GXLP-BMT LUNAR OPPORTUNISTIC SCIENCE

25-09-2012

INNOVATING SOLUTIONS

GLXP-BMT MOONRAISE

MISSION APPROACH AND DEFINITION

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MISSION OBJECTIVES (GLXP + EXTENDED)

- Land in the Lunar surface
- Move 500m over the surface
- Carry a payload of 0.25kg
- Send back HD imagery to Earth (“Mooncast”) including:
  - 360º pictures of Lunar surface
  - Auto-pictures of Lunar Lander and Rover
  - Quasi Real-Time HD video
  - Ancillary data
- Secondary Objectives:
  - Move 5000m with controlled manoeuvres
  - Take pictures of historical objects (only Apollo?)
  - Discover frozen water
  - Survive a Lunar night

- Extended objectives (BMT team): carry an additional payload of 6 kg (Rover Module) + 20 kg (Lander Module) for:
  - Extended science content
  - Help funding the mission

MISSION PHILOSOPHY

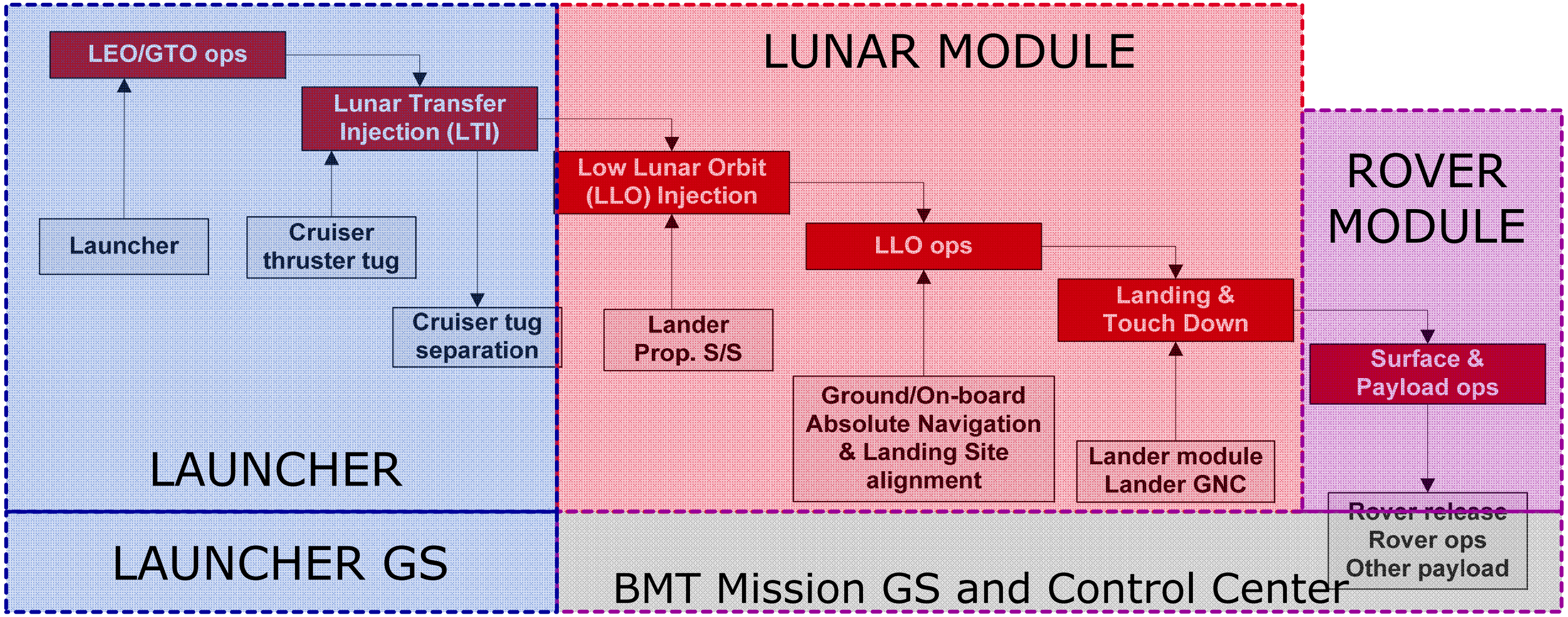
- Low cost mission.
- Short and rapid design and development approach, with constant iteration between the different subsystems and the different stages of development.
  - Use of SW autocoding as far as possible.
- Re-use of expertise, technologies, developments and existing equipment.
- Use (whenever reasonably possible and helped by the short duration mission) of components not "hard" qualified for use in space.
  - Commercial components (COTS).
  - Intermediate models of space equipment that may be available (for example, re-use of EQMs or PFM for use as final flight units).
- Involvement of universities, laboratories and research institutions wherever possible.

