Using Pulsed Laser Ranging to Drastically Improve LEO Orbit Ephemerii

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Abstract

A long-living legacy of space junk larger than 50-100cm, and with 500-1000kg mass reminds us of the danger of collisions and the importance of predicting those accurately in advance. For these objects, present accuracy of orbit ephemerii is totally inadequate. A position uncertainty of order 1km leads to an unacceptable 99.9% false alarm rate for predicted mutual collisions [1].

We propose an orbiting pulsed laser station with a high sensitivity, high data rate detector array to improve orbital location precision to 3cm relative to the station. The station will be equipped with GPS and retroreflectors to allow its position to be determined with the same accuracy relative to references on Earth, and thereby the orbit of every satellite it is able to study. The station will use a 5m focal length, 2.5-m diameter optic feeding a 1Gpixel gateable array of 5μm pixels with 85% efficiency in the visible to establish tracks in sunlight. In staring mode, it will permit tracking objects with solar illumination down to 10cm in size at 250km range, and 25cm at 900km. Having established a track, the electro-optical system then does active rather than passive tracking on a selected object using a 900mJ, 100ps, 1.06μm, 10Hz, 10W repetitive-pulse laser. N such data points per satellite encounter with m encounters over several days improves accuracy further and permits orbit determination. At 900km range, only 200μJ/cm^2 is incident on targets, a fluence level that cannot cause damage to any materials unless further focused. This fluence can be maintained at shorter range by turning down the laser. Range gating together with a 5nm narrowband optical filter can give signal/background ratios of about 100k on most targets.

At the conclusion we briefly review large debris target management (LDTM) using lasers [2], a different system which would only be used on defunct satellites, to prevent collisions by gentle nudging over a period of 5-6 days in advance. At the outset, this would be a 532nm, 100J, 8Hz, 100ps laser adapted from the proposed "L'ADROIT" system [3]. The two systems are synergistic, in that the LDTM laser can use lower power when ephemeris accuracy for these large objects is improved by a factor of 100k as a result of the spaceborne laser ranging proposal.

References

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