The Near-Earth Object Camera

Amy Mainzer

Jet Propulsion Laboratory/California Institute of Technology
Executive Summary

The National Near-Earth Object Preparedness Strategy and Action Plan (Strategy and Action Plan) will improve our Nation’s preparedness to address the hazard of near-Earth object (NEO) impacts over the next 10 years. Its primary role is to help organize and coordinate NEO-related efforts within Federal Departments and Agencies (agencies), with a particular focus on efforts that are already existing and resourced. It seeks to leverage and enhance existing assets and capabilities—National and international, public and private—to effectively manage the risks associated with NEOs. The Strategy and Action Plan builds on efforts by the National Aeronautics and Space Administration (NASA), Department of Homeland Security (DHS), and Department of Energy (DOE) to detect and characterize the NEO population and to prevent and respond to NEO impacts on Earth.

Five strategic goals, each supported by a set of strategic objectives and specific associated actions, underpin the effort to enhance the Nation’s preparedness for potential NEO impacts:

**Goal 1: Enhance NEO Detection, Tracking, and Characterization Capabilities:** NASA will lead the development of a roadmap for improving national capabilities for NEO detection, tracking, and characterization. Supporting actions will reduce current levels of uncertainty and aid in more accurate modeling and more effective decision-making.
NEOs: The Critical Questions

• Need to know **when** impacts could occur and **how bad** they will be

• **When:** Comes from finding objects & determining good orbits for them

• **How bad:** Comes from measuring the impact energy (KE)
  – Impact energy scales as $KE = \frac{1}{2} \text{ mass} \times \text{velocity}^2$
  – **Velocity** comes from orbit
  – Mass = density x volume = density x diameter$^3$
  – Impact energy depends strongly on **diameter**
Why Study Asteroids in Infrared?

• Asteroids reflect <~10% of the sunlight that hits them.

• Impact probability depends on size frequency distribution.
  – Evidence from visible surveys for a break in H mag distribution at ~22 mag (e.g. Granvik et al. 2016), but this could be due to change in albedo distribution rather than size, or a combination of both

• Impact energy scales as KE = ½ mass x velocity\(^2\) \rightarrow\) density x diameter\(^3\)
  – Diameter uncertainties of 2x translate to impact energy estimate uncertainties of factors of 10-30
  – With IR, can usually determine diameter to \(~\pm10\)-25% for most objects with good data & sampling of full rotational lightcurve

• IR is complementary to visible/near-IR: with IR+visible, can get albedos, which correlate loosely with taxonomic class and density
Near-Earth Object Camera (NEOCam)

• NEOCam is a planetary defense mission designed to detect, track, and characterize small bodies throughout the inner solar system
  – NEOCam provides critical decision support for stakeholders who must assess the risks of NEO impacts to Earth and must identify potential mitigation strategies

• NEOCam is optimized for the task of finding and characterizing the risks posed by potentially hazardous objects (PHOs), both as individual objects and as populations

• Expect to discover ~300,000 new NEOs & millions of MBAs, a significant improvement on the number known today
NEOCam

NEOCam is a dual-channel imager operating in a step-and-stare survey mode.

- 50 cm telescope
- Two 16 megapixel HgCdTe focal planes at 4-5.4 & 6-10 μm simultaneously imaged
- Detectors passively cooled to 40K
- Sun-Earth L1 orbit
- First proposed 2005
- Awarded technology development funding in 2011 Discovery
- Awarded Extended Phase A in 2016
- System Requirements Review/Mission Definition Review passed Feb. 2018
- Pre-Key Decision Point B Review for instrument passed Nov. 2018
Options for Improving Knowledge of NEO Population

- Searching in IR also gives good diameters while the survey is being conducted

Volume of sky in which a 140m NEO can be detected each day from different surveys (courtesy J. Masiero)
NEOCam Is Capable of Approaching 90% for PHAs >140m

From NASA NEO SDT Report (Stokes et al. 2017)

• GBO = Ground-based observatory
Optimized for NEOs

- NEOs reflect ~10% of incident sunlight
- ~90% of energy reradiated in thermal IR
- Search in wavelengths where NEOs are bright and stars are dimmer
  - But not so long that cooling requires cryocooler or cryogens

Background sources: stars, galaxies at same depth as 150 m NEO
• The NEOCam survey cadence is optimized for NEO discovery
  – Field of regard covers 45 – 120 deg solar elongation and +/-40 deg latitude (can point at poles)

• Most NEOs >140m are detected on many epochs spanning months or years

• But just in case there is an object of particular interest, we have the ability to interrupt survey & target
Detectors

- Partnership between Teledyne Imaging Sensors, University of Rochester, JPL
- 4 x 1 mosaic of detectors in each channel imaging simultaneously
- Long-wavelength HgCdTe material bonded to 2048$^2$ HAWAII-2RG readout
  - Cutoffs >10 µm demonstrated to exceed NEOCam dark current requirements
- Mode of dark current driven down to <1 e-/sec at 40K
- Radiation testing completed at UC Davis cyclotron
Conclusions

• Astronomers have made significant progress in discovering, tracking, and characterizing potentially hazardous asteroids

• Found about 90% of dinosaur killers
• But only 1% of Chelyabinsk-sized
• Lots more to discover
• Surveys help us understand the big picture