GEODSS Tracking Results on Asteroid 2012 DA14

June 12, 2013

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Abstract

The potential effects of an asteroid passing within close proximity to the Earth were recently realized During the February 16, 2013 event, Asteroid 2012 DA14 passed within an estimated 27,700 kilometers of the earth, well within the geosynchronous (GEO) orbital belt. This was the closest known approach of a planetoid of this size, in modern history. The GEO belt is a region that is filled with critical communications satellites which provide relays for essential government, business and private datum. On the day of the event, optical instruments at Detachment 3, 21OG, Maui GEODSS were able to open in marginal atmospheric conditions, locate and collect metric and raw video data on the asteroid as it passed a point of heliocentric orbital propinquity to the Earth. Prior to the event, the Joint Space Operations Center (JSpOC) used propagated trajectory data from NASA's Near Earth Object Program Office at the Jet Propulsion Laboratory to assess potential collisions with man-made objects in Earth orbit. However, the ability to actively track this asteroid through the populated satellite belt not only allowed surveillance for possible late orbital perturbations of the asteroid, but, afforded the ability to monitor possible strikes on all other orbiting bodies of anthropogenic origin either not in orbital catalogs or not recently updated in those catalogs.

Introduction and Background

What prospective consequence might be realized by a near proximity planetoid flyby of Planet Earth? The potential influence of an asteroid passing within a recent record distance to the Earth was recently realized. On February 16 2013, optical instruments at an Air Force tracking site located in the Hawaiian Archipelago were able to locate and track such an event. A Ground-based Electro Optical Deep Space Surveillance (GEODSS) system, located on Maui, observed and collected data on Asteroid 2012 DA14 as it transited on its projected path. It passed so close to the Earth that it crossed the plain of the GEO Synchronous belt, an orbital belt containing close to 500 artificial satellites. This region in relatively near space resides at approximately 35,000 km above the Earths Equator and contains over 60% of the satellites relied upon in business, government and personal communications as well as other data relays such as television. Although, the U.S. Governments Joint Space Operations Center (JSpOC) and other modeling programs had predicted no imminent collision with Earth orbiting, artificial satellites, the ability to monitor this passage in real time was important should any unforeseen anomalies have occurred in the orbits of the satellites or the planetoid 2012 DA14. Bottke, Vokrouhlick´y, Rubincam, and Nesvorn´y suggest that non-gravitational forces, primarily the Yarkovsky and Yorp Effects should now be considered as important as collisions and gravitational perturbations when factoring asteroid dynamics. Unforeseen forces acting on any of the bodies or miscalculated orbital paths could have resulted in a collision that may have driven pieces into other satellites into an unfortunate, costly chain of events.

The crater pocked surface of the Moon bears testament to the fact that the Solar System is rife with solid matter drifting until captured in the inescapable gravitational field of a larger body. According to the National Aeronautics and Space Administration (NASA), there are 10,034 objects that have been discovered thus far whose paths take them (roughly) within the proximity of the Earth. These pieces of, typically, carbon, ice and rock range in size from sub-millimeter to 578 km, and are collectively known by the generalized term Near Earth Objects (NEO). The smaller particles are countless and, for the most part, non-threatening, in fact, NASA estimates that 100 tons of such sub- millimeter material enters the Earth's atmosphere, harmlessly, each day. However, NASA's Jet Propulsion Lab (JPL) estimates that there are nine hundred and eighty one large rock and metalloid Near Earth Asteroids (NEA's) that are a kilometer or larger that also pass through the Earths neighborhood. The impact of any object on this list would be far from innocuous. Another factor to take into consideration is that quite often, asteroids collide; resulting is smaller pieces referred to as meteoroids that also become NEO's. These often enter our atmosphere as fast streaks of light or "shooting stars ". After entering the Earth's atmosphere, a meteoroid is re-labeled a meteor until stony or metallic material remnants make it to the surface of the planet in which case they become meteorites. Theoretically, the gravitational force of the Earth temporarily captures a NEO on a frequent basis. In fact, Granvik, Vaubaillon and Jedike report that based upon modeling they performed utilizing known cases of this occurrence, they had concluded that a Natural Earth Satellite (NES) of 1meter diameter should be orbiting the planet at any given time. This was determined on the size-frequency and residence time distributions calculations using the massive bodies of the solar system for smaller

NEO’s, This is consistent with a known event in which a NES in excess of 2 meters in diameter orbited the Earth for approximately a year in the 2006 time frame.

It is a somewhat unsettling truth to some when they realize that extra-orbital bodies arriving or passing in close proximity to the planet are a daily manifestation. In fact within days of the 2012 DA14 transit of the planet a large meteorite entered the atmosphere and disintegrated with explosive force just over the surface of Russia. That particular body was assessed to be a piece of a rocky asteroid about 17 meters in diameter and weighing from 7,000 to 13,000 metric tons. Fortunately, because of the density and composition of our atmosphere, there is typically minimal threat to life when such an event occurs. In fact, the Earth's atmosphere shields the planet from the small matter so effectively that the vast majority are thus destroyed before impact. But, according to Mr. Charles Bolden the Chief Administrator of NASA, although meteorites approximately basketball size hit the Earth about once per day, and objects the size of an automobile reach us roughly on a weekly basis, entities the size of the meteorite that exploded over Russia, traverse the Earth's atmosphere very rarely on the human timescale. Unfortunately, artificial satellites are not afforded the atmospheric protection that the surface of the planet experiences Extra-orbital bodies colliding with communications satellites could wreak havoc on the world in many different ways.

