ENVISION M5 VENUS ORBITER PROPOSAL: COMPLEMENTARY SCIENCE OPPORTUNITIES.

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Introduction: EnVision [1] is a medium class mission to determine the nature and current state of geological activity on Venus, and its relationship with the atmosphere, to understand how Venus and Earth could have evolved so differently. It is currently under evaluation in the M5 selection process; if successful, it is scheduled to arrive at Venus in April 2030 and to start a 5-year mapping program from November 2030, after an extended period of aerobraking to circularize the orbit at a nominal 260 km altitude.

Instruments and Science Operations: EnVision hosts three primary instruments:

The S-band Imaging Radar, VenSAR, will:

- Obtain images at a range of spatial resolutions from 30 m regional coverage to 1 m images of selected areas; an improvement of two orders of magnitude on Magellan images;
- Measure topography at 15 m resolution vertically and 60 m spatially from stereo and InSAR data;
- Detect cm-scale change through differential InSAR, to characterize volcanic and tectonic activity, and estimate rates of weathering and surface alteration; and
- Characterize surface mechanical properties and weathering through multi-polar radar data.

The Subsurface Sounder, SRS, will:

- Characterize the vertical structure and stratigraphy of geological units including volcanic flows;
- Determine the depths of weathering and aeolian deposits; and
- Discover as yet unknown structures buried below the surface.

The Venus Emission Mapper, VEM, will:

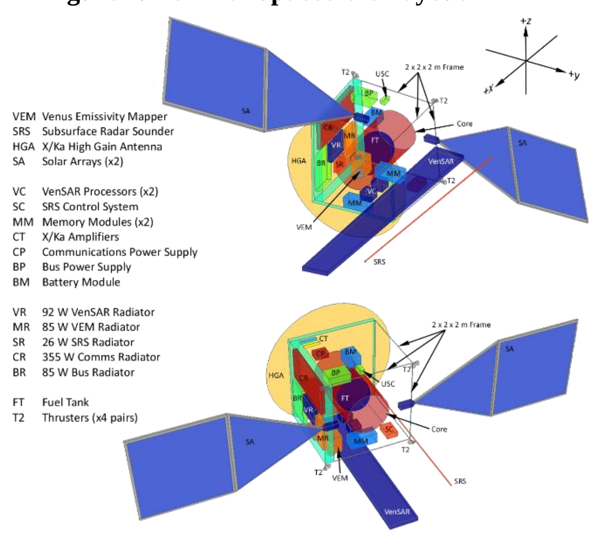
- Search for temporal variations in surface temperatures and tropospheric concentrations of volcanically emitted gases, indicative of volcanic eruptions; and
- Study surface-atmosphere interactions and weathering by mapping surface emissivity and tropospheric gas abundances.

EnVision will also take advantage of its low circular orbit to provide gravity and geoid data at a geologically-meaningful scale, measure spin rate and spin axis variations to constrain interior structure, and use its X/Ka-band communications system for radio science.

Design and Operations: EnVision M5 has a simplified mechanical design (Figure 1), with a fixed SAR and HGA, and an AOCS capable of several rapid pointing changes during each 90-minute orbit. These allow for radiator, power generation, communications, science, and radar operational modes. Daily Earth-pointing communications occur in 6 hour blocks, occupying four of the 15½ orbits in each 24 hour period.

The 3-m body-fixed HGA achieves a link rate sufficient to return a total of 336 Tbits during the nominal mission. The solar array generates nearly 5.6 MJ per orbit; nominal mission requirements are 3.4 MJ per orbit, at a peak rate of 2 kW.

Figure 1. Nominal Spacecraft Layout



Opportunities: The nominal layout includes one free face (the +*z* face in Figure 1), which in principle may be used to carry a small additional payload, of 100-200 kg, depending on the final output characteristics of the Ariane 6.2 launch vehicle. The volume available is up to 2 × 2 m on the faceplate and ~0.5 m in the +*z* direction. The payload may be released prior to, during or after orbit circularization. Early release of an atmospheric probe, balloon or lander may be desirable, since the initial 24-48 hour capture orbit allows an extended communication period and planet-wide field of view to track probe or balloon movements and to relay data. Additionally, VenSAR will be able to locate a 2-m diameter lander, or smaller if a suitable reflector is fitted, and provide context images at 1 m resolution.

Alternatively, the payload may consist of one or more small orbiters designed for release into a 24 hour orbit or shorter orbit, including a complementary low circular orbit. These may carry IR/UV imagers and spectrometers, e.g. to extend global cloud monitoring or other time series data, or provide bistatic or SAR receiver functionality for radio science experiments.

Complementary Science Opportunities: In addition to payload opportunities, EnVision itself provides a powerful and flexible platform for complementary science. Bistatic and radio science operations are possible at X, Ka and S band (3.2 GHz), and bespoke imaging modes and incidence angles are freely selectable within thermal and communication constraints, in any combination of transmit and receive modes (i.e. HH, HV, VH, VV). Stripmap resolutions of up to 2 m (single look) and 1 m spotlight are possible for 10 × 10 km areas.

EnVision could act as both a relay and a data store for other independent missions to Venus, as several Mars orbiters have done, greatly widening the scope for complementary or additional science.

Exhortation: We encourage the Venus science community to support the selection of EnVision by considering complementary payloads and/or science operations. The huge volume of SAR data obtained during the mission will be made freely available to the science community as early as practicable, within processing constraints. We reiterate the opportunity for science experiments and target selection, and encourage researchers to contact the proposers with proposals.

References: [1] Ghail R. C. (2016) *EnVision proposal*, https://arxiv.org/abs/1703.09010.