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SPACE EXPLORATION AT GMV

INNOVATING SOLUTIONS

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  - GMV and the Space segment
  - How could you get there
- Space exploration for us
  - Pin point landing on the Moon
  - Mars Sample Return and the autonomous Rendezvous
  - Planetary Defense
- A special focus on asteroids, the HERA mission
- Conclusions

The Space Segment

GMV

WHO WE ARE

A GLOBAL TECHNOLOGY GROUP

Multinational technology group

Headquarters in Spain (Madrid)

Over 1,400 employees

Aeronautics, Space, Defense & Security, Cybersecurity, Intelligent Transport Systems, Healthcare, Banking & finances, and ICT industries.

Private capital

Subsidiaries in 10 countries

Roots tied to the Space and Defence industry

Engineering, development and integration of systems, software, hardware, specialized products and services

Founded in

1984

GMV IN THE WORLD

SPAIN
MADRID – HEADQUARTERS
VALLADOLID
SEVILLE
BARCELONA
VALENCIA
LEON
ZARAGOZA

COLOMBIA
FRANCE
GERMANY
MALAYSIA
NORTH AMERICA
PORTUGAL
POLAND
ROMANIA
UNITED KINGDOM

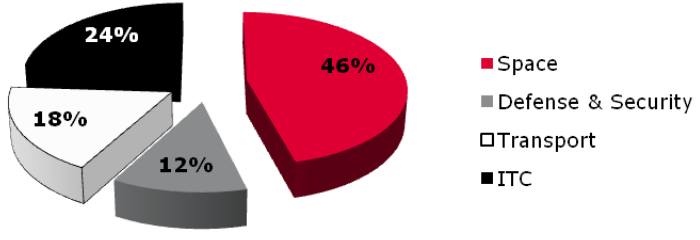
BRANCHES AND OFFICES

PROJECTS

WHAT WE DO

GMV provides engineering, expert support services and turn-key IT systems and solutions for these markets

- Aeronautics
- Space
- Defense
- Security
- Healthcare
- Transportation
- IT & Telecommunications



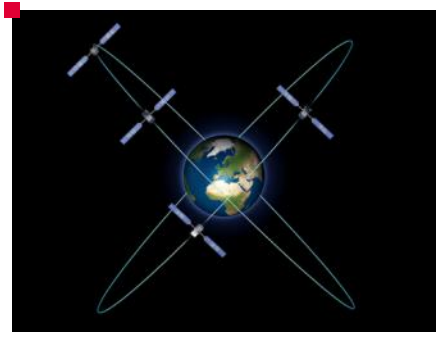






SPACE

#1 Worldwide Satellite Control Center provider to commercial telecom operators (+300 Satellite missions worldwide).



European leader in satellite navigation processing ground segment (**EGNOS** and **Galileo**).

Reference supplier for on-board **GNC/AOCS** subsystems.

Major provider of EO Services and Applications.

SPACE NEWS Top 50

Included in SpaceNews' Top 50 Space Manufacturing Industries

How can you be a part of this?

There is not only one way to work in space:

- Academic career
- Be part of a space organization
- Attend to ESA trainings
- Do a internship in a space company… or your thesis!
- …

BE CURIOUS

BE FLEXIBLE

LOOK FOR NEW CHALLENGIES

GMV view

Space exploration

What does space exploration need?

Running a lot of studies, participating to real missions, listening to experts. There are several technologies to develop/improve to allow space exploration:

- Launchers
- Electrical propulsion
- Optical communication
- New Mission Control Center concept
- …

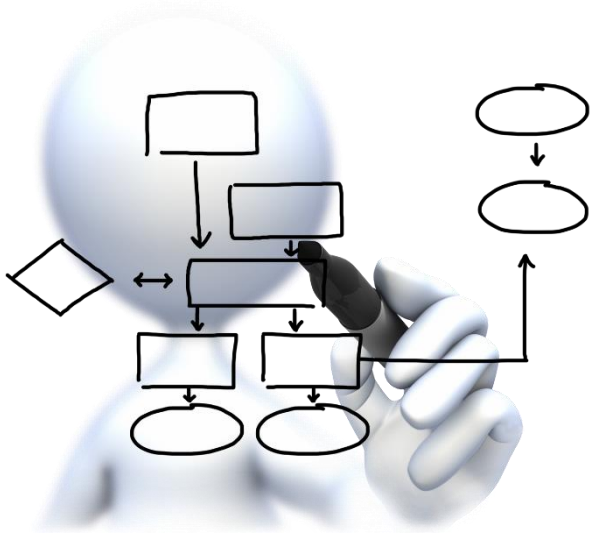
But our focus is on the on-board technologies the will guarantee more autonomy to the SC, saving cost and allowing to go further into space and closer to planets, moons, asteroids.

This can be obtained with an **autonomous GNC system**

Navigation, Guidance and Control

GUIDANCE

NAVIGATION



CONTROL

Where am I?

