PILOT: an ESA Product for Safe and Precise Landing of Future Lunar and Planetary Missions

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Issue/Revision: .

Reference:

Status:

- Future missions (robotic and manned) are likely to require specific capabilities in terms of landing precision and safety
  - Landing dispersion < 1 km, goal few 100’s m
  - Detect and avoid surface hazards (slopes, roughness, shadow), in real time and in challenging illumination conditions
- These capabilities can be provided or enhanced by autonomous Visual Navigation (VN) and Hazard Detection and Avoidance (HDA) technologies

[1] ESA Exploration Strategy, ESA, 2015

[2] Guidance, Navigation, and Control Technology Assessment for Future Planetary Science Missions – Part II. Onboard Guidance, Navigation, and Control (GN&C), NASA/JPL, 2013

[3] NASA Space Technology Roadmaps and Priorities: Restoring NASA's Technological Edge and Paving the Way for a New Era in Space, Steering Committee for NASA Technology Roadmaps; National Research Council of the National Academies, 2012

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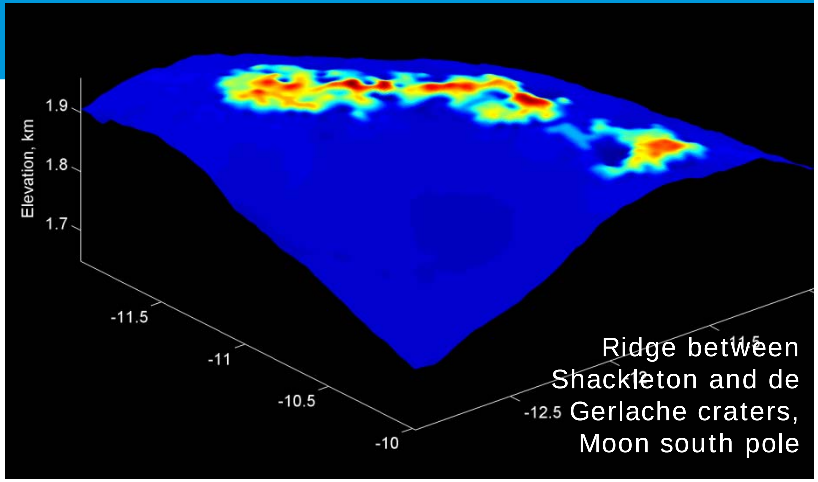
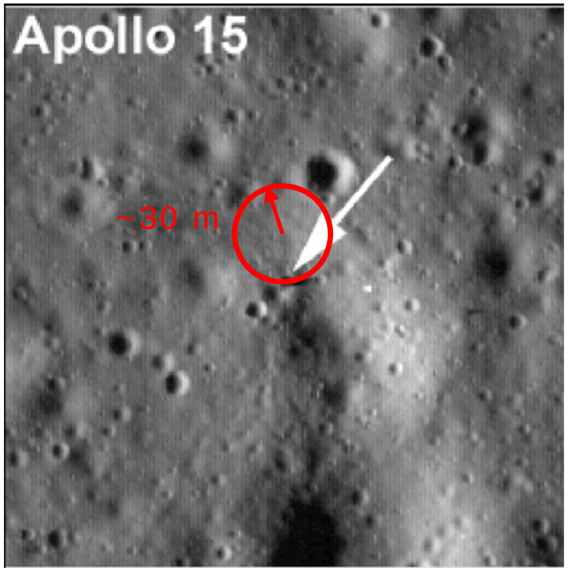
- Safe and precise landing capabilities will allow to:
  - access small and potentially hazardous areas of interests, e.g. those with potential resources: illumination, volatiles
  - landing safely close to existing assets or previously sampled locations
  - increase the probability of overall mission success
  - realise global access to planetary surfaces





Apollo 15 lunar module, Falcon.
Image width: 384 meters (about 1,260 ft.)

