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Orbit Refinement with the STARE Telescope

Lance M. Simms, Don Phillion, Wim De Vries, Vincent Riot, Brian J. Bauman and Darrell Carter

Lawrence Livermore National Laboratory, Livermore, CA, 94550, USA

Abstract

The proposed Space-Based Telescopes for Actionable Refinement of Ephemeris (STARE) mission, which will consist of a constellation of nano-satellites in low Earth orbit (LEO), intends to refine orbits of satellites and space debris to less than 100 meters uncertainty in order to help satellite operators prevent collisions in space. To prove this is possible, a prototype STARE payload was used to refine the orbit of NORAD 27006 using a series of six ground-based images captured over a 60 hour period. The refined orbit, based on the first four observations made within the initial 24 hours allowed for prediction of the satellite's trajectory to within less than 50 meters over the following 36 hours, as verified by the final two observations taken within that period. This paper describes the tools and methodology used to capture the images of NORAD 27006 and refine its orbit—the same ones that will be used during the STARE mission. The details of verifying the accuracy of the orbit over the next 36 hours are then presented, lending credence to the capability of STARE to accomplish its mission objectives.

1. Introduction

Accurately predicting the location of a satellite in low Earth orbit (LEO) at any given time is a difficult enterprise. The primary reason for this is the uncertainty in the quantities needed for the equations of motion. Atmospheric drag, for instance, is a function of the shape and mass of the satellite, as well as the density and composition of the tenuous atmosphere through which it is moving. In a typical scenario, all of these quantities are poorly known (Vallado and Finkleman, 2008). And over many days, other difficult-to-model phenomena, such as solar radiation pressure and gravitational field perturbations due to earth solid body and ocean tides, influence the movement of the satellite (Vallado, 2005). These uncertainties and the incompleteness of the equations of motion lead to a quickly growing error in the position and velocity of any satellite being tracked in LEO.

In order to account for these errors, the Space Surveillance Network (SSN) must repeatedly observe the set of nearly 20,000 objects it tracks. With each new observation, it is able to fit the orbit and generate a fresh Two-Line Element (TLE) that contains the orbital information for the object. The problem is that even with these continuously modified TLEs, the positional uncertainty of an object can be as large as approximately

Corresponding Author: Lance Simms - simms8@llnl.gov
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