MAIN MISSION REQUIREMENTS

- Mission lifetime < 15 weeks (including contingency)
- Top-down approach:
  - Launcher➔Propulsion S/S➔Dry&wet mass➔Payload mass
- Omnidirectional LM comms capabilities
  - Ground stations: Maspalomas (15 m) and/or Robledo (34 m, TBC)
- LM as comms relay of the rover
  - Direct low-rate rover-ground comms link (contingency)
- Landing at any latitude within ± 35 deg with an accuracy of 1 km (1-sigma) wrt the selected historical rest and at the beginning of the lunar day.
  - The LLO shall be polar-like orbit along or close to the terminator.
- During the DL, landing site images will be acquired and sent in real-time (TBC) to ground
  - Off-line identification of target historical device to later guide the rover

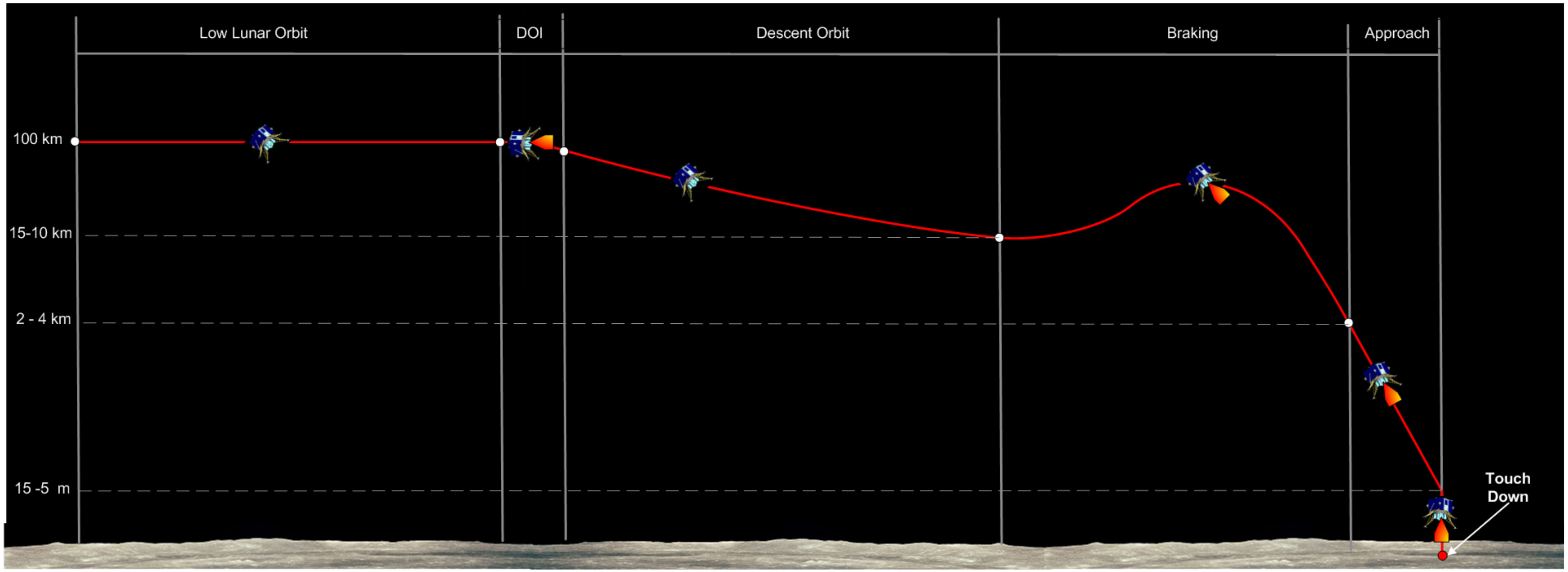
MISSION ARCHITECTURE

1. The launch vehicle, in charge of putting the Lander module (LM) + Rover Module (RM) into an orbit towards the Moon.
2. The design, development, manufacture and ops of the LM.
3. The design, development, manufacture and ops of the mobile rover platform for exploration.
4. The ground segment and ground operations.