[4] T. Brady, S. Paschall, The Challenge of Safe Lunar Landing, 2010 IEEEAC paper #1177

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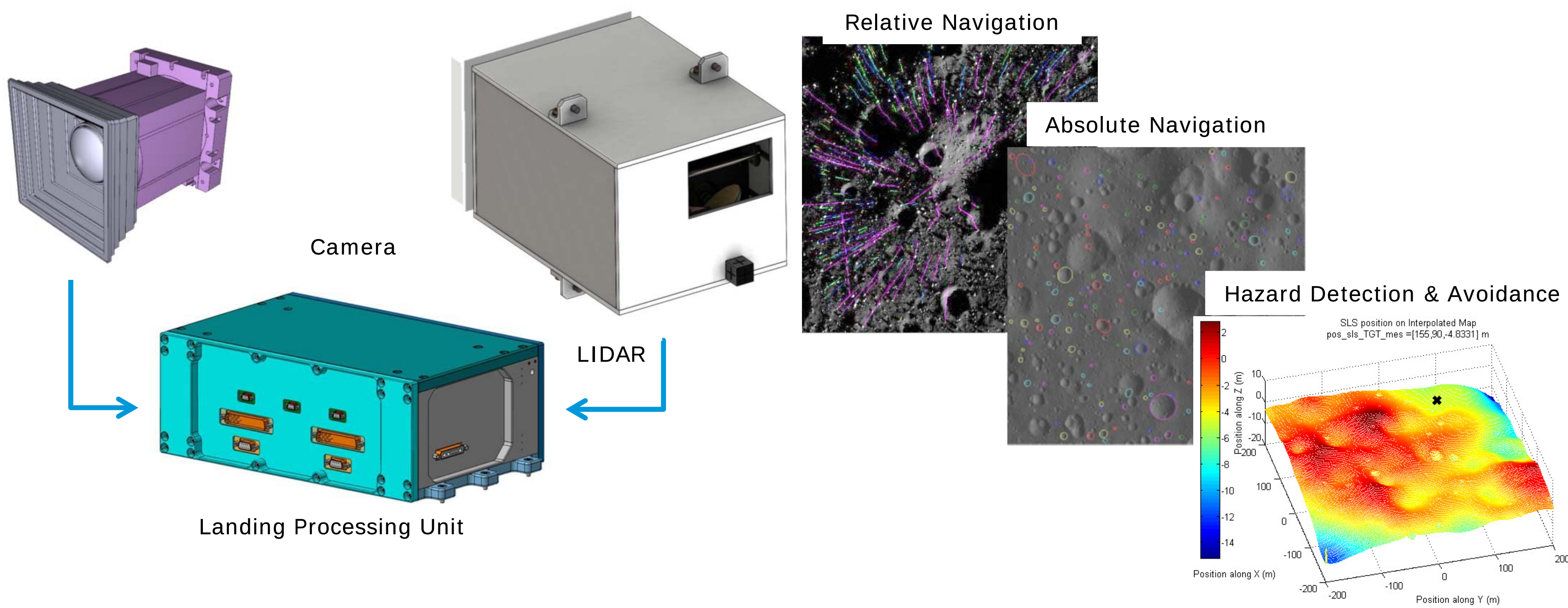
- ESA is pursuing the development of VN and HDA technologies through the **PILOT** project

