High-resolution imaging of potential targets in advance of any spacecraft mission is important for reducing mission cost and risk and improving science returns. In particular, ground-based radar imaging provides highly-accurate ephemerides and shape and spin state information for objects that pass near the Earth. At higher resolution, radar images show surface features such as boulders and potential fissures and constrain internal structure. Examples of radar observations of objects prior to spacecraft arrival include Itokawa [1], Bennu [2], Toutatis [3,4,5], and 103P/Hartley 2 [6].

Recent upgrades to the Deep Space Network (DSN) Goldstone Solar System Radar allow the transmitted waveform to be modulated at up to 40 MHz [7], providing resolution as fine as 3.75 m in line-of-sight distance for nearby targets, primarily near-Earth asteroids (NEAs). Bistatic observations, transmitting with an antenna at Goldstone and receiving with either another Goldstone antenna or a larger antenna such as the Arecibo Observatory or the Green Bank Telescope, give the highest possible sensitivity combined with high resolution. High-resolution bistatic radar imaging has revealed spin state changes for Toutatis and the presence of boulders on many NEAs. Examples include 2005 YU55 [8], Toutatis [9], Duende (2012 DA14) [10], and 2014 HQ124 [11].

In the near future, a new high-resolution transmitter on Goldstone’s DSS-13 antenna will be able to transmit a signal modulated at 80 MHz, improving line-of-sight resolution by a factor of two to 1.875 m. This will allow many new projects: seeing previously-invisible surface details; measuring the size distributions of boulders and craters on NEAs; obtaining better estimates of the masses and densities of asteroids from radiation pressure perturbations to their trajectories; and further improved trajectory predictions for small spacecraft targets.

As with the current 3.75-m-resolution system, the new high-resolution transmitter will provide the best scientific results when operated in bistatic mode with a large antenna as the receive station. Equipment recently installed at Arecibo and scheduled for installation at Green Bank by early 2015 is able to record 80-MHz-coded radar echoes.

Somewhat further into the future, a 1.875-m-resolution transmitter may be installed on a 34-m antenna at the DSN’s Canberra complex [12]. Although less sensitive than bistatic observations between Goldstone and Arecibo or Green Bank, this would allow radar detection of objects in the far southern sky, which current radars cannot see. It would facilitate rapid follow-up of newly discovered radar targets and of small NEAs making very close flybys, which move very quickly across the sky at closest approach, preventing those objects from being lost.

These new capabilities for high-resolution radar imaging will further improve characterization of potential mission targets.

References: