AUTONOMOUS PRECISION LANDING WITH HAZARD AVOIDANCE

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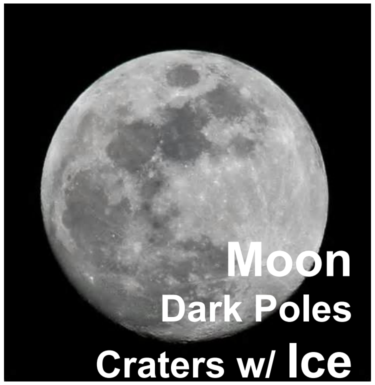
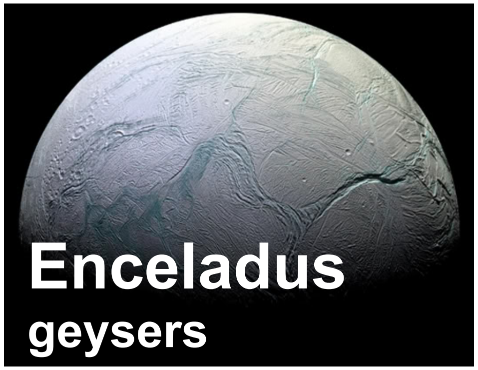
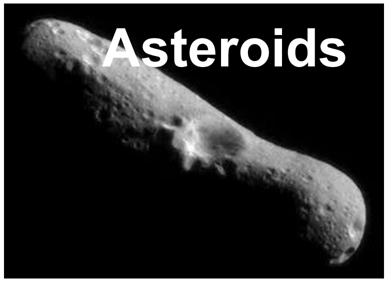
CAPABILITIES

- Autonomous real-time navigation technology for safe precision landings on any solid solar body under any lighting conditions







CAPABILITIES

- Terrain Relative Navigation within 30 m (1σ) of a pre-defined landing target
  - Requires orbital reconnaissance information
  - ALHAT field-tested two methods for TRN
    - Passive optical camera given adequate ambient surface illumination; ~1 kg, very low power and small footprint
    - Active lidar systems under any ambient lighting conditions - sensor choice can vary depending on single or multiuse sensors

CAPABILITIES

- Autonomous Hazard Detection and Avoidance (HDA)
  - Utilizes an active 3-D lidar sensing system to identify safe landing areas in real time during the approach trajectory
  - Detects small local surface slope and roughness hazards (1° / 30 cm)
  - Both flash lidar and scanning lidar sensors are viable options
  - Lidar Sensor ROM: 6 to 7 kg, 50 to 100W, 4400 cm^3
- Precision velocimetry & ranging
  - Doppler Lidar
    - Three-beam CW sensor with an operational range of ~2.5 km provides surface-relative vector velocity accurate to < 1 cm/s and LOS ranges accurate to 17 cm. ROM: 13 kg, 70W
  - Laser Altimeter
    - Pulse sensor with an operational range of 50+ km provides range accuracy 30cm and precision <8 cm. ROM: 6 kg, 50W

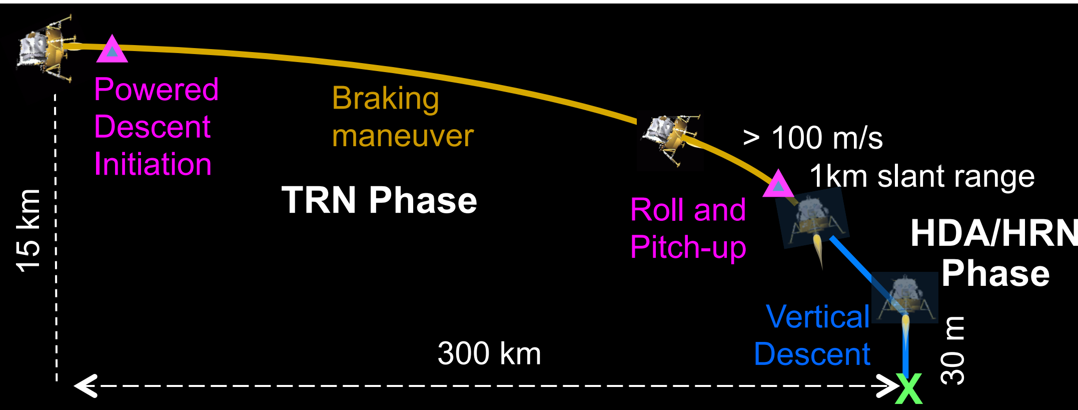
ALHAT

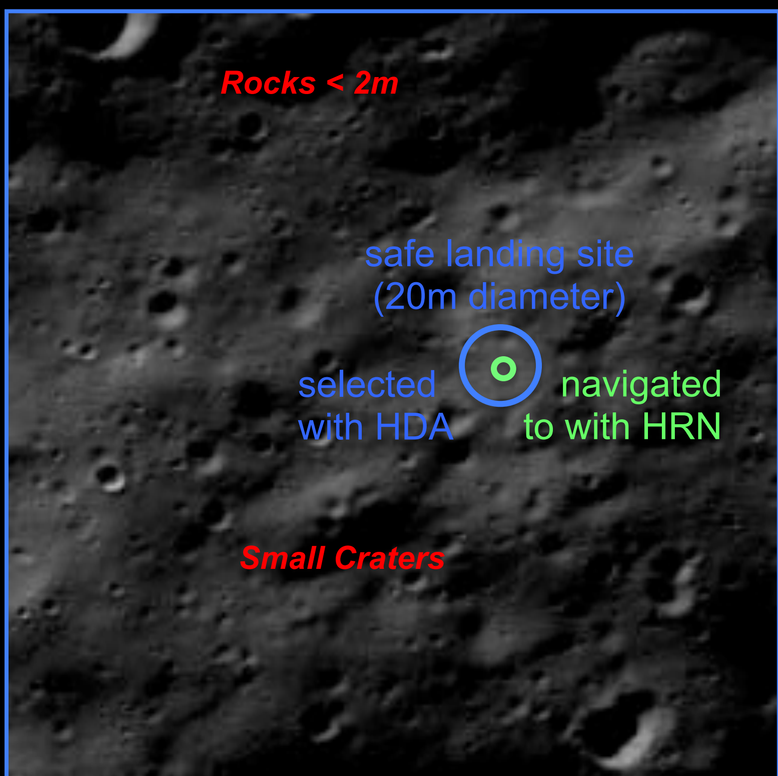
Autonomous Precision Landing and Hazard Avoidance Technology

