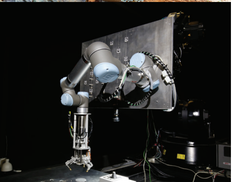
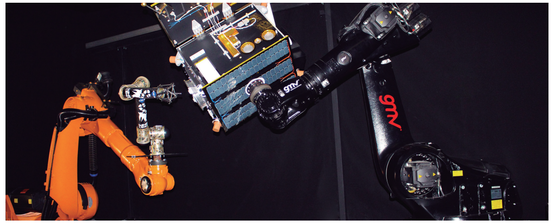


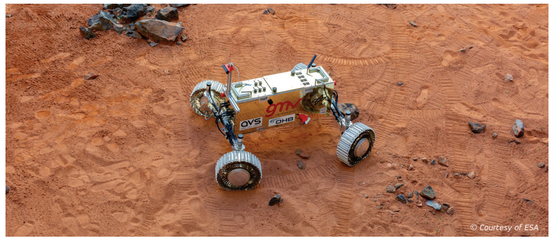
Robotic facilities

Platform-art©: ADVANCED ROBOTIC TESTBED FOR ORBITAL AND PLANETARY SYSTEM AND OPERATIONS TESTING

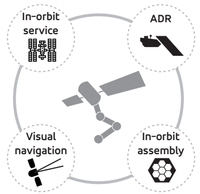
Platform-art© is GMV's Hardware in the Loop (HIL) robotic test facility. It is designed for verification and validation of Guidance, Navigation and Control (GNC), sensors and robotic technologies at short range phases within rendezvous, formation flying and active debris removal (ADR), servicing missions, as well as other relative scenarios including lunar, planetary or asteroid landing.



SPoT (planet surface terrain): GMV's head office hosts an 182 m2 area simulating a Martian landscape with red soil of similar grain size to Martian soil, rocks and a Martian panorama. This facility provides a large testing area and an outdoor environment to test different robotic applications under natural lighting conditions from an annex serving as a space control center. The soil characteristics are matched to some regions on Mars, and the rock colors, sizes and distribution are intended to match images from Martian missions.

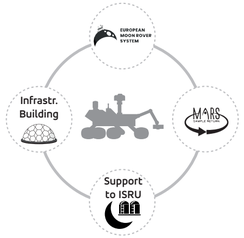


Robotic fields covered



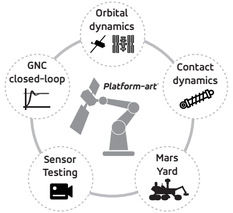
Orbital Robotics

- Advanced control for debris capture and removal.
- Visual navigation & inspection in-orbit.
- Robotic assembly of large and flexible structures.
- Robotic in-orbit servicing & refueling for life extension.



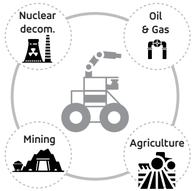
Planetary Surface Robotics

- Autonomous agents for planetary exploration and In-Situ Resource Utilisation.
- Visual odometry & mapping (SPARTAN), path planning & trajectory control.
- Situational Awareness, visual recognition and pose estimation for collaborative scenarios.



Simulation & Test Facilities

- Orbital dynamics simulation for RdV, FF and IOS.
- Navigation sensors test.
- GNC closed loop experiments.
- Contact dynamics (ADR, In-Orbit Assembly).
- Planetary robotics test campaigns.



Terrestrial Robotics

- Autonomous inspection & service in hostile environments.
- Navigation & mapping in unknown areas.
- AI for cooperative working with humans.

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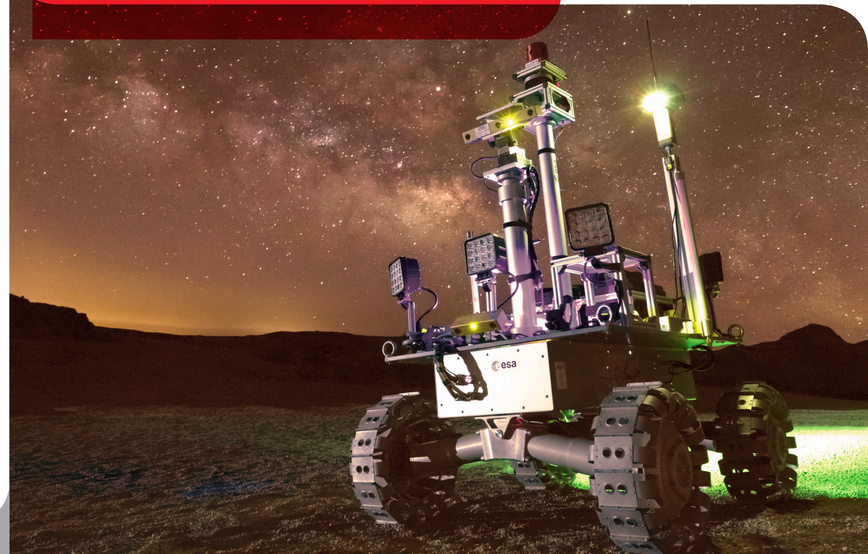
SPACE

