ASTEROID TRACKING USING OPTICAL BEACONS. G. A. Konesky[1], [1]K-Plasma, Ltd.
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Introduction: Accurate tracking of Near-Earth Objects is important both for potential hazard assessment [1], and somewhat more forward-looking, as a potential Near-Earth resource [2]. A radio beacon mission, for example, has been proposed to track asteroid 99942 Apophis, which will pass under the orbits of geostationary satellites on April 13, 2029. Accurate tracking is essential to monitor possible interaction with Earths' gravitational "keyholes" which may result in an impact in 2036.

While space-qualified radio beacon technology is mature, increasing advances in space-borne laser optical communication make this a viable alternative [3]. There are two primary advantages to an optical approach. The first is the exceptional communication bandwidth available [4, 5], and the second is the ability to focus energy into a compact beam with a relatively small aperture, as can be seen by:

$$G_a = 10 \log_{10} (\pi D / \lambda)^2 \qquad (1)$$

where G_a is the gain of the aperture relative to an isotropic radiator (in dBi), D is the aperture diameter, and λ is the wavelength. In other words, the same antenna gain that would require a dish many meters across at microwave frequencies, can be had by an aperture only a few centimeters across at optical frequencies.

This has important ripple-down effects in overall mission design from reduced payload mass and size to a smaller, less expensive launch vehicle.

Using a link budget margin calculation approach [6] various tradeoffs can be considered for laser transmitter power and aperture diameter, but again, with the goal of minimizing payload mass, the trade would favor smaller aperture and higher power laser. For example, a proposed Mars-to-Earth optical data link [4] would use a 30 cm aperture and an average laser power of 5 Watts at 1064 nm, for a maximum range of 2.7 AU. This also falls within the range of Near-Earth Objects.

Terrestrial reception of an optical signal represents the largest drawback of this approach due to weather limitations, however, ground based adaptive optics [7] can restore marginal signals. Consideration is given to on-orbit reception. The tradeoffs here are greater expense and complexity (the received optical signal would still need to be relayed back to Earth), although it also benefits from high availability.

In a transponder mode, the same spacecraft optics could be used to receive an interrogation signal from Earth, and then transmit a response, providing an asteroid tracking capability with unprecedented accuracy.

Finally, we consider some practical issues related conducting such a mission. For example, the "landing" of the NEAR spacecraft on asteroid 433 Eros in 2001 was an exceptional feat, but may not be practical on asteroids such as 25143 Itokawa, which are likely a "flying rubble pile."

References: [1] Gehrels T. (1994) *Hazards Due To Comets and Asteroids,* [2] Lewis J. et al. (1993) *Resources of Near-Earth Space*, [3] Aviv D. (2006) *Laser Space Communications,* [4] Hemmati H. (2006) *Deep Space Optical Communications,* [5] Konesky G. (2000) *Moon-to-Earth High Bandwidth Optical Communications Link,* Optical wireless Communication III, SPIE press, [6] Alexander S. (1997) *Optical Communication Receiver Design,* [7] Tyson, R. (1998) *Principles of Adaptive optics.*