

Global Shape of (4) Vesta from Dawn FC stereo images. F. Preusker¹, F. Scholten¹, K.-D. Matz¹, T. Roatsch¹, R. Jaumann¹, C. A. Raymond², and C. T. Russell³, ¹German Aerospace Center, Institute of Planetary Research, D-12489 Berlin, Germany (Frank.Preusker@dlr.de), ²Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109-8099, USA, ³UCLA, Institute of Geophysics, Los Angeles, CA 90095-1567, USA.

Introduction: NASA's Dawn mission has observed the inner main belt asteroid (4) Vesta from July 2011 until September 2012 [1,6]. One of the prime science goals was the determination of the global shape of (4) Vesta represented by a digital terrain model (DTM). The DTM is particularly important, because it is essential for derivation of physical properties of (4) Vesta as well as for precise ortho-image registration, mosaicking, and map generation of monochrome/color framing camera images. In addition a DTM is needed for quantitative geomorphologic analysis and precise photometric analysis from detailed local surface inclination. For this purpose the entire illuminated surface was imaged stereoscopically using the Dawn Framing Camera (Dawn FC) [2].

Data: Starting from a Survey orbit at an altitude of about 2,700 km in August 2011, the Dawn FC acquired 1,179 clear filter images with an image scale of about 255 m/pixel. By end of September 2011, Dawn started its primary stereo image campaign from a high resolution mapping orbit (HAMO) at an altitude of about 700 km and completed the campaign after an extended stay in July 2012. During HAMO, the Dawn FC acquired about 5,550 clear filter images with an image scale of about 65 m/pixel and has imaged at least 95 % of Vesta's surface.

In both mapping phases the surface was imaged several times under similar illumination conditions (Sun elevation and azimuth), but different viewing conditions (by tilting the spacecraft). This allows to analyze the images stereoscopically and to construct stereo topographic maps as well as ortho-image mosaics.

Methods: The stereo-photogrammetric processing for (4) Vesta is based on a software suite that has been developed within the last decade. It has been applied successfully to several planetary image data sets [3-6] and covers the entire workflow from photogrammetric block adjustment to DTM and map generation.

Differences in illumination	<10°
Stereo angle	15-55°
Incidence angle	0-85°
Emission angle	0-55°
Phase angle	5-160°

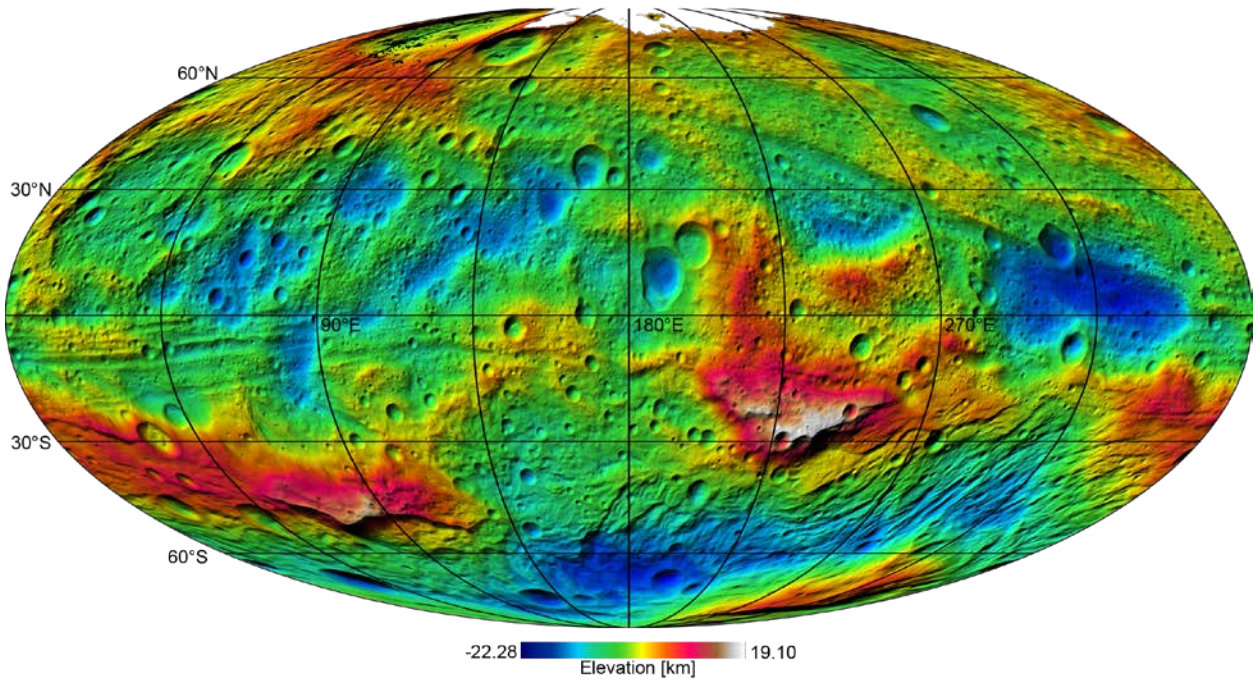
Table 1. Requirements for stereo processing.

