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

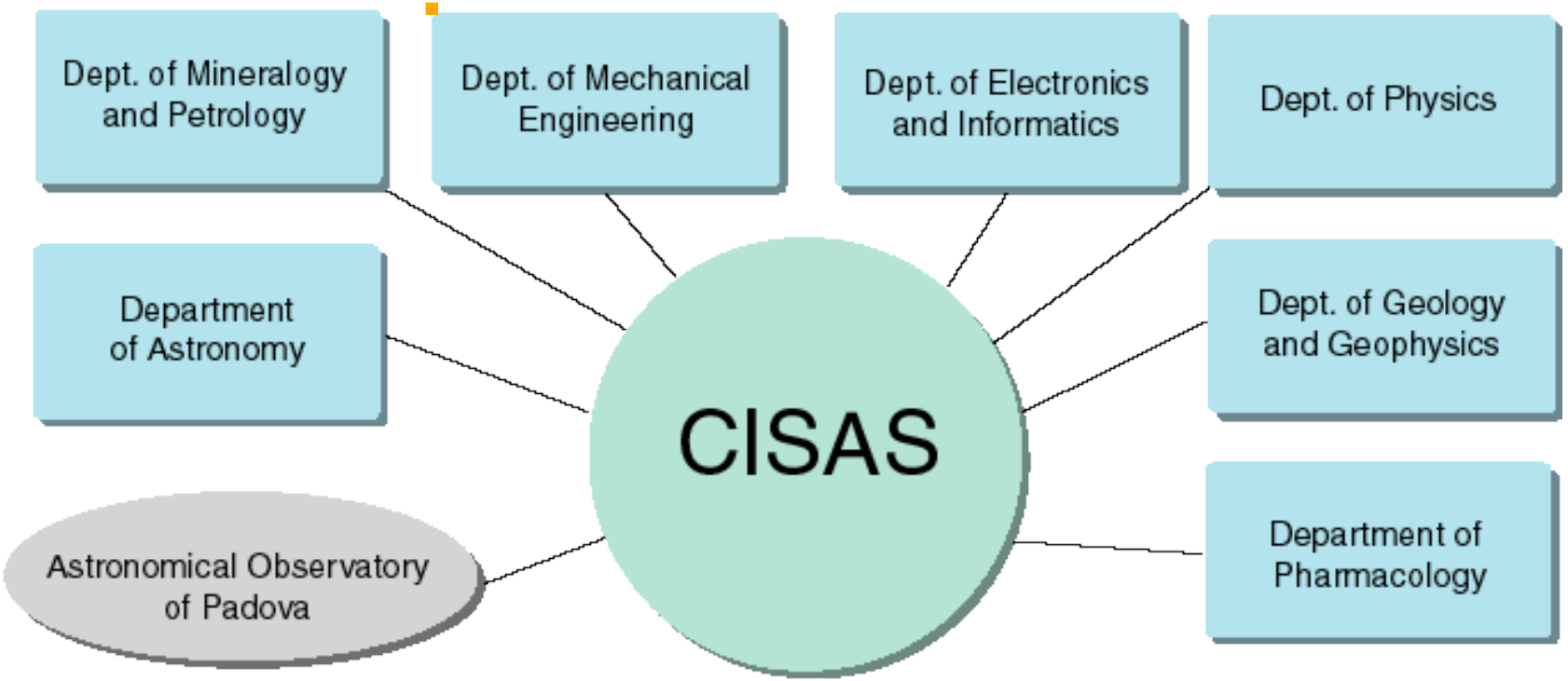
***Nautica Celeste*, da *IX Ecloghe*, 1962**

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.

CISAS



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

CISAS consitution

- CISAS includes more that 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 fundation 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

