Venus In Situ Transfer and Analysis (VISTA).

Introduction: Venus was the target of the very first interplanetary mission, Mariner 2, and many missions through the early decades of the interplanetary exploration age. After Magellan 30 years ago, US Venus exploration has been largely stagnant until the selection of NASA Discovery missions VERITAS and DAVINCI and participation in ESA's EnVision These missions will address major science questions about the past and present of Venus. Nevertheless, many additional and crucial questions about the history of Venus, and similarities to and differences from Earth, will remain unresolved even after the success of these new missions. Significant turning points in the evolution of Venus require knowledge that is not obtainable by the selected suite of upcoming missions, but can be attained by an innovative approach in the next 20 years if precursor science and technology paves the way.

Science: The Venus In Situ Transfer and Analysis mission concept (VISTA) is a mission concept to understand the root of the "home versus Hell" story. In the same way that the Mars Exploration Rovers, Mars Science Lab, and Perseverance have provided measurements that unravel the mysteries of Mars, provides an opportunity to obtain measurements that cannot be obtained by a simple, short-term mission to Venus. The VISTA architecture offers an opportunity to make sophisticated measurements from an arbitrarily large number of surface sites (limited by mass or cost), as well as from the atmosphere through which assets must move to deliver surface samples. Rich geologic and atmospheric science answers are accessible with this architecture. The central goals of the mission and the science strategy envisioned by this study project are, through analysis of multiple surface, aerosol, and atmospheric samples, to answer two questions (1) When and how did the evolutionary paths of Venus and Earth diverge? And (2) What were the fundamental branch points that set the sister planets on such different paths? (Figure 1). Measurements desired span geochemical analyses, including isotopic instrumentation, aerosol analysis, atmospheric analysis, and imaging. The mission lends itself to opportunistic science, so other measurements may be valuable also.

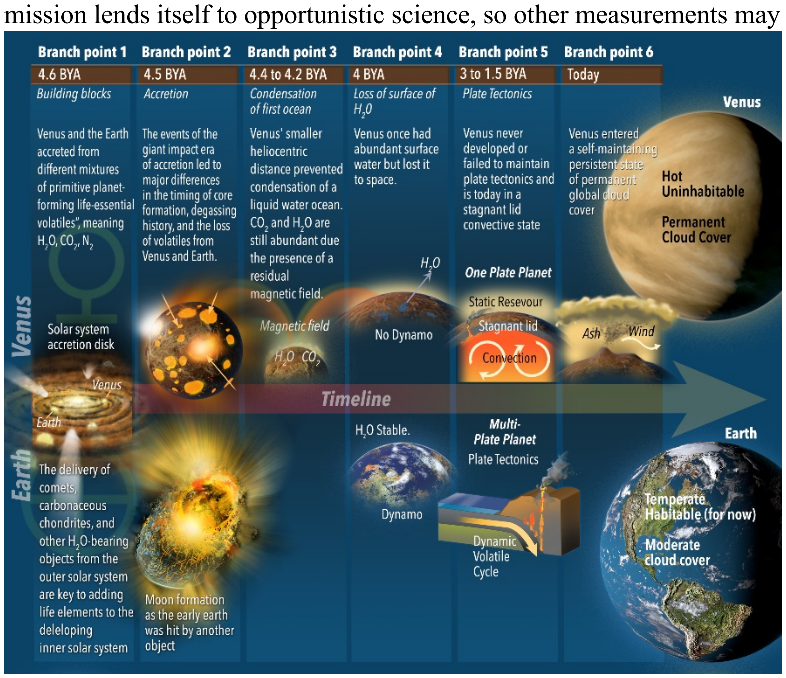

Figure 1. Timeline of Earth and Venus Divergence

Mission Architecture: VISTA is a concept for a Flagship mission to collect and deliver samples from multiple locations on the planet surface, as well as from within the Venus atmosphere, to a highly-capable, long-lived Aerial Laboratory for detailed analysis with modern instrumentation. Characterizing the composition, structure, and isotopic ratios of these samples will answer questions of surface composition across multiple geologic provinces, These measurements will help answer questions about the fundamental branch points in the evolution of Venus (see STM). Studies of atmospheric aerosols will support models of cloud formation. The longevity of VISTA will provide further information on atmospheric circulation, and provide a platform for detecting rare seismic and volcanic events.