Where am I supposed to be/go

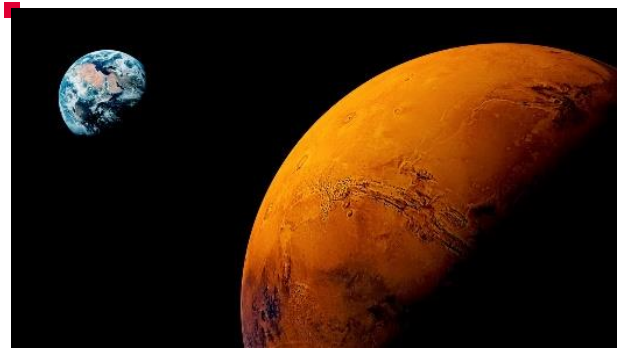
Let’s go!

Current missions and near future

Moon

Pinpointing autonomous landing

- Lunar Lander



Mars

Autonomous RdV for the Mars Sample Return mission

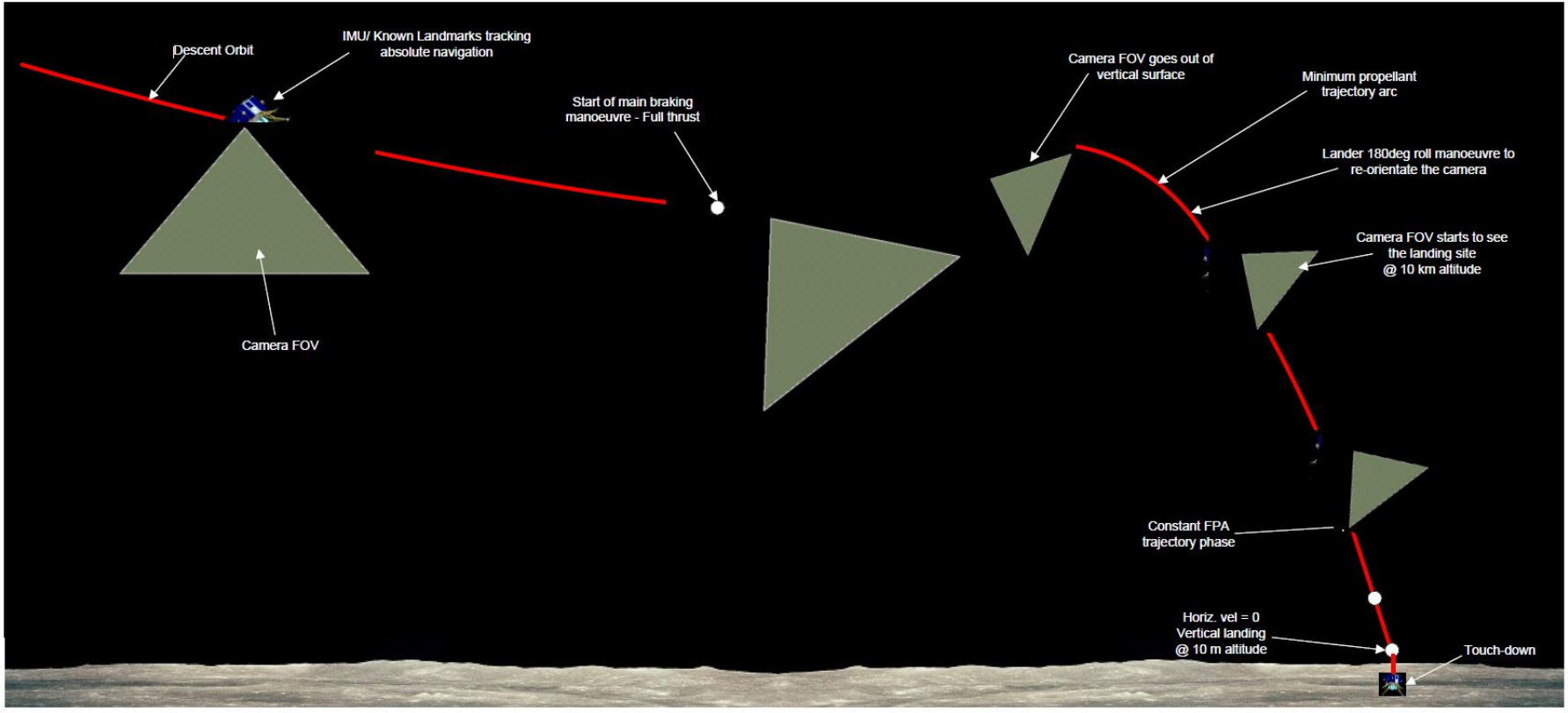
- MSR

Asteroids

Mission analysis and autonomous vision based GNC

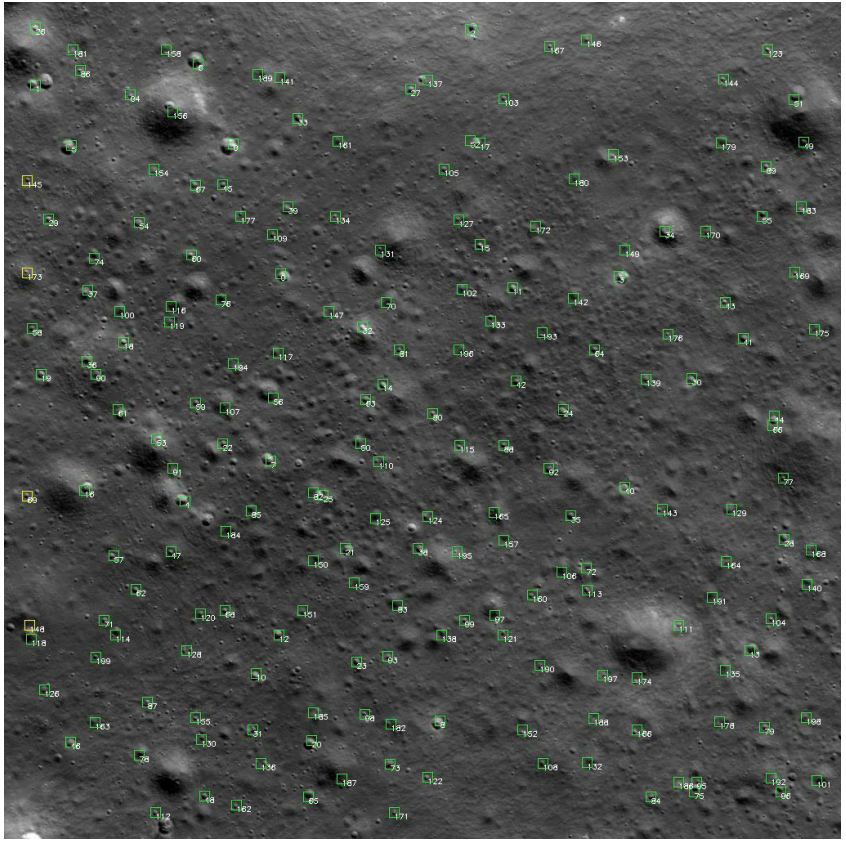
- ROSETTA
- AIM & HERA

The Moon – Pinpoint landing

