band TX

- **Budapest Univ. of Technology**
  - Langmuir Probe

- **Technical Univ. of Delft**
  - AODCS S/W Experiment

- **Technical Univ. of Munich**
  - S-band Ground Station

- **University of Zaragoza**
  - Mission Analysis

- **University of Vigo**
  - GENSO for ESEO

- **Cranfield University**
  - Deorbiting Device

- **AMSAT-UK**
  - Educational HR Payload
To be held at the University Residential Centre of Bertinoro (FC)

1st week:
Space Environment
Orbital Mechanics
Attitude Dynamics and Control
Mission Analysis
AGI/STK Fundamentals

2nd week:
S/C subsystems
Remote Sensing
S/C AIV
Ground Segment
Course Test

20 students in each course, to be repeated three times in 18 months (Grants 9 ECTS)
To be held at ALMAspace’s premises (1 week), **granting 3 ECTS:**

- Mechanical Design
- Mechanical and Thermal Analysis
- Electronics Design
- Power Electronics Design
- PA/QA/SA Management

**Spacecraft Subsystems AIV Workshop (Mechanical)**
**Spacecraft Subsystems AIV Workshop (Thermal)**
**Solar Panels Assembly Workshop**
**Hardware-In-the-Loop Simulations Workshop**
To be held at UniBO’s premises (4 weeks), **granting 6 ECTS:**

Students from the Universities Network are hosted (in small groups of 5 individuals) at UniBO premises for a period of 4 weeks working in close connection with personnel involved in the ESEO mission:

1) to let students gain experience in space-system design, prototyping, assembly and integration by applying knowledge and skills previously achieved during Lectures and Training Courses

2) to perform payload engineering activities under the assistance of a team of experts
Spacecraft envelope and architecture:
Platform subsystems block diagram and layout:
Payloads layout:

**Top Plate:**
- GPS Antenna
- AMSAT Antenna

**Tray 5:**
- GPS

**Sector 4:**
- ES
- LMP LCB

**Sector 3:**
- MPS Tank
- uCAM

**Sector 2:**
- TRITEL
- AMSAT

**Panel 2:**
- DOM

**Sector 1:**
- S-Band HSTX
- S-Band HSTX Antenna

**Bottom Plate:**
- LMP LDE
- ES
- S-Band HSTX Antenna
- TRITEL
- uCAM
G/S architecture:

- **Primary Ground Station Network**
  - Forli, Italy (TM/TC RX/TX Main)
  - Vigo, Spain (TM/TC RX/TX Backup)
  - Munich, Germany (Payload RX Main)
- **Secondary Ground Station Network**
  - ESA ESTRACK Network (Payload RX Backup)
  - GENSO Network (TM RX)
- Amateur radio community support through AMSAT-UK payloads
µCAM
Provide Earth imaging capability onboard the ESEO satellite. The instrument is configured for wide angle, color imaging using RGB Bayer filter interpolation at 8bit color depth.

TRITEL Dosimeter
Provide radiation measurements with advanced dosimetric instrument based on three dimensional silicon detector telescope comprising six identical fully depleted Passivated Implanted Planar Silicon (PIPS) detectors and designed to measure the energy deposit of charged particles.

S-band transmitter and patch antenna
Provide communication between ESEO and ground station on downlink with the maximum data rate of 5 Mbps. The modulation planned to be used in BPSK and data rate is switchable between 64 kbps and the maximum value.
Langmuir probe
Investigate the solar activity analyzing the normal characteristics of the plasma and acquire scientific data of the geomagnetic disturbances induced by solar eruption and CME (coronal mass ejection). Obtain more information about plasma anomalies investigating the magnetic disorders and observing the spatial and temporal extent of plasma anomalies including the South-Atlantic anomaly, the Equatorial anomaly, etc.