While many trades remain open, VISTA contains multiple flight elements: the Aerial Lab, the Sampling Landers, the Ascent Vehicles, the Sample Retriever, and an orbiter for communications and navigation (Figure 2). While converging on a single point design was not the purpose of the workshop, an example VISTA architecture can be described. In this example, the Aerial Lab and Sampling Landers are packaged into a single entry system for delivery at one time. The Lab, equipped with Sampling Landers, deploys and the Lab balloon inflates in the middle atmosphere, stabilizing at ~50 km where atmosphere properties are temperature = 10–50 °C, density = 0.2–1.0 kg/m^3, and winds are 50–70 m/s E and ±20 m/s N/S. The entry deceleration requirement is < 50g for instruments. The Aerial Lab performs checkout, then determines weather patterns while the orbiter aerobrakes to operational orbit (equatorial or near equatorial orbit). One at a time, a Sampling Lander deploys, each equipped with a Sample Collection System and an Ascent Vehicle, at the appropriate point ahead of a given target ellipse, defined

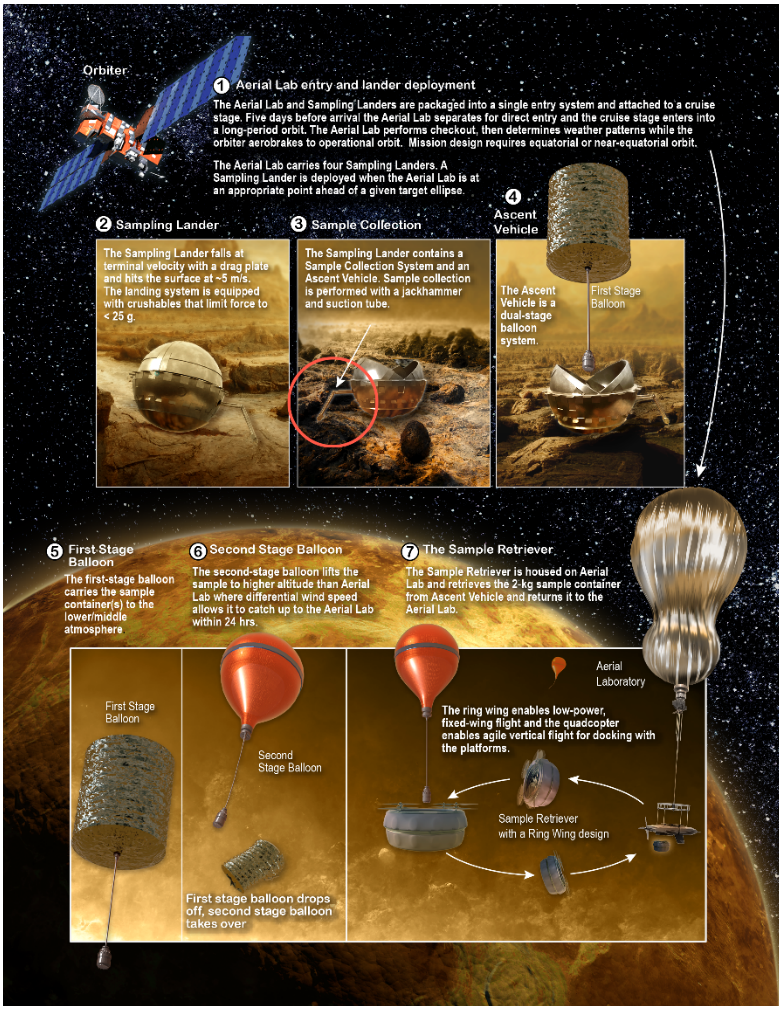

Figure 2. VISTA Mission Architecture

by navigation uncertainty of AL and uncertainty of wind profile to surface. Aerosols are collected on an exposed sampling surface and staged vacuum canisters can collect atmospheric samples during descent. during the descent. The Sampling Lander falls at terminal velocity with a drag plate and hits the surface at 5 m/s, using crushables that limit force to < 25 g. A geological sample is collected rapidly using a jackhammer/percussive drill sampling system, and transferred into a collection volume using pneumatic flow. An image will be taken of the surface and sample container before and after each collection for contextual scientific comparison. Surface duration is ~1 hour. The Ascent Vehicle is a dual-stage balloon system for lower/middle atmosphere, ascending over ~3 hours. The sample collection system is left behind so that lifted mass is only 2 kg. The second stage balloon then lifts sample to higher altitude than the Aerial Lab, where differential (eastward) wind speed allows the Ascent Vehicle to catch up to the Aerial Lab within 24 hrs, passively riding the winds. The Aerial Lab changes altitude to control local winds and leverages outboard propellers for finer control. Finally, a Sample Retriever, housed on the Aerial Lab, retrieves the 2-kg sample container from the Ascent Vehicle and returns it to Aerial Lab. Sample Retriever range is ~60 km and using a "docking sting" that mechanically attaches to both the Ascent Vehicle and Aerial Lab. The sample analysis train takes ~2 weeks per sample to go through all desired analyses, including decision-making from humans-in-the-loop on Earth. This process is repeated until all Sampling Landers are exhausted.

Venus and Earth are often described as "sister planets," but in fact, we know very little about the evolution of Venus over time. The VISTA mission concept seeks to deliver information about the divergent paths of Earth and Venus through a long-lived, flagship-class *in situ* sample capture mission.

Technology Challenges: Many of the technology needs for VISTA overlap with those required by other Venus architectures, including those identified in the 2019 Venus Technology Roadmap. Some noteable exceptions to this include: autonomous operations, rendezvous capabilities, sample handling, long-lifetime aerial platform (months to years), instruments for geological isotope measurements, and aerosol sample collector.

References:

[1] https://kiss.caltech.edu/workshops/VenusInSitu/VenusInSitu2.html

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