

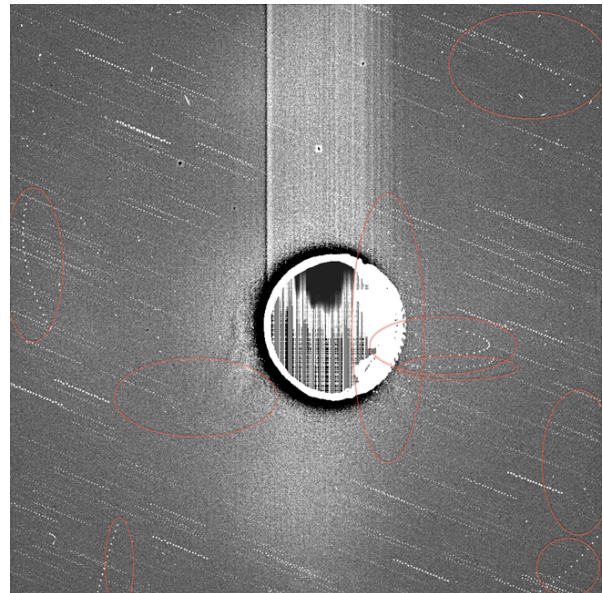
**EXPERIMENT TO DETERMINE THE UPPER LIMITS OF THE SEARCH FOR SATELLITES OF VESTA.** L. A. McFadden<sup>1</sup>, D. R. Skillman<sup>1</sup>, N. Memarsadeghi<sup>1</sup>, J.-Y. Li<sup>2</sup>, M. Mutchler<sup>3</sup>, B. McLean<sup>3</sup>, U. Carsenty<sup>4</sup>, S. Mottola<sup>4</sup>, S. Hellmich<sup>4</sup>, M.V. Sykes<sup>2</sup>, P. Tricarico<sup>2</sup>, E. Palmer<sup>2</sup>, C.T. Russell<sup>5</sup>, C. A. Raymond<sup>6</sup> <sup>1</sup>NASA Goddard Space Flight Center, Greenbelt, MD, <sup>2</sup>Planetary Science Institute, Tucson, AZ <sup>3</sup>Space Telescope Science Institute, Baltimore, MD, <sup>4</sup>DLR, Berlin, <sup>5</sup>IGPP, UCLA, Los Angeles, CA, <sup>6</sup>Caltech/Jet Propulsion Lab, Pasadena, CA.

**Introduction:** The Dawn mission executed a satellite search between May and July 2011 because the presence or absence of natural satellites provides a piece of the collisional and dynamical history of Vesta. The collisional history of Vesta has been active as recently as 1 BY ago [1,2] and the existence of the Vesta family [3] also provides many candidate bodies to be held in orbit around Vesta. The deepest satellite search prior to this was conducted using Hubble Space Telescope and searched to a detection limit of 44 m diameter [4]. Data acquisition, processing and multiple search approaches have been described in [5]. No satellites were found in two types of searches described below. Here we describe the experiment designed to determine the limits of the search in which artificial satellites of random orbits were implanted in two sets of images. Our purpose was to find the limiting magnitude of the Vesta satellite search and determine the completeness of the search.

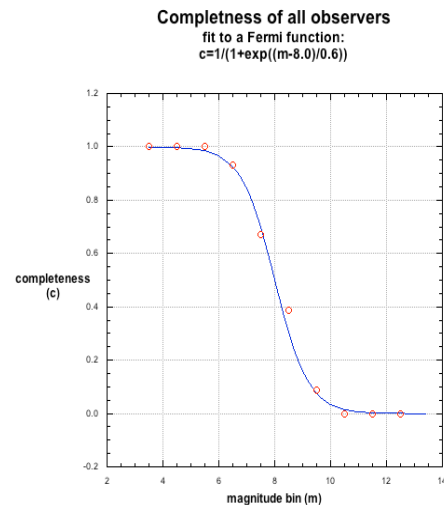
**Artificial Satellite Generation:** We first worked with the Optical Navigation imaging sequence 16 (OpNav16) acquired with Dawn's Framing Camera [6]. This is the last sequence in which Vesta does not fill the camera's field of view (Fig.1). Satellites with random circular orbits of 1.1 to 10 Vesta radii, with random inclinations, centered on Vesta were implanted into the sequence of 20 images calculating the position of the satellite with respect to Vesta's center for each image at each time. A dedicated satellite search mosaic was also carried out. To assess the limits of searching this series, we took Station 5 images in all three mosaics and inserted simulated satellites. The satellites are in arbitrarily oriented circular orbits with radii 1.1 to 100 Vesta radii. They cover a range of magnitudes and the motions are consistent over all images. Synthetic satellites were also generated using the software image simulator developed for the proposed German "AsteroidFinder" space mission [7] realistically reproducing the basic steps of the image formation process: optical transfer through the optics, image projection onto the detector, charge accumulation in the CCD, charge transfer and readout process.

**Results:** We had five searchers look for satellites in OpNav 16 images and six co-authors searched the station 5 mosaics. For the OpNav 16 sequence, the 50% completeness instrumental magnitude is 8. The magnitude equation calculated against UCAC3 cata-

logue stars is  $y=0.9977x + 12.555$ . Our 50% completeness apparent visual magnitude is 20.54.



**Fig. 1** Randomly Implanted satellites in OpNav16 appear as curved arcs when the sequence of 20 images is stacked and summed. Red circles guide the viewer to them.



**Fig. 2** Completeness of OpNav 16 search in instrumental magnitude.

**References:**

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- [2] Marchi S. et al. (2012) *Science*, 336, 690.
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- [5] Memarsadeghi, N. et al. (2012) *Proc. SPIE*, 8296, Computational Imaging X, 82960H. [6] Sierks et al. 2011, *Space Sci. Rev.* 163, 263. [7] Mottola et al. 2008 In *ACM 2008* held July 14-18, 2008, Baltimore, MD. *LPI Contribution No. 1405*, paper id. 8140.

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