RAPID:
A Robust and (Semi) Autonomous Platform for Increased Distances

gmv
INNOVATING SOLUTIONS

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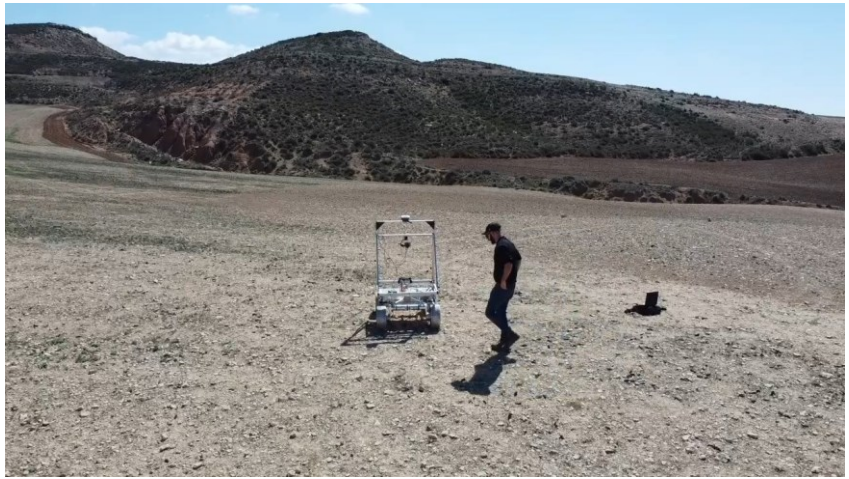
RAPID Intro & Concept



RAPID: Objectives and Problem areas

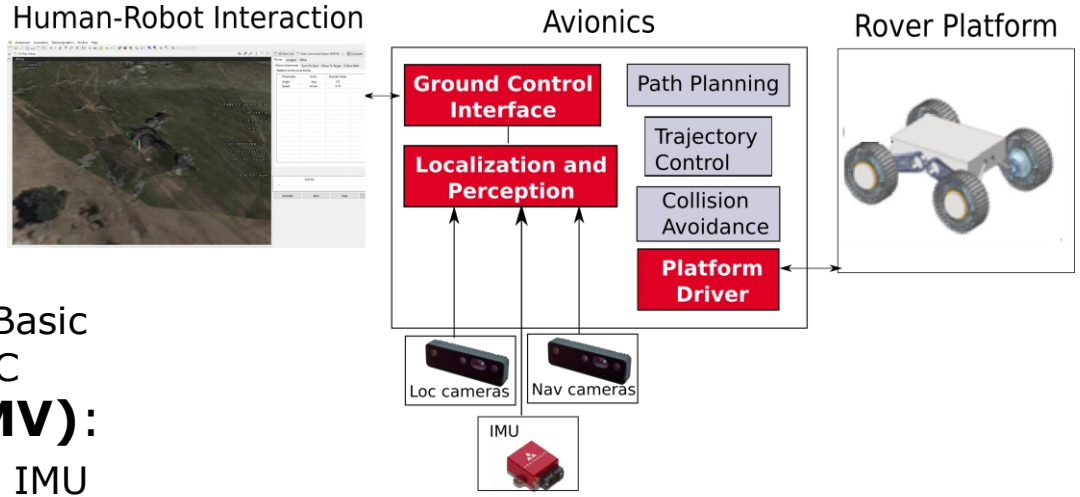
- Core Objective of the activity:
- **"The development of a semi-autonomous rover capable of traversing safely lunar areas at an average speed of 1.0 m/s, using a semi-autonomous GNC system based on visual navigation"**
- The rover shall be able to be tele commanded from an HRI (ground station)
- The HRI shall use MMI technology suitable for in-space tele-operation
- Shall be tested in an analog to the Lunar Mare area

We identified a set of potential problem areas like:

- **Locomotion and suspension**
- **A GNC for continuous driving**
- **HRI Challenges: Tele-manipulation and semi-autonomous modes-**
- **Scaling the results to a Moon mission**

