ASSOLOMBARDA

Incontro Assolombarda – DAER

DIPARTIMENTO DI SCIENZE E TECNOLOGIE AEROSPAZIALI

Le competenze e la ricerca tecnologica del Politecnico per il settore dello Spazio

25 Ottobre 2024

Politecnico di Milano – Dipartimento di Scienze e Tecnologie Aerospaziali

POLITECNICO MILANO 1863

Space Engineering Lab

Space Engineering Lab **personnel includes**:

- 3 Full Professors
- 5 associate professors
- 8 assistant professors
- 75 Postdocs+PhDs

20 M EUR in Contracts and studies on space topics within the last 5 years

500 Students Master in Space Engineering

In alphabetical order **4 research groups**:

- ASTRA
- DART
- COMPASS
- SPIRE

Detailed in the followings

COMPASS research group – C.Colombo

- Research group within Space Mission Engineering Lab with research focus on
  - Modelling methodologies and tools for space traffic management, distributes space systems, planetary defence and astrodynamics applications
- Team: 2 associate professors (Camilla Colombo, Gabriella Gaias), 1 RTDa, 2 PostDocs (Giacomo Borelli, Yeerang Lim), 11 PhDs
- Main project funding and partners:

COMPASS research group

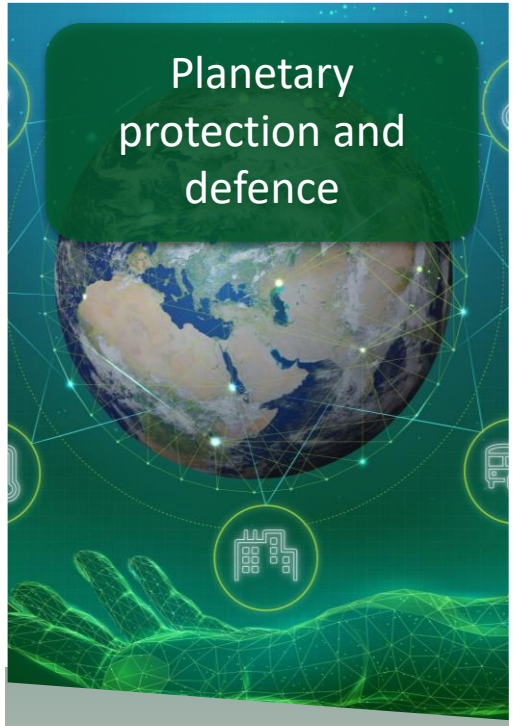
Space sustainability

- Space debris long-term evolution modelling
- Space capacity allocation
- Space debris indicators
- Cislunar space situational awareness
- Collision risk analyses

Space traffic management

- Collision avoidance manoeuvres
- End-of-life disposal design
- Re-entry modelling
- Fragmentation characterisation and reconstruction
- Active debris removal
- On-orbit inspection and servicing

Planetary protection and defence



- Asteroid deflection
- Planetary protection analysis
- Missions to asteroids
- Astrodynamics

Mission design

- E.Cube mission
- SpEye mission
- Formation flying large aperture synthesis mission
- REMEC mission
- Technology demo mission for deployable surface-based debris

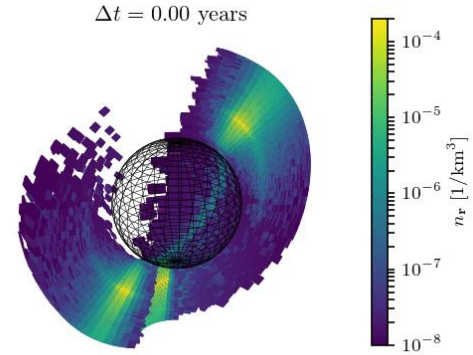
Space services

- Formation flying for Earth observation
- Socio-economic impact of space missions
- Satellite constellations
- Guidance navigation and control

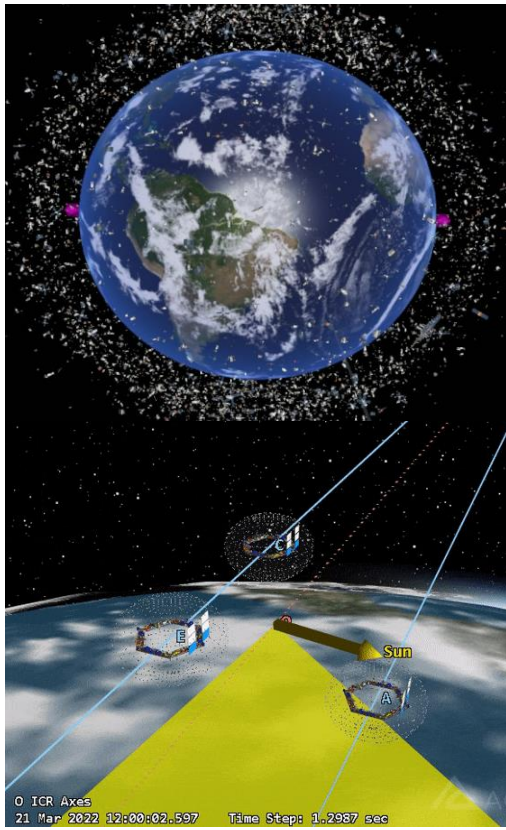
Further material

@COMPASS_polimi www.compass.polimi.it

Main current projects



- ERC: GREEN SPECIES: Robust control of the space debris population to define optimal policies and an economic revenue model for sustainable development of space activities. (Prime: PoliMi)
- ASI-IHS: Development of the algorithms for the Italian Space Traffic Management infrastructure. (Prime: Telespazio)
- ESA: THEMIS Development of the ESA operational software for Tracking the Health of the Environment and Missions in Space: software development, debris modelling.
- Mission analysis of debris missions design involving on board software for collision avoidance manoeuvres: ASI e.Cube
- Mission design involving formation flying application and guidance and control schemes for: ASI SpEye (on-orbit inspection), ESA Tri-Hex (formation flying for remote sensing), IO Endurance
- Part of Italian Space agency Delegation at Inter-Agency Debris Coordination Committee (C. Colombo), Un-mandated Space Mission Planning Advisory Group (C. Colombo), ESA Close Proximity Operations Working Group (G. Gaias)