TRN = Terrain Relative Navigation

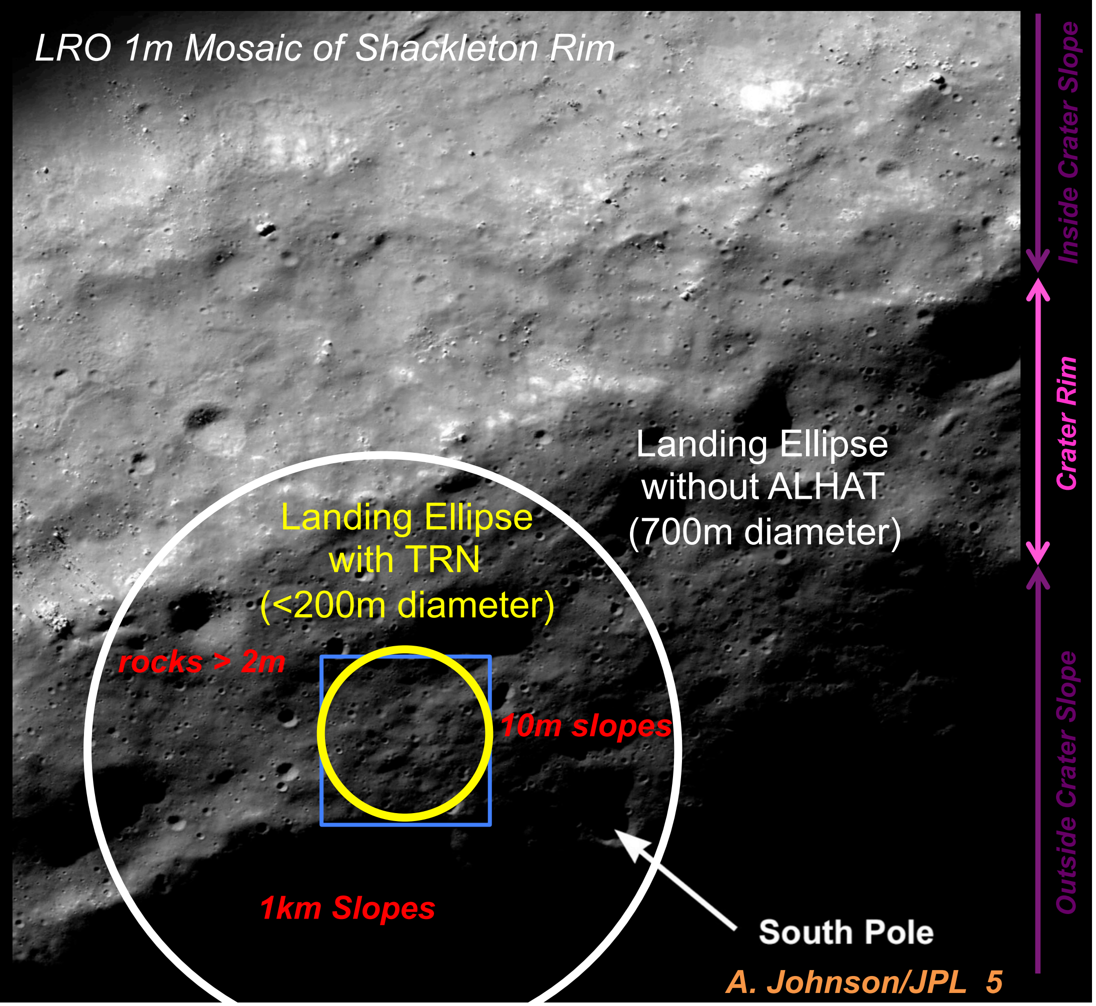
HDA = Hazard Detection and Avoidance

HRN = Hazard Relative Navigation





Hazard Map Area (200x200m)



IMPLEMENTATION

- A lander can choose to use the entire ALHAT System or only individual capabilities with supporting sensors and software
- Requirements levied on the host spacecraft include regulated power, thermal control, command/data management, and mechanical integration
- All sensors must have a clear view of the surface during approach and landing
- Approach and landing attitude profile will impact sensor location and pointing

IMPLEMENTATION

- ALHAT sensors provide ground-relative navigation measurements – a Kalman navigation filter has been developed to process the ALHAT sensor data
- ALHAT HDA data processing approach for crewed lunar landings leverages a separate Compute Element with multicore CPU and FPGA for high speed, parallel processing in real time. Embedded processing is used for the Doppler lidar and laser altimeter sensors.
- Data processing architecture for robotic landers can be tailored for specific missions with the potential for sharing on-board computing resources

TECHNOLOGY READINESS LEVEL

- Prototype ALHAT system has been tested in relevant terrestrial environments using helicopters, winged aircraft, and the rocket-powered Morpheus vertical take-off and landing vehicle
- The ALHAT Team considers all techniques at TRL 6 and ready for spaceflight infusion
- Space-qualified passive optical cameras are readily available
- ALHAT lidar sensors require additional refinement for spaceflight applications

SCHEDULE

- The utilization and implementation of ALHAT systems is dependent on the landing destination, mission profile, lander design, etc.
- In order to develop GFE systems for spaceflight, the ALHAT Team will require a significant influx of funding from HEOMD, STMD, and/or SMD starting in FY15
- Any of these ALHAT landing system capabilities can be ready for integration in a spacecraft within three years
- Expertise is available to develop/refine sensor and software ICDs starting in the fourth quarter of FY14

AO LIBRARY CONTENT

- Information is highly dependent on the mission utilization of ALHAT technologies.
- Please use POCs for desired information

INTEGRATION COSTS

- Integration costs are dependent on mission requirements and associated sensors and software
- Integration costs must include:
  - Physical integration such as mounting, power connectivity, data connectivity, precision alignment, etc.
  - Software integration and testing to ensure needed functionality
- Experience has shown that considerable integration testing will be required before systems are space-ready

POINTS OF CONTACT

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