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NEA Close Rendezvous and OperationS Satellite

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Abstract

The NEA Close Rendezvous and OperationS Satellite (NCROSS) is a technology demonstration mission, which demonstrates deep autonomous navigation and Autonomous Rendezvous and Proximity Operations enroute to and at a near-Earth asteroid (NEA). The technologies demonstrated by NCROSS and the spacecraft platform, a rebuild of the LCROSS bus, enable an ensemble of future NASA missions, including those specifically identified by the NEA User Team (NUT) and the Human Explorations Frameworks Team (HEFT) and also missions associated with low Earth orbit (LEO) proximity operations, such as orbital debris removal, and on-orbit servicing.

1. Introduction

The NCROSS mission demonstrates autonomous rendezvous, sequencing and commanding during close proximity operations and environmental characterization at an NEA using angle only navigation and terrain relative navigation. This is demonstrated in an environment where our current understanding of natural forces break down under the low gravity conditions. Under these conditions, dust levitation, electrostatic and Van der Waals forces interact on scales dissimilar to those found in other environments (e.g., LEO) and with potentially important degrees of influence. NCROSS also tackles the additional challenge of autonomously approaching and intercepting a very small, tumbling asteroid with an unknown variety of weathered surface features, orientations and illuminations, and no predictable infrastructure for docking or navigation, enabling a variety of future robotic and human missions to safely approach, survey, touch or deflect unpredictable and uncooperative targets.

2. Goals and Objectives

The ultimate goal of this technology demonstration mission is to show ARPO at a NEA. NCROSS builds upon current state-of-the-art, and integrates the lessons learned from past and current ARPO missions. It is implementing two main technology demonstration areas, autonomous deep space navigation and an ARPO demonstration at a NEA.

1. Autonomous deep space navigation, during the cruise segment.

2. Autonomous rendezvous, docking, close proximity operations and formation flying, after arrival at the NEA target.

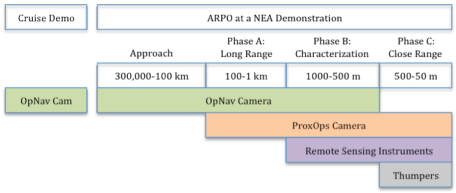

Figure 1: Autonomous Rendezvous and Proximity Operations phases.

2.1 Cruise Segment

Early in the flight segment during the cruise phase, NCROSS will demonstrate autonomous deep space Navigation during a Deep Space Maneuver. This can be tested at low risk because it requires no additional hardware investments in the NCROSS spacecraft or payload and all actual maneuvers will be based on existing primary navigation through the Deep Space Network (DSN). The benefit of this demonstration will be that it lays a foundation for the use of autonomous navigation as the primary source of state information on future missions. This specific

demonstration can provide a useful product during an otherwise uneventful part of the primary mission.

2.2 Autonomous Rendezvous and Proximity Operations Segment

The ARPO goals, addressed in key phases, is demonstrated as NCROSS approaches the target NEA.

After first acquisition of the NEA, the ARPO system's optical navigation camera is used to autonomously locate and stay on target, approaching from a 100 km distance down to 1 km. The ARPO system's second camera, the proximity operations camera, overlaps the navigation camera's coverage and determines surface features and the rotation rate of the NEA.

At 1 km to 500 m from, the NEA, during the Survey and Characterization phase, the proximity operations camera supports rapid imaging processing. Here, additional remote sensing instruments, including a UV-Visibel spectrometer and thermal imager, are included to fully validate that the ARPO System meets the needs of future missions. For example, by sequencing the various observations using the remote sensing instruments (all are recommended by the NUT) with the on-board ARPO mission manager, the ARPO system is exercised to its fullest capabilities. These instruments provide additional measurements regarding possible debris hazards such as the identification of dust and debris using the UV-visible spectrometer and thermal imagery.

In the close-range phase, the onboard system brings the spacecraft to within 5 radii of the NEA demonstrating autonomous low altitude approach. The spacecraft deploys surface probes and adapts navigation within a dynamic environment that has resulted from the deliberate NEA surface interaction. Finally, the targeting of the NEA is verified from the spacecraft imagery (visible and thermal) and the deployed surface probe telemetry.

3. Spacecraft Platform

In order to focus on the technology demonstration aspects of the mission, an experienced team has been assembled to provide a low-cost, low-risk hardware solution to enable a historically high-cost asteroid rendezvous mission and demonstrate autonomous rendezvous and proximity operations at a small asteroid.

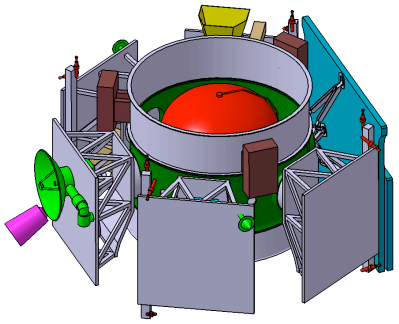

Figure 2: NCROSS, rebuilt of LCROSS

The NCROSS mission utilizes a rideshare opportunity for access to space. It would launch as a secondary payload, being inserted into an Earth fly-by orbit, while it uses its onboard propellant for cruise, target rendezvous and proximity operations.

The secondary payload manifest option enables significant mission cost savings. The NCROSS spacecraft engineering development approach traces directly to the LCROSS design and production with minor upgrades and a payload specifically developed to support the proximity operations demonstration and mission phases. Key spacecraft changes address the need for additional Delta V, deep space communications, launch packaging, and the new payload.

4. Summary and Conclusions

The NEA Close Rendezvous and OperationS Satellite (NCROSS) is a flight demonstration of key, enabling autonomous navigation and ARPO technologies.

The mission benefits multiple communities regarding future science, precursor and human missions to NEAs (SMD, ESMD, with derivatives for planetary defense, academia, aerospace industries). The ARPO technologies will enable other mission classes including on-orbit spacecraft servicing and removal of large orbit debris objects. Extension of LCROSS spacecraft to NCROSS mission establishes a low cost rideshare-enabling platform for cost-effective NASA, DoD and IC space missions.