Precise and **I**ntelligent **L**anding using **O**nboard **T**echnologies



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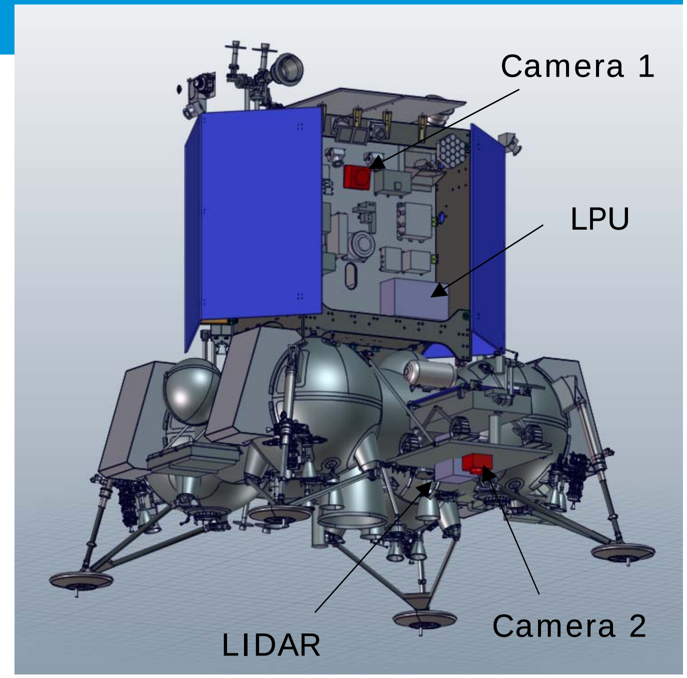
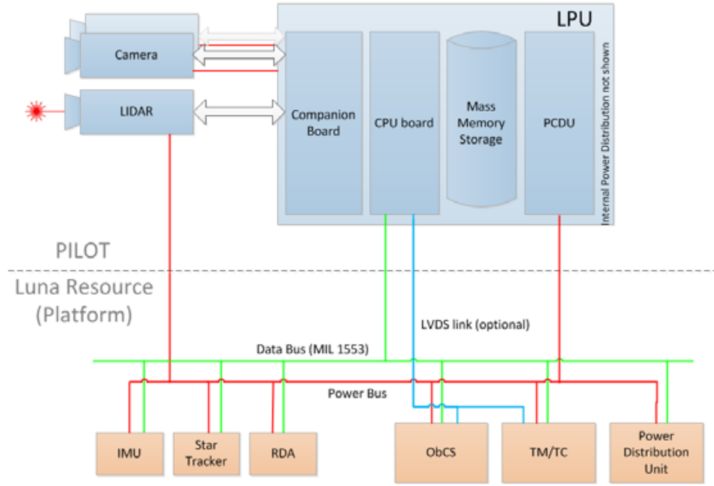
