Proceedings of the Lunar and Planetary Laboratory Conference XII, June 4-5 2009

Identifying accessible asteroid targets for spacecraft sample return missions

C. Hergenrother*

Presenting and Corresponding Author: chergen@lpl.arizona.edu

Asteroids are found throughout the entire solar system. The most accessible objects for rendezvous are located in the vicinity of Earth and have low eccentricities and inclinations. In other words, these are objects that require a minimum amount of fuel to travel to and are within the capabilities of the Discovery and New Frontier programs. Power and thermal constraints require the target asteroids to approach no closer than 0.8 AU from the Sun and travel no further than 1.6 AU from the Sun.

Size provides an additional constraint. A large fraction of asteroids with diameters less than 200 meters rotate as quickly as once every 1 to 60 minutes. Not only does such rapid rotation greatly increase the risk to near-surface spacecraft operations, but also centrifugal forces can eject regolith particles from the surface. As a result, small asteroids may not possess any loosely bound material for sample return.

There are only 27 objects that have low delta-V orbits and are large enough to be sample return targets. Of these, a dozen have been taxonomically classified, of which five objects are known to be carbonaceous.

It is expected that additional sample return targets will be identified in the future. Last year over 800 near-Earth asteroids were discovered and the discovery rate should increase by an order of magnitude as new surveys such as PanSTARRS and the LSST become operational. The large discovery rate of known near-Earth asteroids is not producing a similar increase in the number of objects suitable for sample return. The total number of known near-Earth asteroids has been steadily increasing since the advent of wide-field CCD surveys in the late 1990s. The number of accessible asteroids greatly increased between 1996 and 2002. Since 2002 the increase in accessible asteroids slowed markedly even though the capabilities of the surveys have improved (increased sky coverage, deeper limiting magnitude, coverage extended to the Southern Hemisphere).

The cause for the slowdown in the discovery of accessible asteroids is due to the great efficiency for finding objects on such orbits. Accessible asteroids are located on orbits that do not stray very far from the Earth's orbit and once every 3-10 years each object experiences a low delta-V encounter with Earth. During the course of these encounters, these asteroids are discoverable by existing surveys for many months. As a result, most accessible asteroids have been found. Future surveys will uncover many fainter objects on accessible orbits but they will be too small to consider for easy sample return.

Of the 27 currently known objects on accessible orbits, 16 remain unclassified. A program to physically characterize these asteroids has been established. As a result of this program, the number of characterized sample return targets will increase by a factor of 2 or 3. The increase in knowledgewill greatly aid the planning of future sample return missions.