

White Paper for an Alternate Science Investigation for the Kepler Spacecraft

Name: Ames Research Center, Code DL

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Abstract

This paper proposes the use of the Kepler spacecraft to enhance mitigation capabilities for protecting government and commercial spacecraft from orbital debris.

Description of Proposed Science Project

There are more than 21,000 pieces of orbital debris larger than 10 cm known to exist. Additionally, there are approximately 500,000 particles between 1 and 10 cm in diameter. It is believed that the number of particles smaller than 1 cm exceeds 100 million.¹ Orbital debris can be hazardous to manned and unmanned spacecraft. With a growing commercial space industry, more and more spacecraft and space-travelling humans will be vulnerable to orbital debris.

Measurements of near-Earth orbital debris may be conducted by ground-based and space-based observations of the orbital debris environment. Data is acquired using ground-based radars and optical telescopes, space-based telescopes, and analysis of spacecraft surfaces returned from space. Some important data sources have been the U.S. Space Surveillance Network, the Haystack X-Band Radar, and returned surfaces from the Solar Max, the Long Duration Exposure Facility (LDEF), the Hubble Space Telescope (HST) and the Space Shuttle spacecraft.²

NASA has previously used two optical telescopes for measuring orbital debris: a 3-m-diameter liquid mirror telescope, which is referred to as the Liquid Mirror Telescope (LMT), and a charge-coupled device (CCD), which is referred to as the CCD Debris Telescope (CDT). Both of these optical telescope programs were terminated in 2001.³

Another capability for locating orbital debris is the Air Force Space Surveillance System (AFSSS). In an August 12th press release, the Air Force announced it would shut down AFSSS due to budget constraints. Three days later, the Air Force also announced that the replacement next-generation space-object tracking system was being delayed due to sequestration. According to Gen. Shelton, commander of the Air Force Space Command, the new Space Fence will not become available until at least fall 2018.⁴

To meet the need for locating and tracking space debris, it is contemplated that the Kepler telescope may be re-purposed to optically detect debris. According to the Call for White Papers, Kepler is in a heliocentric orbit trailing Earth at a distance of approximately 0.5 AU. Currently, Kepler is pointing out of the ecliptic plane with its sun shield facing the Sun.

¹ NASA Orbital Debris Program Office, Frequently Asked Questions, <http://orbitaldebris.jsc.nasa.gov/faqs.html>

² Id. at <http://orbitaldebris.jsc.nasa.gov/measure/measurements.html>

³ Id. at <http://orbitaldebris.jsc.nasa.gov/measure/optical.html>

⁴ Gruss, Mike, "With Current System Slated for Closure, Air Force Defers Next-gen Space Fence", Space News, Vol. 24, Issue 33, August 26, 2013

To function as an orbital debris telescope, it is contemplated that Kepler be rotated 90 degrees about its Y axis (as seen in Figure 2 of the Call for White Papers). Such rotation would put Kepler's X axis (its viewing direction) pointing toward Earth. It is contemplated that Kepler's large field of view photometer with its 42 CCDs could optically detect space debris orbiting the Earth. Similar to the transit method used by Kepler to find planetary systems, Kepler may be able to detect transiting orbital debris. For low Earth orbiting- and geosynchronous orbiting-debris, Kepler's photometer may be capable of tracking such debris against a portion of Earth that is lighted by the Sun. For polar orbiting-debris, Kepler may be capable of locating such debris from reflections of sunlight from the debris against the darker backdrop of space.

Use of Focal Plan and Target Apertures

In its quest for distant planets, Kepler focused on many stars looking for a minuscule dip in the star's brightness indicating a possible transiting planet. According to the Kepler website, a star's image would be spread across a "postage stamp" of 30 pixels, where stars being observed are approximately 600 light years away. It is contemplated that when Kepler is pointed at Earth, a "postage stamp" size image would represent a small area of the Earth. Therefore, a minuscule dip in light brightness from each "poster stamp" size image could indicate a piece of orbital debris, after factoring out changes in light brightness due to atmospheric changes, like clouds, aircraft, etc.

For polar orbiting debris, a "postage stamp" size image from the photometer may indicate debris by a minuscule increase in light. That is, a piece of polar orbiting debris may reflect sunlight in Kepler's direction where Kepler could detect such small increase in light within the "postage stamp" image, against the backdrop of darker space.

Planned Integration Time

To be determined

Expected Data Storage Required

To be determined

Data Reduction or Analysis Plans

To be determined

Class of Science

The category of science for the proposed activity could be space flight operations safety.

Target Duration

According to the Call for White Papers, Kepler can accurately point its boresight for about 4 days with two operational reaction wheels and without thrusters. However, there is expected to be a 1.4 degree drift over the 4 day period.

Depending on the image size that Earth projects on Kepler's 42 CCDs, it is contemplated that Kepler's photometer could measure minuscule changes in light across its 42 CCDs as Earth moves relative to Kepler's boresight. The relative movement between Kepler and Earth may be caused by Kepler's drift or the natural orbit of Earth. It is contemplated that Kepler would periodically need to be repositioned to repoint at Earth.

Duration of Science Program

As Kepler moves away from Earth, at some point in time, Kepler's sun shade will not sufficiently block sunlight from entering the photometer while Kepler is pointed at Earth.

Scientific Impact

As many national governments and now commercial companies place more and more spacecraft and humans in space, it is imperative that orbital debris be detected and accurately tracked to ensure space operations safety.