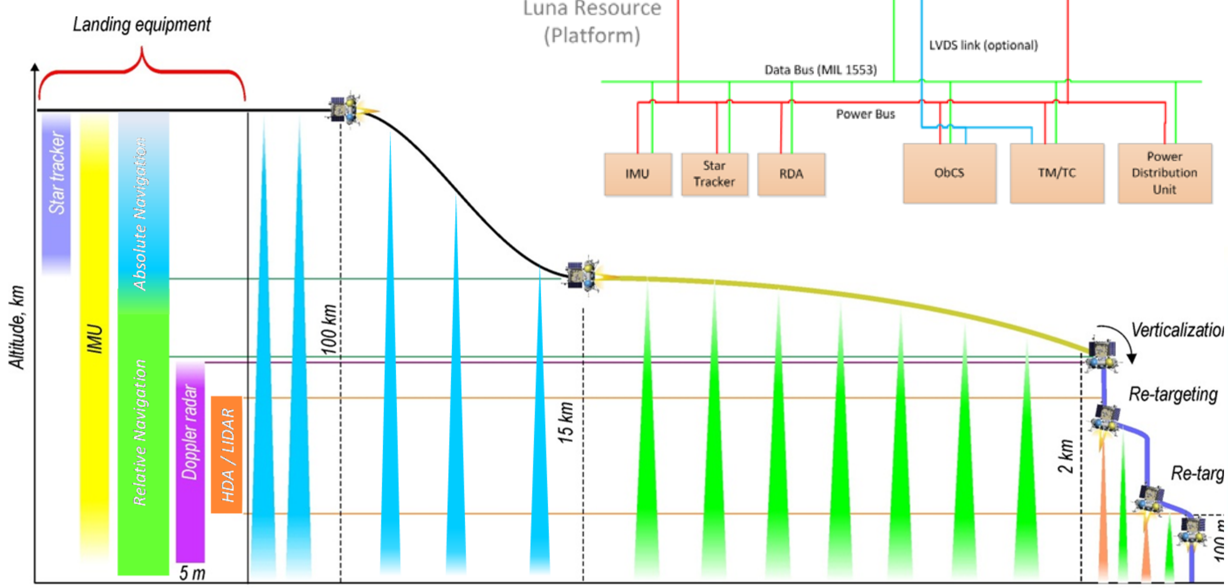
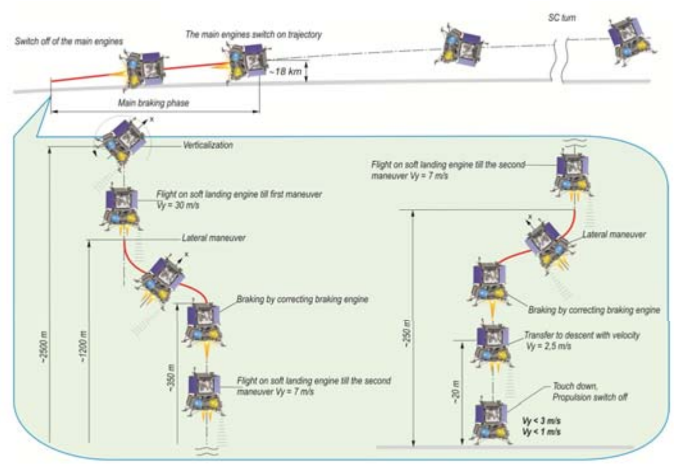
First PILOT flight opportunity: on-board the Russian Luna-27 lander mission, targeting challenging landing areas in the South Polar region of the Moon.