Concept and Consortium

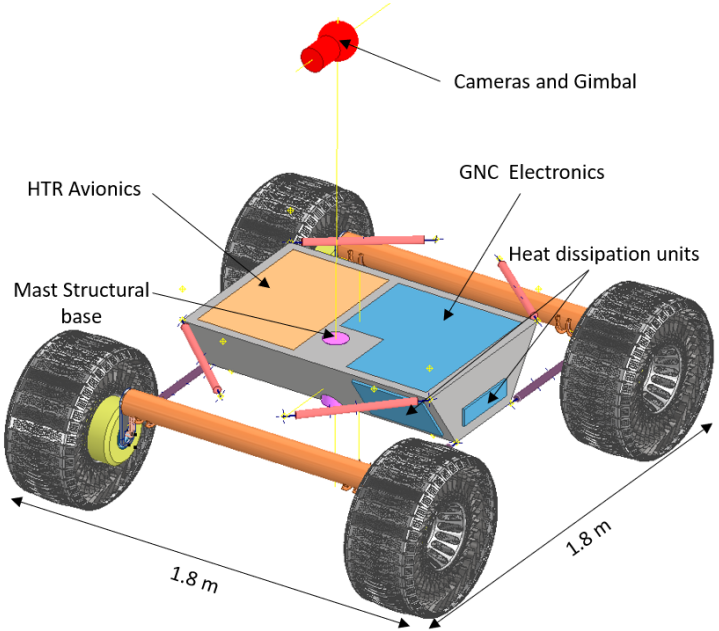
- **GMV as main integrator**
- **Rover platform** with flexible wheels and skid system (**HTR**)
- **Avionics** containing:
  - **Motion Control: (HTR)** Basic motor's control/odometry via OBC
  - **GNC avionics & SW (GMV)**:
    - Dedicated computer, cameras, IMU
    - Perception and localisation part based on SPARTAN **(GMV)**
    - Guidance and control based on ESA-PRL Github repository (**UMA**)
- **HRI** we rely on the CLEAR developments as well as the SW implemented in 3DROCS (**NRB**).



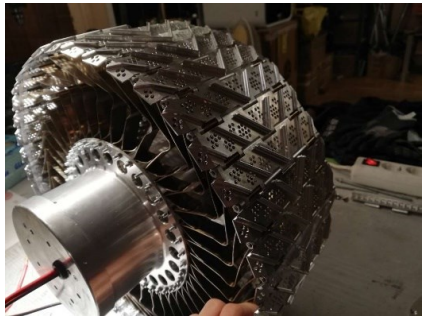
RAPID Rover platform challenges

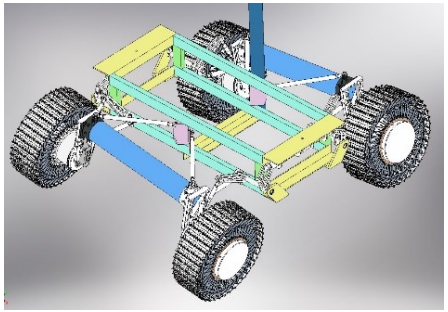
Challenges for the rover platform: Rover dimensions and scalability

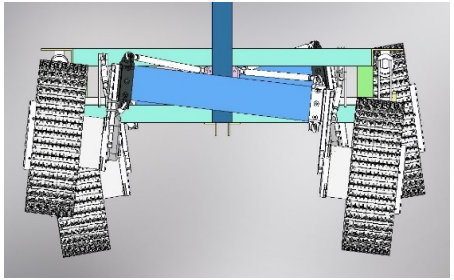
Baseline (Lunar): 300Kg, 1.8x1.8m Baseline (Terrestrial): 60 kg, 1x1m

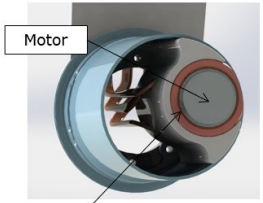


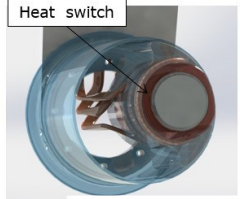
Challenges for rover platform: wheel, suspension & thermal management

