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NEWSLETTER DEL DIPARTIMENTO DI INGEGNERIA INDUSTRIALE DELL'UNIVERSITÀ DEGLI STUDI DI PADOVA

SPECIAL ISSUE
To the memory of Stefano Debei

DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

UNIVERSITÀ DEGLI STUDI DI PADOVA

C O P E R T I N A

In memoria di Stefano Debei
To the memory of Stefano Debei

P A G I N A

Cerimonia di intitolazione dell'aula M1 in onore del Professor Stefano Debei

Stefano Debei, già Professore ordinario presso il Dipartimento di Ingegneria Industriale e Direttore del Centro Studi e Attività per lo Spazio "Giuseppe Colombo" (CISAS) dell'Università di Padova, è stato ricordato il 7 settembre 2023, con la cerimonia di intitolazione dell'aula M1 nel Complesso Didattico di via Venezia del Dipartimento di Ingegneria Industriale.
Dopo la prematura scomparsa di Stefano, ricercatore di fama internazionale nel campo della strumentazione spaziale e dell'esplorazione del sistema solare, avvenuta prematuramente il 7 agosto 2022, tutti i docenti hanno deciso di dedicare alla sua memoria l'aula più grande dell'edificio.
L'evento si è aperto con il saluto e il ricordo della Rettrice dell'Università, prof.ssa Daniela Mapelli, seguito dagli interventi commemorativi dell'assessore regionale allo Sviluppo Economico Roberto Marcato, e della prof.ssa Stefania Bruschi, Direttore del Dipartimento. A seguire colleghi e amici hanno condiviso i loro affettuosi ricordi del suo lavoro: Federico Zoppas, presidente del Cluster Aerospaziale Veneto; Giampaolo Piotto, attuale direttore del CISAS; Enrico Flamini, ex capo scienziato dell'Agenzia Spaziale Italiana; Erasmo Carrera, presidente dell'Associazione Nazionale di Aeronautica e Astronautica. Tutti hanno parlato dell'instancabile impegno di Stefano e dei risultati ottenuti per il progresso dell'esplorazione spaziale.

"L'Università di Padova perde un grande scienziato - ha detto la Rettrice Mapelli - e io personalmente ho perso un caro amico: una notizia che ha lasciato di stucco me, come tutti coloro che lo hanno conosciuto. Impossibile non amare Stefano: un uomo brillante, sensibile, di rara e fine intelligenza, che ha affrontato la malattia con immensa lucidità e forza di volontà, senza mai perdere la speranza. La grande comunità che forma il nostro Ateneo si stringe attorno alla famiglia e agli amici, con un pensiero speciale per il figlio Cosimo, che è stato il suo primo pensiero e motivo di orgoglio."

Più di 200 partecipanti si sono uniti alla famiglia e agli amici di Stefano in questo saluto di commiato e in espressione di gratitudine per il suo impegno nello sviluppo dell'attività di ricerca del Dipartimento.

Sistemi aerospaziali

Aerospace systems

DII research group

Measurement and Technologies for Space
Flight dynamics and space systems

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Project activities have been carried out in collaboration with:
Alessio Aboudan

Center of Studies and Activities for Space "CISAS" G.Colombo

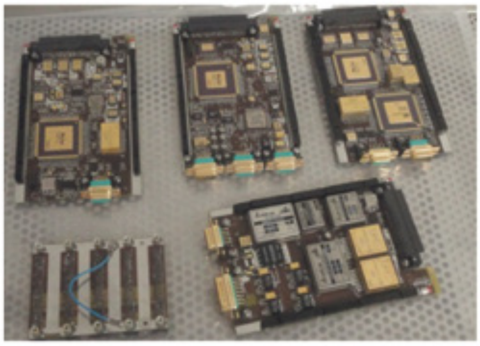
Main research topics:

- Measurements, instrumentation and technologies for aerospace applications

The modular central electronic unit (CEU) for data handling and management in Martian atmosphere investigations

A highly modular Central Electronic Unit (CEU) for data handling and management in Martian atmosphere investigations was designed, integrated and qualified as part of the DREAMS (Dust characterization, Risk assessment, and Environment Analyser on the Martian Surface) experiment in ExoMars 2016 Mission. The CEU was developed in a joint effort by TEMIS and the space research group headed by Stefano Debei at University of Padova to handle, acquire and transmit medium and low-rate data from sensors dedicated to investigating the Martian atmosphere. The system was designed to communicate with an external host to receive commands and transfer telemetry, transform power from different sources, perform sensors' switch on and off, acquire scientific sensors and their housekeeping monitors, and provide housekeeping data and health status. The high modularity of the CEU architecture makes it easy to customize and interface with different types of equipment and instrumentation for various missions.
The CEU was successfully operated during in flight checkouts of 2016 Mars mission and even switched on for nominal operation during Mars landing, achieving the maximum Technology Readiness Level 9 for planetary missions.

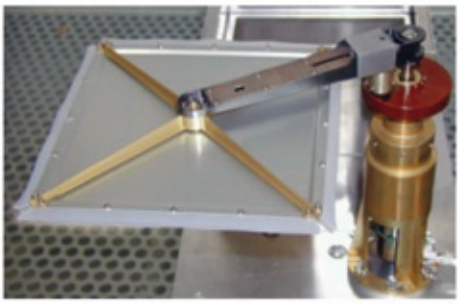
Flight Model for the CEU of DREAMS for EXOMARS 2016

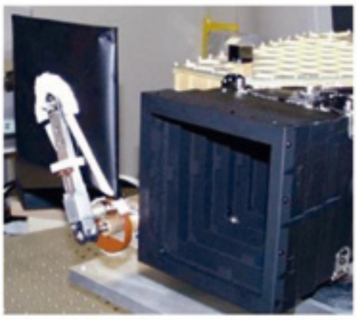


Example of Modularity of CEU configuration using different board configuration on common backbone

