NASA JPL's Planetary Defense Activities

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Abstract. The public has consistently ranked Planetary Defense as one of NASA's top priorities. NASA's Jet Propulsion Laboratory (JPL) has many activities in support of Planetary Defense Goals. Four major activities are described in this abstract.

Through NASA's Planetary Defense Coordination Office (PDCO), JPL supports the the Center for Near Earth Object Studies (CNEOS). CNEOS's primary function is to compute high-precision orbits for Near-Earth Objects (both asteroids and comets), predict close approaches, and calculate impact probabilities for all NEOs over the next century. CNEOS offers many on-line services, including:

- Horizons – a high-precision on-line computation service that produces highly accurate ephemerides for any of over one million solar system objects
- Sentry – a NEO impact monitoring system that provides long-term impact hazard assessment by identifying all possible potential impacts of each object over the next century.
- Scout – a short-term impact hazard assessment that calculates impact risk for newly dicovered objects appearing on the Minor Planet Center webpages as potential asteroids and possible impactors
- CNEOS also develops hypothetical impact scenarios in support of cross-agency and international exercises and conferences.

In addition to leading CNEOS, JPL currently is managing the Near Earth Object Surveyor Mission, a project that will design, build and deploy an infrared telescope to detect and characterize NEOs. Once launched and inserted into its operational orbit, NEO Surveyor will detect thousands of NEOs that are larger than 140 meters in size, contibuting to a goal mandated by the U.S. Congress. Objects of this size are of particular interest as they would at the very least cause major regional damage if they impacted the Earth. NEO Surveyor's 50 centimeter diameter telescope will have the sensitivity to ensure that NASA responds to the U.S. Congressional mandate.

Another key component of planetary defense is the characterization of Near-Earth Objects (NEOs) using radar. JPL manages the Goldstone Deep Space Communications Complex as part of NASA's Deep Space Network, with the primary purpose of communicating with spacecraft across the solar system, but the Goldstone dishes are also used for Solar System Radar. The antennas transmit radio waves and receive the return echoes to characterize these objects at up to meter-scale resolution. The radar is used to image planets, asteroids, and comets to provide scientists with a better

understanding of the size, shape, surface characteristics, speed, and trajectory of these objects.

JPL is looking toward the future by developing an advanced concept that intercepts a NEO called Apophis. CNEOS has made high-precision predictions for the asteroid Apophis, which will come very close to the Earth, within 31,000km on April 13, 2029. This once-in-a-lifetime extremely close encounter of a large asteroid (~370m in diameter) provides scientists with an up-close look at a large, primordial body. The Distributed Radar Observations for Interior Distributions (DROID) concept involves an international collaboration with the French Space Agency CNES to image the asteroid prior to and after Earth close approach to examine changes caused by the tidal forces. The concept includes deploying two CNES-provided CubeSats that perform bi-static radar to examine the interior of the asteroid. DROID also performs a fly-by of another NEO on the way to Apophis, in direct response to the National Academies' Planetary and Astrobiology Decadal Survey recommendation for a flyby reconnaissance mission to assess capabilities and limitations of flyby characterization methods to prepare for a short warning time of a NEO threat.

Planetary Defense is an essential part of NASA's goals and is an important international cooperative enterprise. Through the CNEOS small body database, the development of the NEO Surveyor mission to detect asteroids currently hidden to us, the ground-based radar observations using the Goldstone antennas, and the DROID advanced concept to explore *in situ* a potentially hazardous asteroid with our international partner CNES, JPL is strongly supporting NASA and the international community's goals of early detection, characterization, and mitigation of NEOs and potentially hazardous asteroids.

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