Collaboration interests

- Mission concepts exploiting distributed systems (swarms, formation flying) for Earth observation (e.g., synthetic radar apertures and passive interferometry)
- Products/tools/services to enhance sustainability of the outer space
- Development of on-board software for collision avoidance manoeuvres and other applications
- Development on on-ground software for space traffic management and space sustainability applications
- Circular economy in space Life Cycle Assessment of space missions

SPIRE RESEARCH

02 Associate professors

02 Assistant professors

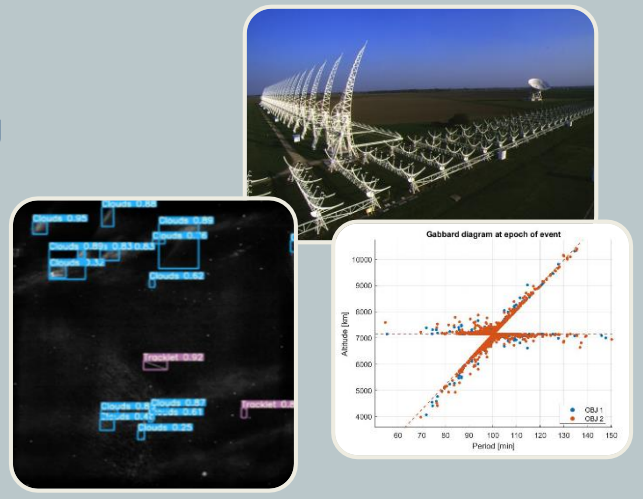
02 Postdoctoral researchers

16 PhDs and researchers

EXPERTISE

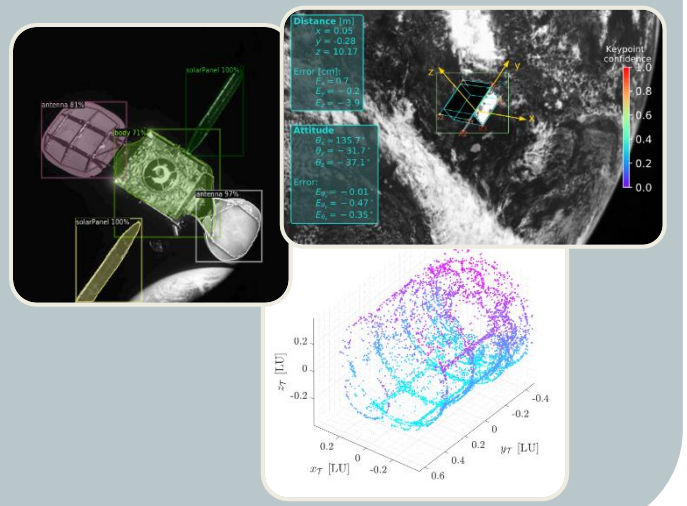
Space surveillance

- Ground-based and space-based **object monitoring**
- Sensor network optimization and **sensor tasking**
- **Conjunction, reentry** and **fragmentation** monitoring
- **Maneuver detection** and threat assessment
- **Collision avoidance** maneuver design
- **Uncertainty** propagation, **collision** probability computation, collision avoidance maneuver



Guidance, Navigation and Control

- Autonomous **GNC strategies for inspection**
- AI for **relative pose estimation**
- AI for **feature and satellite capability recognition**
- Rendezvous with **underactuated systems**
- GNC for **free-flying space manipulator** for ADR/OOS



PROJECTS

Ground-based Space Situational Awareness

- Scientific and technical activities in support to C-SSA/ISOC and simulation of sensor architectures for SST (**ASI**, **ItAF**)
- Development of an infrastructure for space traffic management (**ASI**, **NextGenerationEU**)
- Dynamic beamforming for multi-receiver radars (**INAF**, **EUSST**)
- Innovative and iNteroperable Technologies for spacE Global Recognition and Alert, INTEGRAL (**EU**)
- Fragmentation analysis for in orbit breakup (**ESA**)

Funding Institutions

Main Partners

SPIRE RESEARCH

Surveillance and
Prox**I**mity operations
REsearch team of
Politecnico di Milano

PROJECTS

Space-based Space Situational Awareness

- ASSAI: Autonomous Space-Based Situational Awareness & Artificial Intelligence (**EDA**)
- AstroTwin: Realization of Satellite digital twin for autonomous SSA activities (**NextGenerationEU, NODES**)
- Study for a constellation of satellites in VLEO for enhanced space-based SSA and Spectrum Monitoring (**EDA**)
- GEORyder: access to GEO orbit through a reusable kick stage vehicle allowing transfer from GTO to GEO (**EU**)
- ACTIVA: design of autonomous collision avoidance maneuvers onboard (**ESA**)