Robotic solutions and Autonomous Systems

- Space Robotics: planetary surface and orbital
- Terrestrial robotics: surface, aerial and underwater
- Simulation and on-ground Test facilities



Services & technologies provided

GMV provides a wide range of services and technological solutions, which include:

Robotic facilities for testing, including engineering support for tests set-up, integration of customer equipment/systems, telemetry generation and post-processing.

AI Solutions for advanced robotics (recognition, pose estimation, locomotion and manipulation).

Field trials planning, data collection, validation and logistics support.

Robotic systems consultancy and support to system design and integration. End-to-end solutions.

Onboard autonomy, including autonomous navigation, onboard planning and scheduling, fault detection/isolation and accommodation of failures. **GMV Brain** is the GMV's suite of products for robotic onboard autonomy.

Terrain **mapping and path planning** solutions.

Robotic odometry and navigation systems, covering the whole spectrum of sensing and processing techniques:

- Visual odometry (both monocular and stereo). SPARTAN is the GMV's product for visual odometry and mapping (Both processor and FPGA parallelized versions available).
- Integration and processing of measurements from active sensors (Laser ranging and scanning systems, Time Of Flight cameras).
- Integration and processing of measurements from passive sensors (stereo, hyperspectral).
- GPS and differential GPS solutions.
- Data fusion techniques from navigation sensors (IMU, gyroscope, inclinometers).
- Simultaneous Localisation and Mapping (SLAM) techniques.
- Generation and processing of Digital Elevation Maps from raw measurements (point clouds).

Advanced **situational awareness** techniques for robot operation.

Design, Development and Validation of innovative robotic control systems for a variety of robotic platforms, ranging from surface exploration rovers to robotic arms for capture and assembly operations.

Autonomous systems: *GMV brain*

GMV brain **is Artificial Intelligence for mobile robots to enable robust operation in the real world. It consists of a framework, highly extensible and customizable to any robot, in which GMV has embedded its own products for navigation, planning and autonomous decision making.**

- **Robust validated and verified technology originated from space technologies for planetary exploration applications**
- **Highly modular and generic architecture that can be complemented by 3rd party components or extensions**
- **Flexible for a large number of scenarios and demonstrated for specific use cases.**

Key components of this framework are:

Mission Planner

- Takes high-level goals from the users and plans the set of actions needed to achieve the goals
- Automatically generates low level plans to achieve the commanded goals when requested by the agent
- Can be commanded to execute high level goals (e.g "inspect point A", "bring tool B")
- Executes the plan and monitors for correct execution
- Re-plans in case nominal plans become unfeasible or if new goals are received
- Allows cooperation between several robots, in a:
  - Multi-agent architecture: multiple agents exchange information for collaborative plan execution
  - Single-agent architecture: a single agent is able to control several robots to achieve common goals

Autonomous Agent

- High-level autonomous robot controller based on layered architecture

Autonomous Navigation

- Robust Sensor Fusion
- Odometry, including visual odometry
- GNSS localisation and path planning
- Simultaneous Localisation and Mapping (SLAM)
- Trajectory control, Obstacle and hazard detection and avoidance

Robotic Manipulation

- Compliant cooperative manipulation, robot-robot or robot-human
- Robotic arm motion planning and execution.
- Force/impedance controlled manipulation for robust interaction with environment
- Coordinated arm-rover manipulation

Inspection

- Vision based perception
- Opportunistic science based on autonomous target detection

Simulations

- Simulation for planning, training and visualisation
- Internal simulation for decision making and learning

Hardware Abstraction

- Compatibility with a range of robot platforms, computer architectures and sensors

Formal Validation

- Additional tools for formal validation of code and functionality

Machine vision

- Visual odometry for robot localization
- Object detection and 3D localization (e.g. for inspection applications)
- Human detection for safety and cooperation
- Vision-based autonomous manipulation

Opportunistic science

- AI for the detection of targets of interest based on AI techniques on pattern recognition