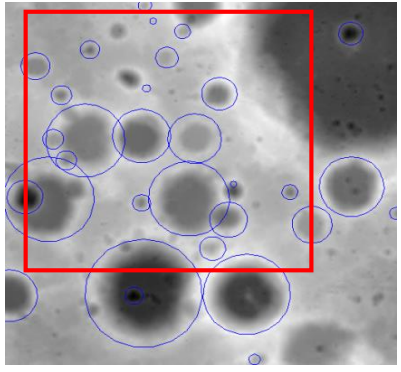


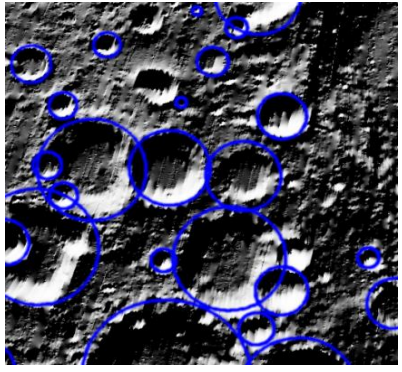
The Moon – Autonomous Navigation

Pilot and the **Luna-Resurs** mission

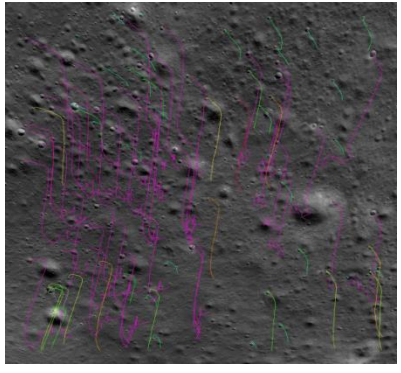


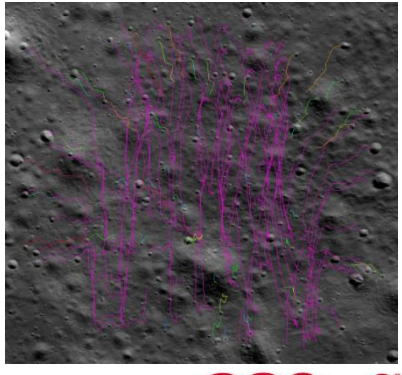
AbsNav





RelNav

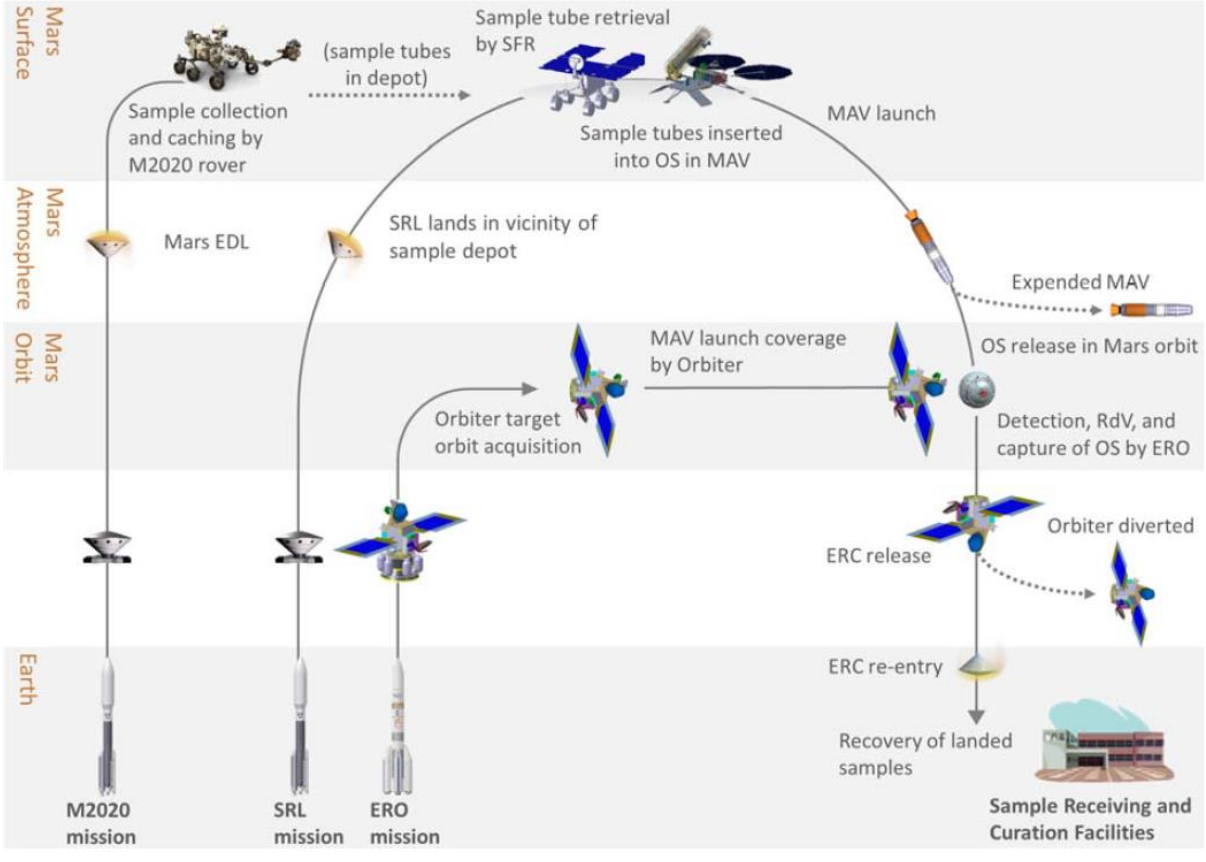




Mars RdV

Mars Sample Return is the next step:

- 3 joint missions between ESA and NASA
