VALENTInE: A CONCEPT FOR A NEW FRONTIERS CLASS LONG DURATION IN-SITU BALLOON MISSION TO VENUS. Arredondo A.[1], Hodges A.[2], Abrahams J. N. H.[3], Bedford C. C.[4,8], Boatwright B. D.[5], Buz J.[6], Cantrall C.[7], Clark J.[8], Erwin A.[9], Krishnamoorthy S.[9], Magana L.[10,11], McCabe R. M.[12], McIntosh E. C.[13], Noviello J. L.[14,15], Pellegrino M.[7,16], Ray C.[10,11], Styczinski M.[17], Weigel P.[9], [1]U. Central Florida, [2]Georgia Inst. of Tech., [3]U. Calif., Santa Cruz, [4]Lunar and Planetary Inst., USRA, [5]Brown U., [6]Northern Arizona U., [7]U. Colorado Boulder, [8]GeoControls Systems-Jacobs JETS at NASA JSC, [9]Jet Propulsion Laboratory, California Institute of Technology, [10] U. Texas San Antonio, [11] Southwest Research Inst., [12]Hampton U., [13]U. Calif. San Diego, [14]Arizona State U., [15]NASA GSFC, [16] The Charles Stark Draper Laboratory, Inc., [17]U. Washington.

Introduction: Venus and Earth are similar in bulk composition, size, density, and approximate distance from the Sun, yet Venus's modern-day climate and surface geology is distinctly different [1]. Previous missions to Venus revealed unusual volcanic features, possible continental crust, widespread volcanic plains, a weak magnetic field [2], and insights into the Venusian atmosphere [3,4]. Unfortunately, data from these missions were limited in spatial and temporal resolution and global extent. A future mission to Venus is critical to address fundamental questions surrounding the chemical composition and dynamics of the Venusian atmosphere [5], its geologic history [6,7], its internal structure [8,9], and its habitability throughout time [10,11].

We present the ***Venus Air and Land Expedition: a Novel Trailblazer for In situ Exploration*** (VALENTInE) mission to meet this need. VALENTInE is a variable altitude balloon that will passively float in Venus's atmosphere between 45 and 55 km altitude. VALENTInE will acquire atmospheric data at varying latitudes and longitudes in addition to mapping the surface geomorphology and mineralogy across multiple terrains.

Mission Objectives: The VALENTInE mission concept is driven by four main science objectives:

1. Determine whether the driving force of the superrotation of Venus's atmosphere is caused by horizontal or vertical momentum transport.
2. Determine whether the atmospheric composition and noble gas inventory of the Venusian atmosphere is a product of outgassing from the initial protoplanetary source or if there are significant contributions from exogenic sources.
3. Determine whether the tesserae regions (particularly Aphrodite Terra) are felsic and relatively older than surrounding regions.
4. Determine if there is any evidence of a recent dynamo preserved in the rock record of Venus.

Mission Overview: A balloon architecture provides a robust system that can survive long-term in the Venusian environment while taking accurate measurements of the lower cloud deck and surface. Two prior balloon missions to Venus, VEGA 1 and VEGA 2 in 1984, have demonstrated the potential for such planetary exploration; however, these missions were short-lived (46 hr), with limited range (54 km).

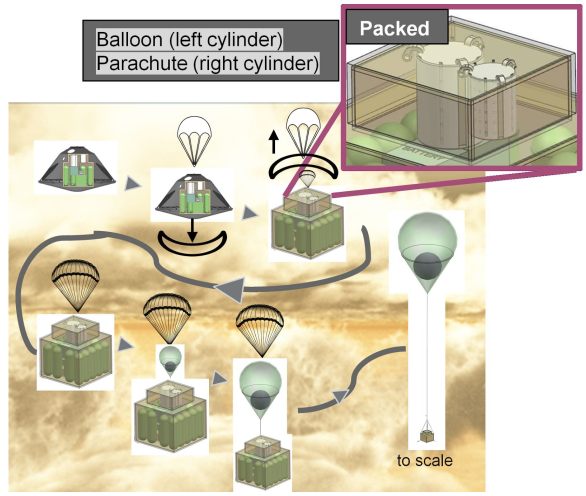

Figure 1. Notional entry [white parachute] and deployment [black parachute] procedure. Flyby carrier not shown. Insert: Packed balloon/second parachute.

Our spacecraft concept consists of a battery powered balloon with a gondola and flyby carrier stage (Fig. 1). Our novel design allows for at least 15 days of atmospheric exploration, including multiple ascents and descents in the Venus atmosphere. VALENTInE is baselined to launch in 2032, cruise on solar power for 128 days, enter, descend, and inflate (EDI) into Venus's atmosphere above Aphrodite Terra, and float in Venus's atmosphere for a total nominal mission duration of 15 days. The balloon, able to control its altitude by changing its buoyancy, will make one full circumnavigation every 4–8 days and move poleward ~1° latitude per day; it will be passively directed by the horizontal air currents on Venus. The balloon can only be controlled in the z direction, and the expected latitude range is ±10° from EDI. The balloon itself will be a tracer for atmospheric structures such as zonal winds [5, 12]. During the 15-day operational period, there will be five dips to 45 km for a compositional study of the lower atmosphere and geological and magnetic mapping of the surface. Dips are used to take images and measurements closer to the surface and to obtain in situ vertical atmospheric profiles between 45 and 55 km.

