ENVISION: TAKING THE PULSE OF OUR TWIN PLANET. R. C. Ghail[1] and the EnVision team, [1]Imperial College London, Department of Civil and Environmental Engineering, London, United Kingdom, SW7 2AZ. *r.ghail@imperial.ac.uk*.

Introduction: EnVision is an ambitious ESA M-class mission proposal to measure rates of change in, and exchange between, its interior, surface and atmosphere, and to illuminate the processes involved. Since it was first proposed in response to the M3 call in 2010, and in light of that debrief, EnVision has taken advantage of a number of technical advances, discussed here, and a tighter focus made possible by focusing on the clouds down.

Science Background: 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 [1], [2] particularly from Venus Express data [3] 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.

Three possible geodynamic frameworks have been proposed, each with profound implications for understanding the nature and habitability of terrestrial planets in other stellar systems. The episodic resurfacing model [4], [5], [6], [7], [8] 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 (e.g., [9], [10], [11], [12], [13]) 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 favor an intermediate level of dominantly plume-related activity (e.g., [14], [15], [16], [17]).

Observations of the middle atmosphere and surface by ESA's Venus Express implies a relationship between ongoing geological activity and atmospheric chemistry.

Science Objectives: EnVision aims to determine the nature of and rate of change caused by geological and atmospheric processes, by acquiring:

- gravity and geoid data at a geologically-meaningful scale (~50 km), to test models of interior processes and structure;
- topographic profiles at 300 m resolution, with stereo and interferometric topography also possible;
- repeated InSAR imaging of potentially volcanically and/or tectonically active target areas at a resolution better than 60 m globally and upto 2 m locally;
- surface elevation change measurements of few millimeters over a 5 year period, to constrain rates of geological change in potentially active target areas;
- rates of weathering and surface alteration from InSAR decoherence data; and
- cloud top altitude, cloud structure and wind speed data on both day and night sides, to better understand cloud dynamics and evolution.

Payload: These objectives are achieved by a range of instruments centered around a phased array radar system capable of InSAR, altimetry and radiometry, together with a gravimeter, and an instrument suite selected from an X-band radio sounder, lidar, a spectrophotopolarimeter, IR and UV spectrometers, magnetometer, double Langmuir probe and dust collector. The most demanding aspects of the mission are orbital accuracy and data volume. Current studies allow for an average data rate of 10 Mbits/sec at Ka-band via a 2·9 m 550 W steerable high gain antenna (HGA), and solid state storage of 48 GB to ensure continuous data coverage through up to 18 days at superior conjunction.

Radar. A new S-band radar, based upon NovaSAR, is under consideration. Operating at a wavelength of 9·4 cm reduces the risk of atmospheric uncertainties (decoherence), at the cost of a slightly higher change detection threshold, but the primary benefit is a significant overall radar system mass reduction (~25%) for an antenna more than a third larger in area. Preliminary studies allow for global InSAR coverage at a resolution of at least 50 m in 40 km wide swaths, a beam-sharpened (stripmap) resolution of 5 m and a linear altimetric mode with a 1 m vertical and 150 m along-track resolution. The radar will also operate in an emissivity mode at 10 km resolution and may also undertake right-looking, VV polarized and stereo-mode operations.

Mission Outline: With a launch date expected in the mid-2020s, the 5-year nominal mission provides 8 cycles of 3763 polar orbits, with each cycle equal to one sidereal Venus day (243 Earth days), enabling EnVision to acquire data at all points on the surface (instrument limitations notwithstanding) and returning to the same orbital position, for interferometric purposes, at the end of each cycle. This mission profile is considered sufficient to distinguish between the principal geodynamic frameworks but the hardware is nominally designed for a minimum 7-year program. Should sufficient fuel and power remain at the end of the nominal mission, an extended mission may be desirable to refine and expand the study of any activity discovered.

The Venus environment is extreme: not only is the solar flux nearly twice that at Earth, Venus itself reflect 75% of the energy it receives. To cope with this and maintain a suitable environment for the science payload, EnVision will, like Venus Express, employ thermal control zones and kapton insulation to eliminate as much thermal radiation as possible. EnVision will also benefit from development work for and experience on the Bepi Colombo mission, particularly the Mercury Planetary Orbiter, which faces similar (and more extreme) issues.

The solar panels must also be designed to operate in this environment; the GaAs panel design employed by Venus Express will be enlarged for EnVision to meet its significantly higher ~2 kW power requirements.

Orbit Control. A nominally 300 km altitude circular orbit and precise station keeping, repeating each cycle to within 100 m, is essential for InSAR acquisition. Achieving this within M-class mass limits (~1500 kg) requires an 8-month aerobraking cycle and an ion drive for interplanetary transfer and orbit station keeping.

The ion drive offers a number of advantages, particularly lower mass and a continuous low thrust orbit correction that minimizes interference with the gravity experiment. Orbit knowledge is gained both by X/Ka-band Doppler tracking and an advanced accelerometer that will provide a globally consistent gravity field with at least twice the resolution of Magellan.

The 8 month aerobraking cycle to circularise the orbit will use both the solar panels and the radar antenna as ‘sails’ to increase the drag experienced and so reduce the orbital eccentricity. A number of experiments will be possible during this cycle but the primary experiments will start once the orbit is circularised.

During a mapping cycle the daytime half of each ~90 minute orbit consists of a 15 minute InSAR imaging swath, 15 minutes of emissivity acquisition, and 45 minutes of altimetric mode SAR and atmospheric instrument suite data, including the lidar or X-band sounder. The HGA will return data when the Earth is visible while solar power is available, although a lower power night-time mode is available during inferior conjunction.

Opportunities: the M4 call is likely to be in the latter half of 2014. Until then the instrument suite is not final and we welcome proposals, particularly for surface/atmosphere interactions and cloud studies. Science opportunities also exist within the existing instrument suite, particularly the radar. All are invited to register their interest and support in the mission; in the first instance, please contact the author.

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