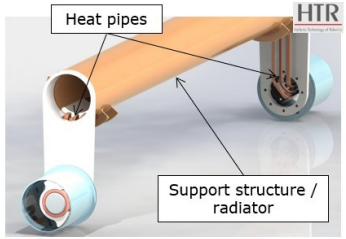


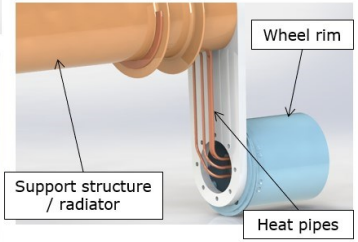


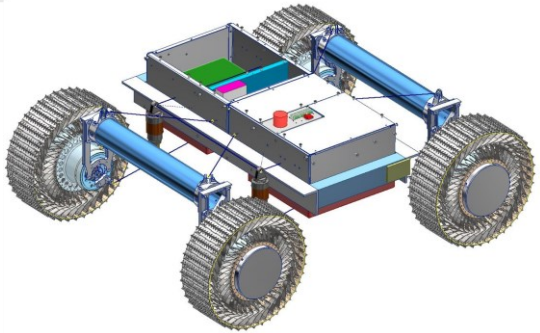








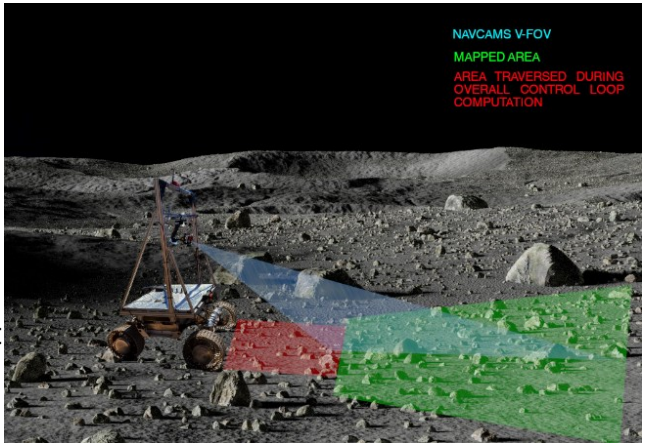




RAPID GNC challenges

Challenges: Continuous localization and perception

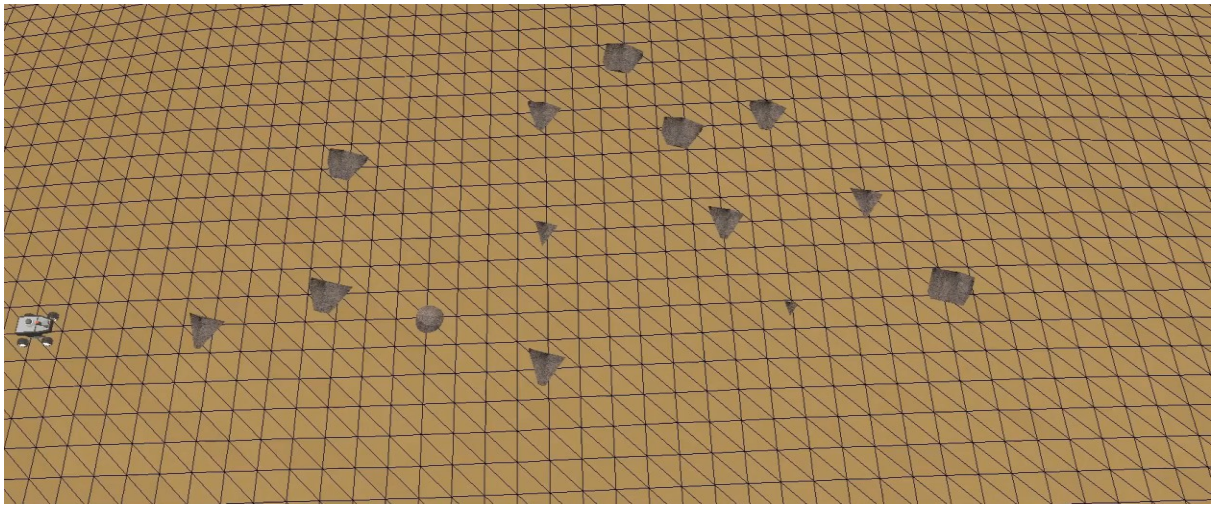
- Ad hoc solution using **SPARTAN** (Space Performance and Robust Terrain Awareness Network)
- **Camera selection**
  - **Compact solution with a ~75 mm. baseline** was adopted for both NavCams and LocCams
- Continuous Localization **- Visual Odometry** (VO)
  - **Sufficient frequency**
  - Positioning of the LocCams is critical
    - **>70% image overlap** between consecutive frames
    - **Installed on the chassis** to minimize vibrations
    - Tilt **orientation was fine-tuned**
- Continuous Perception
  - Abrupt Orientation changes/Mechanical Vibrations
    - **Gimbal** to maintain a fixed orientation w.r.t. its axis of rotation
    - **Gimbal + NavCams installed on an arc**, i.e. instead of a mast
  - **Stereo Mapping**
    - **DEMs up to 6 m** in front of the rover
    - **Nearest ~2 m. is not mapped**
      - the distance traversed at full speed during the computation of the overall control loop plus a safety margin.
  - **Far Obstacle detection**
    - **Identifying rocks and subsidence** on the lunar surface from monocular images.
    - Proactively anticipate potential obstacles in the rover's path.