Instruments: The VALENTInE instrument payload will allow for extensive study of the geology, atmosphere, and interior of Venus. The instrument suite consists of six instruments. The mission profile for each instrument is shown in Fig. 2.

Lower Atmosphere Meteorology Analyzer (LAMA) is an atmospheric structure instrument consisting of a thermometer, barometer, and accelerometer to continuously measure temperature and pressure as a function of altitude, longitude, and latitude.

TracE and Noble Gas Investigator (TENGI) is a neutral mass spectrometer used to sample the dense atmosphere. TENGI will operate continuously at 45 km and 55 km and will measure D/H ratios, as well as Ne, Ar, and O isotopic ratios.

Kilometer Scale Spectral Imager (KSSI) is a multispectral imager (850-1150 nm) used to resolve surface features on the order of km.

Near InfraRed Multispectral Photometer (NIRMP) is an Infrared (IR) photometer used to image the surface through the clouds to characterize mineral assemblages at five different areas of the surface. *NIRMP* will be operated during dwell.

ELevation RECONnaissance (ELREC) is a light detection and ranging (LIDAR) instrument used for measuring topography at five different areas of the surface. The ELREC data will be combined with those of *NIRMP* to determine mineral assemblages and how they correlate to topography.

Magnetic Exploration and Interior Detective (MEID) is a magnetometer used to detect any near-surface magnetic anomalies. The magnetometer will continuously operate at all altitudes.

Mission Design: The spacecraft's propulsion system will have a wet mass of 930 kg and will be launched on an Atlas V rocket. The spacecraft will jettison the payload upon arrival in Venus's atmosphere before decelerating to orbital velocity.

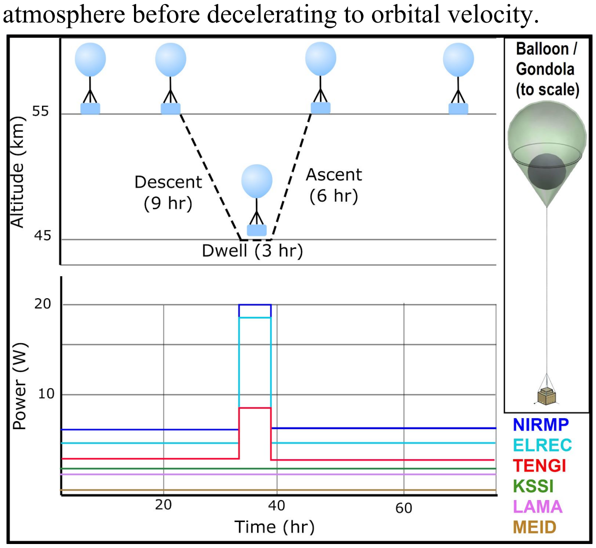

Figure 2. Notional power-dip profile while the balloon is on the dayside.

Risks and Challenges: Raising and lowering the spacecraft to dip beneath the haze layer require a large amount of energy. This issue was partly compensated by limiting the number of dips over the 15 day prime mission. Power needs for pumping helium are reduced by slowing the descent speed, which consequently increases spatial resolution of in situ measurements between 45 and 55 km.

The main limitation for the duration of the mission is the need to carry 15 days' worth of batteries. The bus experiences external Venusian temperatures ranging from ~27°C at 55 km altitude to ~110°C at 45 km altitude. These high atmospheric temperatures require thermal protection for the bus (instruments, electronics, and flight systems) during its descent, dwell at 45 km, and ascent. The bus is maintained at a mechanically safe temperature range of -10°C to 50°C using white external paint, multi-layer insulation (MLI), mechanical/thermal isolation (e.g. Ti, composites), and ~57 kg of Phase Change Materials (PCM). Images and spectra taken below the haze dominate the available data transmission regardless of the time spent at 45 km. Therefore, less time at the lower altitude mainly reduces the coverage of in situ measurements there.

Further, we assumed an unrealistically low-density material for the helium storage tanks on the gondola. However, this issue is partially resolved if we were to jettison 75% of the spent helium storage tanks. After the entry process, the balloon volume remains mostly inflated and storage tanks are required only for reducing balloon volume in dipping to 45 km.

This mission was planned against an expected New Frontiers 5 (NF5) cost cap of $1B, as the NF5 call had not yet been released. The mission we describe fits within the predicted cost cap if the flyby carrier stage, responsible for powering the spacecraft during cruise and for relaying in situ measurements back to Earth, can be contributed by another space agency.

Acknowledgments: We thank the JPL Planetary Science Summer School, especially A. Nash, J. Scully, K. Mitchell, L. Lowes, and J. Armijo, and our mentors from JPL Team X. Thank you to our review panel for their insightful review.

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