

# **Unique search and track procedures utilizing the Ground-based Electro-Optical Deep Space Surveillance (GEODSS) worldwide sites**

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## **ABSTRACT**

The GEODSS Vela Search Team developed revolutionary, new procedures for searching for man-made objects in deep space. The procedures were designed to find the Vela communication satellites launched in the 1960s. The satellites were in very high and eccentric orbits and had not been tracked in over 40 years. The approach used the sun to provide illumination along with modifying optical parameters. The GEODSS team has found 6 lost Vela satellites and enhanced the Air Force Space Command satellite catalog. This Vela Search Team worked with the Air Force to aggressively launch a first-ever proactive campaign against a series of lost satellites using our three GEODSS optical detachments. Two new tactics, techniques & procedures were successfully used to capture very hard to track objects. The revisit time was increased from intermittent and yearly tracking to weeks or better for 3 Vela's lost for over four decades. Lessons learned were established for Vela & other orbit types. The Joint Space Operations Center (JSPOC) analysts stated that the Vela search and tracking was a great success. Additionally, a GEODSS Space Shuttle Track Team was the first to use a deep space observing telescope to observe the space shuttle flying at low altitude. The Team developed a procedure using modified optical viewing parameters and new search techniques using the GEODSS telescope in a mission it was not designed to perform. The team was able to observe the space shuttle 14 times over two nights. The ability to observe and then successfully repeat the process was an astronomical achievement. The GEODSS team accomplishment contributed to shuttle safety and mission success.

## **1.0 GEODSS Mission**

The GEODSS system is comprised of three Detachments (Dets) at geographically-separated locations at Socorro, New Mexico (Det 1); Diego Garcia, British Indian Ocean Territory (Det 2); and Maui, Hawaii (Det 3). Each detachment/site operates with three optical telescopes. The Air Force Space Command, 21<sup>st</sup> Space Wing, 21st Operations Group (21 OG), Peterson Air Force Base (AFB), Colorado, has responsibility for all GEODSS Dets. The GEODSS system supports the United States Strategic Command (USSTRATCOM) and the warfighter's requirements through the detection and surveillance of deep space satellites. The system detects, tracks, identifies, and reports on all deep-space man-made objects in the Earth's orbit within the telescopes field of view. The GEODSS Dets perform the mission using three 1-meter telescopes each with a 1.68 degree field of view, low-light-level electro-optical cameras, and high speed computers. These optical sensors detect sun light reflecting off space objects. Mission operations are conducted between civil sunset and sunrise ("civil" signifies when the ambient light is out of the atmosphere, equating to 6 degrees solar depression). Satellite information is provided to the Joint Space Operations Center (JSPOC) located at Vandenberg AFB, California.

BAE Systems provides all necessary GEODSS personnel resources needed to perform mission requirements 24-hours-a-day, 7-days-a-week basis.

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## 2.0 GEODSS Operations

The GEODSS optical sensor system is capable of a variety of search, track, and optical signature operations on earth orbiting objects out to and beyond geosynchronous distances. The three GEODSS Sites provide approximately 60 percent of all deep space observations and nearly 80 percent of all geosynchronous observations [1]. GEODSS is a dedicated deep-space surveillance sensor with a primary mission of providing positional data, and a secondary mission of providing Space Object Identification (SOI) brightness data. The system is limited by inclement weather such as thunderstorms, rain showers, and heavy cloud cover. All sensors operate at night for tracking and detecting satellites from civil sunset to civil sunrise. Sensor time allocation is based on two main factors, tasking priority and object visibility. Daily sensor tasking is accomplished in accordance with Strategic Directive 505 (SD-505), Volumes 1 and 2. In addition, each day the GEODSS sites receive a Consolidated Task List (CTL) that directs collection of observations on satellites, broken down by priority and number of required observations. The higher the tasking Category (CAT), the more robust detection sequence selected, and thus, a greater amount of tracking time spent on the object.

## 3.0 Finding VELAs

Between 1963 and 1970, the US launched 12 Vela satellites into deep space orbits beyond GEO using six launches. Once the Vela satellites were turned off at the end of their useful life, it became difficult to maintain their element sets and they became literally lost in space.

