ENVISION: UNDERSTANDING WHY EARTH'S CLOSEST NEIGHBOR IS SO DIFFERENT.

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Introduction: EnVision was selected as ESA's 5th M-class mission, targeting a launch in the early 2030s. The mission is a partnership between ESA and NASA, where NASA provides the Synthetic Aperture Radar payload. The scientific objective of EnVision is to provide a holistic view of the planet from its inner core to its upper atmosphere. Mission phase B1 started in December 2021 to complete trade-offs, consolidate requirements, interfaces and system specifications. Phase B1 will be concluded with the Mission Adoption Review planned in fall 2023, followed by Mission Adoption in 2024. To meet its science objectives, the EnVision mission needs to return 210 Tbits of science data to Earth, with a large distance-to-Earth dynamic range (from 0.3 to 1.7 AU), from a low Venus polar orbit, in the hot Venus environment (exacerbated by the operation of highly dissipative units), while operating three spectrometers in an almost cryogenic level environment. This needs to be achieved within constraints on the spacecraft mass as well as Agency programmatic boundaries. Achieving the science objectives under these multiple constraints without oversizing the spacecraft calls for a careful planning of science operations, making the science planning strategy a critical driver in the design of the whole mission, against which the spacecraft and ground segment are then sized.

EnVision payload reference operations scenario: The payload reference operations scenario simulation demonstrates that all identified surface targets can be imaged with VenSAR, with a performance fully compliant with the science requirements. The first two cycles allow imaging once 80% of the identified Regions of Interest (RoIs) at 30-m resolution. The following two cycles are mostly devoted to 2nd observations of these areas for stereo topography mapping and the two last cycles to 3rd observations of the "activity" type. Dual polarization and high-resolution SAR observations can be performed at any longitude at least once across the 6 cycles. The overall data collection strategy is to obtain the widest range of data types that enables us to put the highest resolution datasets into regional and global context. Similarly, understanding atmospheric processes requires a combination of global-scale mapping with targeted observations resolving smaller-scale processes.

Mission design: The mission design needs to accommodate the operation of the science instruments, namely VenSAR (standard, stereo, polarimetry, HiRes, altimetry, nadir, near-nadir and off-nadir radiometry modes), SRS (high and low density modes), VenSpec-M, VenSpec-H (cooling and nominal), VenSpec-U (Nominal and SNR- limited modes) and Radio Science Experiment (gravity experiment and radio-occultation experiment) such as to achieve the mission objectives in terms of surface coverage and repeated observations, while taking into account the constraints posed by the spacecraft design (e.g. wheel offloading manœuver duration and frequency, slew manoeuvers for pointing, mass memory capacity constraints, thermal and power constraints), the instrument design (e.g. VenSpec-M operates on the night side, VenSpec-U operates on the day side, cooling of VenSpec-H is required) and mission boundaries (e.g. the baseline science duration is six Venus cycles and starts in 1st half of 2035).

Earth's nearest Earth-sized world: Venus is the only spatially resolvable, Earth-sized world other than the Earth, where a diversity of geophysical envelopes, their interactions and evolution at several time scales and spatial scales, may be monitored from a variety of instrumental concepts and support long-term evolutionary models of Earth-sized exoplanets. Thus, its exploration offers unique opportunities to answer fundamental questions about the evolution of terrestrial planets and the habitability within our own solar system. Many significant questions remain on the current state of Venus, suggesting major gaps in our understanding of how Venus's evolutionary pathway diverged from Earth's. Comparing the interior, surface and atmosphere of Earth and Venus is essential to understanding what divergent processes have shaped both planets; this is particularly relevant in an era where we expect hundreds of Earth-sized exoplanets to be discovered.