- GMV participated in the iGNC study, dealing with one of the most critical phase, the RdV with OS
- We are now responsible for the RdV phase and we also are involved in the SFR

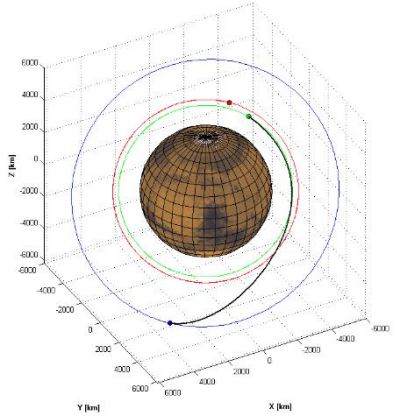


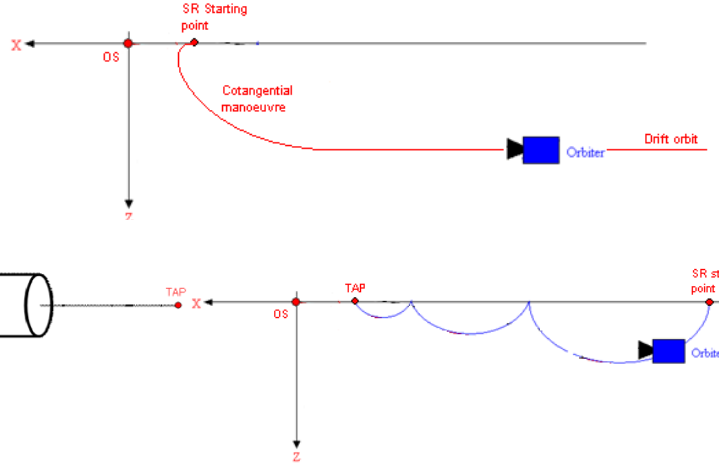
Mars and Autonomous RdV

During past years GMV worked in many ESA activities aimed at developing, validating and verifying GNC and IP algorithms for MSR rendezvous and capture phase.