De-orbiting device
Help mitigate the space debris issue in LEO using drag sails. Specific objectives for the payload are:

- Primary objective: develop and demonstrate an effective de-orbit mechanism for ESEO,
- Secondary objective: study aspects of the satellite / atmosphere interaction relevant to spacecraft drag and attitude dynamics.
AMSAT-UK Payload
Provide a downlink telemetry that can be easily received by schools and colleges for educational outreach purposes. The system includes L-band receiver and VHF transmitter.

GPS Receiver
Prove on board real-time sub-meter operational positioning, which has been demonstrated on ground by replicating the on board operations. The system is based on COTS baseband processing unit, providing the raw GPS measurements coupled with a custom on board computer performing data filtering and precise orbit estimation.

AODCS Software Experiments
Provide an in-situ platform for advanced algorithms demonstration including attitude determination and control, fault tolerant attitude determination and control, orbit determination and control.
The baseline launcher for the ESEO Satellite is Vega, but a wide compatibility with other launch vehicle has been considered in the design of the mission and system:

- PSLV
- DNEPR
- ROCKOT
- SOYUZ
- FALCON

In particular the possibility of exploiting a VERTA launch (qualification phase of the Vega launcher) and VESPA adapter is considered.

**Target orbit:**

- SSO with 10.30 LTAN, 523 km

<table>
<thead>
<tr>
<th>Orbital Parameters</th>
<th>Mean System of Date</th>
</tr>
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<tbody>
<tr>
<td>Semi-major axis</td>
<td>6904.82699 km</td>
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<tr>
<td>Eccentricity</td>
<td>0.00134790</td>
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<tr>
<td>Inclination</td>
<td>97.47884°</td>
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<tr>
<td>Ascending Node</td>
<td>137.34203°</td>
</tr>
<tr>
<td>Argument of Perigee</td>
<td>67.74183°</td>
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<tr>
<td>True Anomaly</td>
<td>292.25995°</td>
</tr>
</tbody>
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Coverage:

Maximum Revisit Time (RC 15+01/07)
WHY A LOW-COST EDUCATIONAL SPACECRAFT?

• Large scientific and technological programs have very long development times and are incompatible with hands-on education
• Let’s compare NASA/ESA/ASI Cassini-Huygens with ESA’s ESEO:

<table>
<thead>
<tr>
<th></th>
<th>Cassini-Huygens</th>
<th>ESEO</th>
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<tbody>
<tr>
<td>Mission Concept</td>
<td>1982</td>
<td>2007</td>
</tr>
<tr>
<td>Start of Mission Implementation</td>
<td>1989</td>
<td>2013 (current)</td>
</tr>
<tr>
<td>Launch</td>
<td>1997</td>
<td>2016 (TBC)</td>
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<tr>
<td>Development time</td>
<td>8 years</td>
<td>30 months</td>
</tr>
<tr>
<td>Number of people involved</td>
<td>+5000</td>
<td>250 (TBC)</td>
</tr>
<tr>
<td>Budget</td>
<td>$3.27 Billions</td>
<td>~ 2.5 M€</td>
</tr>
<tr>
<td>Cruise Time</td>
<td>7 years</td>
<td>~ 25 min</td>
</tr>
<tr>
<td>From Implementation to Target Orbit</td>
<td>15 years</td>
<td>3 years (TBC)</td>
</tr>
<tr>
<td>Years of Operations</td>
<td>20</td>
<td>0.5</td>
</tr>
</tbody>
</table>
• ALMASpace/UniBO selected as System Prime Contractor
• Involvement of 10 EU Universities + AMSAT-UK
• 60+ students involved on site plus ~120 at their home institutions
• ESEO launch currently foreseen at end 2015/beg 2016
• ESEO’s “mantra”:
  “I hear and I forget; I see and I remember; I do and I understand” *

*Confucius - China's most famous teacher, philosopher, and political theorist, 551-479 BC

Students make up in enthusiasm what they lack in experience!
Thank you!

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