Mapping constraints for continuous navigation

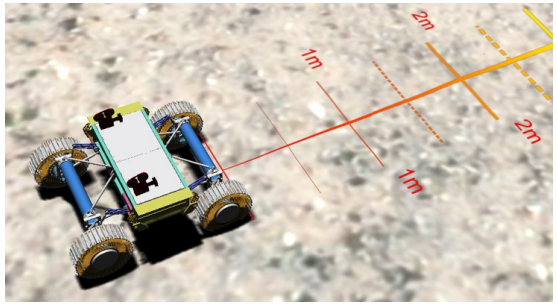
Challenges: Continuous Guidance

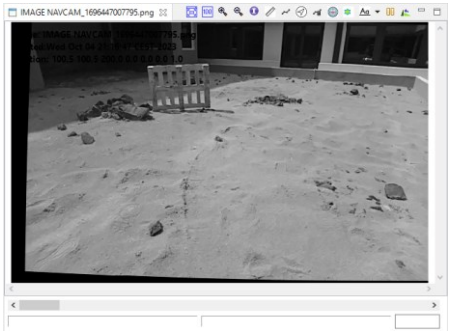
- **Global Path planning:**
  - Based on orbital imagery.
  - Far obstacles avoidance.
- **Local Path Planning**
  - Local path repairing
- **Trajectory controller:**
  - C-pursuit.
  - Guarantee a safe corridor.
- **Locomotion control:**
  - Skid-steering adaptation.
  - Ackermann compatible.

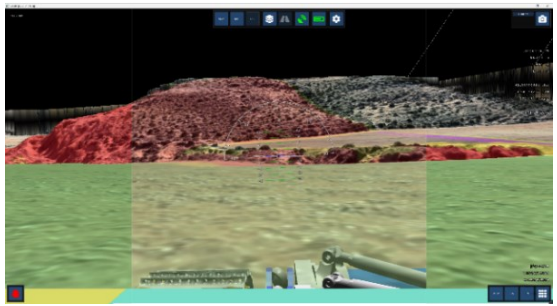


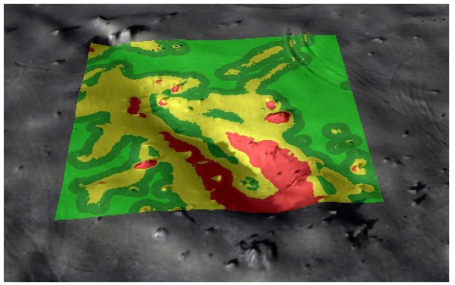
Challenges: HRI

- 3DROCS Instantiation for RAPID
- A New Touch Screen MMI that combines telemanipulation with interactive autonomy
- Telemanipulation with external devices