Front cover for space optical telescopes: a legacy from ROSETTA to JUICE

The Front Door Mechanism (FDM) for the OSIRIS experiment of the ROSETTA mission has been developed and optimised to provide protection of the telescope, reliable functioning and being single point failure tolerant. Its combined translational and rotational motion allowed also the preservation of internal calibration surface for the entire duration of the mission,.
The ROSETTA mission was launched in 2004 and reached the comet in 2014 after several gravity assists, and deep space hibernation. It has been orbiting around the comet for roughly two years collecting enormous amount of data of the peculiar celestial body and ended in September 2016.
The innovative design of the cover system developed for the protection of the telescopes allowes for a variety of options in its utilisation, from full dust and light tightness, to just partial detachment from the baffle surface. Also the details of the motion can be tuned to the needs of the mission.
Its reliability and robustness in a wide range of operative conditions has been have been demonstrated during the entire mission.
As legacy of the successful design of the front cover for the ROSETTA mission, another cover mechanics (Cover Mechanism - COM) for the JANUS Optical Head Unit of the JUICE mission has been prepared with very minor modifications to the initial design. All qualification has been successfully performed and the JUICE mission has been launched successfully on 14 April 2023 and is now travelling towards Jupiter and its moons.





Front Door Mechanism Flight Model in open position during characterization (top left) and mounted on the Flight Model WAC telescope (right)

COM subsystem and its components in rendering (left), flight model (centre), during vibration tests (right).

Sistemi aerospaziali

Aerospace systems

DII research group

Measurement and Technologies for Space
Flight dynamics and space systems

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- Measurements, instrumentation and technologies for aerospace applications

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Aerospace systems

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Main research topics:

- Measurements, instrumentation and technologies for aerospace applications

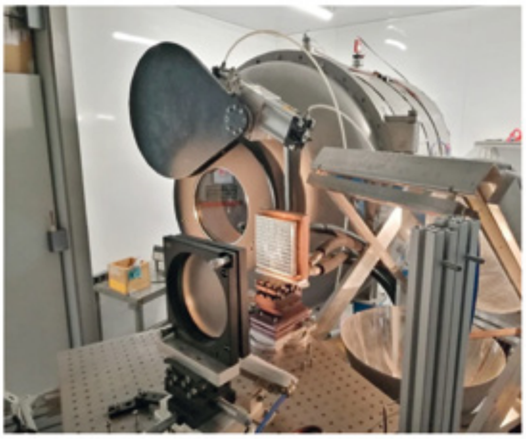
The High Flux Solar Simulator facility at Laboratory of Measurement for Space

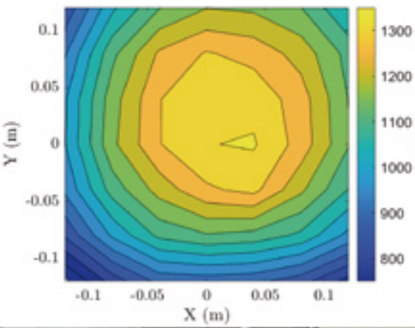
The High Flux Solar Simulator facility has been developed at University of Padova to study and assess the performance of satellite hardware for missions to the Solar System's inner planets.

The facility can reproduce the intensity and spectral distribution of the Sun's radiation up to 8 Solar constants (around 10000 Watt/m^2) and the emitted flux can be directed to the viewport of a Thermal Vacuum Chamber in order to test space equipment under representative pressure and temperature conditions. After the verification of optical path alignment, a series of tests has been conducted to evaluate the flux homogeneity installing a commercial pyranometer on cartesian reference and moving the slide within the target area. A final Class A classification for the spatial non-uniformity of irradiance as for ASTM E927-19 has been achieved.

The facility has afterwards operated for validation campaign of satellite radiators in simulated orbital condition, verifying the repeatability of reproduced flux during continuous long-term operation.

High Flux Solar simulator installed near the Optical aperture of Thermal Vacuum Chamber in the Laboratory of Measurement for Space





Mapping of radiative flux uniformity at the viewport of the thermal vacuum chamber

Verification of Solar Simulator flux during operation using a pyranometer and activating a remotely controlled shutter mechanism for input window

Designing reusable satellites for Europe

Sistemi aerospaziali

Aerospace systems

DII research group

Aerospace Propulsion
PROPAS

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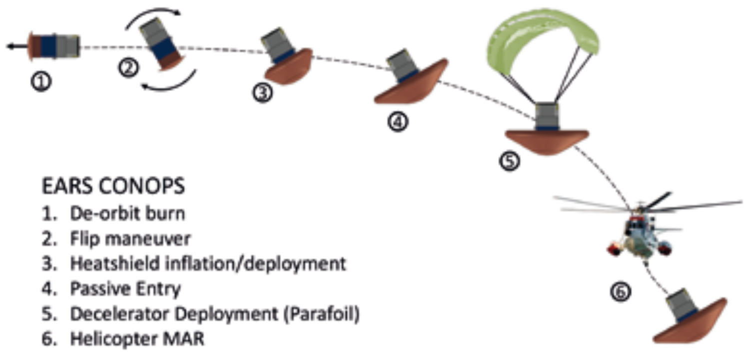
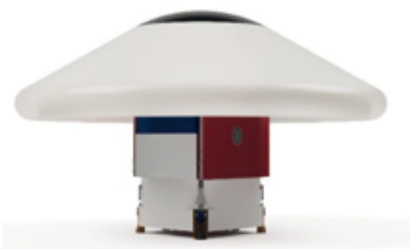
With the recent advent of large constellations of small satellites in Low Earth Orbit the problem of orbital debris has grown dramatically. Moreover, a typical satellite is very expensive and built only for a single mission. One way to reduce both costs and pollution in space is to do something that has never done before: design a satellite capable of operating in space, re-enter on Earth, be recovered and reused again multiple times. The EARS (European Advanced Reusable Satellite) project, funded by the European community through the Horizon program, has exactly this ambitious goal. The EARS project is led by CNR (Consiglio Nazionale delle Ricerche) and includes five other partners form all over Europe, including research centers, universities, small and large companies. UNIPD is responsible for the system design studies, defining the architecture and coordinating the technical contributions from the other partners. The EARS platform is based on the MP42 bus from Kongsberg Nanoavionics with the addition of two specific modules: an inflatable heat-shield on top and a recovery-propulsion section on the bottom. The propulsion system developed by T4i provides in orbit mobility and precise de-orbiting. The inflatable heat-shield allows for conventional operations during launch and in obit while guaranteeing a ballistic re-entry with relatively moderate thermomechanical loads. The von Karman Institute is in charge of developing the necessary thermal protections. After parachute deployment, a dedicated GNC unit developed by Deimos guides the parafoil toward a specific direction where the spacecraft is finally recovered in mid-air with a helicopter to avoid impact with the ground or the sea. The capability to recover the payload after each mission also opens up new possibilities to exploit microgravity conditions for scientific research and to produce ultra-pure crystals for several applications including high value sectors like the pharmaceutical and semiconductor ones. The final goal of EARS is to provide an affordable, flexible, frequent, sustainable access to Space for Europe.