Funding Institutions

EUROPEAN DEFENCE AGENCY

European Commission

esa

Main Partners

INFINITE ORBITS

DAWN AEROSPACE

deimos

skylabs

arianespace arianeGROUP

LEONARDO

IBST Berlin Space Technologies

gmv INNOVATING SOLUTIONS spaceapplications SERVICES

ThalesAlenia Space a Thales / Leonardo company

nurjanatech

optec S.p.A. OPTICAL & OPTOELECTRONIC SYSTEMS

tyvak International SRL

TNO innovation for life

nlr

der Bundeswehr Universität München

FLYSIGHT

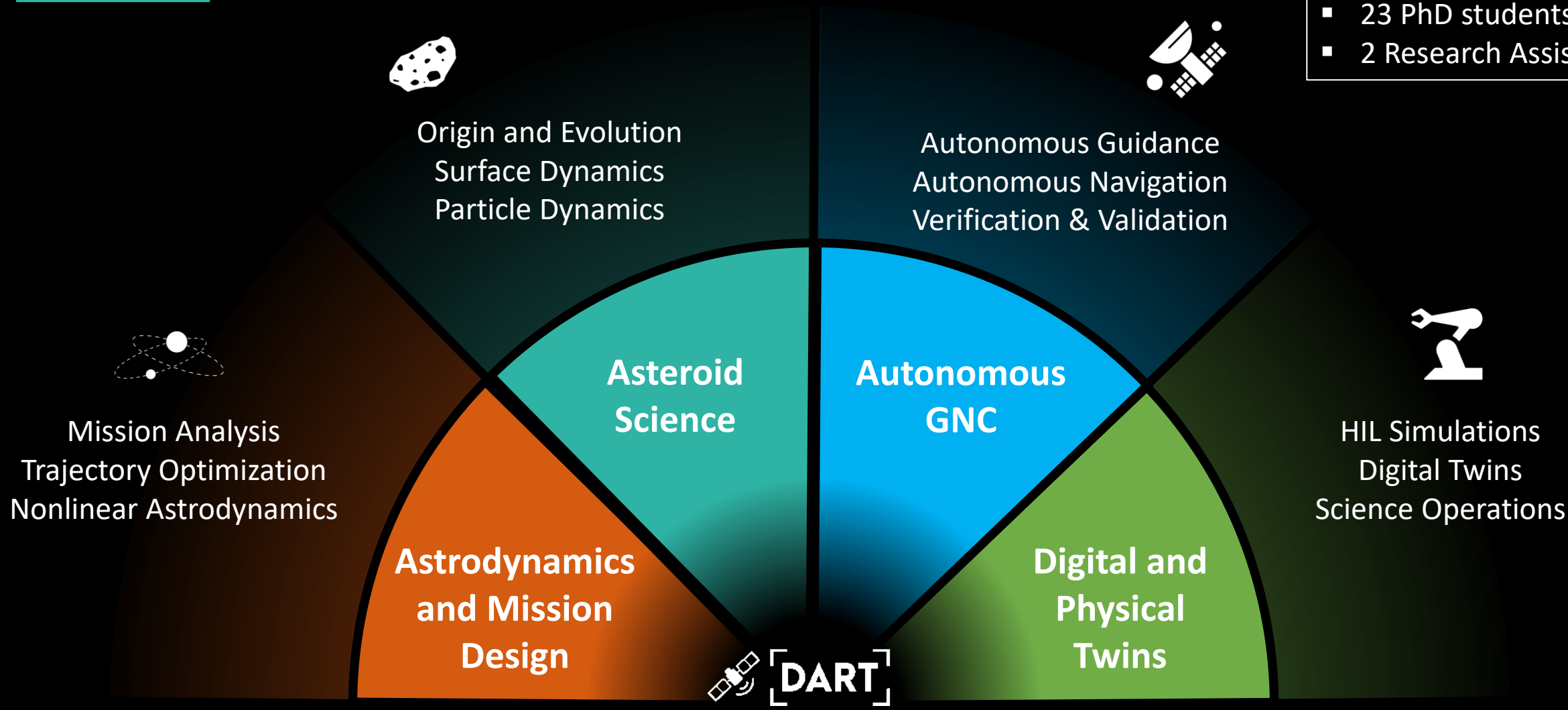
cnit consorzio nazionale interuniversitario per le telecomunicazioni

SPIRE RESEARCH

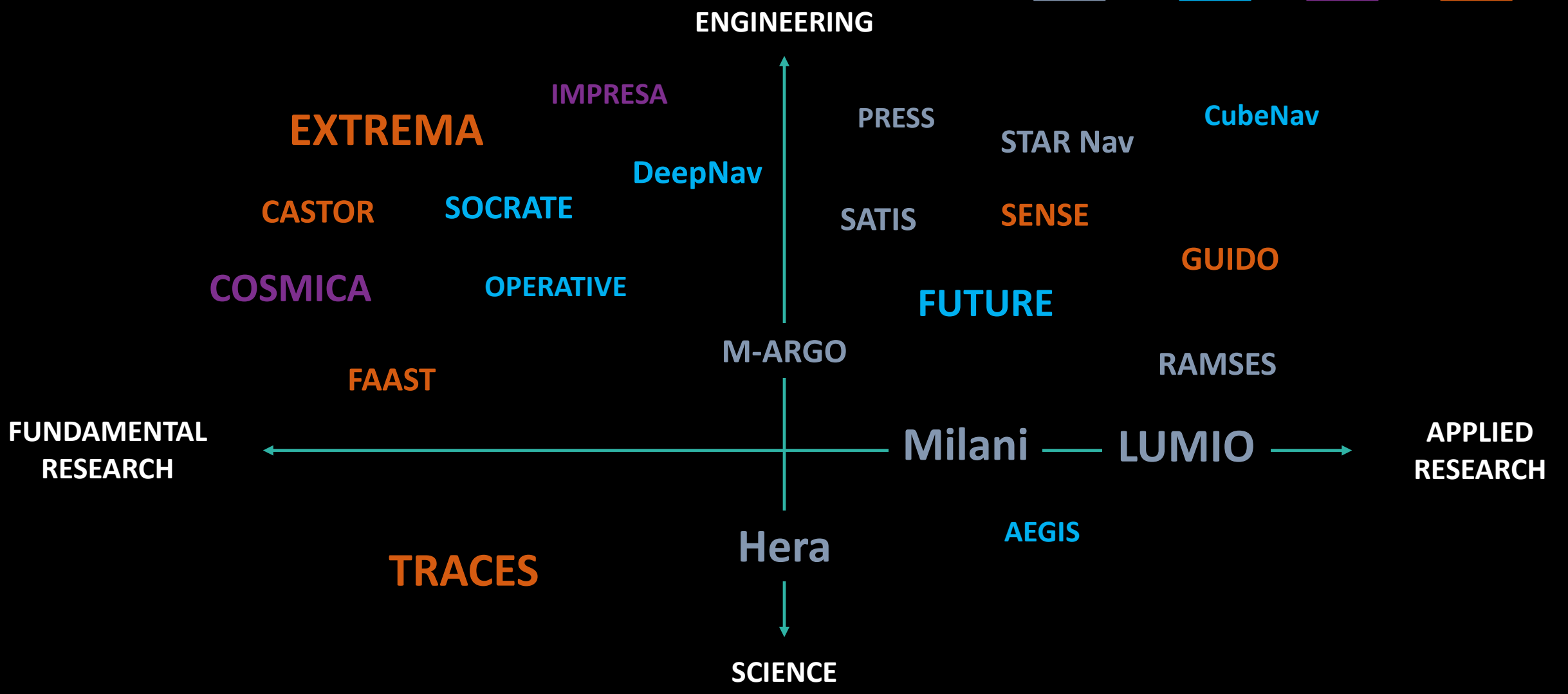
Surveillance and
Prox**I**mity operations
REsearch team of
Politecnico di Milano

