ISIS
Impactor for Surface and Interior Science
ISIS Mission Concept

Send an independent, autonomous impactor spacecraft, to the asteroid target of the OSIRIS-REx mission

1. Co-manifest impactor with InSight launch
2. Arrive after OSIRIS-REx has completed its science objectives (i.e., sample collection)

ISIS creates crater tens of meters in diameter

1. OSIRIS-REx images the impact from a safe vantage point (~1-meter resolution)

Seismic reverberations throughout the asteroid cause global modifications

1. After debris clears, approach asteroid for imagery of crater and previously mapped terrain (~2 cm resolution). Also collect spectra of pristine material exposed by impact

Deflection experiment

1. Measure asteroid delta-V due to impact
Cross-cutting Exploration & Science Benefits

ISIS delivers Discovery-level Science, closes Exploration SKGs and demonstrates NEO Mitigation Technology, all for a small fraction of the cost of a Discovery mission.

- Cratering experiment – regolith properties and geophysics
- Seismic experiment – global alterations (toppled rocks, landslides) due to shock wave/reverberations, lofting of material far from impact site
- Ejecta – size distribution of regolith, understanding meteorite formation process
- Imaging of crater – formation processes, morphology and subsurface geology
- Spectroscopy of pristine material from depth provides context to OREx sample
- Characterization of any volatiles released from impact site
- Thermal properties of disturbed & undisturbed areas
- Topographic mapping before and after to reveal exhumed volume and material mobility
- Particulate environment following impact over a wide range of disturbance energies
- Rotational excitation can constrain the interior mass distribution.
- Measure delta-V imparted by impact – determine momentum enhancement due to ejecta

The Planetary Defense aspects of a deflection experiment will generate significant public interest.
ISIS/ORIRIS-REx Operations Concept

1. Pre-impact characterization of asteroid ephemeris
2. Move to safe observing location and image ejecta cone as it expands over a period of several minutes.
   - 50 km gives 0.7 m/pixel with Polycam
3. Monitor ejecta as it dissipates (15-20 days)
4. Perform slow flyby(s) for imaging and spectra (15-20 days)
5. Enter radio science mode
   - Few km terminator orbit for 15-20 days
6. Total time from impact 45-60 days
   - Assume 90 days science operations from impact to departure, including margin
**ISIS Schedule Compatible with OSIRIS-REX**

### ISIS Baseline Mission

- **Launch**: 9-Mar-2016
- **Mission ΔV**: 1.29 km/s
- **Arrival & Impact**: 10-Feb-2021
- **Arrival Phase Angle**: 9°
- **Impact Velocity**: 13.4 km/s
- **Impact Mass**: 440 kg
- **Impact Energy**: 50 GJ (~9t TNT)

### Key Dates

- **Acquisition**: 08-15-18
- **Rendezvous**: 10-15-18
- **Stow Sample**: 01-02-20
- **Baseline Departure**: 01-03-20
- **Backup Departure**: 06-28-21

### Duration

- **60 Days**
- **275 Days (Rendezvous to 1st Sampling Attempt)**
- **170 Days (funded margin)**
- **426 Days (Quiescent Operations)**
- **116 Days**
- **90 days of impactor science ops**
ISIS Flight System Overview

- System designed around flight-qualified ESPA.
  - Imposes **no impact** on host SC/LV interface.
- Modular Flight System
- Spacecraft Architecture emphasizes simplicity and reliability
  - No Comm. Crosslink (to observer s/c)
  - No Pyrotechnics
  - No Deployments
  - No Mechanisms
Potential Stakeholders

} Science – This mission scheme is extraordinarily cost effective and aligned with NASA Science Mission Directorate objectives
   } Planetary Decadal Report, “The first and most important [criterion] was science return per dollar.”

} Technology – NEO Mitigation is a Space Technology Grand Challenge
   } Terminal guidance demonstration
   } Earth impactor deflection demonstration

} Exploration
   } ISIS squarely addresses numerous “Critical” Strategic Knowledge Gaps (SKGs) for human exploration of NEAs
   } Characterize geotechnical properties, particulate environment, mechanical response, structural integrity and local stability of sub-km NEAs

ISIS is a natural candidate for joint funding. In the current climate, this may be imperative in order to take advantage of the InSight secondary payload opportunity.
Schedule

} Time is short!
   } The InSight launch provides a critical constraint on the viability of the ISIS mission concept

} Starting 3-month pre-phase A study
   } High concept maturity crucial for short development schedule
   } Leading to a mid-2013 Decision Point

} ISIS development schedule assumes ~30 month Phase A-D
   } Aug. 2013 Phase A start to make Mar. 2016 InSight launch
Conclusions

ISIS is a low-cost mission that addresses NASA strategic goals and provides Discovery-class science returns across a wide range of small body science disciplines.

The mission leverages NASA’s investment in the OSIRIS-REx mission and takes full advantage of the New Frontiers-class instrumentation on the observer spacecraft.

Co-manifesting with InSight further improves the cost-effectiveness.

NEAR-Shoemaker is NASA’s only NEA rendezvous mission so far. The second will be OSIRIS-REx, twenty years later.

The convergence of OSIRIS-REx schedule and Insight launch opportunity is an extraordinary alignment that will not be repeated again soon.

ISIS represents a once-in-a-generation opportunity to fly a low-cost asteroid cratering experiment.