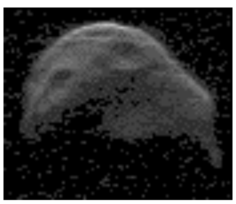
RADAR RECONNAISSANCE OF NEAR-EARTH OBJECTS

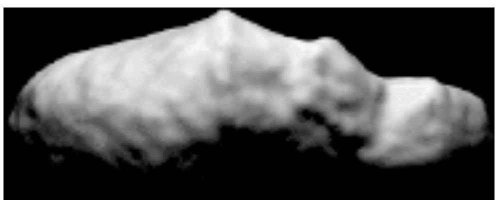
Radar is the most powerful astronomical technique for characterizing near-Earth objects and refining their orbits.

Whereas near-Earth asteroids (NEAs) look like unresolved points through groundbased optical telescopes, the Arecibo and Goldstone radars can image NEAs with resolution as fine as several meters. These images reveal the NEA's size, shape, spin state, topography, and multiplicity, i.e., whether or not it is a binary. Radar can determine the masses of binary NEAs and in some cases solitary NEAs, and is sensitive to surface roughness, porosity, and metal abundance. **Radar has produced the best physical characterizations of potentially hazardous NEAs as large as a kilometer and the best images yet of a binary small body.**

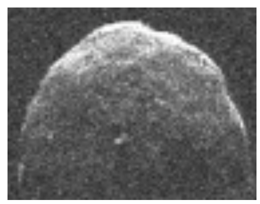
Radar echoes from NEAs have revealed both stony and metallic objects, featureless spheroids and shapes that are elongated and irregular, objects that must be monolithic pieces of rock and objects that must be unconsolidated rubble piles, small-scale morphology ranging from smoother than the lunar surface to rougher than the rockiest terrain on Earth or Mars, objects with craters and linear structures, rotation periods ranging from several minutes to several weeks, non-principal-axis spin states, contact binaries, and binary systems.



(53319) 1999 JM8
radar image



(4179) Toutatis
radar-derived model



(100085) 1992 UY4
radar image

(1620) Geographos
radar image

Radar is invaluable for refining orbits of potentially hazardous NEAs. Range-Doppler measurements provide line-of-sight positional astrometry with precision as fine as 10 m in range and 1 mm/s in velocity, with a fractional precision typically 100 to 1000 times finer than with typical optical measurements. **Radar reconnaissance adds decades or centuries to the interval over which we can predict close Earth approaches and dramatically refines collision probability estimates based on optical astrometry alone.**

Radar is responsible for our most accurate orbits for potentially hazardous NEAs. During the past decade, observations of newly discovered asteroids have revealed errors from ~100 km to ~100,000 km in optical-only range predictions. **Radar could easily make the difference between knowing only that an object will "pass closer than the Moon" and knowing whether or not it will hit the Earth.**

For comets, trajectory prediction is hampered by optical obscuration of the nucleus and by uncertainties due to non-gravitational forces. **Radar reconnaissance of an incoming comet would be the most reliable way to estimate the size of the nucleus, could reveal the presence of large particles in the coma, and would be critical for determining the likelihood of a collision**.

Spacecraft operations close to a small asteroid are extremely difficult due to the complexity of the gravitational environment, which depends on the object's size, shape, spin state, and mass distribution. **If it turns out to be necessary to have a sequence of missions beginning with physical reconnaissance and ending with a deflection, then a radar-derived physical model would speed up this process, reduce its cost, decrease complexity in the design and construction of the spacecraft, and improve the odds of successful mitigation.**

Mor information about NEA radar is
available from Steve Ostro (JPL):
ostro@reason.jpl.nasa.gov
http:// reason.jpl.nasa.gov

radar-derived model of (66391) 1999 KW4