DART group – F. Topputo & F. Ferrari

35 Researchers
- 4 Faculty members
- 6 PostDocs
- 23 PhD students
- 2 Research Assistants



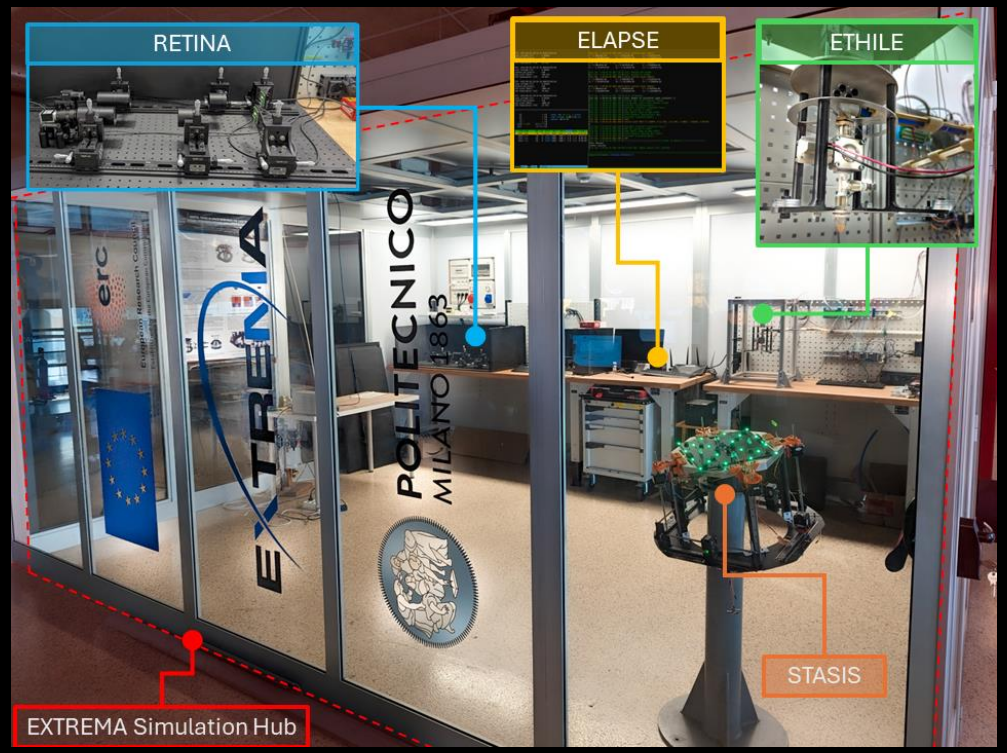
Overview of projects

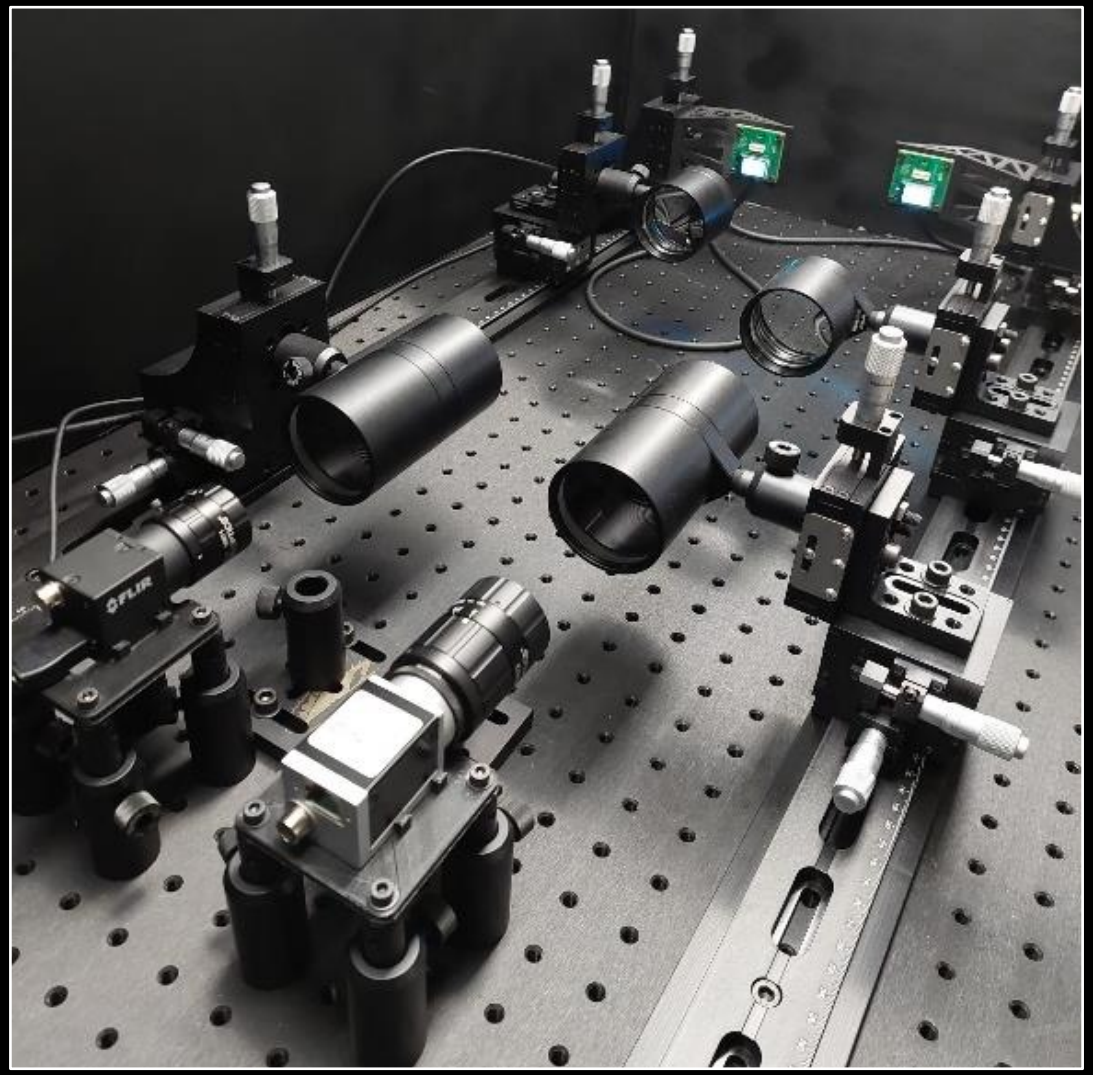