CISAS

- ***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

CISAS

- ***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)**

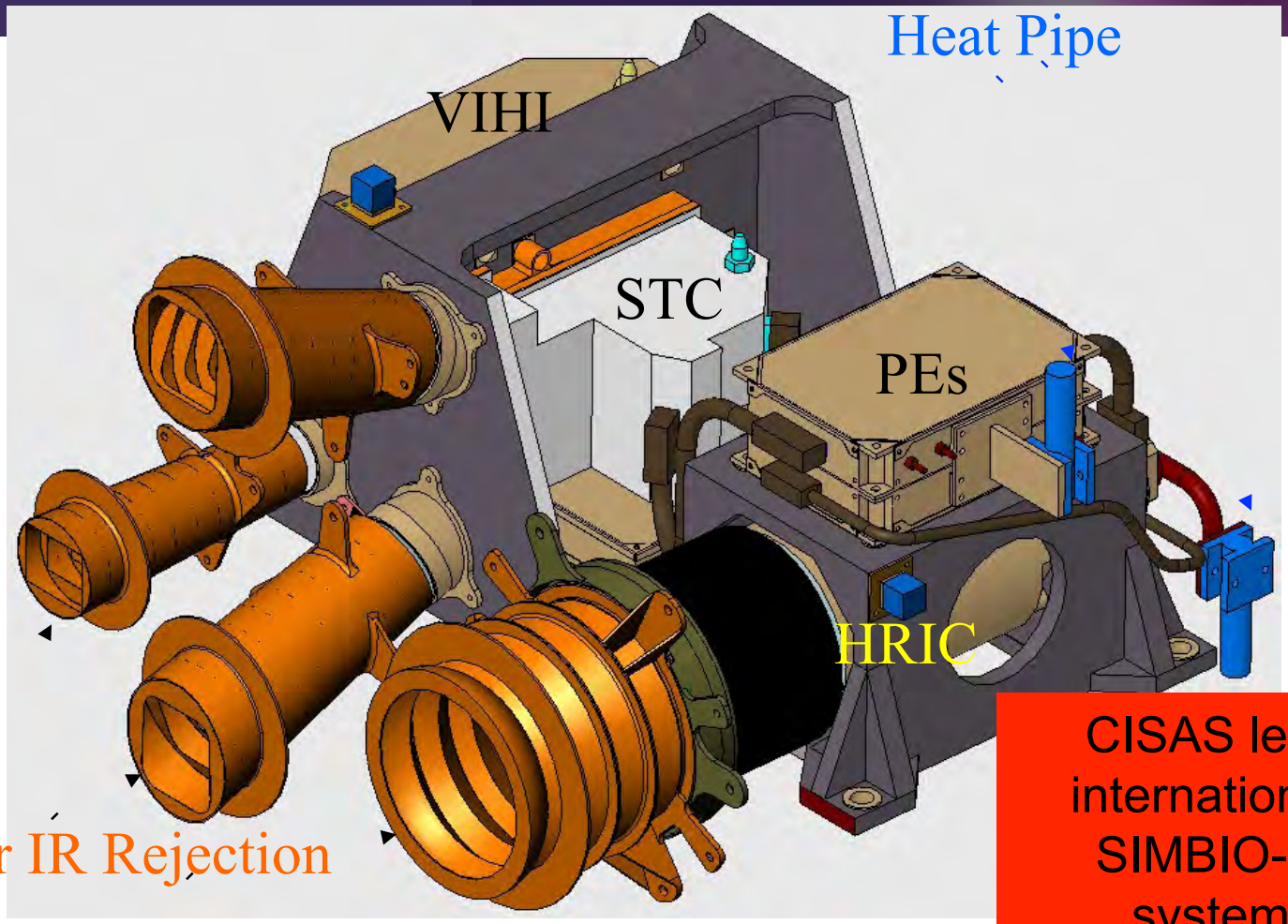
    Solar coronograph

CISAS Space Robotics

CISAS

- **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**

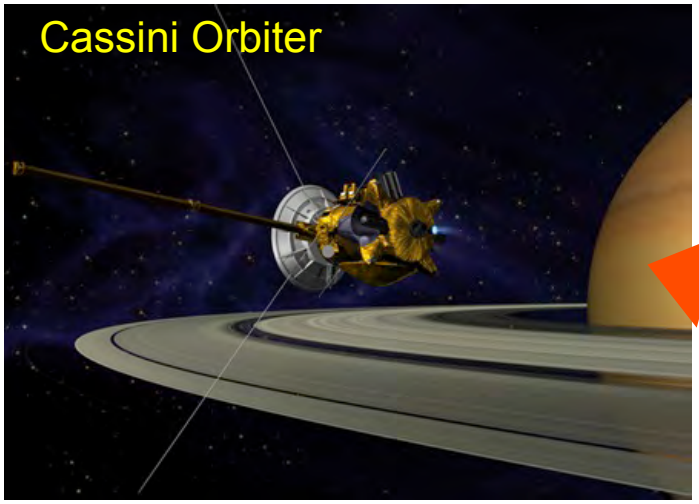
SIMBIO-SYS



Baffles for IR Rejection

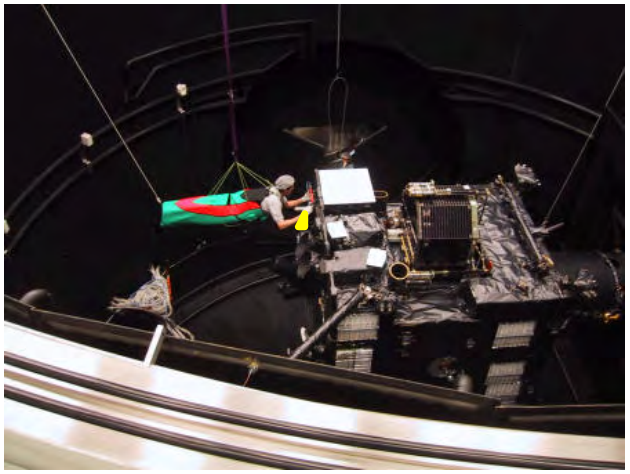
CISAS leads the international team SIMBIO-SYS at system level

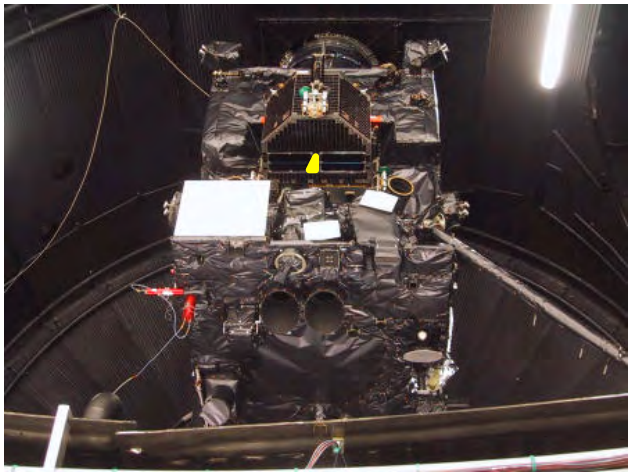
Cassini Huygens Missione: Saturn system Exploration



Huygens landed on Titan
(14 January 2005)

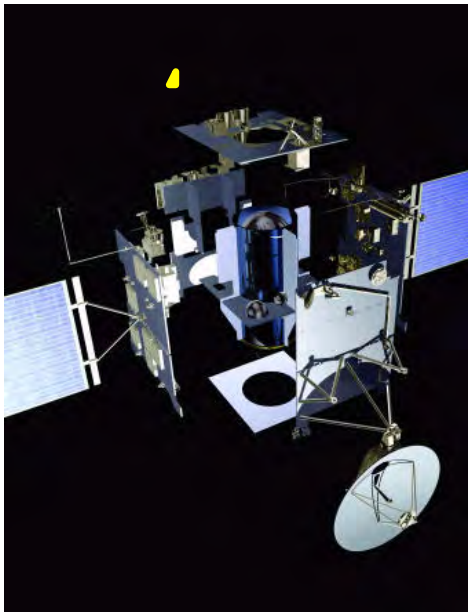
Rosetta Mission





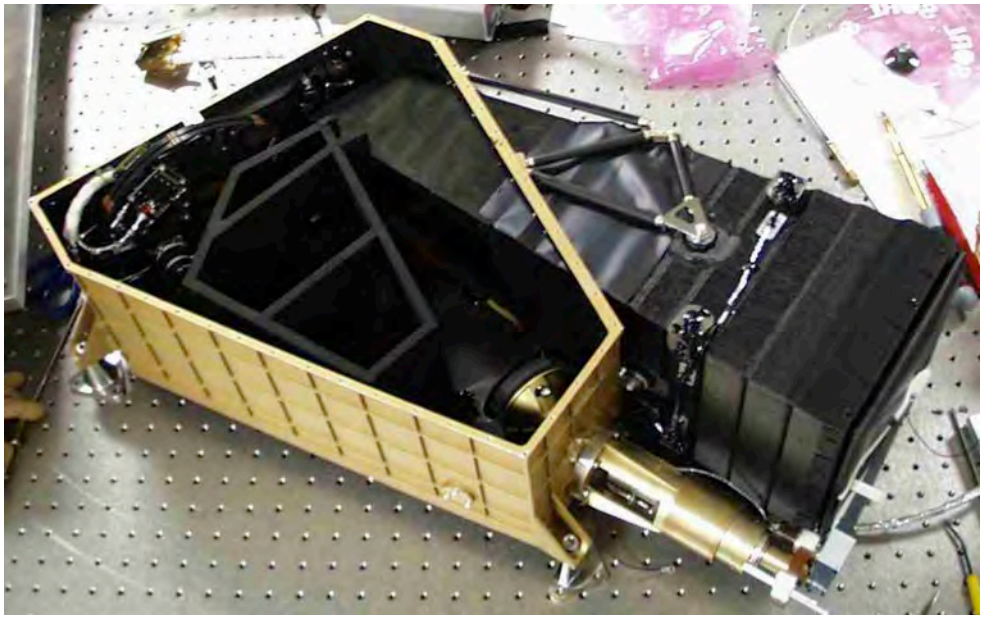
CISAS Contribution

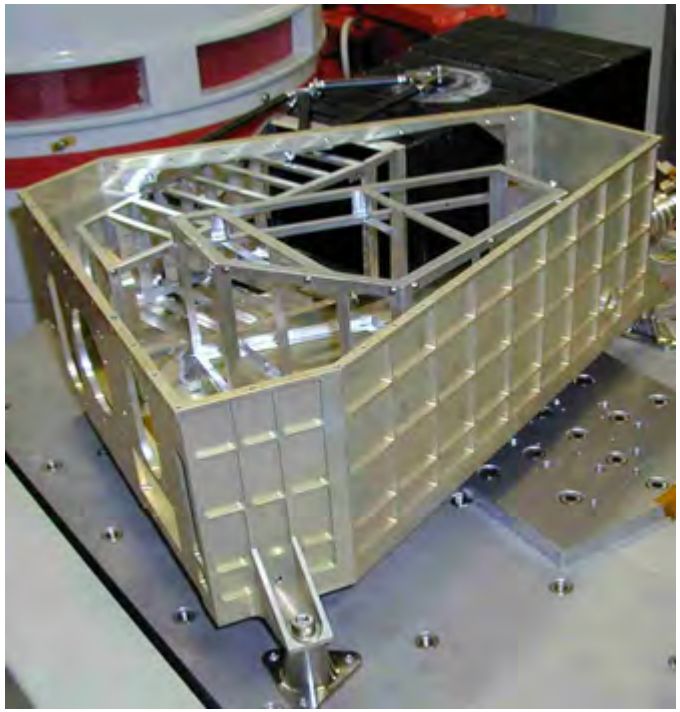
- WAC Telescope
- OSIRIS Mechanisms
- VIRTIS Spectrometer
- Lander: Solar Panel Qual