MISSION ANALYSIS: DESCENT & LANDING

- Descent and Landing Phases:
  - DOI: Descent Orbit Injection. From 100x100km orbit (Low Lunar Orbit) to 100x15km orbit (Descent Orbit)
  - Braking phase: 100% of available thrust
  - Approach phase: reduction of thrust level to allow controlability
  - Terminal phase: 10 meters total vertical descent



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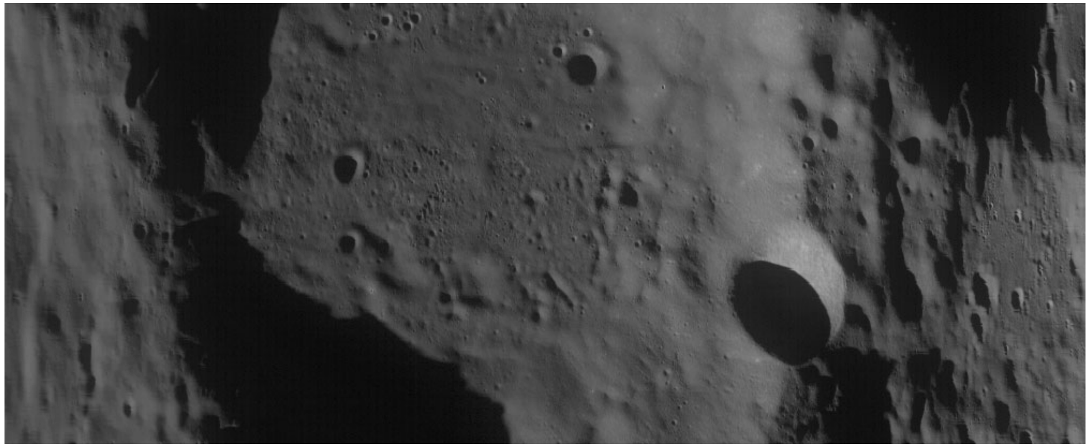
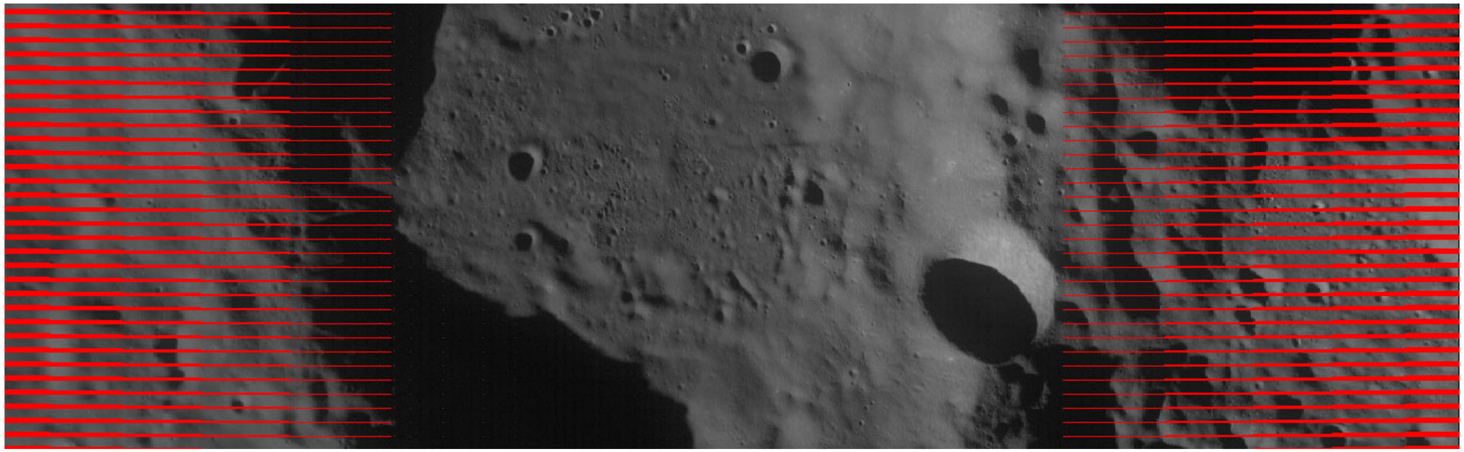
MOON SURFACE OBSERVATION (1/3)