Results: We constrained all HAMO clear filter images with our stereo requirements (Table 1) and achieved at least triple stereo image coverage for the entire illuminated surface. In total, about 35,000 independent multi-stereo image combinations were used to determine selected image tie points by multi-image matching for the set-up of a 3D control network of about 83,000 surface points. The control point network defines the input for the photogrammetric least squares adjustment where corrections for the nominal navigation data (pointing and position) are derived. The three-dimensional (3D) point accuracy of the resulting ground points have been improved from ± 55 m to ± 8 m (0.15 pixel). We have also refined Vesta's spin axis orientation, formerly determined from Earth-based observations [7, 8], to: right ascension = $309.0319^\circ \pm 0.005^\circ$, declination = $42.2229^\circ \pm 0.005^\circ$. Finally, 35,000 individual multi-image matching processes at full image resolution were carried out to yield ~2.5 billion object points. The achieved mean forward ray intersection accuracy of the ground points is ± 8 m, which is comparable to absolute 3D point accuracy [9]. Finally, we have generated a DTM with a lateral spacing of 48 pixel/degree (92.7 m/pixel) and a vertical accuracy of about 6 m. The DTM covers approximately 95% of Vesta's surface.

Based on the entire DTM (Fig. 1), we determined a best-fit ellipsoid (285.3/277.7/223.8 km) with its body long axis at 40.6° E w.r.t. the new reference system [1]. Compared to results from Earth-based observations [8], these values are smaller by about 4%. Finally, ortho rectified Survey images and image mosaics have been derived based upon the adjusted orientations and the Survey DTM as the topographic reference [10].

References:

- [1] Russell C.T. et al., (2012), *Science*, 336, pp. 684-686. [2] Sierks H. et al, (2011), *Space Science Review*, 163, pp. 263-327. [3] Gwinner K. et al., (2010), *Earth Planet. Science Letters*, 294, Issues 3-4, pp. 506-519. [4] Preusker F. et al., (2011), *Planetary Space Science*, 59, pp. 1910-1917. [5] Scholten F. et al., (2012), *JGR*, 117. [6] Jaumann R. et al., (2012), *Science*, 336, pp. 687-690. [7] Li J.-Y. et al., (2010), *Icarus*, 211, pp. 528-53. [8] Thomas P.C. et al., (1997), *Icarus*, 128, 88. [9] Raymond C.A. et al., (2011) *Space Sci. Rev.*, 163, 487-510. [10] Roatsch T. et al., (2013), *this session*



Global HAMO DTM of (4) Vesta with a lateral spacing of about 93 m (hill-shaded color-coded heights) in Mollweide Projection (equal-area). Heights refer to a biaxial ellipsoid (285x285x229 km).