Space Research at CISAS - University of Padua

CISAS

P. Benvenuti

- Solar System Physics
- Astronomy and Astrophysics
- Space systems
- Space Propulsion
- GPS Geodesy and Geophysics
- Technology Transfer
Vorrei renderti visita
nei tuoi regni longinqui
o tu che sempre
fida ritorni alla mia stanza
dai cieli, luna,
e, siccom'io, sai splendere
unicamente dell'altrui speranza.

Andrea Zanzotto (1921 – 2011)
Center for Studies and Activities for Space “G. Colombo” - Start date January '91.

Current Director: Prof. Piero Benvenuti
Past Director: Prof. Francesco Angrilli
CISAS constitution

- CISAS includes more than 40 members, plus ~50 among technicians, graduate fellows and engineers with external and internal post-doc grants.

- Member Departments make available their own laboratories and infrastructures to CISAS staff.

- New equipment and instrumentation is continuously acquired by the Center.

- The foundation of CISAS rests on the tradition in Space Research developed at the University over the last 30 years and initiated by

Prof. Giuseppe “Bepi” Colombo
CISAS’ mission

CISAS, by means of space studies and research, aims at the interdisciplinary formation of Graduates and Researchers with solid knowledge in the fields of:

- fundamental sciences
- applied research
- industrial and managerial activities.
National and International Collaboration

Main International programs

Mars Express, Venus Express (ESA)
Rosetta (ESA)
Mars Sample Return (NASA-CNES-ASI),
International Space Station (NASA-ESA-ASI, JAXA),
Cassini Huygens (ESA-NASA-ASI)
Bepi Colombo (ESA-ASI, JAXA)
Exomars (ESA-ASI, NASA)
Solar Orbiter (ESA-ASI, NASA)
LaPlace (ESA-ASI, NASA)
Present Missions

- **CASSINI-HUYGENS**
  - HASI Experiment
  - Thermo mechanical Analysis for OMEGA-VIMS

- **PFS for MARS EXPRESS and VENUS EXPRESS**
  - Infrared Spectrometer for research of pre-biotic and biotic substances in Mars and Venus atmospheres

- **ROSETTA**
  - WAC Osiris Telescope
  - OSIRIS Meccanisms
  - Thermo mechanical studies and design for VIRTIS
  - A/B Phases Project for GIADA

- **Stratospheric Balloon Campaigns**
  - Trapani Italian ASI base
  - Kiruna Swedish base
Future Missions

- **Bepi Colombo: mission to Mercury (ESA)**
  - SIMBIO-SYS System Management

- **Mars Exploration Program (ESA-NASA)**
  - Drilling system testing
  - Entry Descent and Landing instrumentation

- **LaPlace (ESA-NASA)**
  - High Resolution Telescope

- **Sounding – Radar Antenna** (ESA Tender won)

- **Solar Orbiter – METIS (ESA)**
  - Solar coronograph
CISAS Space Robotics

- Free-floating robot
  - Laboratory mockup (2D, 3D)
  - Parabolic flight environmental testing

- IPSE for “Mars Sample Return” (NASA JPL)
  - Robotic arm
  - Micropositioning system
  - Gimbal for Space Telescope

- Autonomous Landing and Precision Landing Test Facility
  - (collaboration with Gavazzi Space)

- Autonomous soil penetrator MOLE (ESA Contract in coll. with Tecnomare)

- Biomimetic Robot
  - Walbot (collaboration with Carnegie-Mellon University)
  - Gaia

- PiezoRobot
CISAS leads the international team SIMBIO-SYS at system level.
Cassini Huygens Missione: Saturn system Exploration

Cassini Orbiter

Sonda Huygens

Huygens landed on Titan (14 January 2005)
Rosetta Mission

CISAS Contribution

- WAC Telescope
- OSIRIS Mechanisms
- VIRTIS Spectrometer
- Lander: Solar Panel Qual
Wide Angle Camera Telescope
Mars “seen” by OSIRIS

Some Results

- Viking 2
- Hecates Tholus
- Bysium Mons
- Albor Tholus
- Isidis Planitia
- Terra Cimmeria
- Olympus Mons
Mars atmosphere seen by OSIRIS

Some Results
Some Results (Rosetta WAC)
The Mole Ground Demonstrator is intended to be a test bench to develop and prove in terrestrial conditions the soil penetration technology for a future Subsurface Explorer (SUBEX), which will perform a deep excavation and analyse, by means of an on board specialized instrumentation package, at different depths the Mars subsoil.

The demonstrator has been developed in cooperation with Tecnomare Spa. (European Space Agency Invitation to tender)

### Modules

**Module 1:**
- Sub system for drilling operation

**Module 2:**
- Electronic & subsystem for holding

**Module 3:**
- Payload & sensor
The NAVIGATOR System

Image Acquisition
Image Matching
Terrain Reconstruction
Landing Site Selection
Trajectory Control
GPS Geodesy

- Data acquisition for permanent regional geodetic networks.
- Monitoring of cinematics and dynamics of alpine slopes with GPS techniques.

Measure of earthly gravitational field

- Italian Working Group for the GOCE Mission (ESA).
Hypervelocity and Aerospace Propulsion
The CISAS hypervelocity launcher is unique in the world

- Complete diagnostics of high-velocity phenomena (high-speed pictures, measurement of shocks and fast transient vibrations, electromagnetic emission detectors)
- Numerical tools for high speed transient gas-dynamics (CFD)
- Numerical tools for impact phenomena (SPH, FEM, FEA)
**MAIN PERFORMANCE**

- Speed range: 0.3 - 6.0 km/s
- Projectile mass: 150 mg @ 6 km/s - 500 g @ 300 m/s
- Shot frequency: up to 10 shots/day
- Barrel diameter: 4.76 or 6 mm
- Barrel length: 1.5 - 2.5 m
Hypervelocity
Aerospace Propulsion

- Electrical Propulsion
- Hybrid Propulsion
Space plasma thrusters based on helicon antennas.

Extreme scalability
- Small pushes for position control and satellite-formations attitude
- Primary propulsion for interplanetary probes.

High-efficiency / low-thrust (plasma only)

Low-efficiency / high-thrust (plasma-hydrazine).

End results:
- Operating technology demonstrator
- Numerical code
Electrical Propulsion
Variable Specific Impulse Plasma Thruster
One system including primary propulsion and attitude control

Constant power throttling: Thrust and specific impulse variation
Generation and heating of plasma avoiding electrode erosion
Specific impulse variation between 3000-10000 s

LEO-GEO transfer mass savings
Interplanetary trajectory towards inner and outer planets
Low power used (max 10 kW)

Hybrid PIC simulation of plasma source and plasma acceleration (ion beams) for industrial applications

European FP7 tender won (3.5 M€)
Hybrid-thrusters

Main aspect of hybrid thrusters
- Low development costs
- No safety requirements
- Thrust throttability
- No storage issues
- Higher specific impulse than solid
  (280 s vs 230 s for solid thruster)

CISAS Activities
- Numerical modelling of thruster
- Thruster ground test-bed
- Development of mini-University-Launcher for student training
Technology transfer – last but not least

Robotics and space image reconstruction applied to shoes’ industrial manufacture
Automatic Modelling & Cutting

3D Model

2D flattening for leather or synthetic fabric cutting

Algorithm validation

Prototype