Future Robotic Lander

- Many high-priority science and exploration objectives are uniquely met by landed lunar missions
  - International Lunar Network Mission: Determine the composition and structure of the moon’s interior
  - Lunar Polar Volatiles Explorer: In situ characterization of volatile species; understand current processes
  - Lunar Sample Return: Return rocks from unexplored sites, such as lunar farside or young lava flows, to terrestrial laboratories
  - Human Exploration Precursors: Characterize the lunar surface environment at landing sites: lighting, radiation, thermal, and dust; test technologies; demo ISRU

MSFC/APL Lander Development History

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Validation through Prototype and Testing

- Provides the capability to test GN&C flight hardware and software against a combination of realistic and stressing descent profiles and terrains.
- Open-loop test data is provided to evaluate landing performance and terrain navigation capability in the GN&C high fidelity simulation as well as in a processor in the loop environment.

GN&C - Helicopter Field Testing

- Provides the capability to test GN&C flight hardware and software against a combination of realistic and stressing descent profiles and terrains.
Analysis capability to accurately predict the dynamics of touchdown in a stable manner, given a variety of landing scenarios. 3-D simulation and testing of a subscale lander with rigid- and energy-absorbing legs completed to anchor ADAMS models to test results.

For small landers, DACS thrusters used for primary landing propulsion. DACS thrusters have not operated for long durations; limited performance data is available. Conducted vacuum tests of MDA DACS thrusters for landing (100 lb) and ACS (6 lb) to evaluate performance and thermal characteristics. Thrusters successfully demonstrated RLL flight profile (also continuous 66 sec on landing thrusters, 25 sec on ACS).

Combustion was stable in all tests. Temperature measurements show performance below material thermal limit. Remaining modifications and tests have been identified.

Cold Gas Test Article Overview
- First Flight September 2009
- Mass: 107 kg dry / 146 kg wet
- Approximately 10s of flight time
- Compressed-air propulsion emulates flight system with pulsed operation
  - 3 Descent thrusters (~37 lbf ea)
  - 6 ACS thrusters (~12 lbf ea)
  - Central throttleable thruster offsets gravity
  - 3 compressed air tanks (3000 psi)
- Carbon fiber / Al honeycomb decks
- Custom avionics (COTS components assembled in-house)
- Custom flight and ground software
- Over 150 successful flights

Cold Gas Test Article Flights
- Strap-down and hover tests complete, expected drop test in summer 2011
- Mass: 206 kg dry / 322 kg wet
- Aluminum ortho-grid decks
- Hydrogen peroxide (90%) monopropellant propulsion system
  - Emulates flight system / pulsed operation
  - 3 Descent thrusters
  - 12 ACS thrusters
  - Central throttleable thruster offsets gravity
- Sensors
  - LN200-1 IMU, Roke Manor Radar Altimeter, Illunis optical cameras, Novatel Pro-Pak GPS truth data system, Pressure transducers & thermocouples for housekeeping
- Flight-like Software
  - "In-Control" ground system software
  - Core Flight Executive (cFE) modular software environment

Warm Gas Test Article Overview
- Strap-down and hover tests complete, expected drop test in summer 2011
- Mass: 206 kg dry / 322 kg wet
- Aluminum ortho-grid decks
- Hydrogen peroxide (90%) monopropellant propulsion system
  - Emulates flight system / pulsed operation
  - 3 Descent thrusters
  - 12 ACS thrusters
  - Central throttleable thruster offsets gravity
- Sensors
  - LN200-1 IMU, Roke Manor Radar Altimeter, Illunis optical cameras, Novatel Pro-Pak GPS truth data system, Pressure transducers & thermocouples for housekeeping
- Flight-like Software
  - "In-Control" ground system software
  - Core Flight Executive (cFE) modular software environment

Warm Gas Test Article Hover Test
The MSFC/APL RLLDP team has developed lander concepts encompassing a range of mission types and payloads for science, exploration, and technology demonstration missions.

- Developed experience and expertise in lander systems.
- Incorporated lessons learned from previous efforts to improve the fidelity of mission concepts, analysis tools, and test beds.

Mature small and medium lander design concepts have been developed:

- Share largely a common design architecture.
- Flexible for a large number of mission and payload options.

High risk development areas have been successfully addressed.

Landers could be selected for a mission with much of the concept formulation phase work already completed.

The RLLDP project is well prepared to develop lander systems for lunar or other airless body NASA missions.