HIL Simulations

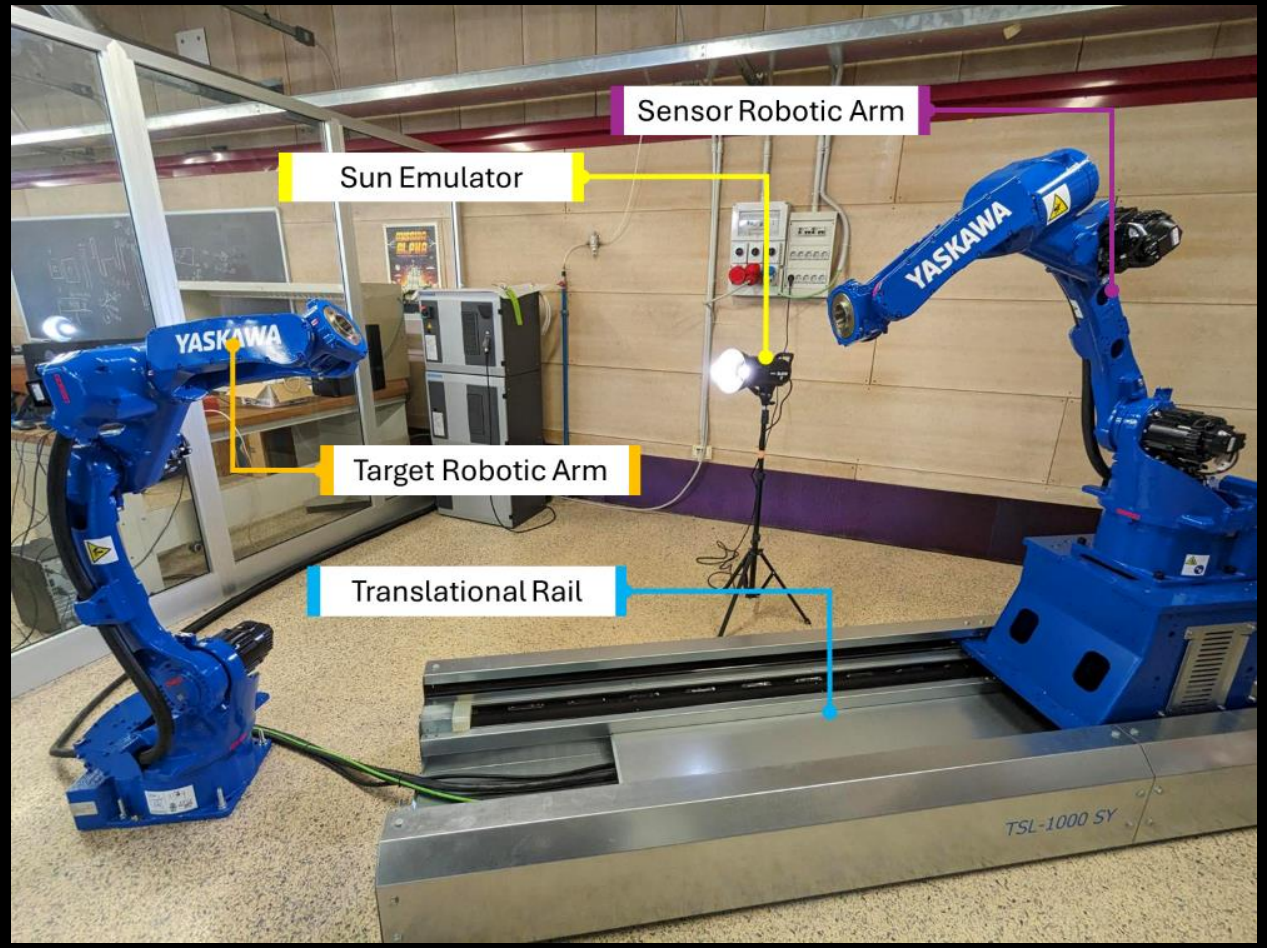
Hardware-In-the-Loop facilies

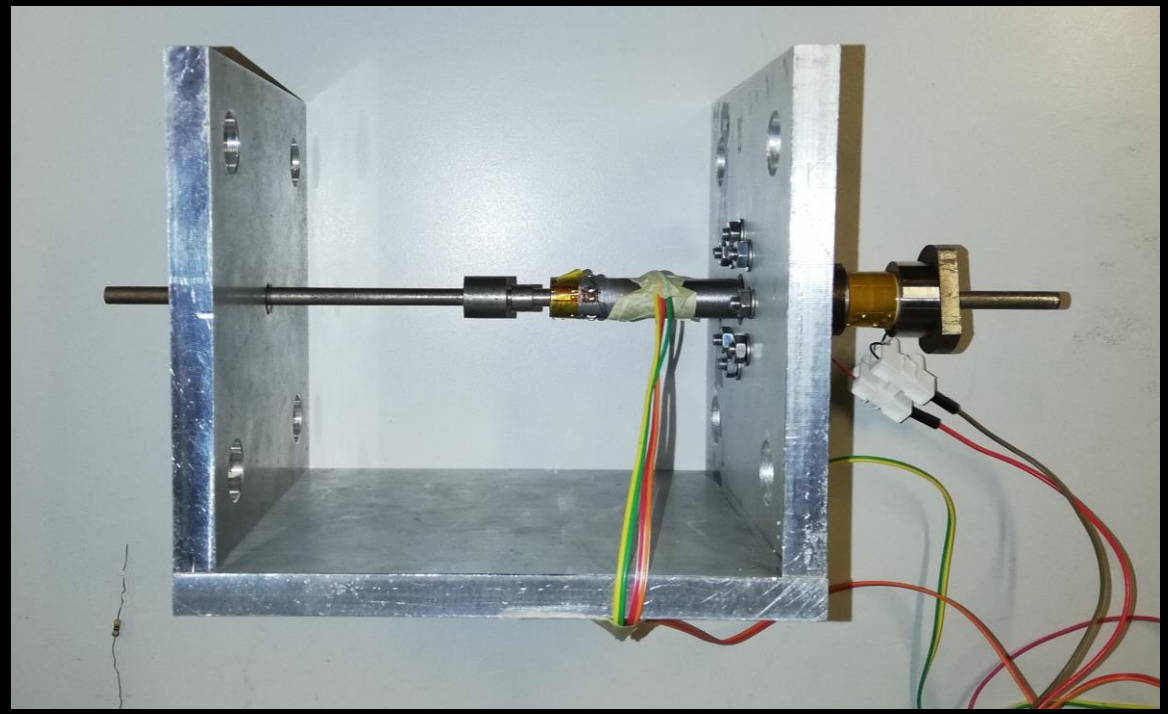
- TinyV3rse & RETINA: camera simulation
- ETHILE: thruster emulator
- STASIS: attitude platform