- Geometric distortion is affecting the LROC WAC images

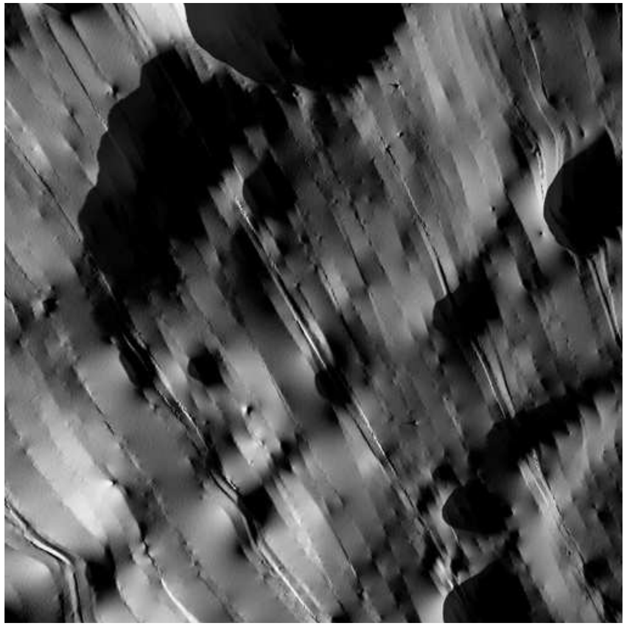


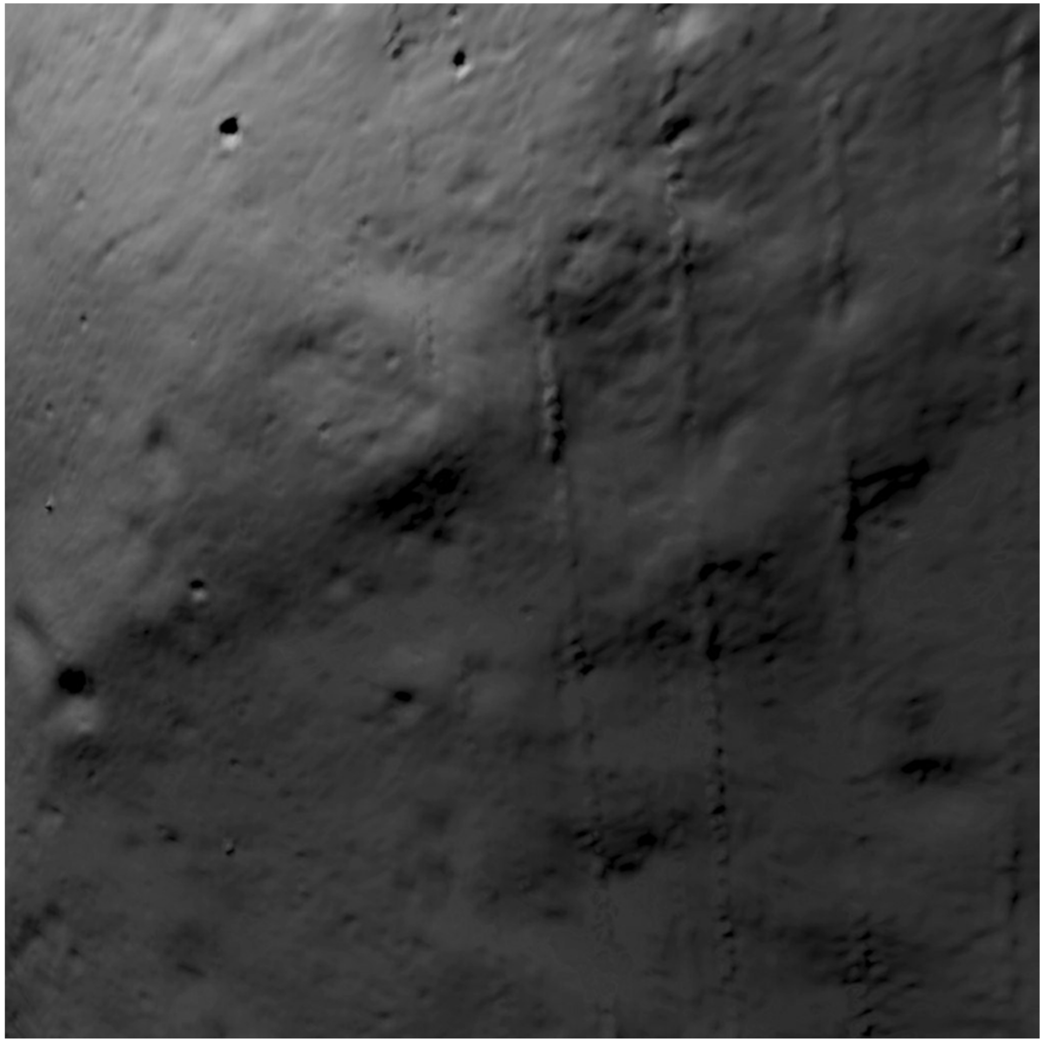


MOON SURFACE OBSERVATION (2/3)