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Luna Glob Camera Demonstrator (PILOT-D) to be flown on-board Luna-25 lander mission:

- Perform an "image campaign":
    - with the same Camera as the one to be flown on Luna-27
    - in the real lunar environment: external (Lunar surface and features e.g. craters, illumination (TBC)) and platform (vibrations, plumes, etc.)
- Re-run the acquired images (and other Luna-Glob landing data) on avionics testbench for further validation of the whole PILOT Subsystem on ground
- Validate in-flight the PILOT Camera Optical Unit

→ Reduce the risk of precision landing for the Luna-27 Lander and other future landing missions

- No image processing performed on Luna-Glob by the Camera Demonstrator

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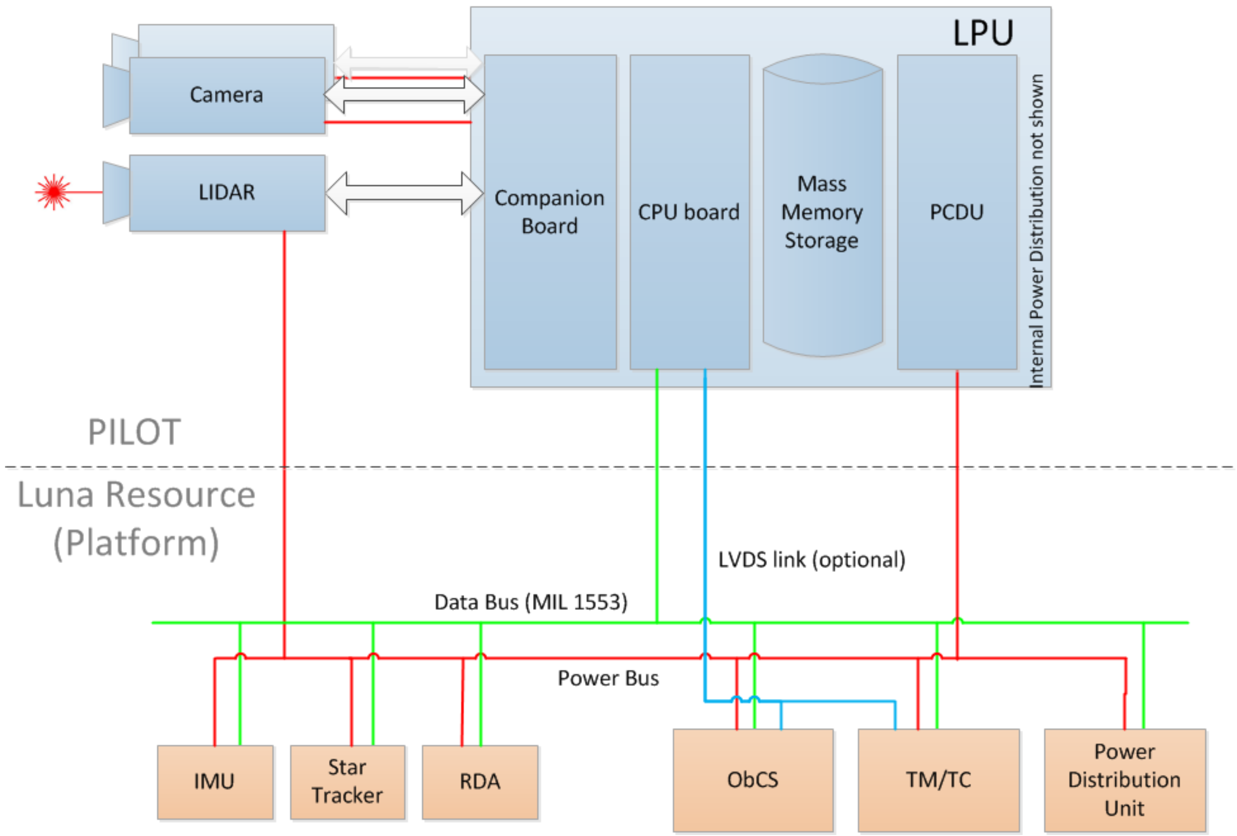
- PILOT is currently undergoing a Phase A level study, which includes design, simulation, software and FPGA prototyping and tests on Avionics Test Bench, LIDAR prototyping
- ESA will place beg. ‘16 an industrial contract for Phase B+ activities, covering:
  - Design
  - Breadboarding
  - production of Development Models for extensive testing at Units and system level
  - advanced Phase C activities

