EPSC Abstracts
Vol. 7 EPSC2012-922 2012
European Planetary Science Congress 2012

EnVision – where next for Venus?

R. Ghail (1) and the EnVision Team
(1) Imperial College London, UK (r.ghail@imperial.ac.uk)

Abstract

EnVision was proposed in response to ESA's 2010 M3 call but was not selected, primarily because of its technical requirements. In light of a detailed debrief, current development is focused on the surface science suite. Originally intended to use Sentinel-1 spares, the radar subsystem is now being redesigned to address additional surface science objectives, and to provide for global surface coverage and a longer mission duration. Under development is a passive detector for one-pass interferometry and an active cooling system.

1. Introduction

EnVision [1 and references therein] is an ambitious but low-risk response to ESA's 2010 M3 call for a medium-size mission opportunity. Its 5-year mission objectives are to determine the nature of and rate of change caused by geological and atmospheric processes, with three instrument suites addressing specific surface, atmosphere and ionosphere science goals. The mission is technically demanding, particularly in terms of data rates and volume, but designed as a solely ESA mission showcasing European capability. EnVision was planned to opportunistically reuse spare Sentinel-1 components; having not been selected, the radar subsystem is being redesigned and optimised specifically for Venus operation. This paper focuses on the surface science objectives and their impact on the radar design.

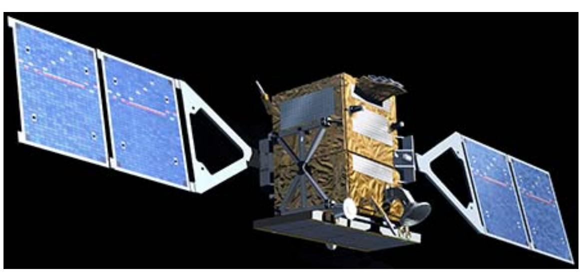

Figure 1: EnVision. The rectangular radar array is the 'plank' at the bottom of the spacecraft.

2. Venus Surface Science

Venus is the planet most similar to Earth in mass, bulk properties and orbital distance, but has evolved to become extremely hostile to life. The major unknown in Venus science is its rate and style of geological activity and the influence any activity has on its atmosphere. There is some evidence for recent geological activity, particularly from Venus Express data but as yet no accepted model that can explain the observed range of geological features, the near-random distribution of craters, and the inferred global heat production. The primary objective of EnVision's Surface Science Suite and the radar subsystem specifically is to determine topographic changes caused by volcanic, tectonic and atmospheric processes at rates as low as 1 mm a^{-1}, to distinguish between three possible geodynamic frameworks that each have profound implications for understanding the nature and habitability of terrestrial planets in other stellar systems.

The episodic resurfacing model proposes a short-lived but intense period of activity ~750 Ma ago, followed by a long period of quiescence that is consistent with the impact crater distribution but predicts minimal rates of volcanic and tectonic activity at the present day, apparently inconsistent with geological observations. Models involving some form of plate-like movement based on geological observations imply the highest levels of volcano-tectonic activity at the present day but have difficulty explaining the distribution of impact craters. Many authors therefore favour an intermediate level of dominantly plume-related activity. Each geodynamic framework predicts different rates and distributions of current tectonic and volcanic activity that in principal can be used to distinguish between them.

The extreme surface conditions on Venus require that the science goals be addressed from orbit. EnVision employs an interferometric synthetic aperture radar (InSAR) and altimeter, together with gravity and multispectral infrared instruments. Long-wavelength topographic and gravity/geoid data will be used to infer deep structures. Shallow structures, such as magma chambers, can be inferred from short-wavelength gravity anomalies and, if active, from regional changes in elevation identified from InSAR data.

Tectonic deformation of the surface may occur in discrete narrow seismic zones, implying a plate-like model, or in widespread aseismic creep, implying a stagnant-lid model. Each of these is detectable using InSAR; a lack of even millimetric deformation would imply episodic catastrophic resurfacing. Volcanic activity causes changes in surface elevation detectable by InSAR and changes in infrared emissivity properties; active eruptions will be directly detectable in infrared data. While the Venus surface is apparently mostly sediment-free, landers have shown it to be strongly weathered, perhaps even consisting of sedimentary rocks. Dunes, wind-streaks and landslides have all been detected in Magellan data but particularly enigmatic are the canali. Any processes that mobilise loose sediment will cause a loss of coherence between successive images; tracking that loss will indicate how active the Venus surface environment is.

3. Radar Subsystem

The primary role of the radar system is to acquire repeated InSAR data from at least three of 8 or more orbit cycles, each cycle taking one Venus day (243 Earth days) during which the entire surface of the planet rotates beneath the orbit. Data from the first two orbit cycles are required to produce an interferometric digital elevation model; data from at least one more cycle (separated in time by several orbit cycles) are combined with data from the first two cycles to detect interferometric (subwavelength) changes in ground elevation during the intervening period. Rates of change in surface elevation as low as 1 mm a^{-1} can be detected over the 5-year design lifespan of EnVision; an extended mission duration would permit the detection of even lower rates of change.

Unlike previous planetary radar missions, EnVision uses a dedicated rectangular array of antenna modules able to transmit and receive in horizontal and vertical polarization. The beam is electronically steerable so that one in every ~100 side-looking SAR pulses is pointed at nadir to determine the vertical ground range. Since the chances of detecting change are greater the longer the interval, InSAR data will not be collected every cycle, permitting a number of other radar experiments. A radiometer mode will provide, for the first time, a detailed model of atmospheric transmissivity. VV/HV/VH operation modes will target low emissivity regions and sedimentary features. Design improvements under consideration include a one-pass interferometer using an extendible low mass mirror array, and a multiple look angle/super-resolution responsive mode to target features of interest.

Assuming that the data rate is accommodated in future upgrades to ESA downlink stations, the main limitation on InSAR operations is the thermal environment at Venus. Power demands necessitate daylight-only operation, severely limiting the dark-sky available for cooling the antenna. An active cooling system is therefore under development to enable global InSAR coverage.

4. Summary and Conclusions

Twenty years after Magellan, the rate and nature of geological activity on Venus remains uncertain and the reasons for its very different appearance to Earth are contentious. Given the difficulty of extended surface operations, InSAR provides the only opportunity to determine rates of geological processes and provide some insight on interior processes. EnVision is an ambitious proposal to undertake long-term InSAR monitoring at Venus. The design of its radar is currently being revised to incorporate new technology, improved data collection strategies and to provide global coverage.

References

[1] Ghail, R. C., and the EnVision team: EnVision: taking the pulse of our twin planet, Experimental Astronomy, Vol. 33, pp. 337-363, 2012.