Facilities & HIL activities





Sample Collection – asteroid drill

Space Economy Observatory – Prof. Franco Bernelli Zazzera

- Joint activity with Dept. of Management, Economics and Industrial Engineering
- Contribution to the specific technical components of the research
- 3 Professors of DAER involved

A couple of examples of contribution to the Observatory

Space Economy Observatory – Prof. Franco Bernelli Zazzera

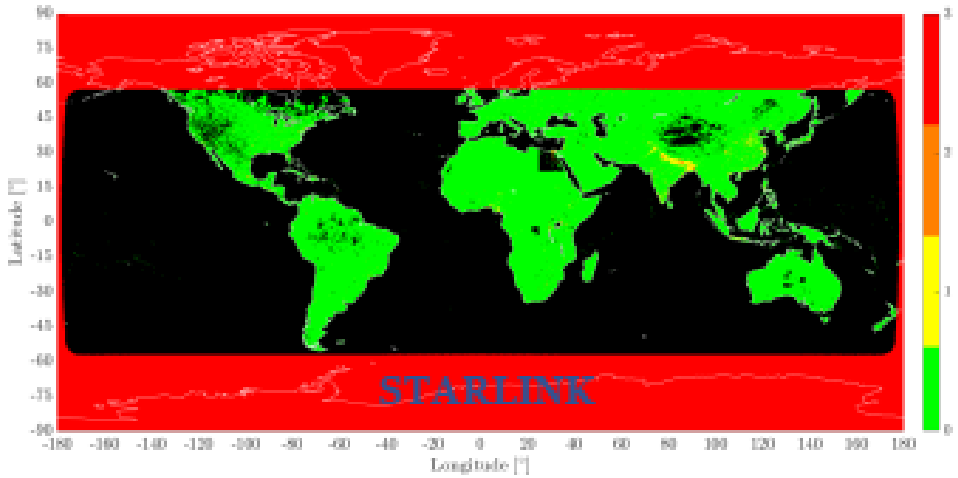
Coverage analysis of IRIDE constellation

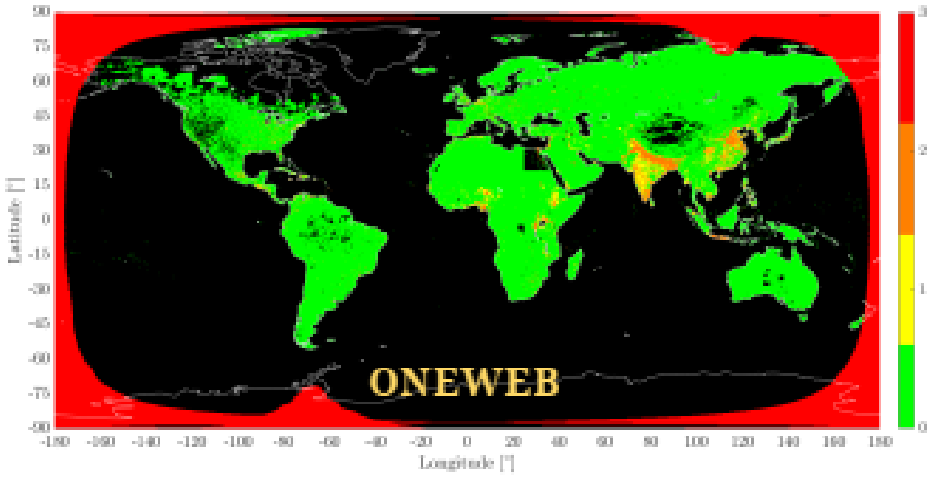
Multi#2 (18 km swath)

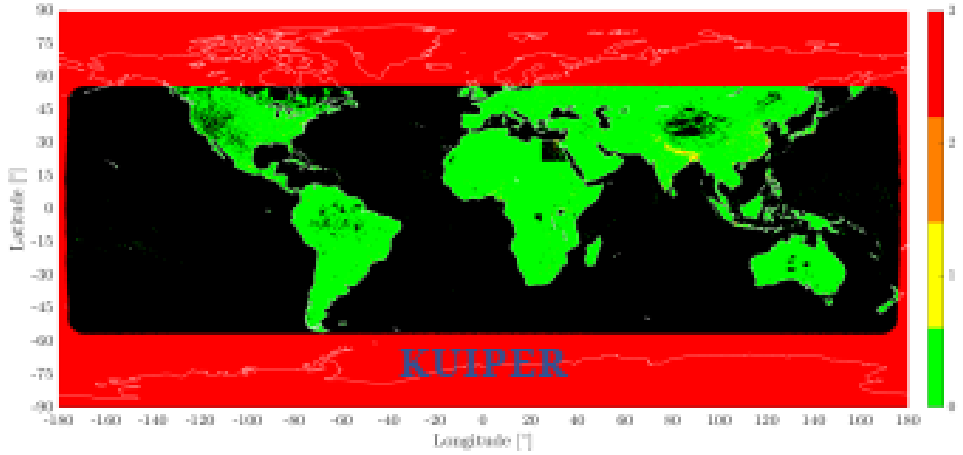
Ripetibilità	Milano	Ragusa
Max	156h01min	205h44min
Min	10h56min	12h44min
Average	60h55min	66h38min

Space Economy Observatory – Prof. Franco Bernelli Zazzera

Estimation of the potential of Satellite Internet services







Advanced Space Technologies for Robotics and Astrodynamics

Scan ASTRA!