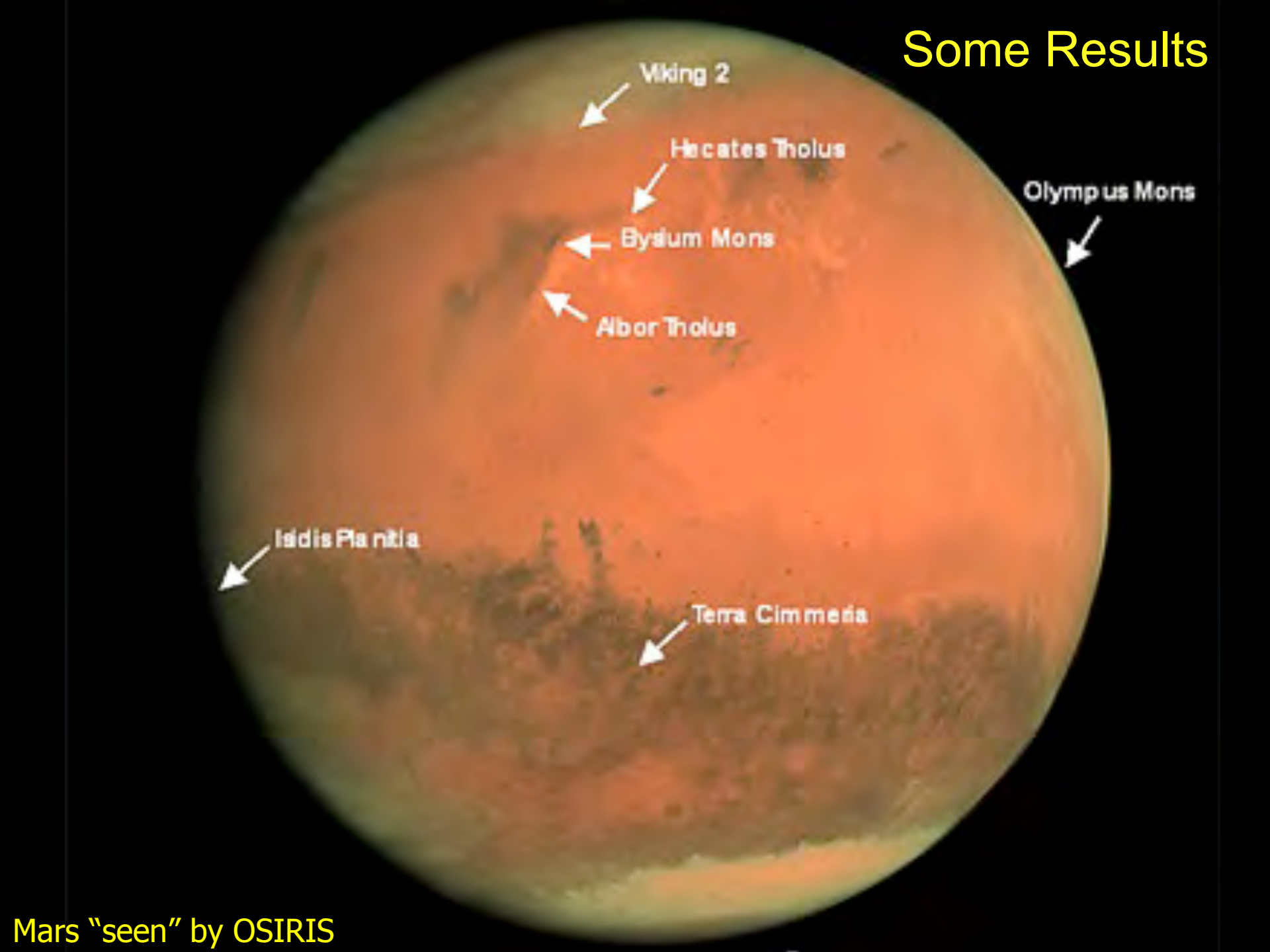
Wide Angle Camera Telescope

CISAS



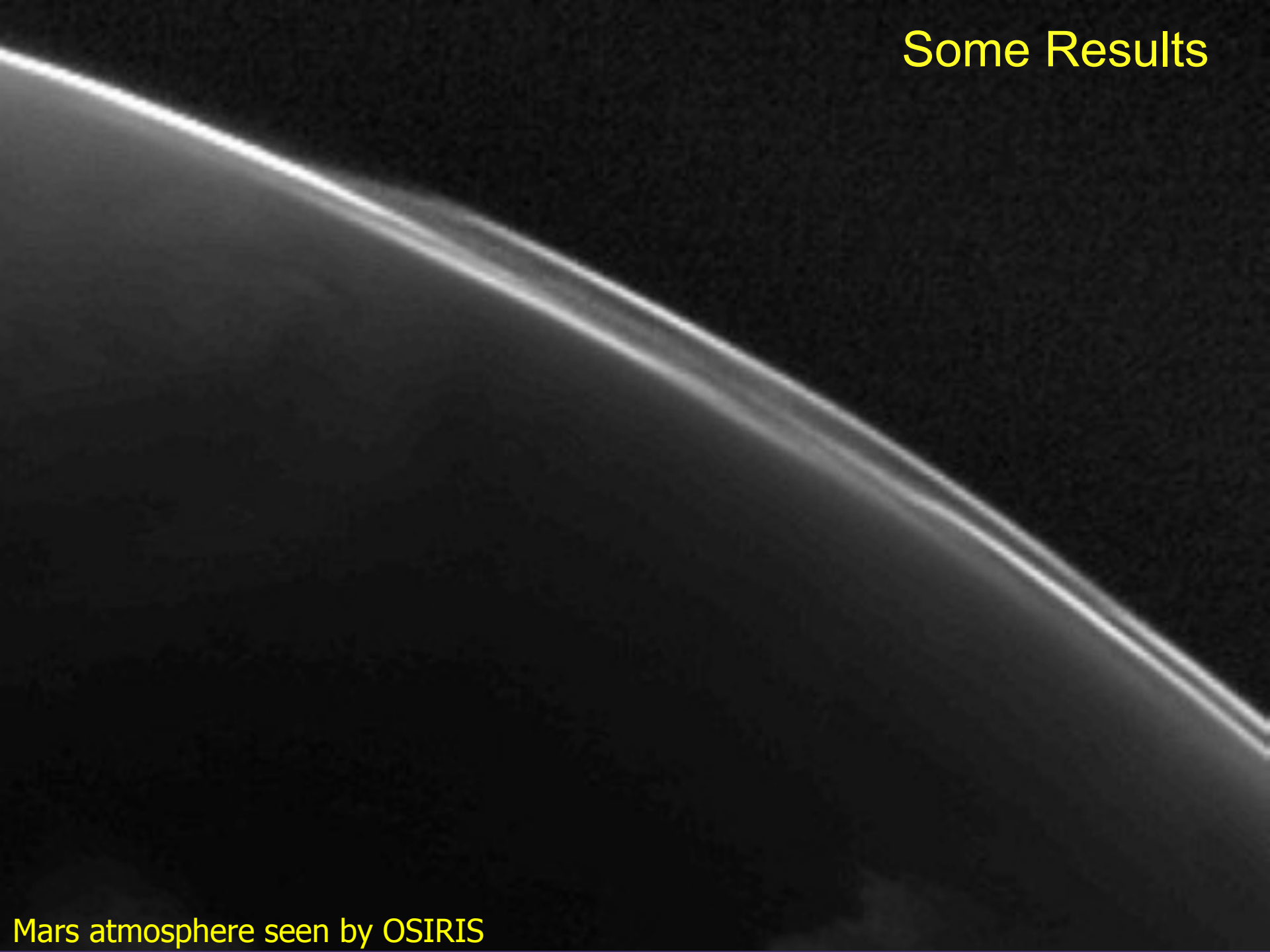


Some Results



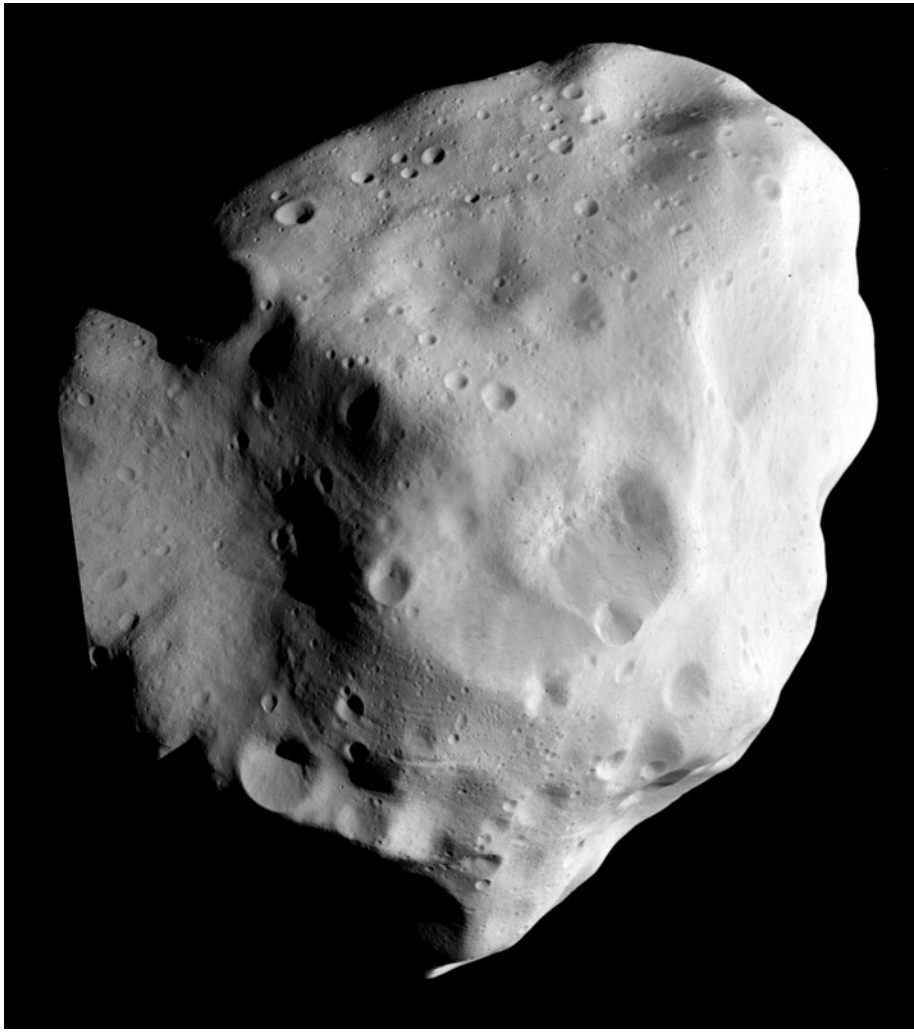
Mars "seen" by OSIRIS

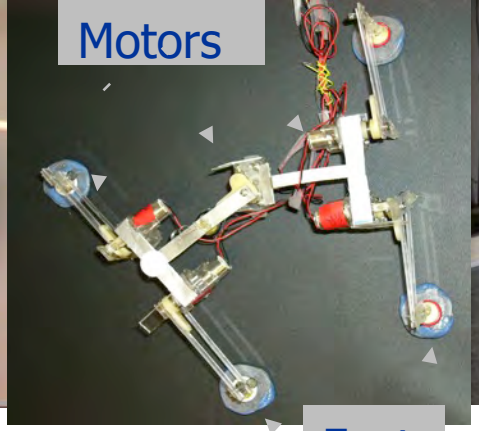
Some Results



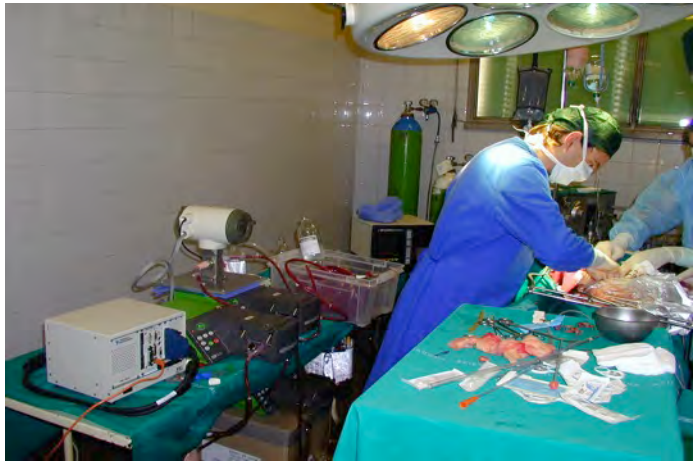
Mars atmosphere seen by OSIRIS

Some Results (Rosetta WAC)





Robotics and Automation



Mole for Mars Exploration

CISAS

Module 3:

payload & sensor

Module 2:

Electronic & subsystem for holding

Module 1:

sub system for drilling operation

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.