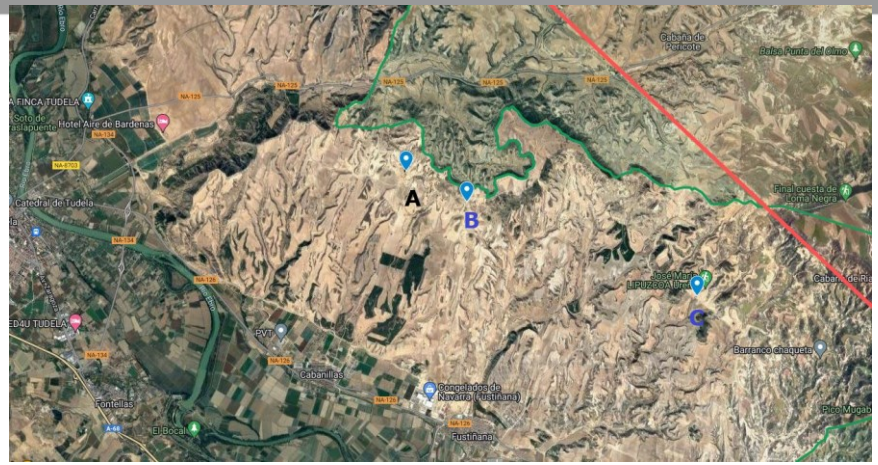






- Ground-interface running on-board for TC/TM
- HK Telemetry
- Images
- Point Clouds/DEM

RAPID Tests Performed



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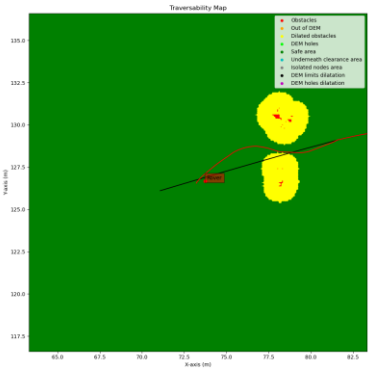
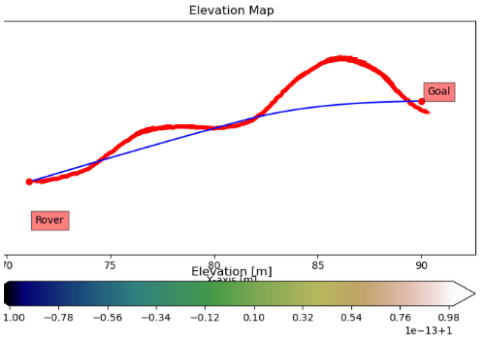
Field tests

Test Set	Goal	Status
Rover Basic Tests	Verify Basic Health, GPS, Direct Commanding	OK
Localization and Mapping Tests	Verify Localization and mapping using Cameras DEM / GT /Spartan	Not completed
Obstacle Avoidance and path planning/ traversability Tests	Guidance	Not completed
Ground Station Test Cases	Monitor telemetry, Displays, Sit awareness, Synoptic, Rehearse, Annotation, Teleoperation, Joystick Mngment	OK

Extended test campaign

- Aimed to fix those problems found during the field tests. These involve:
  - Guidance and far obstacle detection
  - Spartan fine tuning
- We will gather performance parameters and determine the results at different speeds (0.3 m/s 0.7 m/s, 1.0 m/s)





Conclusions

Conclusions

- RAPID is a newly developed rover platform capable of performing traverses at high speeds.
- The combination of its **chassis, suspension and gimbal provides a stable platform,** reducing the mechanical vibrations of the cameras so that valid point clouds and DEMS can be generated even at high speed in harsh terrain (“Luna Mare”)
- Its GNC **is designed to avoid the “stop and go” paradigm**, increasing average speeds
- A **complete HRI has been developed for the rover**, with new features (f.i. the possibility to telecommand it from Earth/International Space Station)
- Tests **demonstrated the capability of the rover platform to run at 1.2 m/s** while telemanipulated.
- **Guidance uses a local/global path planning strategy and is able to replan the trajectory** avoiding the stop/go and successfully overcome obstacles at 0.3, 0.5 m/s
- **RAPID is not finished and is facing its extended test campaign**: a final assessment for both perception and localization and guidance capabilities will emerge from the extended tests

Thank You

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