PROPULSION OPTIONS FOR NEAR EARTH OBJECT CHARACTERIZATION MISSIONS. R. Reinert and R. Dissly[1], S. Benson [2], [1]Ball Aerospace & Technologies Corp. (1600 Commerce St., Boulder, CO 80301, rdissly@ball.com), [2]NASA Glenn Research Center (MS 142-2, Cleveland, OH, 44135, Scott.W.Benson@nasa.gov).

Introduction: Near Earth Objects (NEOs) represent a collection of small bodies (both asteroids and comets) with orbital perihelia less than 1.3 AU. Their close proximity make them attractive targets for detailed characterization via rendezvous spacecraft missions, whether it be for purposes of basic scientific inquiry, or improved understanding for potential planetary defense or resource exploitation. This presentation will compare the performance capabilities of well-characterized space propulsion approaches, both chemical and electric propulsion, to identify their relative cost effectiveness in supporting future NEO characterization missions.

NEO Characterization - Mission Goals: NEOs are attractive targets for rendezvous spacecraft missions for several reasons: 1) Asteroids and comets are primitive bodies that provide information about the composition and accretion processes by which the planets in our solar system formed. 2) Some NEOs are potential earth impact hazards. Effective mitigation planning requires information on their structures over a range of spatial scales. 3) NEOs may offer potential resources to help realize economically sustainable solar system exploration. 4) The close proximity of NEOs makes them easy to reach, enabling rendezvous missions to be relatively inexpensive.

Detailed understanding for any of the above rationale for exploring NEOs will likely require rendezvous missions, with measurements over a period of weeks to months from a closed orbit (e.g., NEAR) or from precision station keeping maneuvers (e.g., Hayabusa). Both of these missions were able to reveal compositional and structural detail of their respective target bodies that would be impossible from the short duration and limited viewing geometry offered by a flyby mission. Rendezvous missions provide the opportunity to determine in detail target object size, shape, mass, mass distribution, spin state, the composition and state of the surface material and interior structure, all valuable for interpreting the origin and evolution of small bodies, and critical for assessing potential mitigation strategies [1]. In addition, exploring the diversity of NEOs in detail is an important step in forming effective plans for potential mitigation, or comprehensive theories for improved scientific understanding.

Candidate Propulsion Approaches for NEO Missions: NEO rendezvous and subsequent long-term station keeping or orbital operations require capable S/C propulsion systems, as shown by the NEAR and Hayabusa missions. There are currently three primary proven approaches to space propulsion: monopropellant, bipropellant, and Solar Electric Propulsion (SEP).

Monopropellant approaches are the least costly but are limited in practice to mission delta-V's of <1 km/s or less. The monopropellant approach demands that the launch vehicle (LV) provide the rendezvous S/C with all of its earth departure momentum, a significant mission cost driver.

Bipropellant systems allow delta-V's of up to about 5 km/s but are more costly. In some cases use of the more efficient bipropellant may allow use of a smaller LV than that required for a monopropellant approach. This can reduce the overall mission cost despite the additional cost at the S/C level imposed by selection of bipropellant propulsion.

The improved efficiency provided by solar electric propulsion can enable either a drastic reduction in LV size or else rendezvous with multiple NEO's using a single launch. Either of these advantages can potentially offset the higher cost of the SEP system to yield the lowest overall cost per rendezvous. SEP can also provide access to NEOs energetically inaccessible to the other propulsion approaches.

This presentation will compare three complete mission concepts, each of which uses one of the above candidate in-space propulsion options. To make a valid comparison, each mission will carry the same science payload, including both remote sensing instrumentation a set of surface probes. Mission characteristics will be compared and cost per rendezvous will be characterized for each mission option to allow determination of the influence of in-space propulsion on the mission level cost per rendezvous.

References:

[1] "NASA Workshop on Scientific Requirements for Mitigation of Hazardous Comets and Asteroids" Final Report, Sept 2002, M.J.S Belton, *ed.* (www.noao.edu/meetings/mitigation/report.html)