EARS Partners
CNR-IFAC (lead)
DII-UNIPD
Deimos
Von Karman Institute for Fluid Dynamics
Technology for Propulsion and Innovation
Kongsberg NanoAvionics

Main research topics:

- Chemical Propulsion
- Electric Propulsion
- Plasma Antennas
- Very Low Earth Orbits (VLEO)

Funded by the European Union

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Italian Space Agency
European Space Agency
Politecnico di Milano

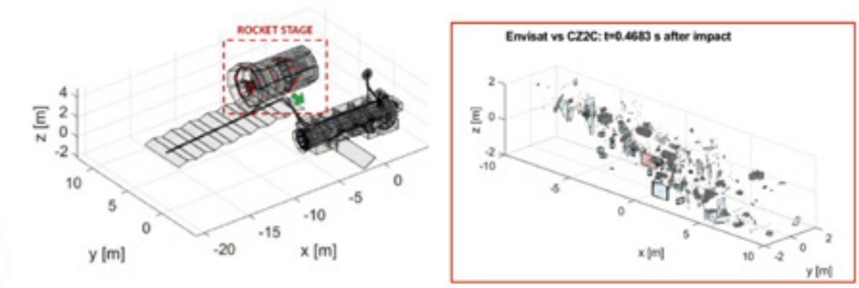
Main research topics:

Space debris:

- Spacecraft fragmentation
- Risk analysis
- Protection systems
- Risk mitigation

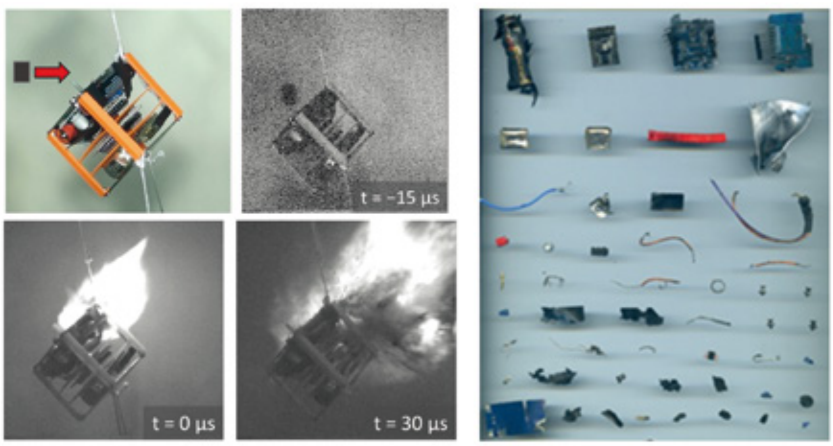
Simulating and modelling in-orbit spacecraft fragmentation

Space debris represent an increasing hazard for satellites orbiting the Earth. To reduce spacecraft vulnerability and to implement mitigation strategies, it is of utmost importance to understand how satellites break-up in consequence of collisions and explosions and how debris are generated. However, only limited information is available on space fragmentation, as ground observations are possible only for objects larger than ~5-10 cm. For this reason, numerical simulations and ground testing are used to integrate the missing information.
In this context, the FLIGHTDS/Space Debris research group has developed a semi-empirical software, CSTS (Collision Simulation Tool Solver), that produces statistically accurate results for complex simulation scenarios of collision and fragmentation events.
In CSTS, spacecraft are modelled as a net of Macroscopic Elements (MEs) of different materials, connected by structural links; collisions are represented as cascade events that involve different MEs. With this approach, it is possible to develop fragmentation models for different types of MEs instead of global models for specific satellite, with results that are more prone to generalisation.
Modelling is also supported by hypervelocity impact test campaigns: the data collected after collisions with sub-scale satellite models is employed both for developing the CSTS Macroscopic Elements and material libraries and for understanding the effect of high-velocity impacts on complex structures.