The scenario is divided into the following phases:

- Search phase and Orbit Synchronization
  - Identification of the target
  - Autonomous OS orbit determination
- Intermediate range phase
  - Cotangential maneuver to OS V-bar
- Short range phase
  - Hopping on V-bar
- Forced motion and capture phase

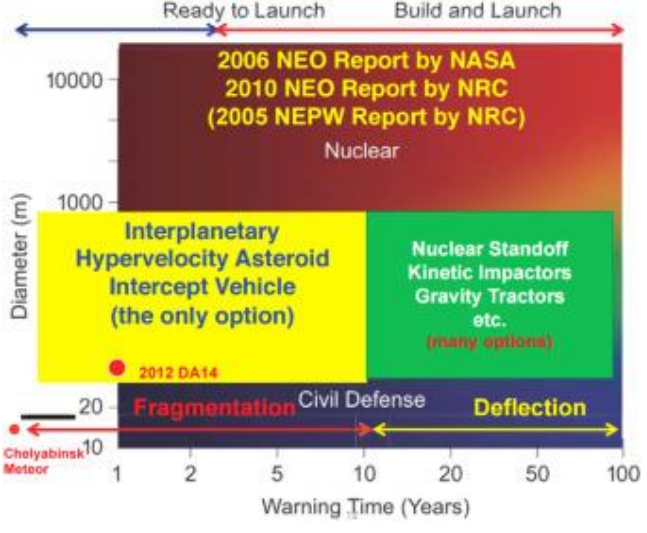




Planetary Defense

What can we do?

- Nuclear
- Gravity tractor
- Kinetic Impactor (valid for the vast asteroid population of diameter ≈100m



Focus on Asteroids

HERA

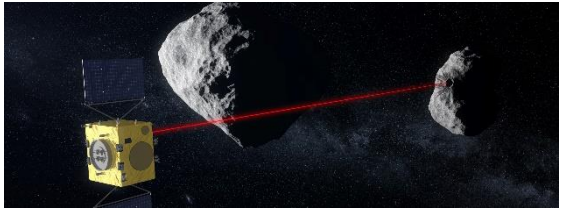
The HERA mission

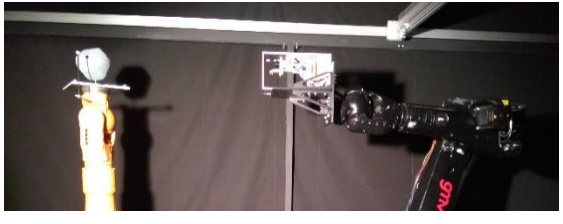
HERA is a European mission of opportunity in the frame of planetary defense, with the main objective of demonstrating the kinetic impactor technique on a binary asteroid system. It is based on extensive work done by the European Space Agency and European industry between 2011 and 2016 (AIM studies in the frame of the AIDA joint mission with NASA).

Main mission objectives:

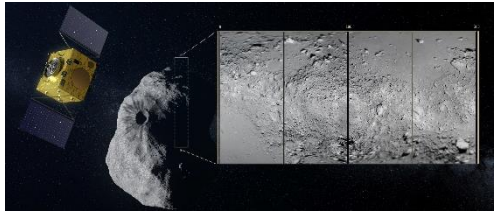
Kinetic impactor technique demonstration