The task of keeping tabs on the ever increasing number of artificial satellites falls upon Air Force Space Command (AFSPC) and its Satellite Sensor Network (SSN) which includes GEODSS. Testifying before the United States House of Representative, Committee on Science, Space, and Technology General William L. Shelton Commander, AFSPC stated that his command catalogs and tracks approximately 23,000 manmade objects in Earth Orbit. He further stated that there are in excess of 500,000 more artificial satellites estimated to be orbiting the Earth. These objects rage in size from the proximity of a softball to the International Space Station. Space is increasingly becoming the medium in which the world relies upon to conduct business, govern domain and attend to personal matters. This holds true for billions of individuals across the planet. The artificial satellite is used by 90% of the Earth's population on a daily basis. There is no hard socio-economic bar on access as is evident in the fact that there are currently 6.6 billion mobile subscribers in the world, and, that number is climbing. According to the Satellite Industry Association 58% of the known satellites are used for communications. Each of those was put into space with a launch price of roughly ten thousand dollars per pound according to NASA. In order to achieve profitability the satellites must then stay operational for at least 10 years to just break even. This makes satellite manufacture and placement into space, a most daunting enterprise.

GEODSS is an AFSPC space track telescope constellation dedicated to the SSN with a primary mission of tracking artificial satellites to derive or update orbital dynamics The GEODSS system is comprised of three Detachments (DETs) at geographically-separated locations. Detachment 1 at Socorro, New Mexico Detachment 2 at Diego Garcia, British Indian Ocean Territory; and Detachment 3 at Maui, Hawaii. Each detachment/site operates with a three optical telescope configuration. The Air Force Space Command, 21st 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) requirements through the detection and surveillance of deep space satellites. The system detects, tracks, identifies, and provides angular velocity positional data on all deep-space man-made objects in the Earth’s orbit within each sites field of coverage. The GEODSS Sites perform their mission using three standard 1-meter telescopes at each site. These telescopes are able to process a 1.68 degree field of view through their low-light-level electro-optical cameras, and high speed computers. These parameters make GEODSS Instruments the ideal platform in which to detect asteroids. Not surprisingly, tracking asteroids using GEODSS Telescopes is not an unknown concept. MIT/Lincoln Labs use GEODSS type instruments in New Mexico for exactly that mission on a NASA contract. In fact the Haleakala GEODSS Location had been the site of one of the original Near Earth Asteroid Tracking (NEAT) endeavors. The NEAT discovery team at the NASA/Jet Propulsion Laboratory had a cooperative agreement with the U.S. Air Force to use a Maui GEODSS telescope to discover near-Earth Objects. The NEAT team acquired a CCD that had been built for a space based platform and designed a camera and computer system for the GEODSS application. The CCD camera format was 4096 x 4096 pixels with a field of view of 1.2 x 1.6 degrees.

When used for NEO discovery efforts, Air Force contractor personnel operated the telescope and the data was routed directly to the Jet Propulsion Laboratory for analyses. The NEAT system began observations in December 1995 and observed for 12 nights each month centered on the new moon through December 1996. Beginning in January 1997, the number of observing nights was reduced to the six nights each month preceding the new moon because of increased Air Force operational requirements upon the facility. In February 2000, NEAT operations were transferred from the one-meter GEODSS telescope to another optical venue.

Methods

As referenced earlier, JSpOC Analysts had assessed a low collision probability for this event. The JSpOC personnel used orbital data from NASA's Near Earth Object Program Office at the Jet Propulsion Laboratory to screen for any potential collisions with man-made objects. JPL catalogs heliocentric orbits for all known planetoids detected within our solar system and places them into different categories based upon orbital characteristics. The analysts then had to model the approach of the asteroid and compare to the known positions Earth orbiting bodies for the entire transit. This is a process that understandably receives very little practice.

Known for their excellent accuracy, GEODSS Telescopes survey a section of space locked upon a star field. As the Earth rotates the instruments compensate accordingly in order to maintain position upon that specific star set. This maintains effective stellar background static, affording the camera the ability to take multiple frames of the designated star field. Once the camera frames are compiled and superimposed on the telescopic image, any moving bodies are differentiated, appearing as moving streaks across the star field. Once the star field anomaly is recognized electronically, angular velocity information is collected off of the streak and forwarded to user agencies. This strategy proved very effective in the detection of the asteroid, matched in part with the optical properties of the GEODSS Telescope. Notably, the Maui telescopes were able to open in marginal atmospheric conditions, locate and collect the metric and raw video data on the asteroid as it passed within close proximity to the Earth. The ability of GEODSS to observe in relatively inclement weather is due to its sealed telescope aperture. This ability allowed the GEODSS Instruments to open in weather that precluded most if not all other telescopes in the Hawaiian Archipelago on that particular night.

Results

Although currently programmed exclusively for tracking satellites in geocentric orbits, GEODSS was able to maintain track on DA14 and collect over two hours of video and one hundred and fifty four metric observations. Even as the collision analysis at the JSpOC proved correct, having that asset with the capability to monitor the pass provided real time verification. Should a collision have occurred, the ability to collect immediate data may have proven invaluable in determining if other collisions might occur with active satellites and the new debris

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