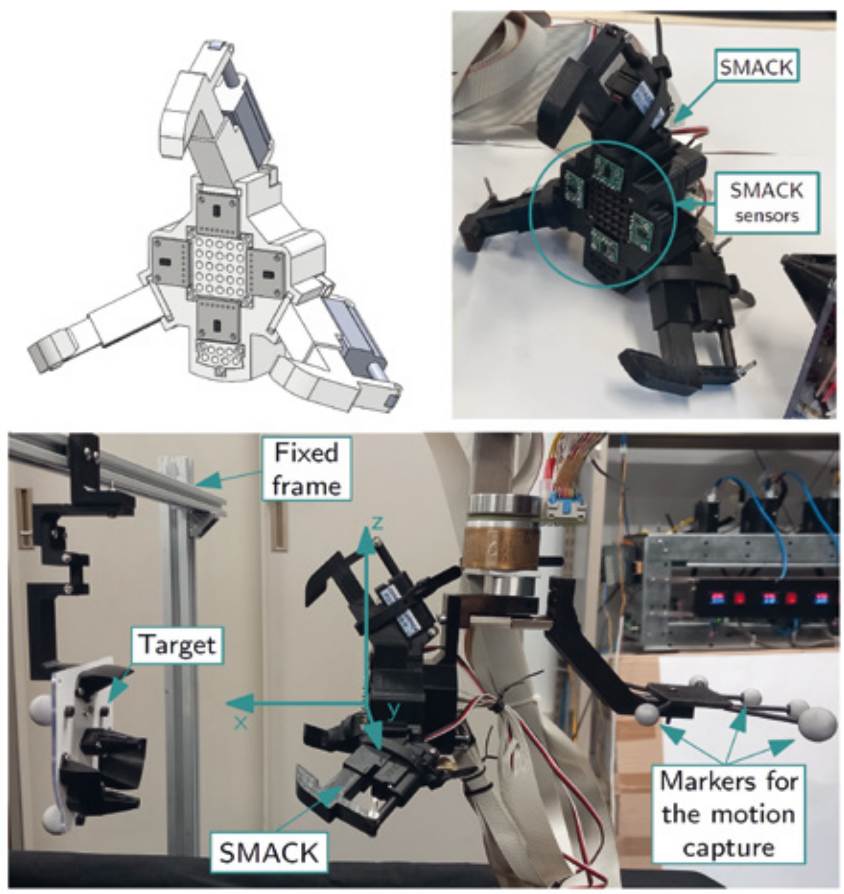
ABOVE:
ENVISAT breakup simulation:
collision scenario (left) and fragments generated by CSTS (right)

BELOW:
Ipact test on a satellite mock-up: frames from high speed camera (left) and a sample of the catalogued fragments (right)



AUtonomous Technologies for Orbital servicing and Modular Assembly (AUTOMA)

The possibility of manipulating objects in space is at the basis of several In-Orbit Servicing (IOS) mission scenarios whose aim is the life extension of existing satellites or the improvement of their functionalities. These results can be obtained by installing additional modules onto a target satellite, thus providing basic functions, like power generation, attitude control, propulsion or communication capabilities. One of the most promising technologies to implement IOS missions are space robots (satellites with one or more robotic manipulators) equipped with dedicated tools. The manipulators allow to berth to the target satellite, to capture / manipulate upgrade modules, and to attach them to the target. In order to advance in IOS technologies, the Department of Industrial Engineer has funded the AUtonomous Technologies for Orbital servicing and Modular Assembly (AUTOMA) project. The project aims at the progress in the development of a smart capture tool for space robots and to validate all the related technologies through experiments executed in relevant laboratory scenarios. The autonomous tool is called SMArt Capture Kit (SMACK) and it is equipped with (1) a suite of sensors to measure the relative pose during the capture procedures; (2) a set of actuators to grasp the module and keep a rigid connection during the manipulation; (3) a computer to execute locally the required software like guidance and navigation algorithms. In order to test the capture and assembly procedures, SMACK has been mounted on the end-effector of the six-degrees-of-freedom robotic arm available at the Space Systems Laboratory, while the target has been represented by a fixed structure. These tests proved the ability of SMACK to manage assembly tasks including the control of the robotic arm with satisfactory accuracy.



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Partners:
Dept. of Information Engineering, UNIPD
Università degli Studi di Napoli «Federico II»

Main research topics:

- Space debris: risk analysis, protection systems from hypervelocity impact, risk mitigation
- Active Debris Removal
- Miniaturized satellites: on-board technologies and payloads
- Systems for rendezvous and docking of satellites

Sistemi aerospaziali

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CISAS Center for Studies and Activities for Space Giuseppe Colombo

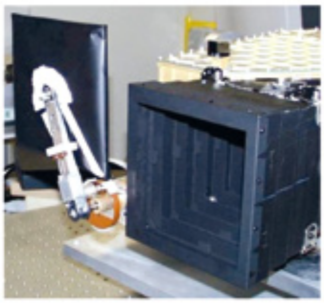
Main research topics:

- Flight Mechanics
  Aerospace flight dynamics
- Balloon and Drones Flights
- Space Systems
  Space Environment
- In orbit servicing
- Planetary Exploration

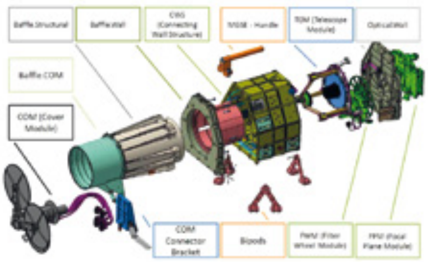
The Janus COM mechanism onboard the Juice probe to the Jovian System

This contribution stands as a heartfelt tribute, commemorating the legacy of our colleague and friend, Stefano. He dedicated all his efforts until the completion of the final space instrument crafted by his team at the Department. After the successful launch of the JUICE (JUpiter ICy moons Explorer) on the 14th of April 2023 all the on board subsystems and instrument have tested their functionalities. The JANUS (Jovis, Amorum ac Natorum Undique. Scrutator) telescope is the imaging system on board the spacecraft and is an optical camera devoted to the study of global, regional and local morphology and processes on the Jovian moons, and to perform mapping of the clouds on Jupiter.
Following the heritage of the successful design of the OSIRIS WAC camera, on board the Rosetta mission, the group of researchers at CISAS "Giuseppe Colombo"-Università degli studi di Padova, led by prof. S. Debei, in collaboration with colleagues of the Leonardo spa Company developed the mechanism responsible for the protection of the telescope during cruise phase.
The COver Mechanism (COM) provides the external closure of the JANUS Optical Head Unit (OHU). It shields the optical parts from contamination, it is light and dust tight and works in the plane of the telescope entrance window avoiding the exposure of the inner surface of the cover itself and the core part of the telescope to the external dust and pollution. The lower part of the cover provides, also, a reference surface for the in-flight calibration of the telescopes. The COM subsystem is mainly composed by the following parts, which can be seen in Figure 3:

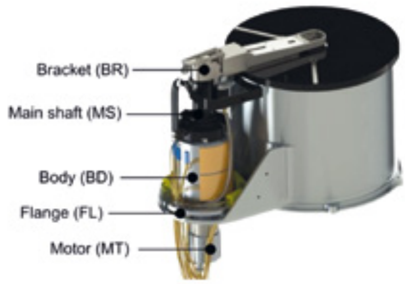
- the stepper motor (MT) for controlling the position of the cover;
- the interface flange (FL) for fixing the mechanism to the baffle of the telescope;
- the main body (BD) were the mechanical parts for allowing the movements are present;
- the main shaft (MS) governing the vertical movement;
- the bracket (BR) holding the cover shield;



[1] Rosetta's Mechanism Flight Model in open position



[2] JANUS telescope overview; on the left the JANUS COM

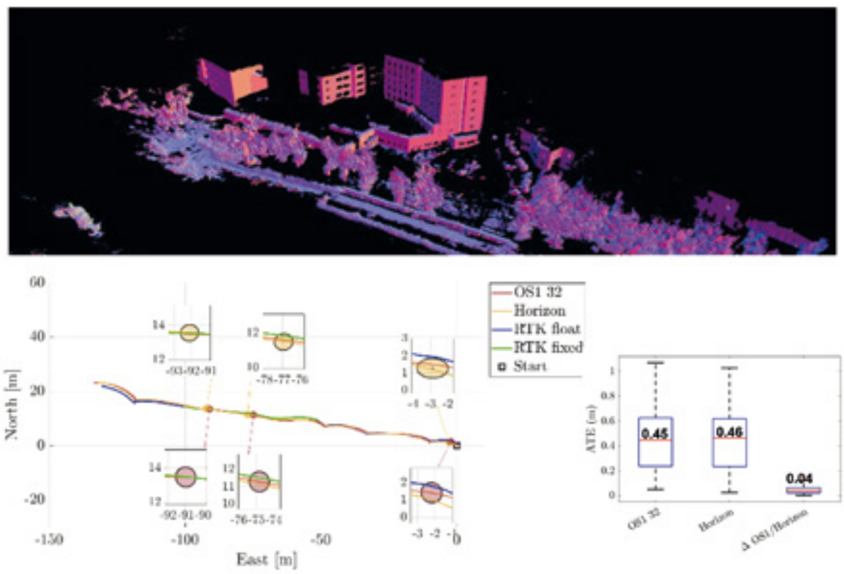


[3] Janus' Front Door mechanism and its subsystems (above); the JANUS COM FM during testing (right)

Roving to Planets with MORPHEUS: A Robotic Test Bed for Planetary Exploration Technologies

The objectives set in the near future by the major space agencies for scientific and human exploration of the surfaces of the Moon and Mars are leading to a growing interest in the development of robotic platforms capable of mapping planetary surfaces, transporting astronauts, assisting them in geological exploration and maintenance tasks. Robotic perception through cameras and LiDARs is essential for enabling rovers' autonomy and safe navigation. Through SLAM (Simultaneous Localization and Mapping) algorithms, it possible to process camera and LiDAR sensor readings and reconstruct unstructured environment maps and tracking rover's trajectory within them in real time. Starting from this research context, the MORPHEUS (Mars Operative Rover of Padova Engineering University Students) project was initiated and supervised by Prof. Stefano Debei in the frame of the Space Robotics course of the MSc degree in Aerospace Engineering of the University of Padova. This project actively engaged students in applying their coursework to the design of a functional rover. MORPHEUS is equipped with a range of technologies that enable autonomous navigation across various terrains, including rugged and rocky landscapes. Its sensor suite, mounted on the chassis, includes a stereo camera and LiDAR sensors for mapping and analyzing the surrounding terrain. The rover is also equipped with a GNSS RTK system, which serves as a ground truth reference for evaluating the metrological performance of ego-motion algorithms. By combining onboard algorithms and machine learning techniques, the rover can identify and navigate around obstacles, ultimately finding the most efficient path to its destination. The MORPHEUS project showcases the effective integration of technology and student involvement in the development of a functional planetary rover, offering potential benefits for future space exploration endeavors.

The MORPEHUS rover and its robotic arm.



(Top) LiDAR scan processed with Voxblox algorithm for real-time mapping of unstructured environments. (Bottom) LiDAR-SLAM performances in reconstructing rover's path.