3 STAFF - 3 PostDocs - 11PhDs

European Commission, esa, ASI, LEONARDO, deimos SPACE, TELESPAZIO a LEONARDO and THALES company, OHB, ThalesAlenia Space a Thales / Leonardo company, ALTEC, ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA, INAF ISTITUTO NAZIONALE DI ASTROFISICA, skylabs, GOMSPACE, LEAFSPACE, dhv technology, ALÉN space, Qascom Trust is Nice, Control is Better., FLYSIGHT, THi, UBOTICA SEEING BEYOND

Expertise

System Engineering

MODELING & SIMULATION

Astrodynamics

- Controlled **trajectory design** in HIFI validated simulators
- Non-keplerian regimes modelling →Cislunar
- Distributed architectures design →constellation,FF
- Proximity maneuvering → landing\IOS

Mission \system Design

- MBSE\CD lifecycle management
- Adaptive multi\single mission planning\scheduling
- In orbit servicing: robotics design and multibody dynamics control synthesis

Atificial intelligence

- **Generative AI** for early design stages
- **Learning techs** for adaptive control and ops planning

BB\PROTOTYPING\V-V

Development

- Component\equipment **breadboarding**
- s\s assembly & integration

Verification-validation

- Component\systems **PIL\HIL** functional, performance tests
- qualification, acceptance **tests**
- **ECSS Environmental tests**

Navigation Guidance and Control in proximity of natural objects\artifacts

- **Multi spectral** on-board **image processing** development and PIL/HIL testing
- **RF based** techniques development and PIL/HIL testing
- **AI based techniques** for **adaptive guidance & control** on-board for per fast reconfiguration\pointing – PIL/HIL

Space systems design, prototyping and verification up to flight

- s\s virtual modeling→digital twins
- Component\equipment breadboarding
- Component\systems MIL tests
- Robotics for In Orbit Servicing

GEOLab

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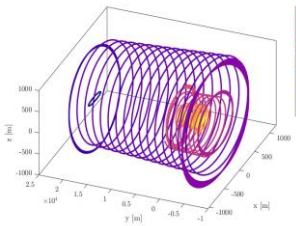
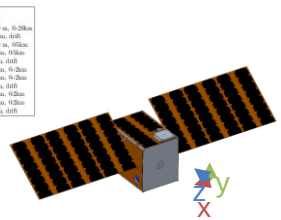
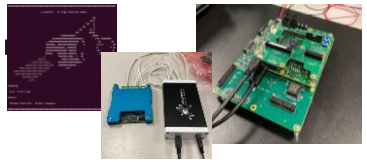
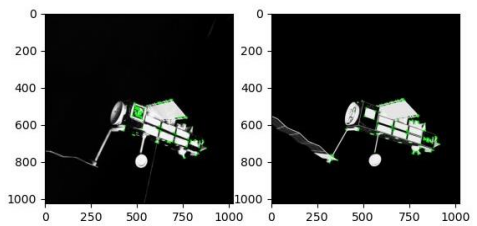
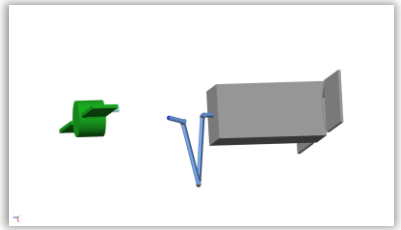
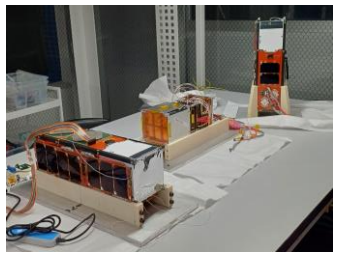
Main PROJECTS

Advanced Space Technologies for Robotics and Astrodynamics

- **HERMES TP\SP** design development and implementation up to operations of a ***fleet of 6 smallsats*** for multimessenger astrophysics
- **HERMES OPS** design development and implementation of the ground segment for operations of the HERMES fleet of 6 smallsats for multimessenger astrophysics
- **e.INSPECTOR** design and development of a In Orbit Servicing mission for close proximity debris ***multispectral inspection and IP based navigation demonstration***
- **VULCAIN** Design and development of a EO ***VLEO formation flying*** for vulcanoes VIS-IR monitoring and ***RF based ISL*** demonstration for ***autonomous navigation***
- **TASTE** Design and prototyping of a smallsat interplanetary mission with ***miniaturized robotics for planetary soil sampling*** and surface mobility
- **CHIPS** design of a ***high stability, fast repointing attitude*** system for smallsat
- **Moonlight** Lunar Navigation & Communication ***constellation design and development***
- **LICIACube** small bodies\smallsat ***proximity maneuvering*** design, implementation operations and ***multibody\multiregime dynamic reconstruction*** and modeling
- **AIVIONIC** ***AI based image processing*** algorithms assessment on ***new generation avionic boards-PIL-HIL for landing***
- **A3** ***AI based image processing*** algorithms for ***On Orbit Servicing on new generation boards*** low power\high speed
- **ORACLE** Design and prototyping of ***payload to fly on the Moon*** in 2028 for \water\oxygen extraction



Scan ASTRA!