- The exploitation of the first PILOT flight opportunity will prepare the utilization of this product in future missions, such as a robotic Lunar Polar Sample Return mission, or in a broader scenario involving robotic and human elements

Back-up charts

PILOT HW schematics



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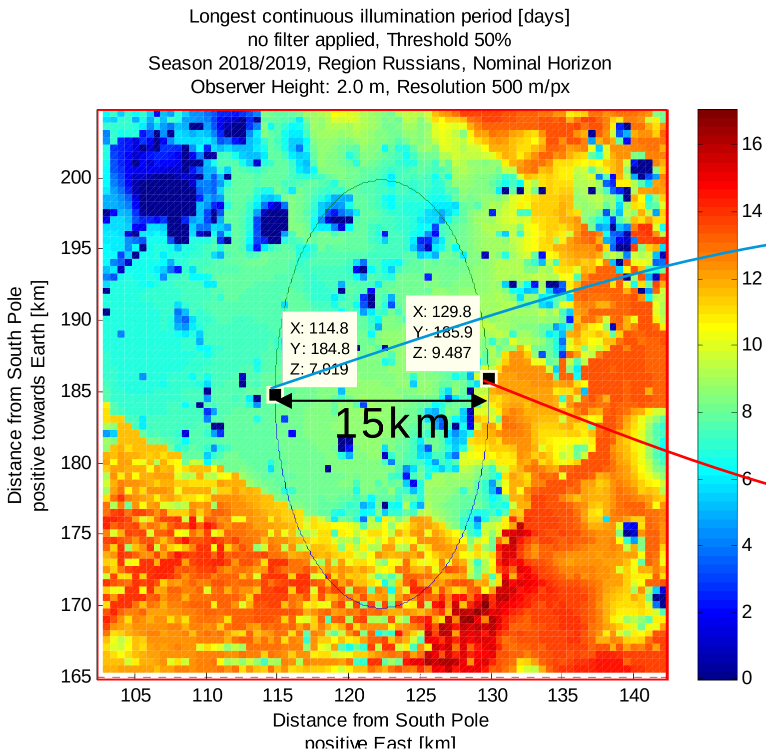
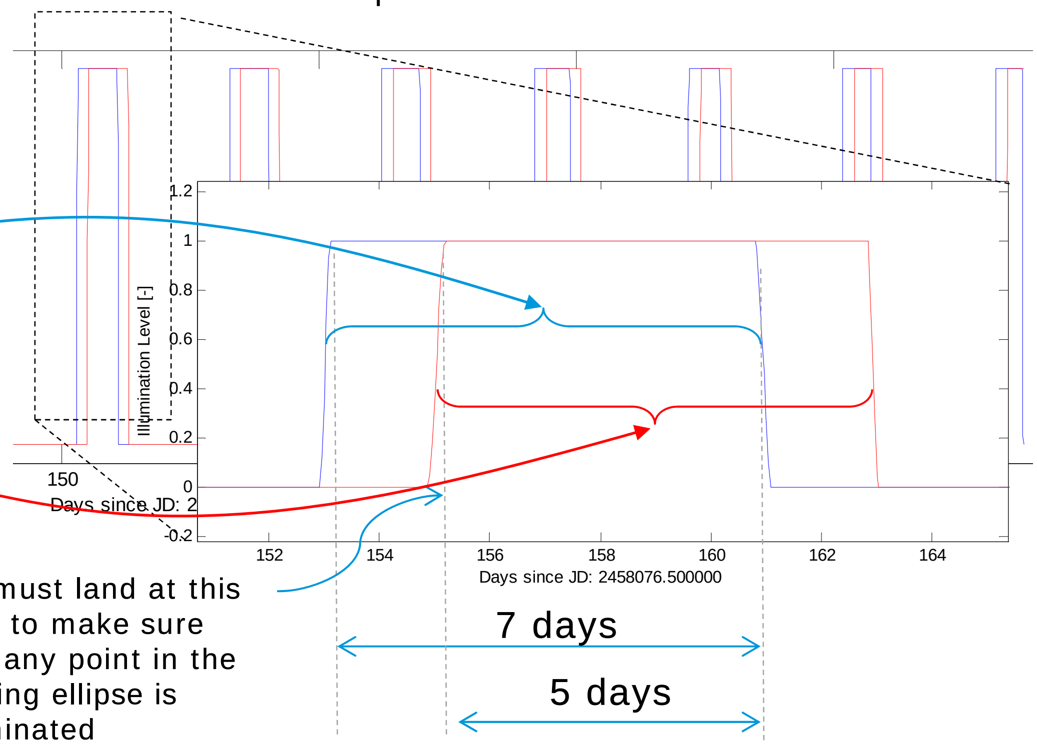
- Additional advantages of safe and precise landing:
    - Reduction of requirements on existing infrastructure (e.g. surface or in-orbit radio beacons for navigation)
    - Reduction of surface mobility requirements
    - Increase of robustness of a multi-element mission in case of failure of mobile surface element
    - Reduction of propellant consumption (like aircraft Continuous Descent Approach)

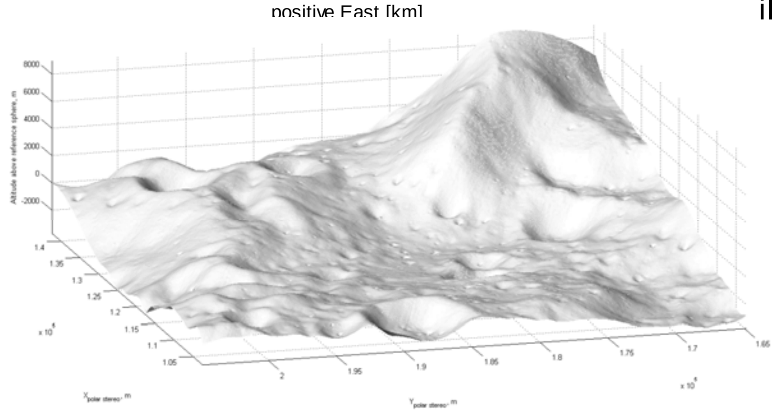
Requirements for missions targeting lunar polar volatiles: Illumination and Navigation accuracy



Illumination pattern: Illumination Level vs Time



We must land at this time to make sure that any point in the landing ellipse is illuminated



➔ Better landing precision increases available surface operation time