Sistemi aerospaziali

Aerospace systems

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The MORPHEUS student team

Main research topics:

- Measurements, intrumentation and technologies for aerospace applications.
- Design and testing of mechanisms for aerospace applications

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Aerospace systems

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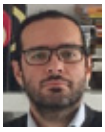

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AMELIA, Italian Space Agency
European Space Agency

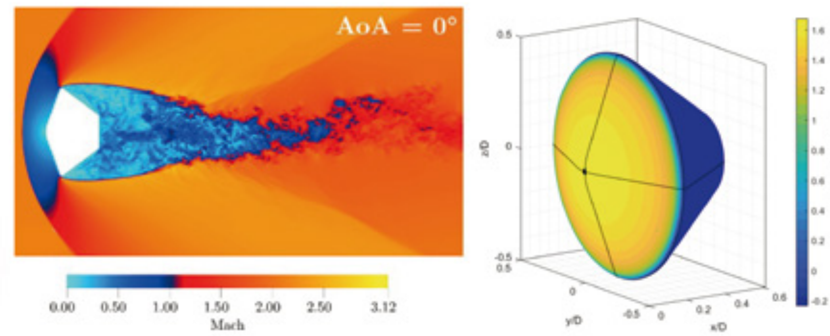
Main research topics:

Probes in planetary descent phases:

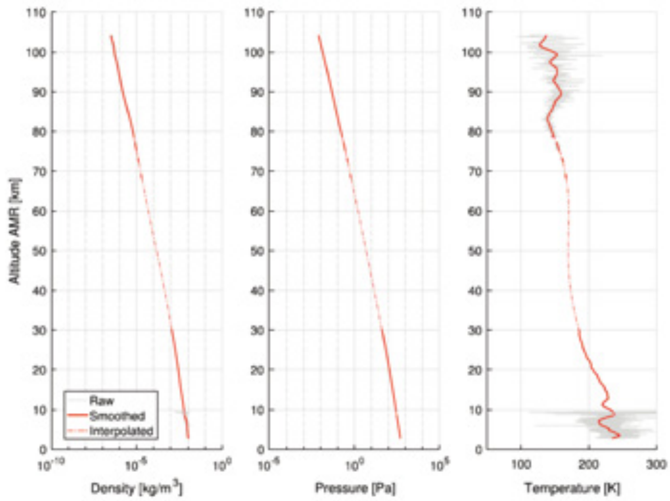
- Spacecraft aerodynamics
- Atmospheric investigation
- High-fidelity simulations
- Supersonic aerodynamics

Aerodynamics of probes during atmospheric planetary descent

Space in-situ exploration remains a constant imperative for understanding the worlds beyond our planet's borders. However, comprehensive planning is essential to ensure the mission's success, which is reaching the scientific site with a space probe. Once the destination is met, the spacecraft encounters the most insidious of its flying phases: entering through the atmosphere of the planet, descending towards the surface, and landing successfully. During this sequence, due to the planet's atmosphere, the module carrying the science equipment flies through multiple different physical scenarios, as they change very rapidly. For this reason, evaluating the aerodynamic response of the probe is paramount, especially during the trickiest moment of the descent: the opening of a parachute to decelerate to a safe terminal speed. Here, multiple complex flow phenomena interact, producing instabilities in the flight that can compromise the spacecraft's attitude, ultimately leading to mission failure (e.g., ExoMars 2016).
Hence, high-fidelity flow simulations can provide results for the dynamical behavior of the probe, aiding in the design process and increasing the mission's success rate. However, this is not the only outcome: during the descent, the probe collects information related to its trajectory, and these measurements can be used to derive the atmospheric profiles of the planet using the module's aerodynamic properties. Increasingly accurate predictions of the probe's aerodynamics can lead to more accurate information on the planet atmosphere derived from the measures, that can employ only limited on-board instrumentation.



ABOVE: Probe descending in supersonic flight: Mach number field (left) and pressure coefficient distribution on its surface (right); adapted from Placco et al. Aerospace Sci. & Tech. 2023
BELOW: Reconstructed atmospheric quantities as a function of the flight altitude. Adapted from Aboudan et al. Space Sci. Rev. 2018



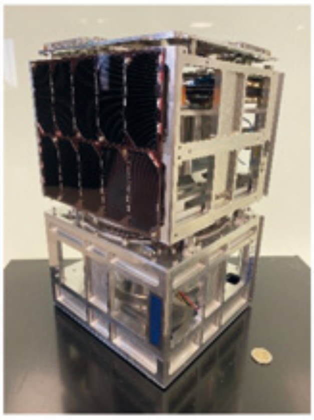
Building a novel flight system for efficient deorbiting of orbital debris

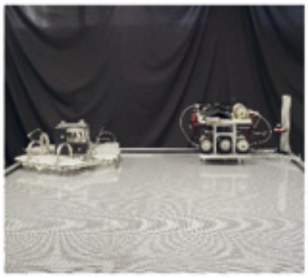
The number of man-made space debris, now exceeding 35000 pieces, that are tracked from ground radars is increasing dramatically with sizes from several meters to a few centimeters (objects smaller than ~5 cm are not trackable from the ground). The United Nation established fifteen years ago guidelines aimed at space agencies and private satellite operators with the goal to limit the growth of debris by requiring a deorbitng of new satellites within 25 years from the end of mission for those flying in Low Eatrh Orbits (i.e., the LEO between 200 and 2000 km of altitude that is by far the most congested region of space). Very recently two US agencies - the Federal Communication Commission (FCC) and the Federal Aviation Administration (FAA) - have issued a much more stringent rule of deorbiting satellites in LEO within 5 years. Consequently, there is an urgent need to develop systems for deorbiting without using the on-board propellant that can be activated at the end of a satellite operational life. Thanks to the evolution in the last decade of very efficient electrodynamic tethered systems (EDTs) that use the natural interaction with the Earth's magnetosphere to produce drag forces without consuming propellant our group, following the pioneering footsteps laid down by Giuseppe Colombo of UniPD and Mario Grossi of the Smithsonian Astrophysical Observatory (USA), has contributed very significantly to the development of these highly-efficient EDTs. In collaboration with five European partners (the E.T.PACK team) and funding from the EIC and ESA, we have designed, built and tested on ground a prototype of a compact deorbiting system with the small volume of a 12U Cubesat. This demo system consists of two modules that will separate in orbit while been connected by a 500-m-long conductive and very light flat tape that will produce the Lorentz force for deorbiting. ESA will provide an opportunity for a demonstration flight of this system in 2025. The demo system is estimated to deorbit from 600 km of altitude in 3 months instead of 15 years by neutral drag decay. Our MTS research group is ontributing to this project with expertise in mission analysis, orbital simulation, deployment control and testing, design of the deployer module and construction of the cold gas system for attitude stabilization during the modules separation. The MTS group also has a unique testing facility - the SPARTANS frictionless table -- that has been used for testing key elements of the system. The E.T.PACK project has received attention from the prestigious space magazine Aerospace America in the 2022 Year-in-Review highlights and three young members of the group have won international awards.