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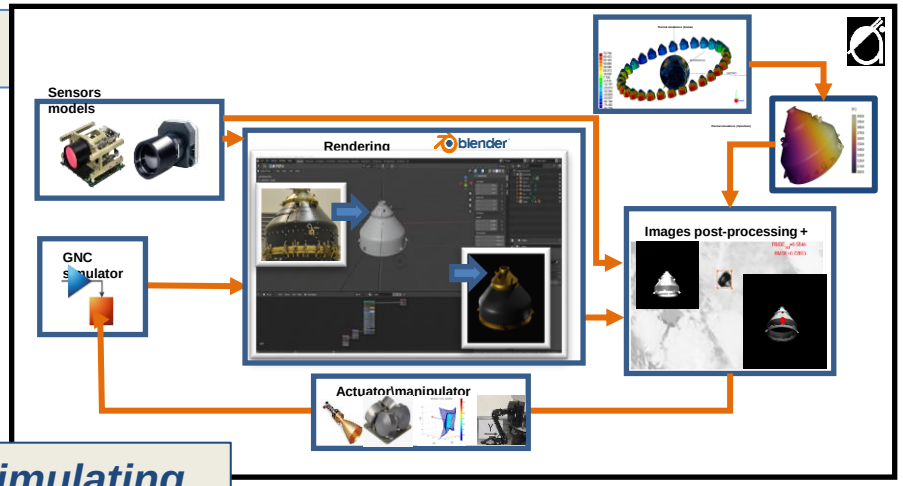
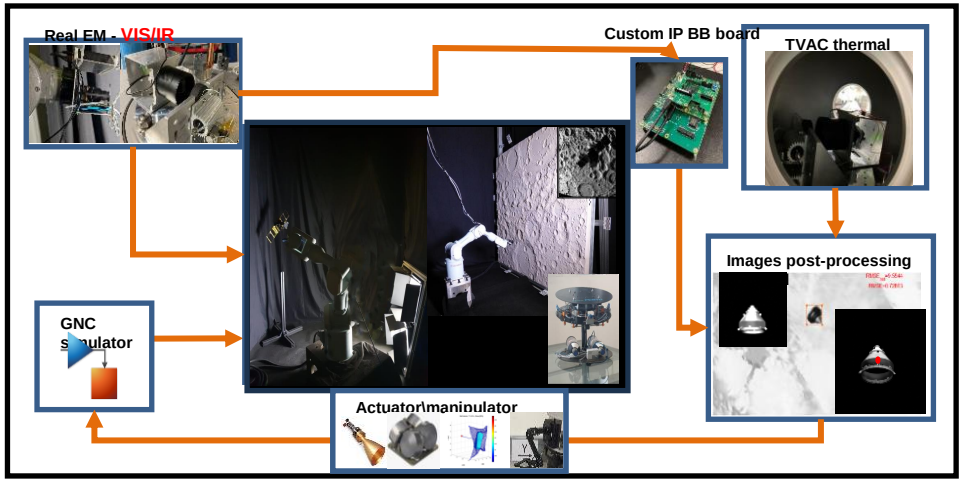
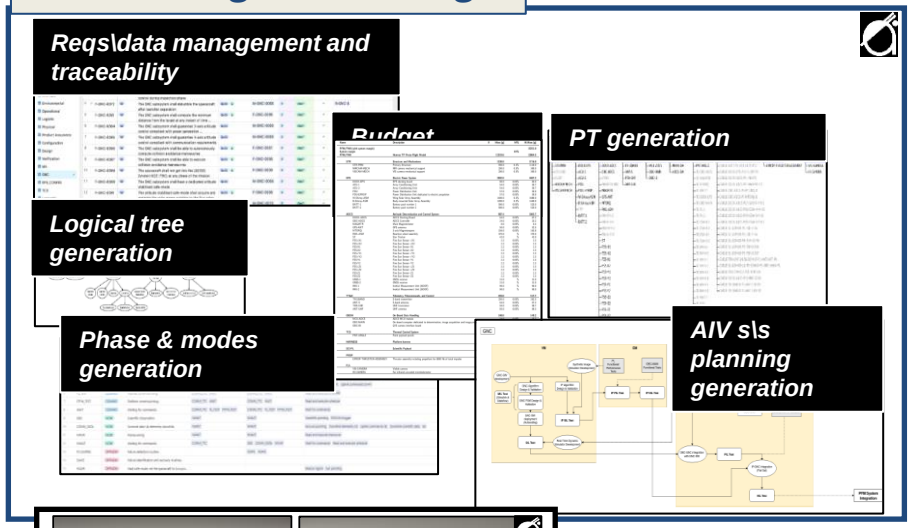
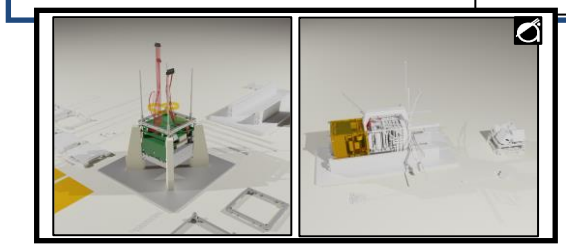
Facilities



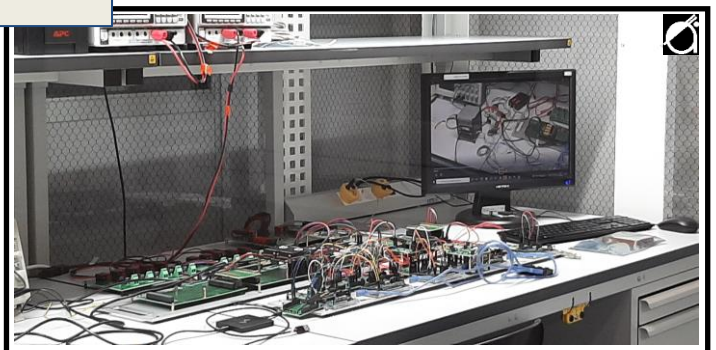


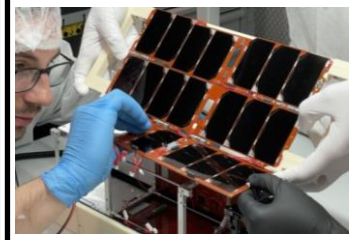
Modelling\simulating

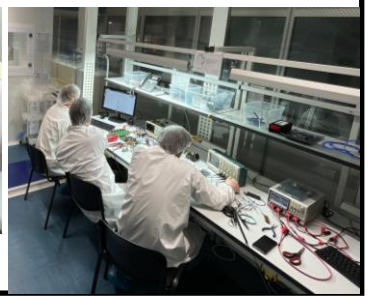




BB\testing







Collaboration interests

- IP based navigation development
- Mission design development with interest in In Orbit Servicing\distributed architectures (i.e. Const\FF)
- OBSW development and V\V
- IP based facility exploitation availability
- Avionic bench for PIL\HIL test campaign availability
- AI related activities
- System Engineering process modeling\automation→ MBSE\DT
- Component\system for planetary exploration modeling development and testing
- …

ASSOLOMBARDA

Incontro Assolombarda – DAER

DIPARTIMENTO DI SCIENZE E TECNOLOGIE AEROSPAZIALI

Le competenze e la ricerca tecnologica del Politecnico per il settore dello Spazio

25 Ottobre 2024

Politecnico di Milano – Dipartimento di Scienze e Tecnologie Aerospaziali

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