Following the GEODSS upgrades to Charge-Coupled Device (CCD) camera technology in 2005, the capability to track deep space objects as uncorrelated targets had become possible. Between 2007 and early 2010, 6 of 12 Vela satellites were “found” by GEODSS sites and added to the space catalogue. The early 2010 discovery of Vela-7 by the Det 3 team at Maui was a great success, but was actually made more significant because of what followed. One week following its discovery, conversations with JSPOC Operating Location D analyst revealed Vela-7 had gone missing because it was not tracked since the initial collection of data on the first few nights. Utilizing one of the GEODSS search patterns, Maui was able to find the missing Vela-7 satellite.

We also learned from the analyst that of the five Vela satellites tracked between 2007 and January 2010, only one was maintained using its JSPOC satellite number on a routine basis. The remainder had become “re-lost.”

The Maui team requested and was granted permission to manually schedule and search for the remainder of the lost Vela’s. Crews used a Special Tasking Category to schedule all Vela objects which allowed crews to pull the Vela’s out of the automatic Consolidated Task List (CTL) scheduler. Once removed, objects were placed onto special tasking worksheets to manually schedule, attempt, and track using Vela analyst numbers provided. When attempting to locate the Vela’s, any uncorrelated objects found in the search area having similar orbits as Vela set a flag for the crews, indicating a possible Vela candidate. Crews tracked these objects through the remainder of their visibility period and rescheduled them for follow up during the next night’s shooting period. This aggressive tracking action which followed initial discovery of Vela-type objects was necessary due to nighttime-only operational limitations and drifting orbits. Personnel adopted a persistent manual follow-up approach upon receipt of Vela elsets propagated to point the sensor and perform a search. Personnel continued to record their successes, as well as their failures, and passed the information onto all crewmembers as lessons learned.

In February 2010 Maui’s clear weather allowed re-discovery of two more Vela’s previously observed, but then lost again in 2008 and 2009. This was a concerted effort using the propagated ELSETs from JSPOC OL-D analysts. Of the three Vela objects tracked in February 2010, Vela-1 had been lost the longest, since March 1968—more than 41 years. Vela 9 and Vela 12 had been lost since June and September 1984, respectively.

The GEODSS sites assign their own set of object numbers for use in tracking uncorrelated objects so that the JSPOC and other tracking sites can identify the source of the original observations and elsets. These GEODSS UCT numbers, tracked several different nights over a period of weeks or months, can provide enough quality data to allow JSPOC analyst to locate lost objects.

In addition, crews using manual control changed the sensor tracking parameters, adjusting them outside their normal default/automatic settings. Recording successes and failures allowed knowledge to pass onto follow-up crews

attempting to find these same Vela objects. This improved the rate of successful follow-up tracking for difficult-to-track uncorrelated targets while using the GEODSS UCT management tool.

The proactive GEODSS Vela search campaign utilized all three GEODSS sites. The campaign resulted in the creation of two new tactics, techniques, & procedures to successfully capture very hard-to-track objects. This reduced the revisit times on lost Vela objects from intermittent and yearly tracking to weeks for the 3 Vela's lost for over four decades.

Current Vela procedures consist of manually taking control of the Automatic Metric Sensor to increase or decrease the amount of GEODSS camera frames and camera exposure time based on the range of the tasked object. The farther the range, the greater the exposure time and number of frames required to enable the system to build up a streak long enough for the system to tag and take observational elset data. If the object is not acquired, follow on action is taken to look around the area of the predicted orbit.

#### **4.0 Conclusion and Way Ahead**

Handoffs between sensors, within strict criteria given to GEODSS operators via orders from JSPOC, should continue to be investigated to determine if an operator-to-operator hand-off model or a direct system-to-system hand-off model would be more beneficial to orbital determination analysts. Site personnel should continue to analyze and modify their search tactics and techniques by attempting a different part of the elset orbit, searching in the opposite part of the orbit. In addition, sites should continue to communicate with each other to refine the elsets and maintain custody of the Vela objects. It will take all three GEODSS Sites to accomplish this task. The three GEODSS sites need to continue to refine the procedure to save time searching through better logging of what's being tracked, when, and how, to pass onto each site. Cross-feed and continued communications between the three sites' Operations Supervisors and Shift Supervisors will ensure continued success. Simple solutions, such as creating an easily accessible 6-part folder for standardization and consolidation of information, has assisted Site 3 in follow-up tracking success. The GEODSS-developed procedure, now known as the Difficult-to-Track UCT Standing Order Revisit Tactic, is merely the beginning of a series of tactics the sites continue to develop and refine to affect the success rate of finding lost objects using the GEODSS Optical Sensors.