TOP LEFT : Aerospace America article on the electrodynamic tethered project E.T.PACK

LOWER LEFT : testing of modules separation and deployment test at UniPD

RIGHT : E.T.PACK prototype with the two modules in the attached configuration





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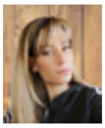

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Partners and sponsors:
- European Innovation Council - EIC
- European Space Agency - ESA
- Centro Italiano di Ricerche Aerospaziali
- Universidad Carlos III de Madrid
- Technical University of Dresden
- Sener Aeroespacial

Main research topics:

- Mission analysis
- Dynamic simulations and control
- System design
- Prototyping
- Ground testing
- Demo flight planning

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ed Attività Spaziali (CISAS) «G. Colombo»

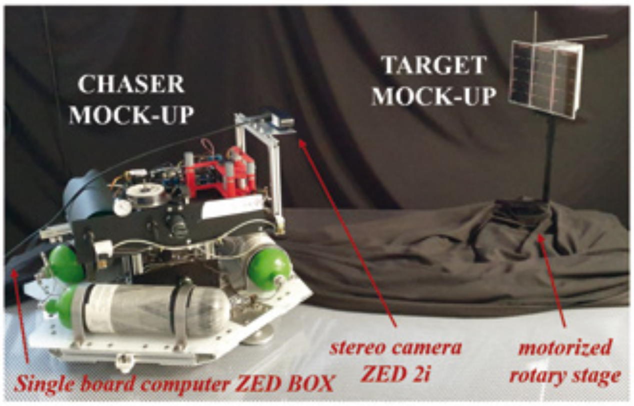
Main research topics:
Vision-based satellite navigation:

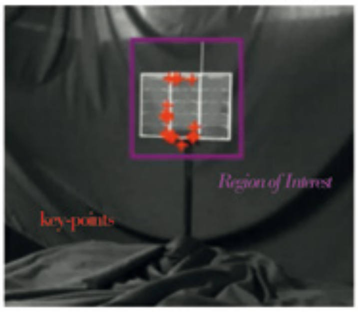
- Relative dynamics measurement
- Navigation system design
- Neural Networks training
- Computer vision
- Experimental validation and testing

Vision-based proximity navigation between satellites with neural networks

In recent years, there has been an increasing interest in utilizing Artificial Intelligence algorithms for space applications. Among the spectrum of Machine Learning techniques available, Convolutional Neural Networks (CNNs) emerge as a well-suited deep learning approach for optimizing Guidance, Navigation, and Control systems during close-proximity operations between satellites.
Our research group has been developing and validating a pipeline for satellite relative navigation based on computer vision algorithms with the aim of computing the measurement vector used by a subsequent Extended Kalman Filter to estimate the relative motion between a chaser satellite hosting a stereo camera and an uncooperative target satellite. The pipeline utilizes the state-of-the-art CNN called You Only Look Once 7th version (YOLOv7) and the feature detector Oriented FAST and Rotated BRIEF (ORB). The network is crucial to reduce the search field of relevant features of the target, speeding up the computing time of the pipeline for a real-time implementation.
The first key aspect of our work was the training of the CNN with both datasets available on the web (pretraining with SPEED and/or COCO) and two datasets, one for object detection and the other for segmentation, realized in laboratory using the representative facility SPARTANS and data augmentation methods. The relative navigation pipeline embedding the trained networks was then tested in a representative laboratory environment using a two-units CubeSat target mock-up and a free-floating chaser mock-up (one SPARTANS module) that hosts the stereo-camera ZED 2i and a mini-PC powered by an NVIDIA Jetson Xavier board.
Particular attention was paid to computing time and performance metrics of the image analysis algorithms devoted to object detection and feature detection. Experimental champaign revealed good results, with the CNN being able to detect the target mock-up with a Region of Interest (ROI) confidence level greater than 90% for 99% of the images and between 75% and 90% for the remaining images.

TOP CENTER : experimental setup used to validate neural networks for proximity navigation between satellites
LOWER LEFT : the target satellite mock-up identified by the CNN (violet box) with key-points (red crosses) used for relative motion estimation. The ROI, the violet box, is the output of the object detection task.
LOWER RIGHT: output of the segmentation task for recognizing the target mock-up contour.





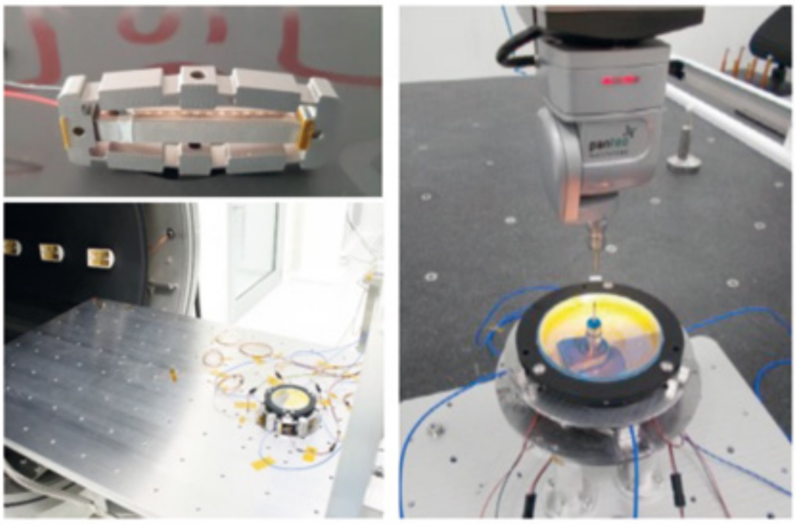
Design, manufacturing and testing of a fine steering tip/tilt positioning mechanism

Telescopes positioned aboard spacecraft in Earth's orbit may exhibit compromised line-of-sight and image performance compared to the pre-launch integration phase on Earth. This degradation is often due to the loads resulting from the launch phase of the mission. Additionally, disturbances from the space environment, such as external thermal radiation sources, introduce temperature variations and thermal gradients. Differential expansions of components, made of different materials or exposed to varying temperatures, can induce optical misalignment with consequential impact on system performance.