- LOLA Digital Elevation Map presents discontinuities and is lacking resolution

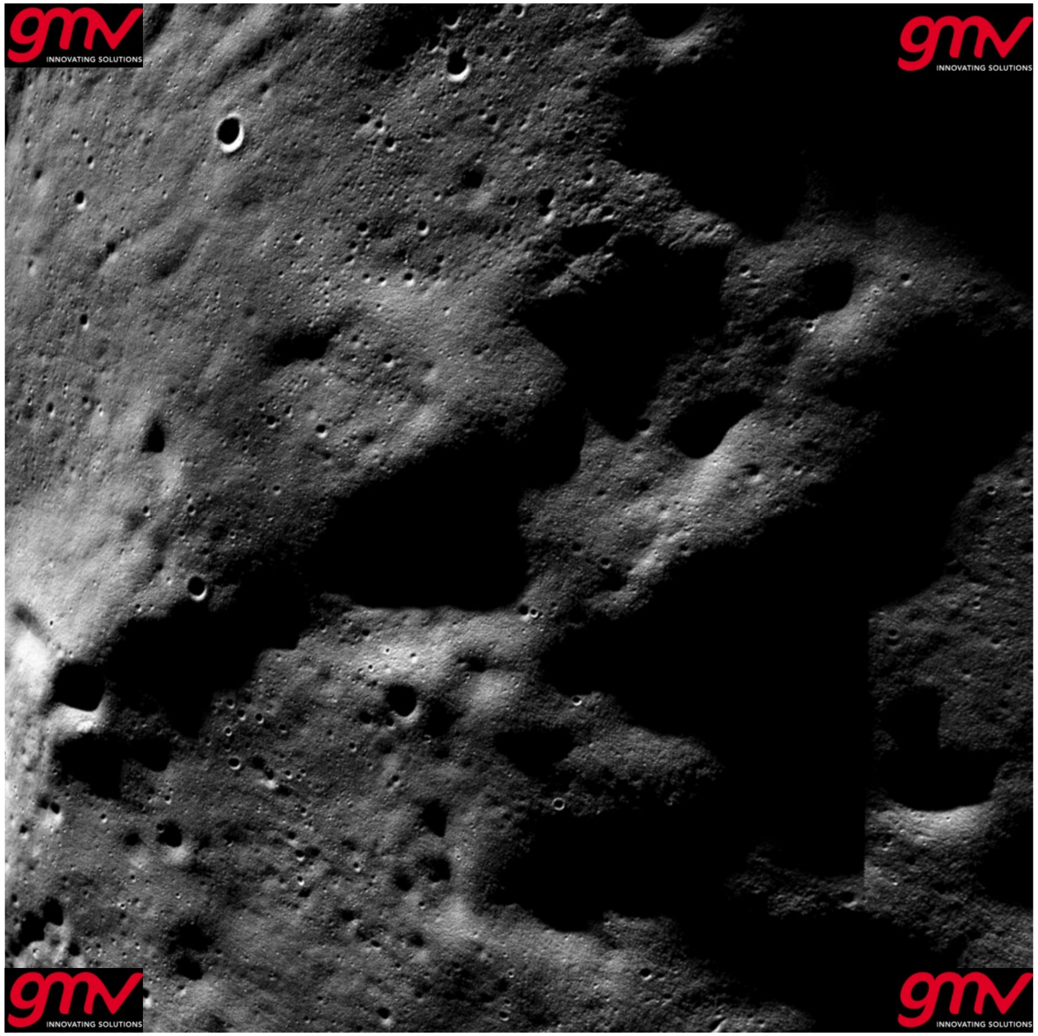
South Pole
(lat. -86, alt. 8 km)
– LOLA DEM





MOON SURFACE OBSERVATION (3/3)

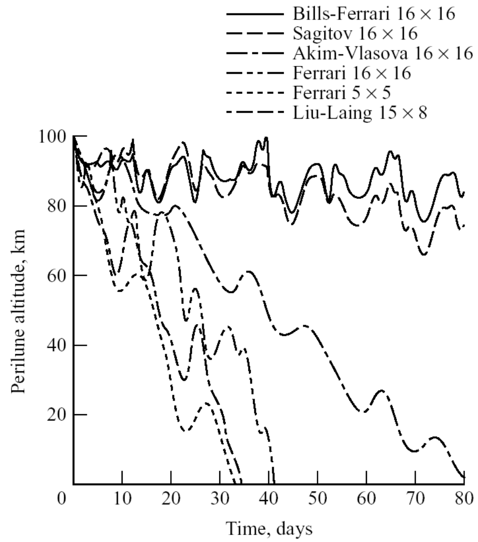
- Fussion of low resolution LOLA Digital Elevation Map high resolution LRO NAC

