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OSIRIS-REx Mission Design to Return a Sample from Asteroid 1999 RQ36

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ABSTRACT

The Origins-Spectral Interpretation-Resource Identification-Security-Regolith Explorer (OSIRIS-REx) spacecraft will travel to the near-Earth carbonaceous asteroid (101955) 1999 RQ36, study it in detail, and bring back a sample (at least 60 grams or 2.1 ounces) to Earth. The scientific and engineering data collected at the asteroid will aid our understanding of asteroids that can impact Earth and operational methods to deflect them.

For planetary defense, 1999 RQ36 is critically important to study as it is the second most potentially Earth-hazardous asteroid known (JPL website http://neo.jpl.nasa.gov/risk/index.html accessed 9/26/2012). Study of 1999 RQ36 also addresses multiple NASA Solar System Exploration objectives to understand the origin of the Solar System and the origin of life, as well as fully addressing asteroid sample return objectives of the NASA New Frontiers program and New Opportunities in Solar System Exploration (NOSSE) report. The OSIRIS-REx mission will serve as a precursor to future asteroid missions by developing specific operational techniques that can be potentially employed on a variety of planetary defense missions (Table 1), and the mission's security-related science objectives (Yarkovsky effect) help to understand the dynamics of Near Earth Objects.

Table 1. OSIRIS-REx Techniques are applicable to Planetary Defense Missions

	Proximity Deflection	Kinetic Impactor	Surface Contact
Detect Natural Satellite	X		X
Establish Size/shape/rotation state	X	X	X
Establish mass and gravity model	X	X	X
Perform near-surface spacecraft operations	X		X
Establish Yarkovsky Effect	X	X	X

To accomplish these goals, the project team has developed a mission design from launch to Sample Return to Earth. The philosophy for the mission design is to move closer to the asteroid using gated mission phases to ensure

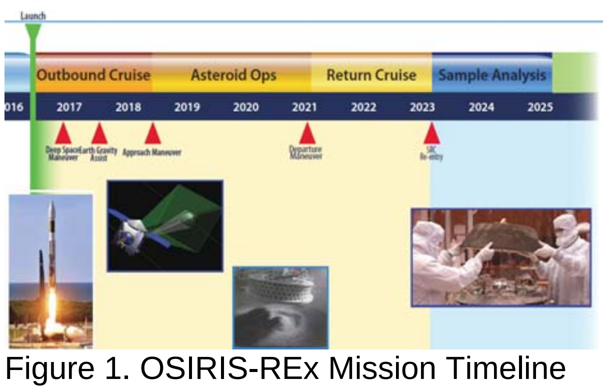

Figure 1. OSIRIS-REx Mission Timeline

science and mission safety goals are met. The mission phases were logically decomposed from the science goals. The main mission phases in Figure 1 are Launch/Outbound Cruise, Asteroid Operations (Science Survey and Touch-and-Go (TAG), and Return Cruise (Earth Return of Sample).

The Outbound cruise phase, which includes an Earth flyby and gravity assist, maintains the spacecraft health while traveling to RQ36. The spacecraft maintains attitude knowledge and control, power management, thermal management, and monitors onboard health and status of subsystems and components. During cruise the initial checkouts of the instruments, subsystems, and components occurs as well as calibration or in-flight validation activities needed to ensure performance during the later mission phases. The period starts at the end of the launch phase and extends until the spacecraft completes the approach maneuvers and the survey of the 1999 RQ36 orbital environment for natural satellites.

The Science Survey phase refines the 1999 RQ36 properties, which can be used to understand the associated impacts on mission performance. The Science Survey Phase consists of the preliminary survey, detailed survey, orbital operations, and reconnaissance of sample sites selected by the mission's Principal Investigator (PI). During approach, the spacecraft performs a staged survey for natural satellites of 1m and then 10cm diameter within the Hill Sphere. After completing the satellite survey the spacecraft begins a 2-month survey. The survey performs 3 tasks: spectrally maps the entire RQ36 surface, collects images and Lidar data for global shape and spin state models, and estimates the mass of RQ36. Based on this data, the team compiles topographic and gravity maps to initially identify candidate sample sites. The following 2-month orbital period collects scientific data around RQ36 to create a higher resolution topographic map and gravity model. The 2-month reconnaissance period conducts sorties at 500m and closer ranges to determine the presence of sampleable regolith and spectral properties of candidate sample collection sites. The reconnaissance portion also provides the required topographic details to safely conduct the TAG, which will collect the RQ36 sample.

The TAG phase collects and stows the samples for return to Earth. The phase consists of the TAG Rehearsal, TAG, mass verification, sample stow, and asteroid departure maneuver. The TAG Rehearsal phase systematically and deliberately practices each step in the sample collection maneuver. The sample collection phase collects >60g of pristine RQ36 bulk regolith in the sampler head, stows the samples in the Sample Return Capsule (SRC), and prepares for return cruise.

The Return Cruise phase transports the sample from RQ36 and ends with the SRC Release phase. The SRC Release phase prepares for SRC release, returns the SRC to Utah, and then performs a divert maneuver away from Earth, which will also maintain a minimum distance of 250 km from Solar System bodies.

Overall, OSIRIS-REx will collect vital scientific and engineering data to understand asteroids that can impact Earth and to document specific operational methods needed by future mission designers of planetary defense missions.