VERITAS: Towards the Next Generation of Cartography for the Planet Venus. S. Hensley[1], S. Smrekar[1], D. Nunes[1], N. Mueller[2] J. Helbert[2], E. Mazarico[3] and the VERITAS Science Team [1]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr, Pasadena, CA 91109 [2]Deutsches Zentrum für Luft- und Raumfahrt, Rutherfordstraße 2, 12489 Berlin, Germany, [3]Goddard Space Flight Center, 8800 Greenbelt Rd, Greenbelt, MD 20771

Introduction: NASA has selected 5 potential Discovery class missions for additional study prior to down selection of one or two missions in early 2017 [1]. The **V**enus **E**missivity, **R**adio Science, **I**nSAR **T**opography **A**nd **S**pectroscopy (VERITAS) Mission is a proposed mission to Venus that was selected as one of these missions. It is designed to obtain high-resolution imagery and topography of the surface, using an X-band radar configured as a single pass radar interferometer (called VISAR) and a multispectral NIR emissivity mapping capability (called VEM). The proposed VERITAS mission will deliver dramatically improved cartographic products of Venus and substantial information for comparative planetology studies of the terrestrial planets and Moon.

Venus Cartography: Early cartographic products of Venus were generated from Earth-based radar observations by the USA and USSR at various wavelengths. These maps were in rough agreement and demonstrated that Venus possessed a variety of relief features. Subsequent observations from orbit by the Pioneer-Venus and Venera 15,16 spacecraft provided initial topography measurements and higher-resolution imagery. NASA's Magellan mission generated nearly global radar imagery at S-band at roughly 100-300 m resolution and global topography at roughly 20 km spatial scales, which after some reprocessing forms the basis for the state of the art Venus cartographic products [2].

Mission Overview: The proposed science mission profile consists of two phases. Science Phase I begins after insertion into a polar elliptical orbit, similar to Venus Express. Following the completion of Science Phase I, aerobraking places the VERITAS spacecraft in a near-polar (88.5° inclination), circular, low-altitude (~220 km average) orbit that allows global observations throughout Science Phase II. The VEM instrument will collect data during Phases I and II whereas the VISAR instrument will operate from the slightly eccentric nearly-polar orbit. Operating for a period of three Venus sidereal days, or cycles, (3×243 Earth days) VISAR will generate imagery and topography globally for the surface of Venus [3]. See [4] for more details.

VERITAS Data Products: VERITAS will generate cartographic products from both instruments and gravity products from spacecraft tracking data.

VISAR Products. VISAR will map surface topography with a spatial resolution of 250 m and 5 m vertical accuracy and generate radar imagery with 30 m spatial resolution globally and 15 m resolution for approximately 23% of the planet surface. VERITAS imagery is naturally orthorectified since it is typically acquired simultaneously and generated in combination with the elevation products. It will thus be inherently more precise cartographically and geodetically than Magellan imagery. These capabilities represent an order of magnitude or better improvement of the Magellan reference system and are expected to reveal definitive information on key geologic processes not possible with the Magellan data.

Another new data layer for planetary sciences will be an elevation precision layer associated with the topography product made possible using radar interferometry for elevation measurements. This product will provide an estimate of the elevation precision for each elevation measurement based on the single pass interferometric correlation and mapping geometry. Thus, users will be able to see areas where elevation measurements are more or less precise and factor that into their analyses. For example, this layer can be used in generating maximal likelihood slope estimates. As will MOLA data on Mars, the elevation will serve as a reference for all other data products.

Repeat pass radar interferometric measurements for selected targets are planned. Using data collected from two cycles over the same area it is possible to measure surface deformation (surface motion projected onto the radar line-of-sight) with several millimeters of precision. Moreover, the interferometric correlation after compensation SNR using the single pass interferometry can be used to detect sub wavelength (radar wavelength is 3.8 cm) changes on the surface.

VEM Products. VEM will generate multispectral Near-IR (NIR) surface composition maps with radiometric sensitivity 100× better than achievable with VIRTIS on Venus Express. These maps will cover 88% of the planet's surface with a resolution of approximately 60 km and will be cartographically referenced with VISAR topography. Referencing the VEM data to topography is an essential step in the data reduction as the elevation-dependent temperature variations must be removed from surface brightness temperature to derive compositional effects.

Gravity Products. Ka-band radio tracking of VERITAS in the low-altitude orbit will enable much-improved recovery of the gravity field of Venus compared to Magellan. Gravity measurements with 145 km spatial resolution and 3 mGal accuracy, both at least 2-3x better than Magellan, will allow precise reconstruction of the spacecraft orbit, which will be the basis for the geodetic accuracy of the VERITAS data products.

Venus Spin Vector: Although not one of the primary science objectives of the VERITAS mission, an estimate of the Venus spin vector and potentially its short short-term derivative variations is planned, using radar tie points is planned. Estimates of the spin rate from Magellan [5] using radar tie points near the poles can be improved with the higher-resolution and globally-distributed tie points that will be generated from the proposed VERITAS mission. Recent evidence for a variable spin rate for Venus [6] highlights the need and value for such studies to provide a proper geodetic reference for Venus map cartographic products.

References: [1] Brown and Cantillo, *NASA News*, 30 Sep 2015. [2] Tanaka K. et al. (1993), *USGS,* 93-516. [4] Hensley S. *et al.* (2015)*, Proc. APSAR 2015*, # 247. [4] Smrekar S. *et al.* (2015), LPSC 46, VERITAS Mission. [5] Davies M. E. *et al.* (1992), *JGR 97,* E8. [6] Mueller N. et al. (2012), *Icarus 217*, 474-483.

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