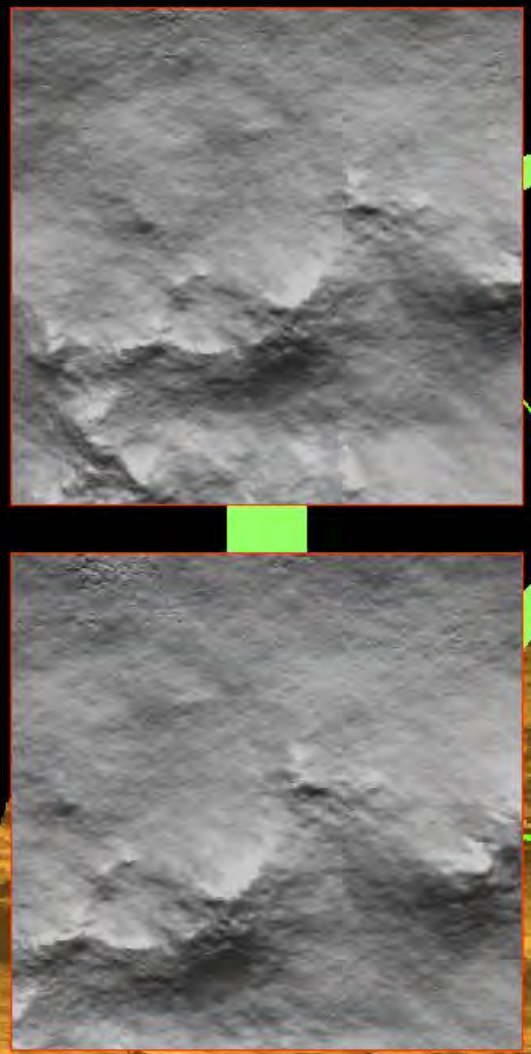
The demonstrator has been developed in cooperation with Tecnomare Spa. (European Space Agency Invitation to tender)

Eni Tecnomare

esa

The NAVIGATOR System

Carlo Gavazzi Space SpA



- Image Acquisition
- Image Matching
- Terrain Reconstruction
- Landing Site Selection
- Trajectory Control

GEOPHYSICS & SPACE GEODESY

CISAS

→ GPS Geodesy

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

→ Measure of earthly gravitational field

- Italian Working Group for the GOCE Mission (ESA).

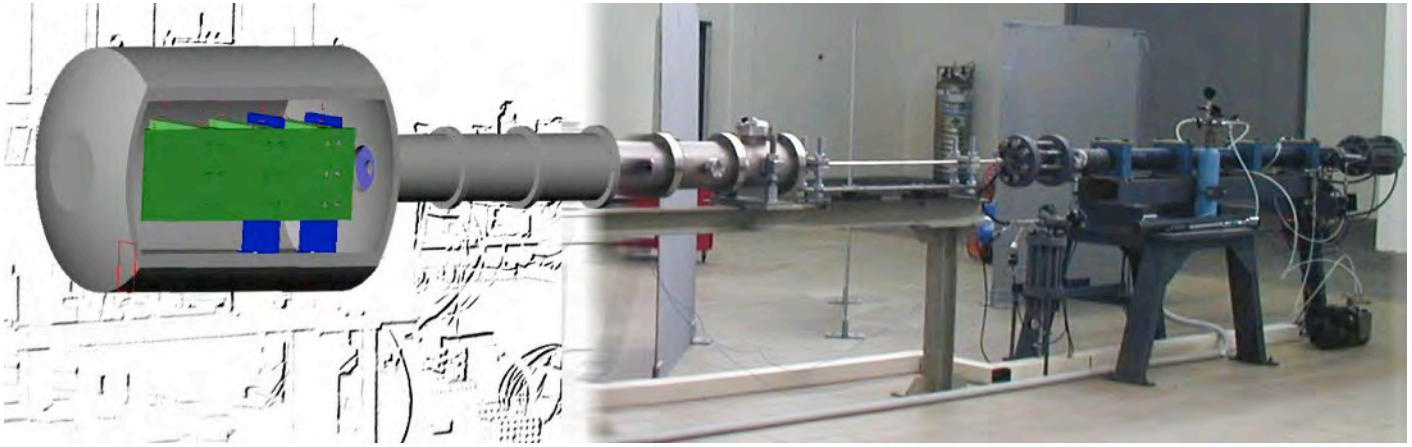
CISAS

Hypervelocity and Aerospace Propulsion

Torino, NEREUS , Oct. 19th 2011

CISAS Hypervelocity Impact Facility

CISAS



- **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)

