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# HIGH-RESOLUTION RADAR IMAGING OF POTENTIALLY HAZARDOUS NEAR-EARTH ASTEROIDS

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## ABSTRACT

Ground-based radar imaging is an important tool to characterize potentially hazardous near-Earth asteroids (NEAs). Radar observations provide extremely accurate trajectory predictions and information on NEA shapes, spin states, and surface properties. Radar imaging also can provide constraints on objects' masses and densities – either from radiation pressure perturbations to their trajectories or from the mutual orbits of multiple-component NEA systems.

Currently, the most sensitive astronomical radar in the world is the ~850 kW planetary radar on the Arecibo Observatory 305-m antenna, which can provide images of NEAs with resolution as fine as 7.5 m in line-of-sight distance. Arecibo currently observes roughly 70 NEAs per year.

Since 2010, the Deep Space Network's ~450 kW Goldstone Solar System Radar transmitter on the 70-m DSS-14 antenna has provided images with resolution as fine as 3.75 m for NEAs passing within roughly 10 lunar distances of Earth. DSS-14 currently observes a few dozen NEAs per year.

As of January 2015, radar imaging resolution a factor of two finer, 1.875 m, is possible for selected objects. A new 80 kW transmitter has been installed on the 34-m DSS-13 antenna, as part of the DSN Aperture Enhancement Project. Although primarily designed for spacecraft telecommunications, this transmitter can also be used for high-resolution radar imaging of objects passing within a few lunar distances. We expect to use DSS-13 to observe a few NEAs per year.

The DSS-13 transmitter must operate in a bistatic mode, transmitting with one antenna and receiving with another – particularly Arecibo or the Green Bank Telescope, but potentially any large radio telescope with an appropriate receiver. Both the Arecibo and DSS-14 transmitters can also be operated bistatically. Bistatic observations can provide higher resolution than Arecibo and higher sensitivity than either DSS-13 or DSS-14. For each potential NEA radar target, we consider telescope availability and the target object's trajectory, size, and spin state to decide which combination of transmit and receive stations to use.

Previous bistatic radar projects with 3.75-m resolution have included imaging campaigns on the NEAs 2005 YU55, Toutatis, Duende, and 2014 HQ124. Possible results for future high-resolution radar projects include measuring the size distributions of boulders and other surface features on small NEAs; and possibly imaging the reconfiguration of asteroids' surfaces due to tides during extremely close Earth flybys.

In the future, radar transmissions could be made with an antenna at the DSN's Canberra complex. This would allow radar imaging of targets in the far southern sky, which current astronomical radars cannot see. It would also facilitate rapid radar follow-up of newly discovered potentially hazardous asteroids, preventing those objects from being lost.

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