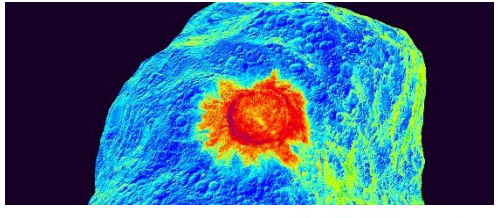
Technology demonstration





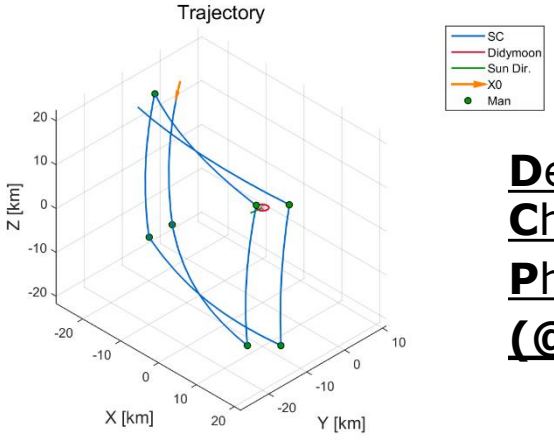
Science



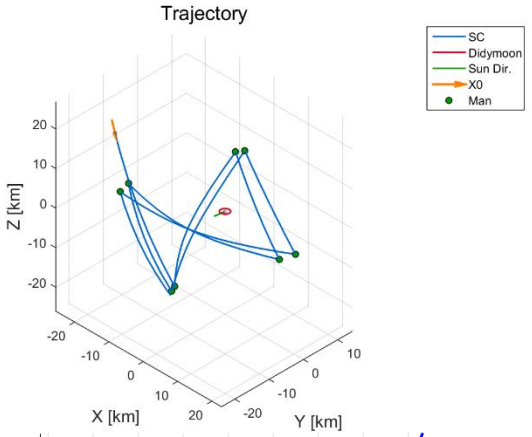


Close Proximity operations

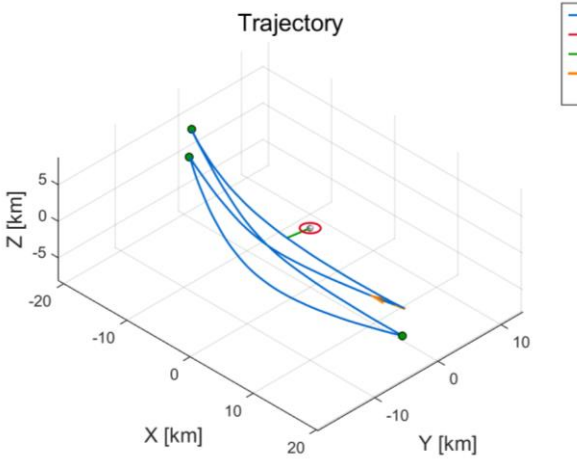
Early Characterization Phase (@35 km)



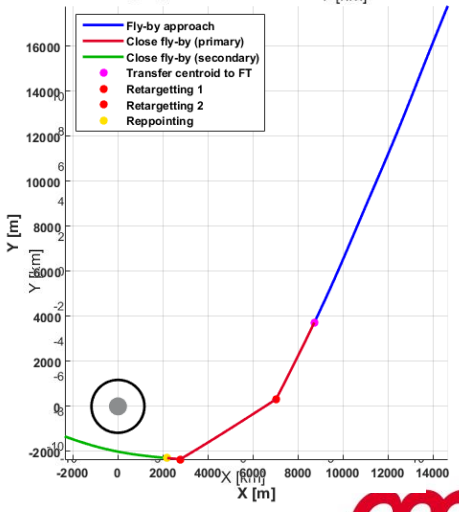
Detailed Characterization Phase (@10 km)



DCP3 (@6 km)



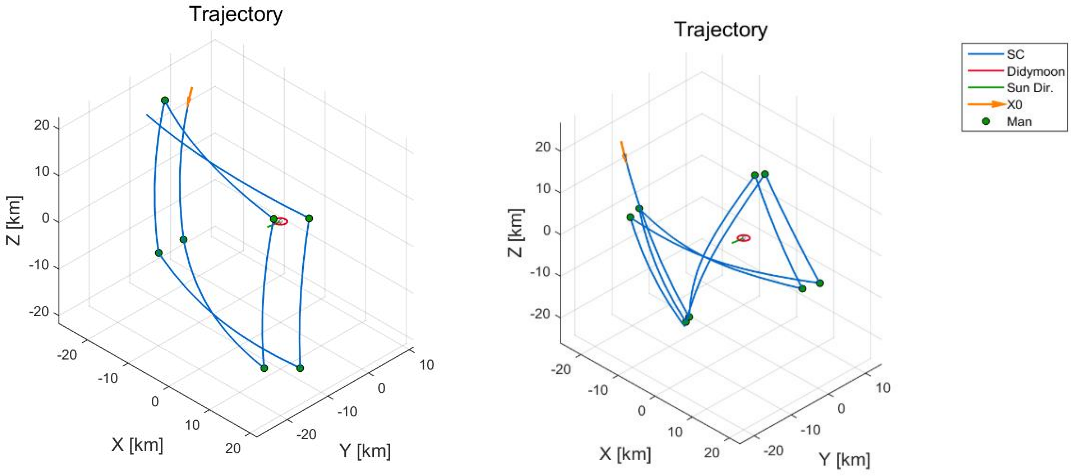
Close Fly-by (@1 km)



