LIGHTCURVE INVERSION FOR SHAPE ESTIMATION OF GEO SATELLITES FROM SPACE-BASED SENSORS

Ben K. Bradley[(1)], **Penina Axelrad**[(2)]

[(1)]*University of Colorado Boulder, UCB 431, ECNT 320, Boulder, CO 80309, 608-279-7393, ben.bradley@colorado.edu*

[(2)]*University of Colorado Boulder, UCB 431, ECNT 320, Boulder, CO 80309, 303-492-8183, penina.axelrad@colorado.edu*

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ABSTRACT

Orbital debris is a major concern for all satellite operators. Debris in the geosynchronous (GEO) belt is of particular concern because this unique region is such a valuable, limited resource, and, from the ground we cannot reliably track and characterize GEO objects smaller than 1 meter in diameter. Due to the growing catalog of both satellites and debris alike, it is necessary to improve orbit propagation and determination of these objects to prevent future collisions. One aspect of this goal is to determine the shape of these resident space objects (RSOs). The intent of this paper is to evaluate the feasibility of using lightcurve inversion (LCI) to estimate the shapes of typical geosynchronous satellites (e.g., box-wing plus antenna), both active and inactive.

While the use of photometric measurements has become popular in the space situational awareness (SSA) community recently [1-4], researchers have used LCI to estimate asteroid shapes and attitude states for some time [5,6]. Thus far, LCI has been proven to be a valuable tool to this end. There have been a few studies, which investigated the use of LCI and related techniques on satellites, but they have assumed known attitude states, only used random polyhedron or cube-shaped objects, and only simulated photometric measurements from ground-based telescopes [7-11]. Other studies in the SSA community have used various Kalman filters, including the use of multiple-model adaptive estimation, to estimate polyhedron and cube-shaped objects as well as attitude [3,12,13]. While these methods look promising, they still focus on "debris-shaped" objects instead of typical satellite shapes.

Our research contributes to studies published to date by performing LCI on satellite-shaped objects in GEO through photometric measurements taken from space-based sensors. Space-based space surveillance (SBSS) is required to observe GEO objects without weather restriction and with improved viewing geometry. With the recent launches of SBSS satellites such as SBSS Block 10, Sapphire, and NEOSSat, this study will help to determine if LCI is a feasible option for utilizing the photometric measurements being produced.

Simulated photometric measurements from space-based optical platforms are used to estimate both convex and concave shape models of box-wing shaped GEO satellites. This feasibility study simulates active (i.e., Earth-pointing antenna and bus and Sun-pointing solar panels) satellites and inactive (i.e., freely rotating) satellites and assesses the challenges/limitations of each case. The LCI results are also used to study the number of observations and extent of varying observation geometry needed to produce reasonable convex and concave shape models.

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