In this particular context, an industrial doctoral project sponsored by Officina Stellare SpA in collaboration with the AeroStructures group of DII, carried out design, implementation, and testing processes of a fine steering tip/tilt positioning mechanism. This mechanism is driven by four multilayer piezoelectric actuators, each preloaded by a compliant mechanical amplifier. The primary objective of this mechanism is to enable movement of an optical payload in three degrees of freedom: translation along its optical axis and two rotations about axes situated on its optical surface. In this way the misalignments can be corrected, and the accuracy of the images restored. The prototype is capable of handling optical components with a mass of 0.75 kg, with maximum stroke of ±64 µm and rotation of ±390 arcsec. Particular attention has been paid to the experimental testing required to achieve space qualification.

ABOVE:
Main phases in the development of the fine steering tip/tilt positioning mechanism. After careful design to minimize the mass, the prototype was built and successfully passed qualification tests for the space environment.

BELOW:
Custom piezoelectric actuator (top left), vacuum test setup (bottom left) and functional test in coordinate measuring machine (right).



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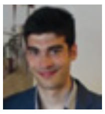

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Partners and sponsors:
Officina Stellare SpA

Main research topics:
Structural design:

- Finite element modelling
- Structural optimization
- Mechanisms for space applications

UNIVERSITÀ DEGLI STUDI DI PADOVA

DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

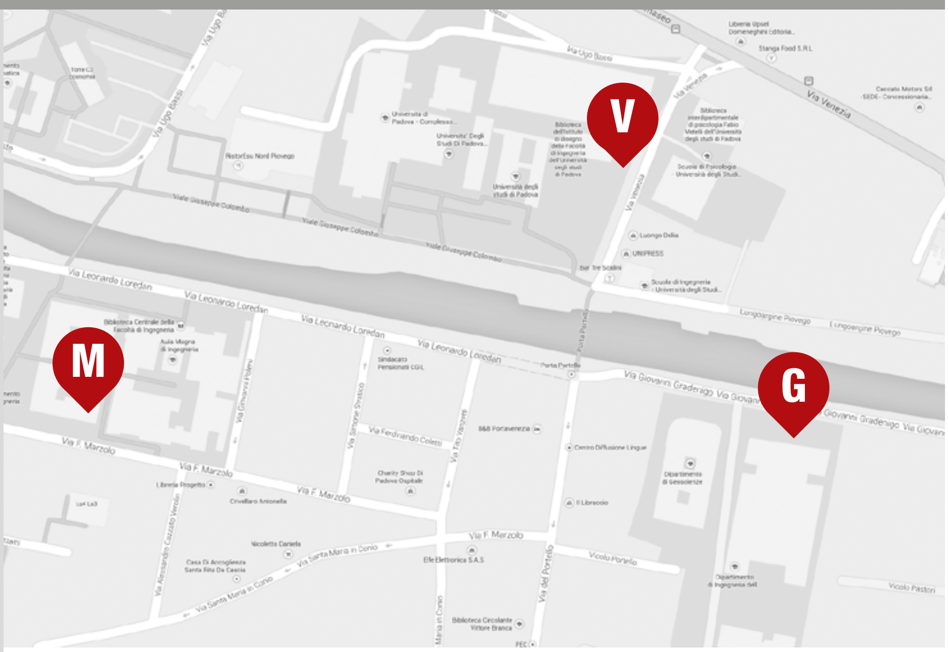
Cover story: Special Issue

Il nostro caro amico e collega Stefano Debei è mancato prematuramente il 7 agosto 2022. Stefano aveva una mente creativa, sempre in movimento, e un forte desiderio di percorrere nuove soluzioni nell'esplorazione planetaria. Alla guida del suo gruppo di ricerca, ha contribuito allo sviluppo di strumenti scientifici utilizzati nelle missioni spaziali per l'esplorazione di Marte, Mercurio, Saturno e le lune di Giove.
Stefano possedeva un modo di fare diretto, esplicito e generoso, con cui offriva la sua disponibilità e il suo consiglio a tutti, compresi colleghi e studenti, che lo trattavano con rispetto ed empatia. Tra le sue attività professionali sono da segnalare quelle realizzate all'Università di Padova, in particolare presso il Centro Studi e Attività per lo Spazio "Giuseppe Colombo", di cui è stato direttore dal 2015 al 2021.

Stefano Debei

La vita lavorativa di Stefano è incentrata sulla ricerca e sullo sviluppo di strumenti e tecnologie satellitari per l'esplorazione autonoma dei corpi del sistema solare; la sua leadership scientifica ha rappresentato un prezioso contributo in tutte le principali missioni effettuate dalle organizzazioni spaziali internazionali.
È stato responsabile tecnico dell'esperimento SIMBIOS-SYS della missione Bepi Colombo; co-investigatore per OSIRIS e coordinatore tecnico del WAC per la missione Rosetta ESA.
È stato membro del Mars Exploration Program Advisory Group (MEPAG); è stato co-investigatore principale di DREAMS per Exomars 2016 e scienziato strumentale per il progetto Moon-Rise presentato dalla NASA.

SEDI



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