CISAS Hypervelocity Impact Facility

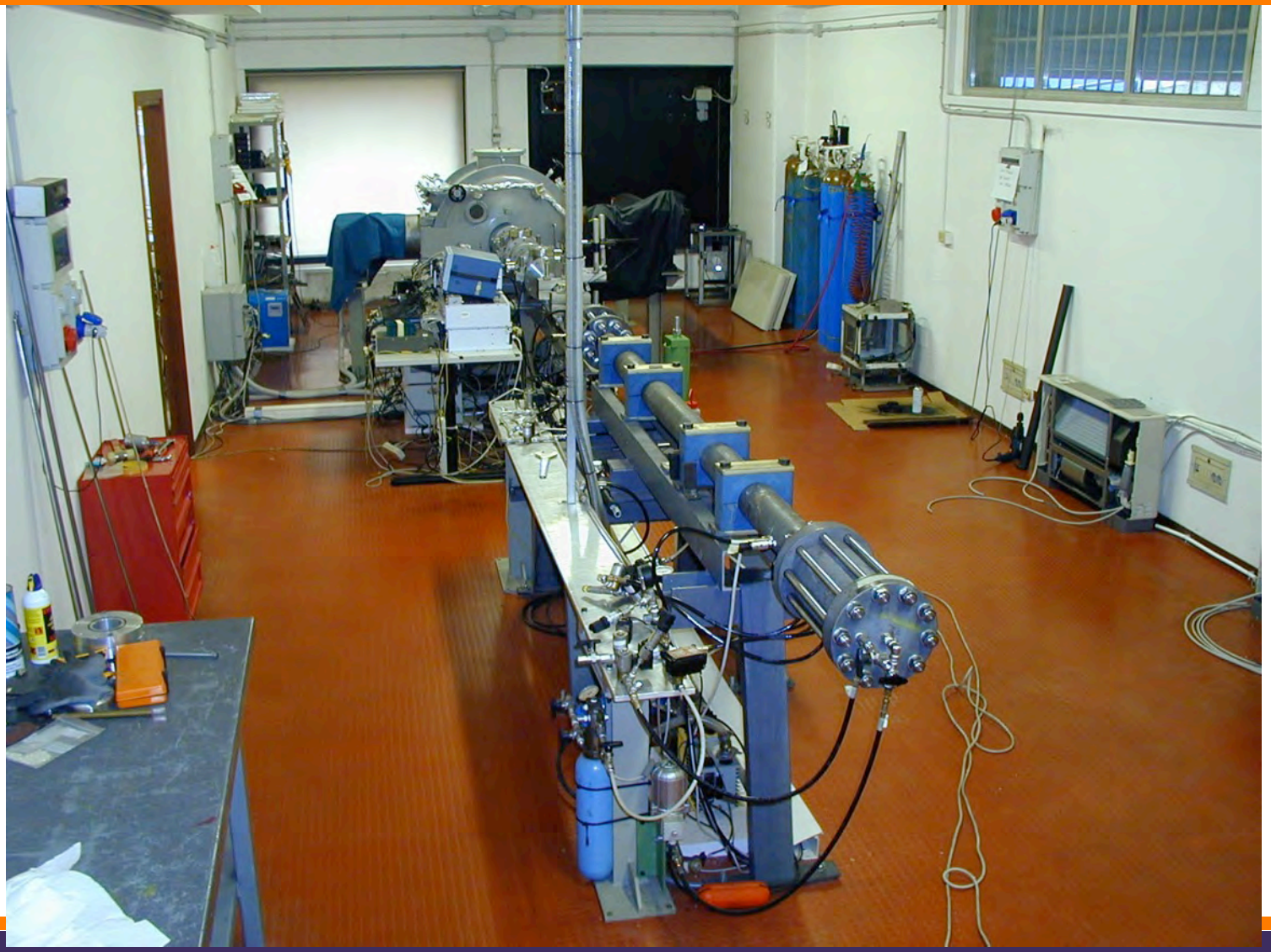
CISAS

MAIN PERFORMANCE

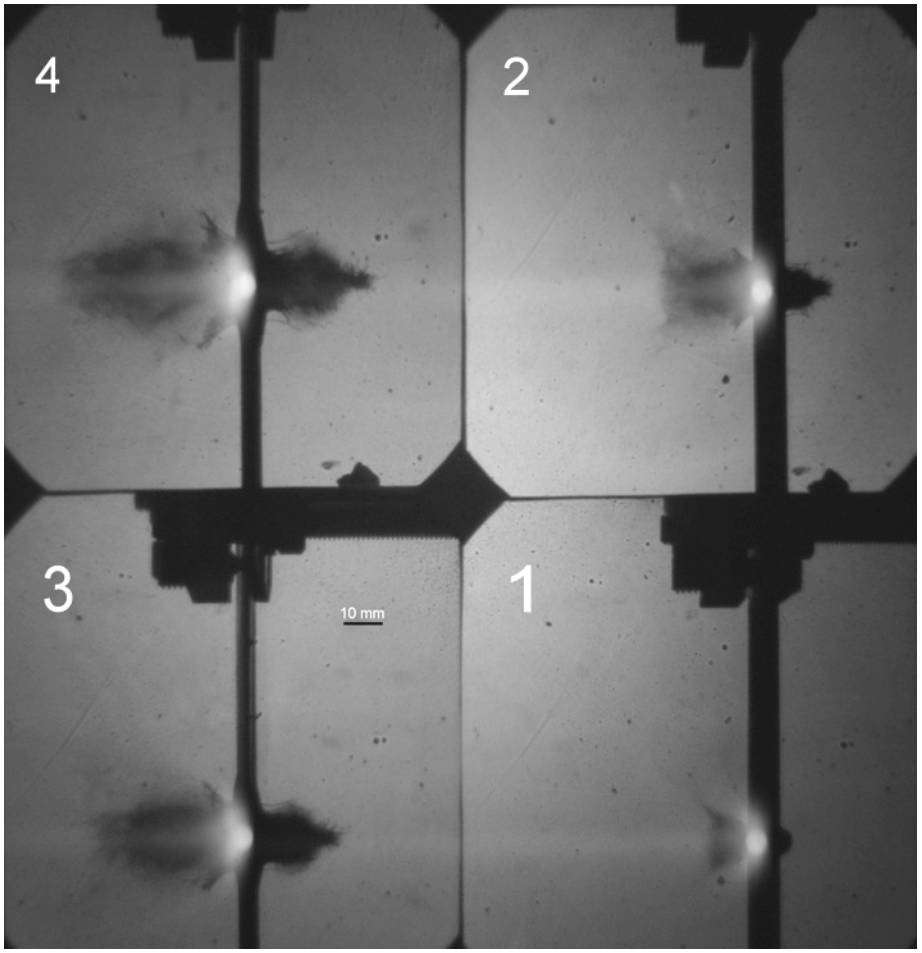
Speed range	0.3 - 6.0 km/s
Projectile mass	150 mg @ 6 km/s - 500 g @ 300 m/s
Shot frequency	up to 10 shots/day
Barrel diameter	4.76 or 6 mm
Barrel length	1.5 - 2.5 m

