Vesta-HED Connection: Comparison of Dawn FC, Hubble Space Telescope, and Ground-Based Observations of Vesta. V. Reddy[1,2], J-Y. Li[3], L. Le Corre[1], C. T. Russell[4], J. E. C. Scully[4], A. Nathues[1], R. Park[5], R. Gaskell[3], S. Holger[1], M. J. Gaffey[2], C. Raymond[5], G. S. Thangjam[1], and L. A. McFadden[6], [1]Max-Planck Institute for Solar System Research, Germany (reddy@mps.mpg.de), [2]Department of Space Studies, University of North Dakota, [3]Planetary Science Institute, Tucson, [4]University of California Los Angeles, [5]Jet Propulsion Laboratory, California Institute of Technology, [6]NASA Goddard Spaceflight Center, Greenbelt, Maryland.

Introduction: The Dawn spacecraft's observations of asteroid (4) Vesta have revealed a surface that shows the highest diversity in albedo, color and composition of any asteroid visited by a spacecraft so far. [1] Hubble Space Telescope and ground-based observations of the asteroid showed hemispherical and rotational variations attributed to igneous and impact processes that have shaped Vesta's surface since its formation [2-5]. In this study we compare interpretation of Vesta's rotation period, pole position, albedo, topography, color and compositional properties from ground-based telescopes, HST and Dawn. The goal of our study is to provide in situ confirmation for prior observations and help identify the strengths and limitations of ground/HST-based studies of asteroids. We also present HST and Dawn albedo and color maps of Vesta in the Claudia (used by the Dawn Science team) and IAU (modified from that Thomas et al. 1997 with improved rotation period and spin axis orientation) coordinate systems. These maps will help observers orient themselves and identify compositional and albedo features from prior studies.

Data Reduction: For this study we used three different data sets: ground-based spectral data from [2] and [3]; HST data from [4-6]; and Dawn FC data from RC1, RC2 and RC3. The best resolution of HST data (38 km/pixel) is best compared to the lowest resolution from Dawn during RC1 (9 km/pixel). Data reduction procedures for ground-based data are described in [2-3]; and for HST data processing in [4-6]. A detailed description of Dawn FC data processing pipeline is presented in the supplementary materials section of [1].

Vesta albedo maps from Dawn data were created in 0.75-μm filter, which shows greatest albedo contrast and also has least amount of infield stray light [1]. This filter is also the closest to HST filter F673N centered around 0.673 μm [6]. Along with the albedo map, we created band depth map, and eucrite-diogenite (ED) ratio map. The band depth map (0.75/0.92 μm) is a single band color-coded map that helps quantify 0.90-μm pyroxene band depth. The ED ratio is a single band rainbow color-coded map that uses 0.98/0.92 μm filters and helps identify eucrite-rich/diogenite-rich terrains on Vesta.

Results: We have linked several albedo features identified on HST maps to morphological features on Vesta using Dawn Framing Camera data. Rotational spectral variations observed from ground-based studies are also consistent with those observed by Dawn. While past interpretation of some of these features was tenuous, they were reasonable for the limitations set by the data and our knowledge of Vesta and HED meteorites at that time. Our analysis shows ground-based and HST observations are essential for planning space missions and provide a necessary framework for the next stage of investigation. Our comparative study has revealed the following:

- Vesta's rotation period as determined by Dawn [7] is 0.222588652 days with an uncertainty of 35 μs. This is consistent with [8] rotational period of 0.22258874 day, the most accurate determination of Vesta's rotational period before Dawn's arrival.
- Dawn has precisely determined Vesta's pole orientation to be (309.03º, 42.23º) with an uncertainty of 0.01º [7]. This is an improvement over HST-based pole position (305.8º, 41.4º)±(3.1º, 1.5º) by [6]. The value we report here is the current value and like all celestial bodies changes with precession.
- Dawn FC lightcurve of Vesta is in excellent agreement with HST data in terms of the shape, amplitude, and phase of lightcurves.
- HST topographic map from [4] is consistent with Dawn shape model. HST range of heights was slightly smaller (-12 km to +12 km) than Dawn (-22.45 km to +19.48 km). The heights range is relative to a 285 km x 285 km x 229 km ellipsoid.
- Global albedo/color maps of Vesta using HST [5-6] are in excellent agreement with Dawn FC maps (Reddy et al. 2012). East-West hemispherical dichotomy observed in ground-based (e.g., 2) and HST images [4] has been confirmed by Dawn FC color images.
- Ground-based telescopic observations indicated the possible presence of a 3-μm absorption feature. [9] and [10] suggested contamination from impacting carbonaceous chondrites as possible cause of this feature. Dawn has detected significant dark material on Vesta's surface, which has been interpreted as carbonaceous chondrite material [11].
- Predominance of diogenite-rich material in the higher albedo Eastern hemisphere observed by

ground-based observers [e.g., 2] has been confirmed by Dawn [1].

- A majority of albedo and color units observed in HST images of Vesta [5-6] have been confirmed by Dawn FC observations.
- Ground-based observations of Vesta have indicated the possible presence of an olivine-rich unit [2]. While we confirm these observations to be accurate, our interpretation suggests that it is most likely impact melt rather than olivine.