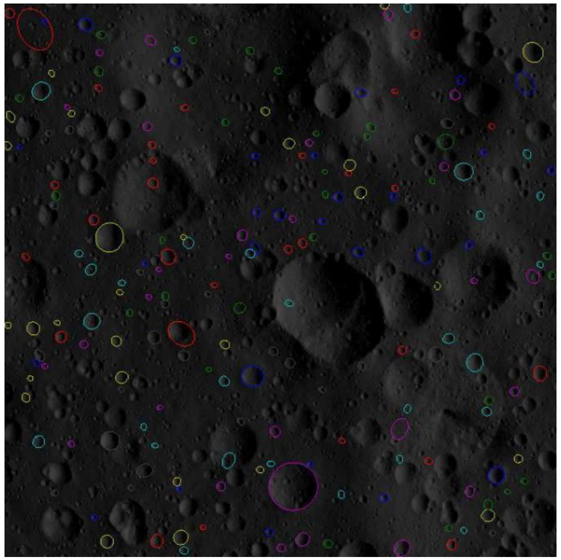


South Pole
(lat. -86, alt. 8 km) –
NAC mosaic over LOLA DEM

MOON GRAVITATIONAL FIELD

- The accuracy of the gravity models can be only roughly quantified by the Ground Tracking based orbit estimation
- The absolute accuracy of the different Moon gravitational models is unknown and different models leads to very different estimation in the orbit propagation (e.g. comparison made by JPL).
- Mascons are not detected by IMU
- Finest Moon gravitational model is LP165P (Clementine, Lunar Prospector at 30 km altitude polar orbit)
- Precise GLXP-BMT on-board navigation (~200 m, 1-σ at 100km orbit altitude) can help improving the gravitational models (particularly for the hidden face of the Moon).

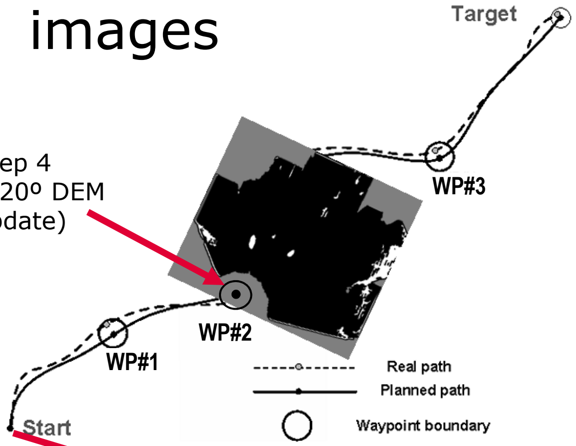




SIMULTANEOUS ROVER NAVIGATION & TOPOGRAPHY

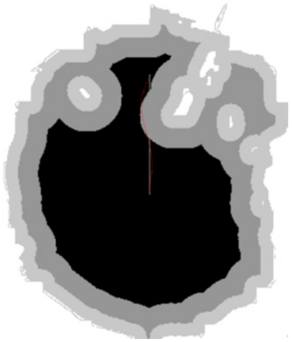
- Rover navigation images/products can be fussed/merged with lander acquired images during Landing and with in-orbit images

Step 4 (120º DEM update)



Step 1 (360º DEM Generation and path-planning)

Hazard map (black means free of obstacles)



Navigation map (white obstacles are enhanced; rover trajectory in red color)

1. Compute Global path planning from the starting point to the target point over the already built DEM. In case that the target point is outside the DEM, a sequential DEM updating/extension and path planning refinement is performed, allowing to get laser scan/images of unknown regions or with better resolution compared to the used ones for building the current operative DEM.
2. Rover travels to the first waypoint WP#1 with continuous navigation.
3. Rover stops at waypoint, laser scan/images acquisition of surrounding area.
4. Camera-based rover localization and DEM update.
5. Path planning refinement
6. Navigation sensors adjustment if required (e.g. IMU and mechanical odometer)
7. Rover travel to the next waypoint WP#2 with continuous navigation.
8. Repeat steps 3 to 7 as many times as required to reach the final target point.

Thank you

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