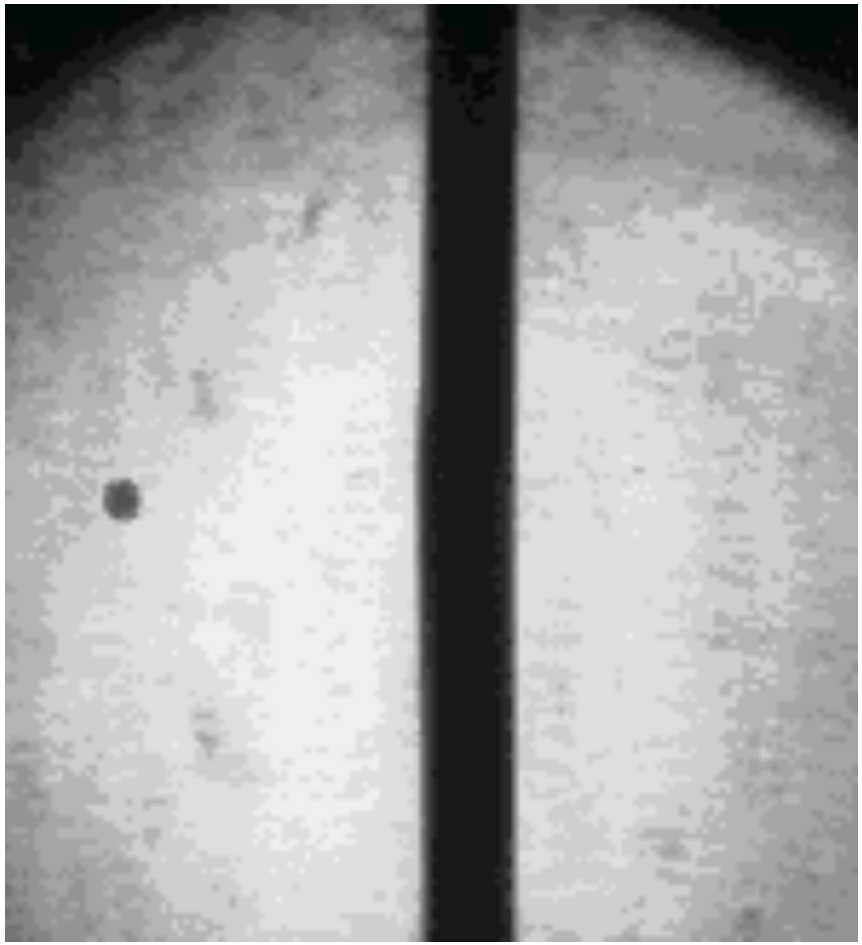
CISAS Hypervelocity Impact Facility

CISAS



Hypervelocity





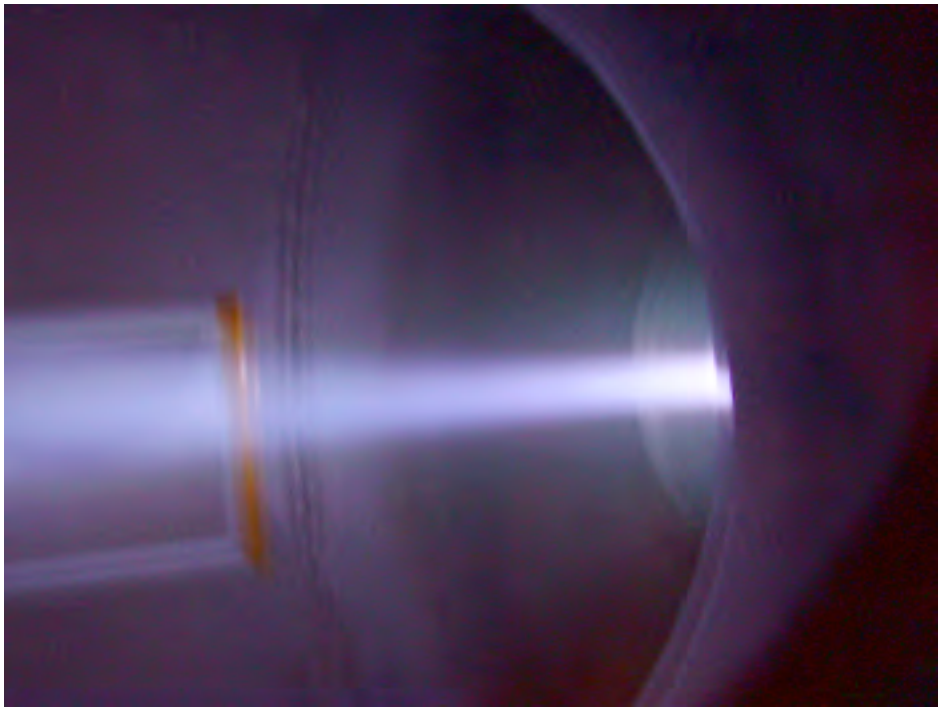
CISAS

Aerospace Propulsion

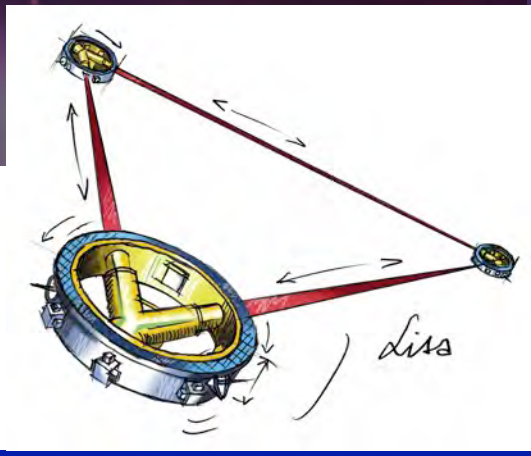
- **Electrical Propulsion**
- **Hybrid Propulsion**

HPH.com Project
Helicon Plasma Hydrazine. COmbined Micro

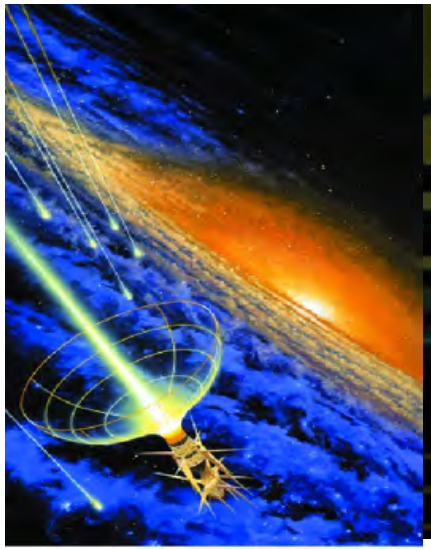
CISAS

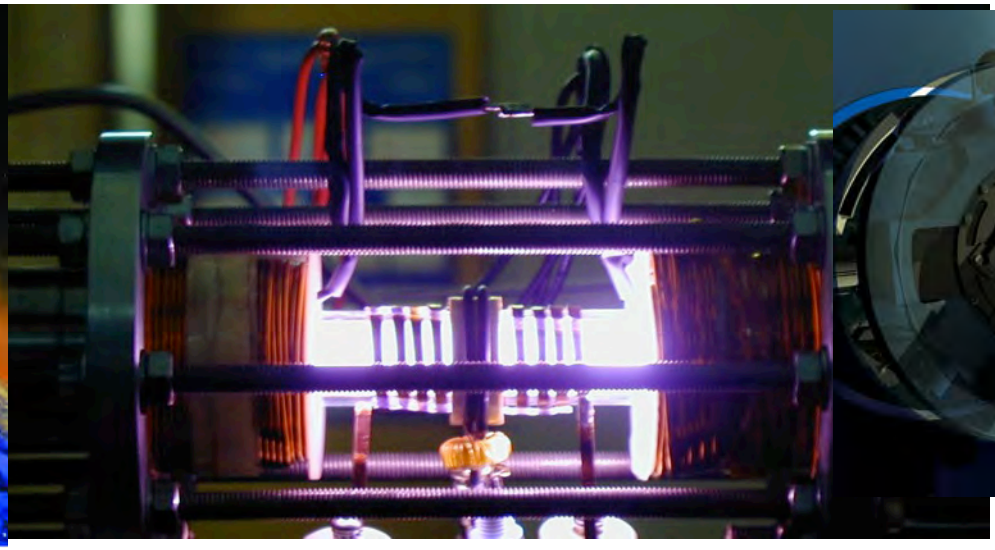


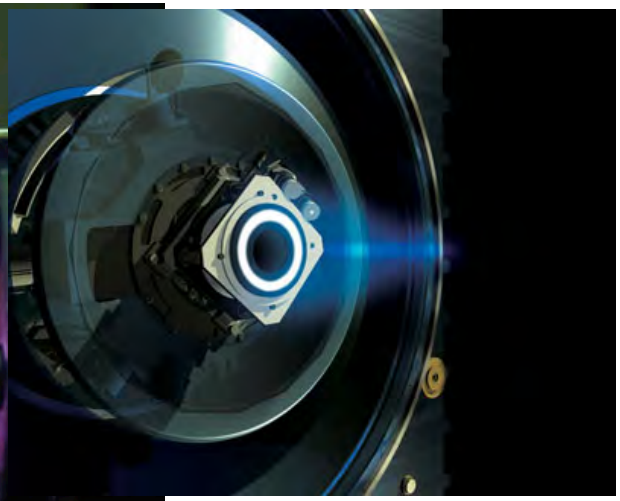
- ***Space plasma thrusters based on helicon antennas.***
- Extreme scalability
  - Small pushes for position control and satellite-formations attitude
  - Primary propulsion for interplanetary probes.
- High-efficiency / low-thrust (plasma only)
- Low-efficiency / high-thrust (plasma-hydrazine).
- End 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

