National Aeronautics and Space Administration

PL&HA Domain

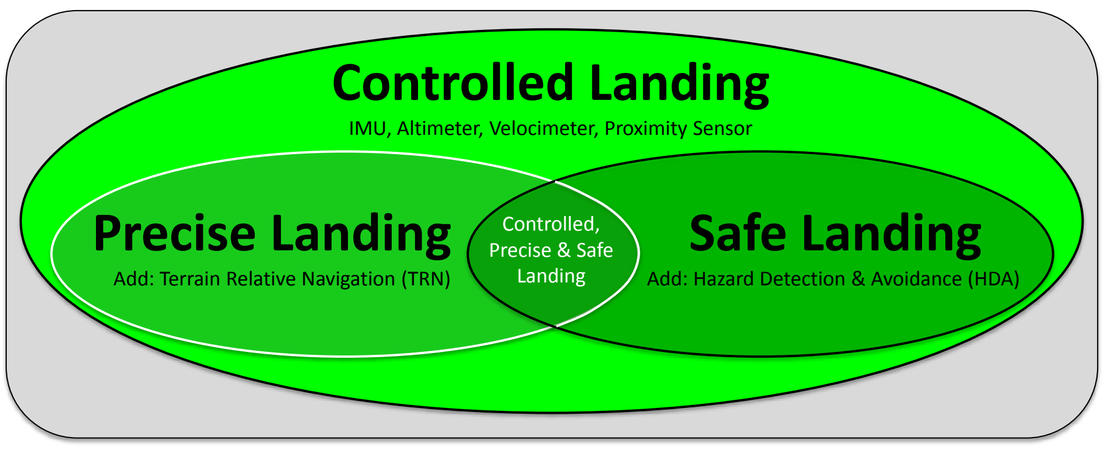
Precision Landing & Hazard Avoidance

DOMAIN MANAGEMENT Edward A. Robertson & John M. Carson III, Ph.D.

HAT: 4.1.a Precision Landing & Hazard Avoidance

OVERVIEW

The Precision Landing and Hazard Avoidance (PL&HA) domain addresses the development, integration, testing, and spaceflight infusion of sensing, processing, and GN&C functions critical to the success and safety of future human and robotic exploration missions. PL&HA sensors also have applications to other mission events, such as rendezvous and docking.



INNOVATION

Autonomous PL&HA builds upon the core GN&C capabilities developed to enable soft, controlled landings on the Moon, Mars, and other solar system bodies. Through the addition of a Terrain Relative Navigation (TRN) function, precision landing within tens of meters of a map-based target is possible. The addition of a 3-D terrain mapping lidar sensor improves the probability of a safe landing via autonomous, real-time Hazard Detection and Avoidance (HDA). PL&HA significantly improves the probability of mission success and enhances access to sites of scientific interest located in challenging terrain.

PL&HA can also utilize external navigation aids, such as navigation satellites and surface beacons.

Advanced Lidar Sensors

High precision ranging, velocimetry, and 3-D terrain mapping

Terrain Relative Navigation (TRN)

TRN compares onboard reconnaissance data with real-time terrain imaging data to update the S/C position estimate