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References: [1] Reddy et al. (2012a) *Science, 336,* 700–704. [2] Gaffey (1997) *Icarus, 127,* 130-157. [3] Reddy et al. (2010) *Icarus, 210,* 693–706. [4] Thomas et al. (1997) *Science, 277,* 1492-1495. [5] Binzel et al. (1997) *Icarus, 128,* 95-103. [6] Li et al. (2010) *Icarus, 208,* 238-251. [7] Russell et al. (2012) *Science, 336,* 684-686, [8] Drummond et al. (1998) *Icarus, 73,* 1-14, [9] Hasegawa et al. (2003) *GRL, 30,* 2123. [10] Rivkin et al. (2006), *Icarus ,180,* 464-472. [11] Reddy et al. (2012b), *Icarus, 221*, 544-559. [12]

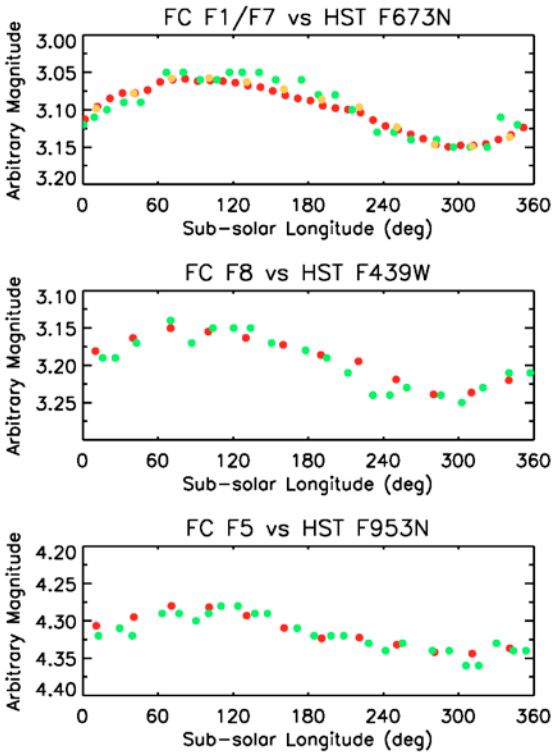

Figure 1. Lightcurves of Vesta from Dawn FC (red) and HST (green). Both data sets are in excellent agreement with each other although the Dawn FC data has lower point-to-point scatter due to higher SNR data.

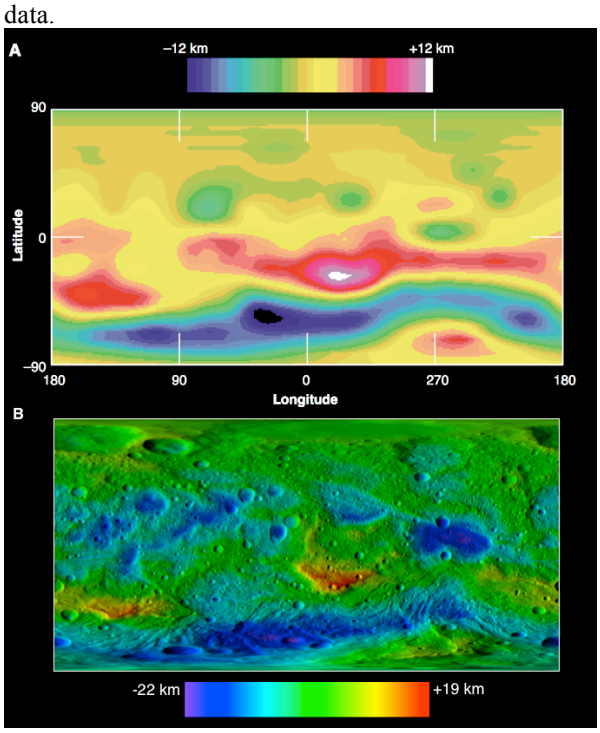

Figure 2. Topographic model of Vesta from Hubble Space Telescope (top) [4] and Dawn FC (bottom). Both shape models are in excellent agreement with each other.

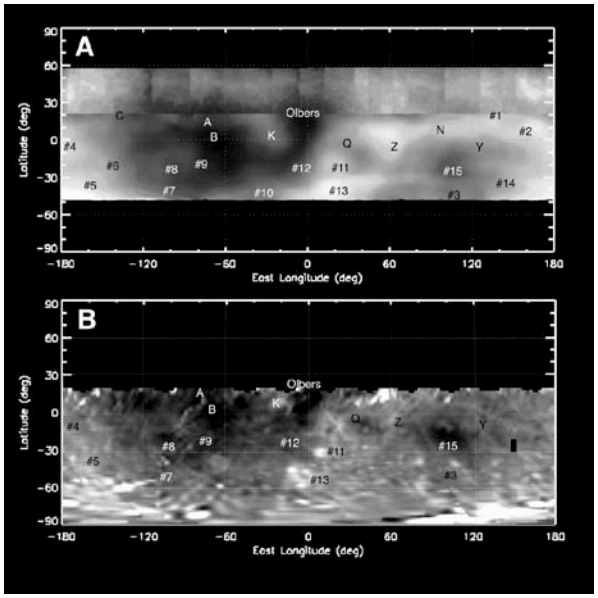

Figure 3. Albedo map of Vesta from Hubble Space Telescope (top) and from Dawn FC (bottom). Several albedo/color features in HST map have been identified in the Dawn FC map.