New Deep Space Optical Search Strategies

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Abstract

The United States Air Force operates a worldwide sensor network dedicated to tracking orbiting satellites. This network contains sensors using both Radio Frequency (RF) and optical systems. These optical systems are referred to as the Ground-based Electro-Optical Deep Space Surveillance (GEODSS) system. These telescopes are primarily used for tracking deep space (period > 225 minutes) satellites.

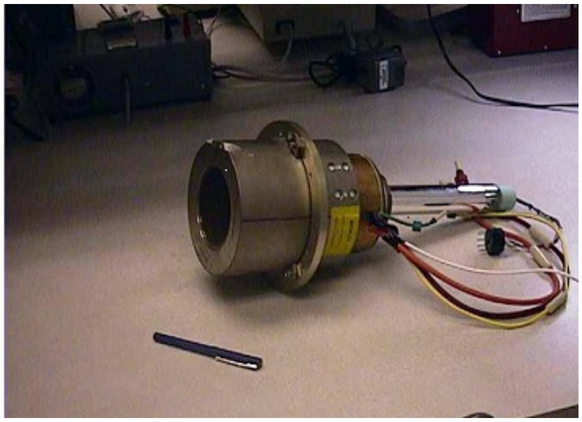
Currently there is a program under way that will replace the Ebsicon vacuum tubes, used for satellite observation data generation, at the GEODSS telescopes. The tubes are being replaced with large format Charge Coupled Devices (CCDs). With CCDs installed, good quality data will be available over the entire field-of-view of the telescope (~1 deg) allowing more effective searches. The CCDs will dramatically decrease the time it takes to produce a satellite observation and significantly increase the productivity of each site.

The CCD upgrade will also allow for effective wide area searches of the sky. These searches will be used to help recover satellites with outdated orbital elements, to find lost satellites and to discover uncataloged space debris. There are several different search patterns being evaluated. Depending on the orbital parameters of the satellite or debris of interest, some search patterns are more effective than others. This paper will discuss the attributes of these various search patterns and highlight the types of satellite orbits they will be most successful in tracking.

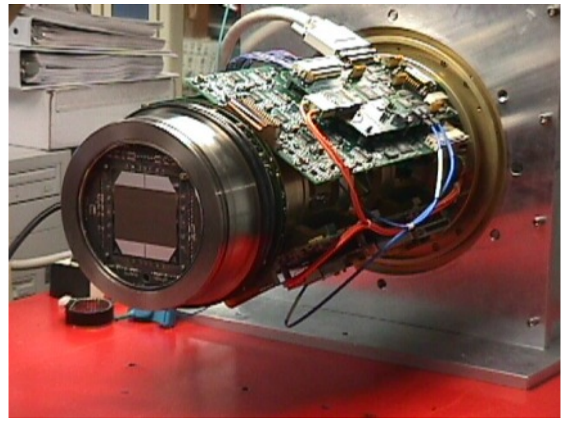
Introduction

The United States Air Force operates a worldwide sensor network dedicated to tracking orbiting satellites. The Ground-based Electro-Optical Deep Space Surveillance (GEODSS) system is an integral part of this network. The GEODSS system is comprised of the three geographically separated sites. Each site contains three one-meter aperture electro-optical telescopes.

At present these telescopes use Ebsicon vacuum tubes to capture the visible light from the Sun that is reflected by the orbiting satellite. Because of distortions present in these vacuum tubes, data quality degraded away from the center of the field-of-view of the telescope. This limited the telescopes search ability. There is a replacement program underway that will replace these vacuum tubes with Charge Coupled Devices (CCDs). With CCDs installed, good quality data will be available over the entire field-of-view of the telescope (~1 deg) allowing more effective searches.



Ebsicon Vacuum Tube



CCD Camera

The primary purpose of these telescopes is for tracking deep space (period > 225 minutes) satellites. Most deep space satellites can be grouped in one of five different categories; geosynchronous, super-geosynchronous or geosynchronous graveyard, geosynchronous transfer, eccentric semi-synchronous 12-hour orbits and circular semi-synchronous 12-hour orbits. Different search strategies have been refined and developed by the CCD upgrade contractor Northrop Grumman, that focus of each of these categories of satellite orbits.

Geosynchronous Belt Searches

- Equatorial Search

A large percentage of the deep space satellite population is contained in or near the geosynchronous belt. One of the simplest searches to envision is to scan the geosynchronous belt from horizon to horizon. This type of search, called an equatorial search, defines a latitude/longitude box in the sky that rotates with the earth.

This search is designed to concentrate on the active geosynchronous belt satellites and will only be a degree in latitude above and below the belt. The minimum elevation constraints of the telescope and the latitude of the site control the actual longitude extent that can be covered. Based on the telescopes field-of-view and the exposure time required to generate a satellite observation this search could be accomplished on an hourly basis.