Asteroid Characterization and SAG mode

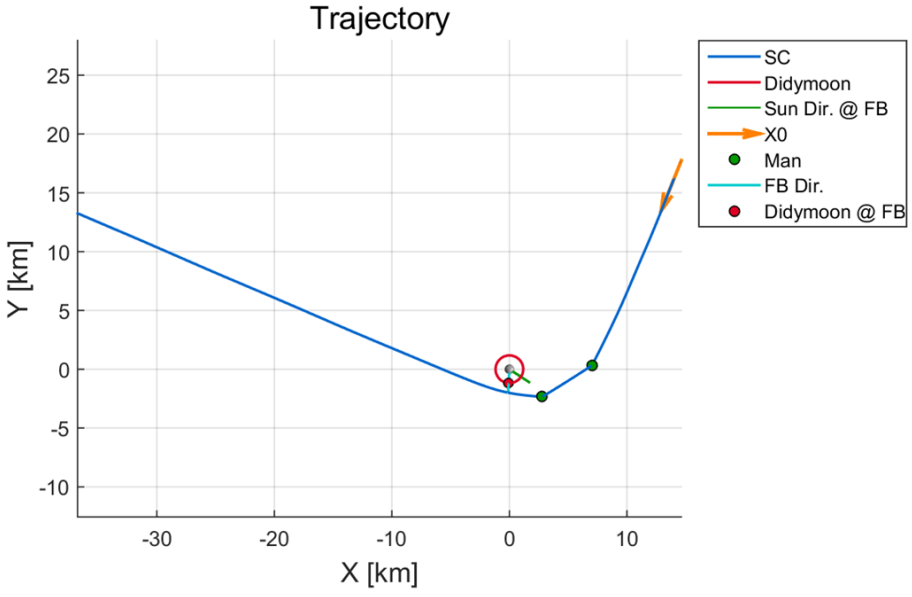
- At first, in the Early Characterization Phase, the SC is manually flown (~30 km)
- Getting closer (~ 10 km), ground based attitude profile leads to the loss of the asteroids from the FoV
- Semi-Autonomous Guidance (SAG): autonomous correction of the spacecraft pointing that prevents loss of the asteroids from the FoV, using autonomous navigation and centroiding measurements

Hyperbolic Arcs



Fully Autonomous GNC

Close Fly-by (@1 km)

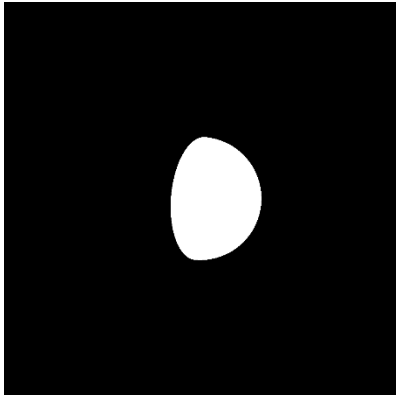


- In order to get even closer, to have high resolution data and maximize science, a sequence of retargeting maneuver will progressively reduce the pericenter of the hyperbolic arcs
- These maneuvers need fast reactions to SC state and have to be performed autonomously (required high precision autonomous navigation based on feature tracking image processing)

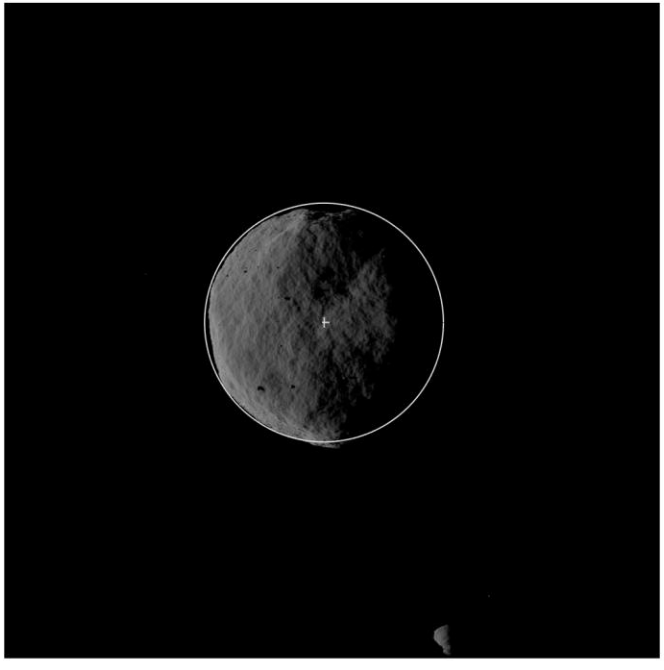
Centroiding based Navigation

Robust technique that can be used when the asteroid is entirely in the FoV

- To be robust to the illumination condition a correlation with the Lambertian sphere is performed
- Robustness to the presence of the secondary in the FoV has been demonstrated



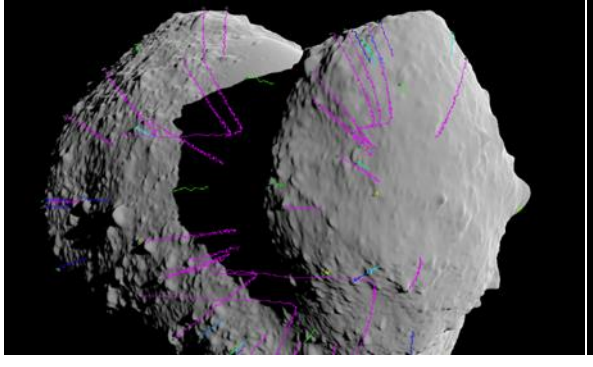
Centroiding IP



Feature Tracking based Navigation

Autonomous retargeting maneuvers require high precision autonomous navigation:

- The IP adopted is the Feature identification and tracking
- The optical measurements enters the navigation filters and allow for an high autonomous spacecraft state estimation on-board



Feature Tracking + Centroiding

Validation approach

- The incremental on-ground validation is based starts with Matlab/Simulink tests and get up to Hardware-In-the-Loop simulations (real camera images included in the loop of the GNC)

- For HERA Phase B1 the qualification model of the Dawn camera (Asteroid Framing Camera) have been used for HIL tests

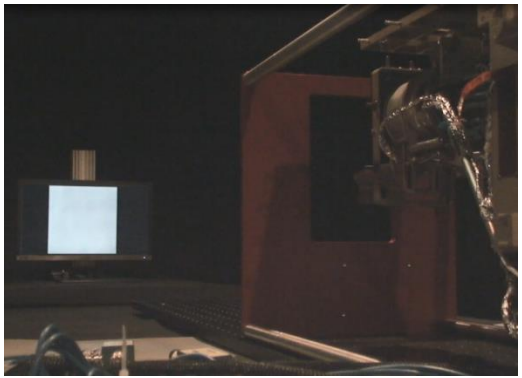
Images from the AFC qualification model

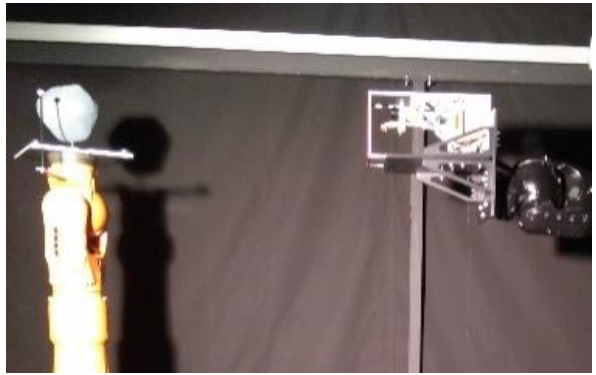
IP binarization

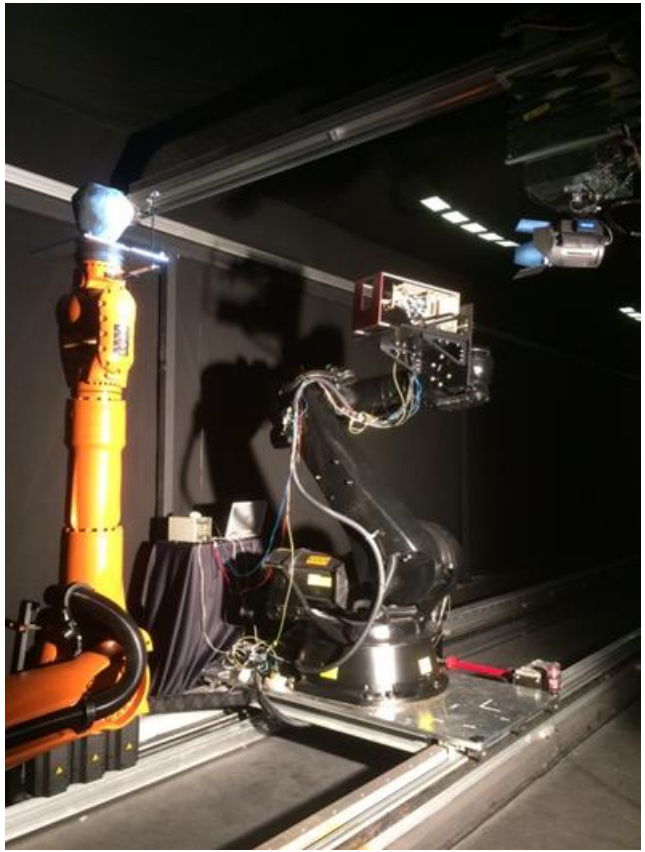
OPTICAL & ROBOTIC LABs

HIL with the AFC qualification camera:

- **Optical lab:** synthetic generated images are projected on a high resolution screen and the AFC takes images in a static environment
- **Robotic lab (*platform-art*©):** the usage of synthetic images is no longer needed thanks to:
  - the space like scenario of ***platform-art***©
  - specifically manufactured mock-ups







In a nutshell

Conclusions

Conclusions

Space exploration is as exciting as it is challenging, especially at GMV!

- Moon, Asteroids and Mars are the new frontiers
- How do we get there? The autonomous GNC system is between the critical technologies to be developed in the near future (The Navigation is the key)
- In the future autonomy will not be limited to GNC, on-board re-planning and decision making will allow to react fast and efficiently to any external stimuli, even AUs away from Earth
- A piece of advice: BE CURIOUS, BE FLEXIBLE, LOOK FOR NEW CHALLENGIES

www.gmv.com

THANK YOU

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gmv BLOG