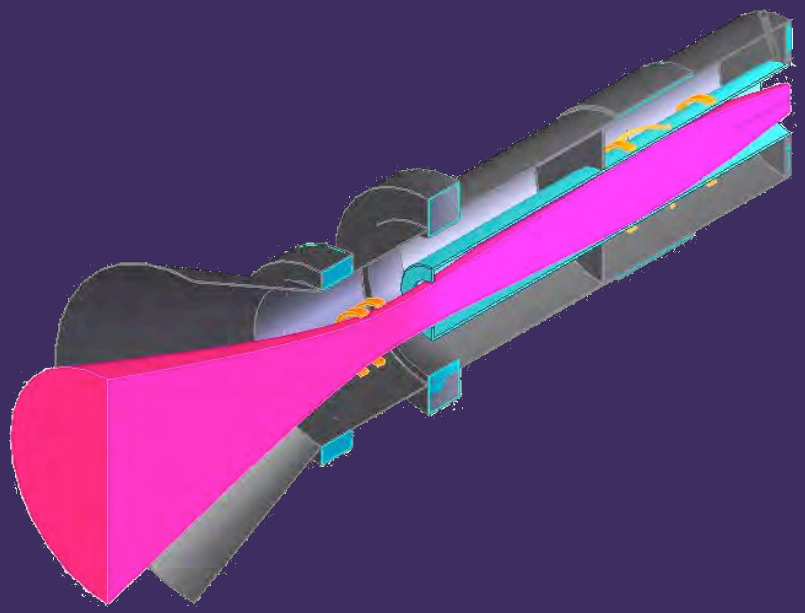
Generation and heating of plasma avoiding electrode erosion

Specific impulse variation between 3000-10000 s

LEO-GEO transfer mass savings

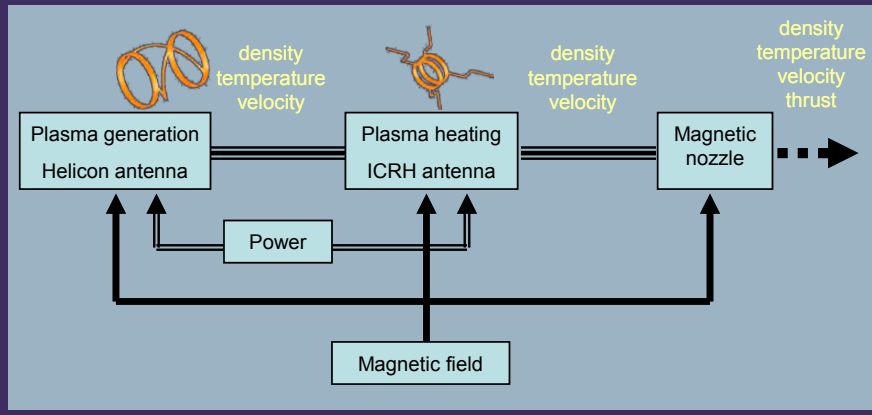
Interplanetary trajectory towards inner and outer planets

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€)



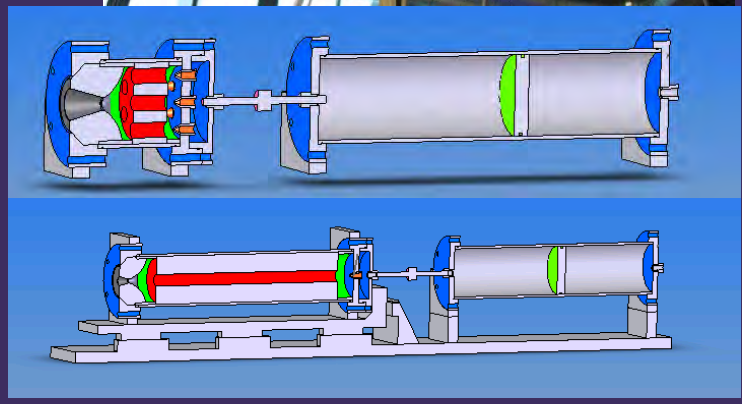
Hybrid-thrusters

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

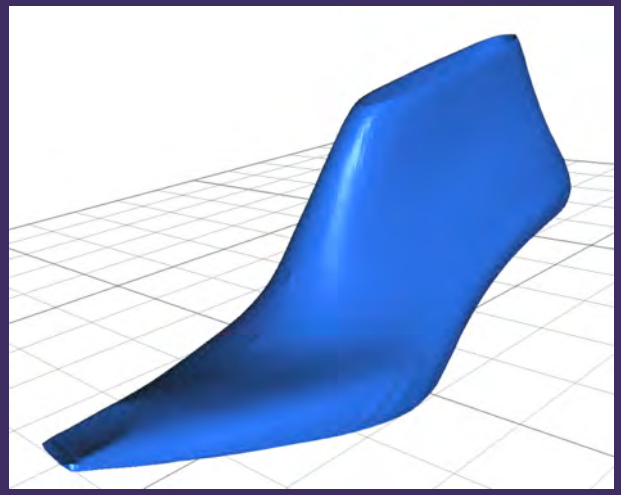


Technology transfer – last but not least

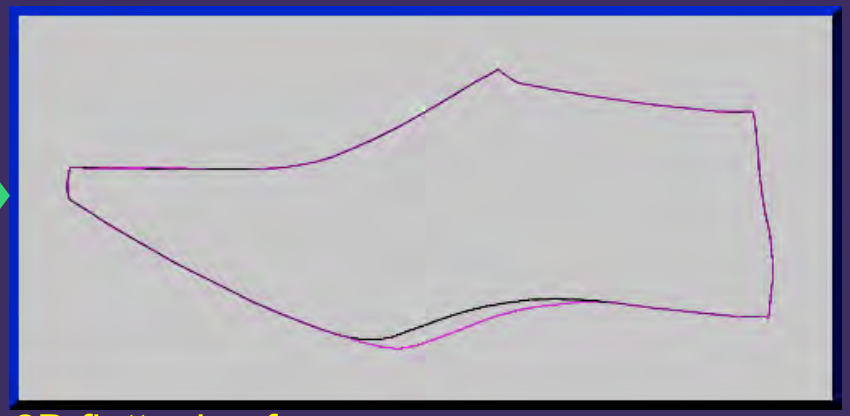
CISAS

Robotics and space image recostruction applied to shoes' industrial manifacture

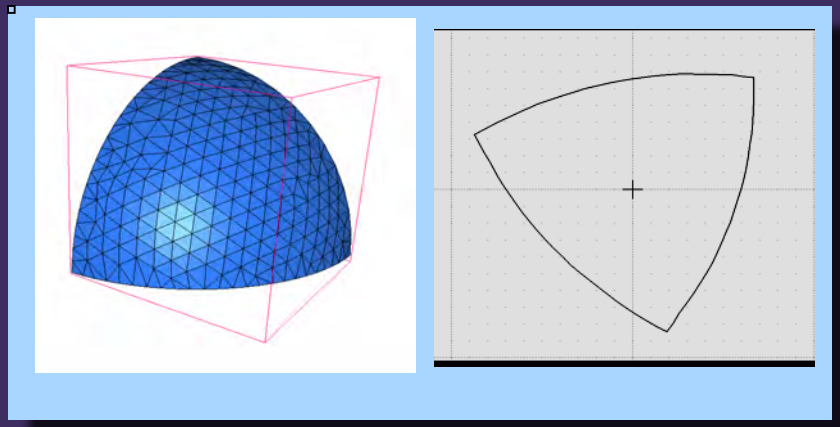
Automatic Modelling & Cutting



3D Model



2D flattening for leather or synthetic fabric cutting



Algorithm validation

Prototype