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Advancement of Planetary Defense in the United States

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EXTENDED ABSTRACT

NASA Headquarters recently established an office to manage the Agency's planetary defense-related projects and coordinate activities across multiple U.S. agencies as well as with international efforts to plan appropriate responses to the potential asteroid impact hazard. The creation of the Planetary Defense Coordination Office (PDCO) is a logical and formal step forward with NASA's NEO Observations program which began nearly two decades ago. Since the program's inception in 1998, NASA-funded efforts have discovered more than 98% of the more than 16,000 NEOs currently known.

As important as it is to mitigate a potential impact event, the essential first step is to find these near-Earth objects as early as possible. To that end, NASA's PDCO leads national and international efforts to:

- detect any potential for significant impact of the Earth by natural objects;
- appraise the range of potential effects by any possible object; and
- develop strategies to mitigate impact effects on human welfare.

Since commencing the program in 1998, NASA has provided funding to upgrade and operate existing 1-meter class telescopes to conduct the search for NEOs. Today, NASA funds three primary ground-based survey capabilities: the Lincoln Near-Earth Asteroid Research (LINEAR) project, the Catalina Sky Survey (CSS), and the Panoramic Survey Telescope and Rapid Reporting System (Pan-STARRS). Recent enhancements to NASA's Near-Earth Object (NEO) Observations Program have led to ~83% increase in the discovery rate of near-Earth asteroids (NEAs) over the past three years.

These survey efforts are increasingly detecting close encounter events (i.e., < 0.001 AU; recent examples include 2012 DA_{14}, 2017 EA and 2017 GM) and have enabled prediction of some small object impact events (e.g., 2008 TC_3 and 2014 AA). Such encounters provide opportunities for NASA's Infrared Telescope Facility (IRTF) to make spectral measurements; or observation by planetary radars at Arecibo and Goldstone to refine the orbit of the object with great precision and even "image" the small primitive body.

Of critical importance is the Minor Planet Center (MPC), where automated systems process observations made by the search teams to determine orbits and what are NEOs. The Center for NEO Studies at the Jet Propulsion Laboratory (JPL) determines more precise orbits for the objects. Both JPL and the MPC utilize processes and procedures for NEO orbit determination and prediction that are sanctioned and monitored by the International Astronomical Union (IAU) and produce data catalogues on small bodies in the Solar System that are utilized world-wide by the astronomical community.

The Wide-field Infrared Survey Explorer (WISE) was reactivated for the purpose detecting NEOs and will continue to operate well into 2018. It is in Sun-synchronous, near-polar inclination (97.5°) orbit around the Earth. The NEOWISE project uses WISE in 'warm mode' (at 3.4 and 4.6μm), and in conjunction with ground-based follow-up, this unique dataset has set limits on population statistics, orbital parameters, approximate sizes, and initial compositional knowledge of the asteroid population.

Further follow-up observations with visible and infrared telescopes (e.g., NASA's Infrared Telescope Facility, *Spitzer Space Telescope*, other NASA-funded NEO observer teams) refine the astrometric positions of an NEO, photometric observations obtain detailed light curve information [thereby constraining NEO shapes and spin state], and collect albedo and spectral data on basic physical properties and mineralogy.

Planetary defense demonstration missions also fall within the purview of the PDCO. The Asteroid Impact and Deflection Assessment (AIDA) mission concept is an international collaboration amongst NASA, the European Space Agency (ESA), the Observatoire de la Côte d'Azur (OCA), and the Johns Hopkins University Applied Physics Laboratory (JHU/APL).

As originally envisaged, AIDA would be a dual-spacecraft mission concept, – NASA's Double Asteroid Redirection Test (DART), and ESA's Asteroid Impact Mission (AIM). The target is the binary near-Earth asteroid (65803) Didymos, which consists of a primary body approximately 800 meters across, and a secondary body (or "moonlet") whose 150-meter size is more typical of the size of asteroids that could pose a more common hazard to Earth. The DART mission is in extended Phase A and led by JHU/APL.

However, the first step in planetary defense is the overarching goal to complete the NEO survey down to 100 meter sized objects. The asteroid hunter mission – NEOCam – is a single instrument, 0.5-meter aperture infrared telescope that would survey the solar system for NEOs from Sun-Earth L_1 Lagrange point (SEL_1). NEOCam is also in an extended Phase A study under the auspices of NASA's PDCO.