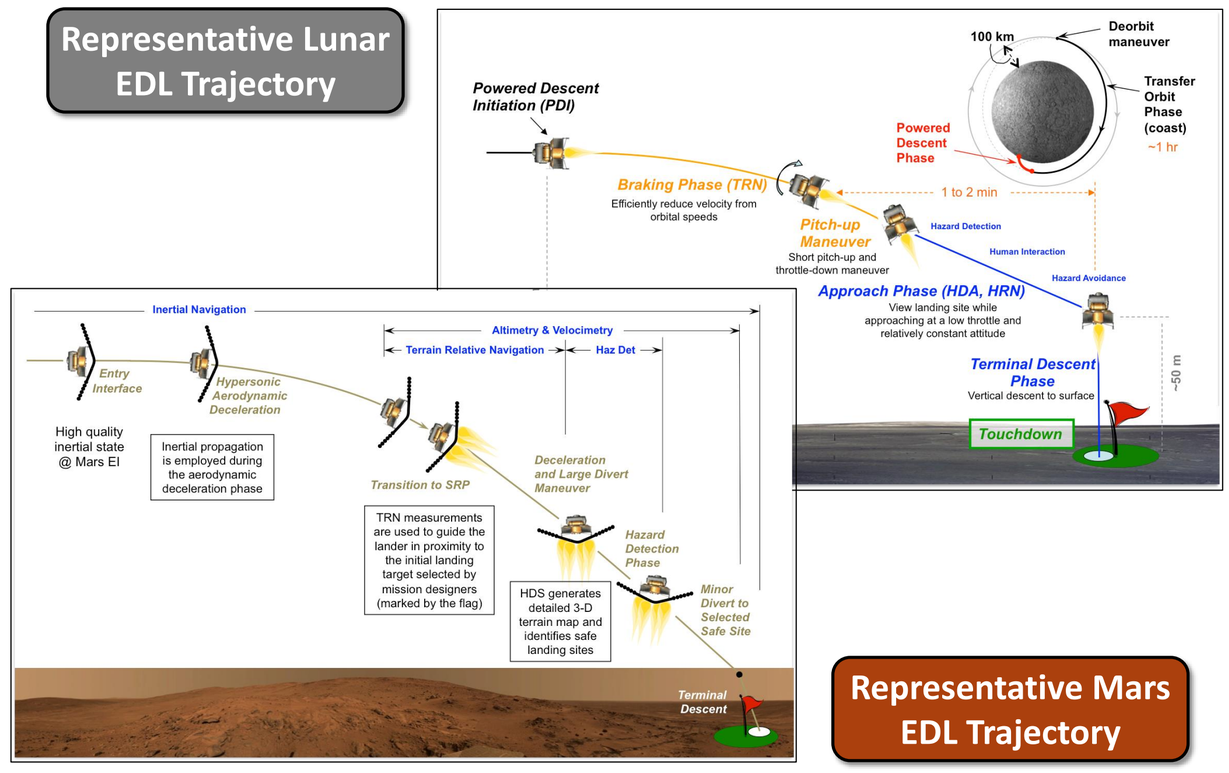
Hazard Detection and Avoidance (HDA)

Generates a high-resolution, 3-D terrain map in real-time during the approach trajectory to identify safe landing targets

Inertial Navigation During Terminal Descent

High precision surface relative sensors enable accurate inertial navigation during terminal descent and a tightly controlled touchdown within meters of the selected safe landing target

Representative Lunar EDL Trajectory



Representative Mars EDL Trajectory

INFUSION SPACE / EARTH

The 2014 Morpheus-ALHAT closed loop free flight campaigns successfully demonstrated several advanced lidar sensors combined with autonomous, real-time HDA.

Both JPL and APL have developed and successfully demonstrated optical TRN techniques. JPL's Lander Vision System is baselined on the Mars 2020 mission. APL's APLNav system is baselined on the Resource Prospector mission.

NASA has funded the CoOperative Blending of Autonomous Landing Technology (COBALT) flights on the Masten Xodiac testbed to demonstrate precision landing using TRN combined with the LaRC Navigation Doppler Lidar (NDL) sensor.

NASA has funded a Europa lander study at JPL using TRN, HDA, and advanced sensors/processing to create a PL&HA capability called the Intelligent Landing System (ILS).

NASA is supporting the infusion of PL&HA functions and advanced lidar sensors into commercial spaceflight missions.

NASA has identified safe, precision landing capabilities as essential for the human exploration of Mars.

PARTNERSHIPS / COLLABORATIONS

The NASA PL&HA effort reflects multiple, successful, long term collaborations across NASA and industry.

FUTURE WORK

Continued development of lidar sensors for ranging, velocimetry, and terrain mapping; Refinement of TRN and HDA algorithms; Advancements in space-qualified processors; Advanced navigation filter development; Infusion of PL&HA capabilities on future robotic and human exploration missions