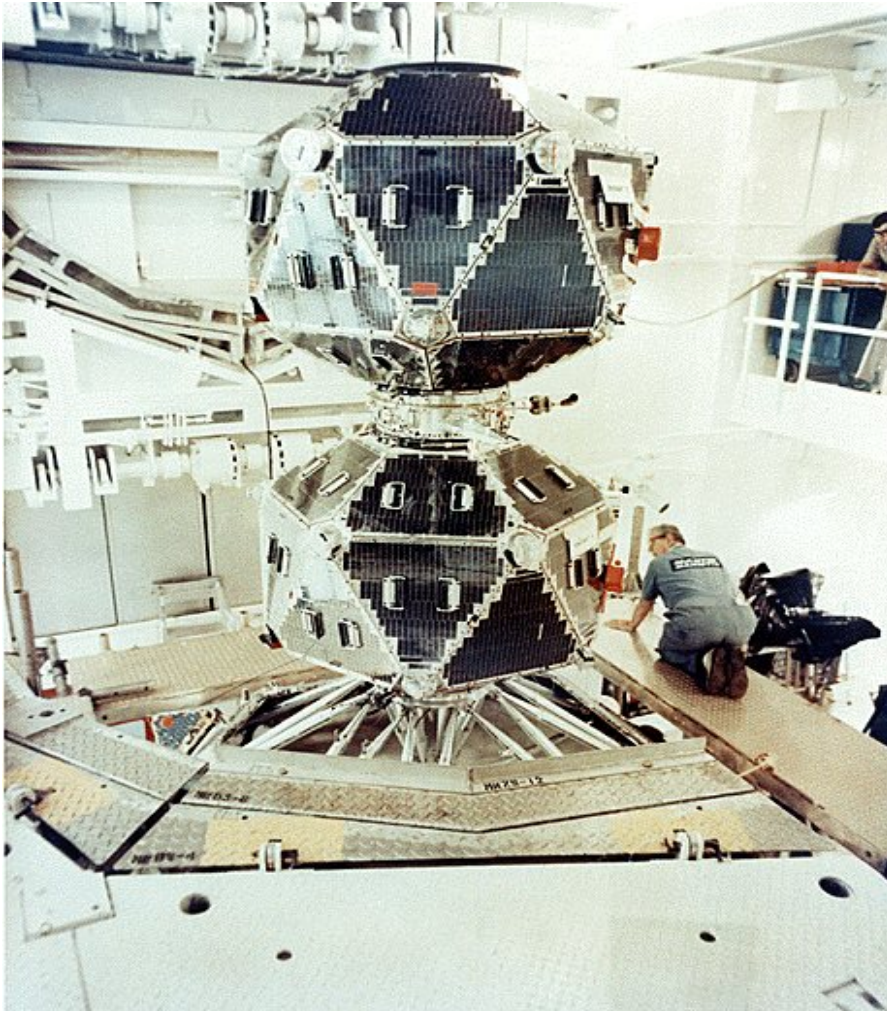


Figure 1. Vela-5A/B satellites in clean room in tandem launch configuration [2.]

## 5.0 References

1. Thurston, Robert, *email transmission*.

2. Wikipedia Commons, the free encyclopedia. No higher resolution is available. Vela5b.jpg (461 × 576 pixels, file size: 94 KB, MIME type: image/jpeg. Commons is a freely licensed media file repository. Date of upload was 2004-06-02. This image is a work of a United States Department of Energy (or predecessor organization) employee, taken or made during the course of an employee's official duties. As a work of the US federal government, the image is in the public domain. For all practical purposes on Wikipedia, the public domain comprises copyright-free works: anyone can use them in any way and for any purpose. Proper attribution to the author or source of a work, even if it is in the public domain, is still required to avoid plagiarism.

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