V-BOSS: Venus Bridge Orbiter and Surface System

The Venus Bridge Orbiter and Surface System (V-BOSS) shows that new, high-priority Venus Science can be achieved using a linked Orbiter + Surface Element (Lander) mission concept at cost bridging SIMPLEX and Discovery. V-BOSS is achievable through optimizing investment in devekoping technologies and platforms, such as the Long-Lived In-Situ Solar System Explorer (LLISSE), leveraging known and flight-ready technology, and use of simple, small, robust systems in innovative approaches to Venus exploration. The V-BOSS architecture (Fig. 1) allows a range of science investigations through modification of Orbiter-Lander platforms through choice of instruments (varying sensors), science themes, or operational modes. This approach provides science not available by other means via simplified, rugged systems operable in-situ on the Venus surface. V-BOSS technologies are stepping-stones to the future of in-situ Venus surface and subsurface science. V-BOSS investigations are pathfinders for more complex/capable/expensive, future missions.

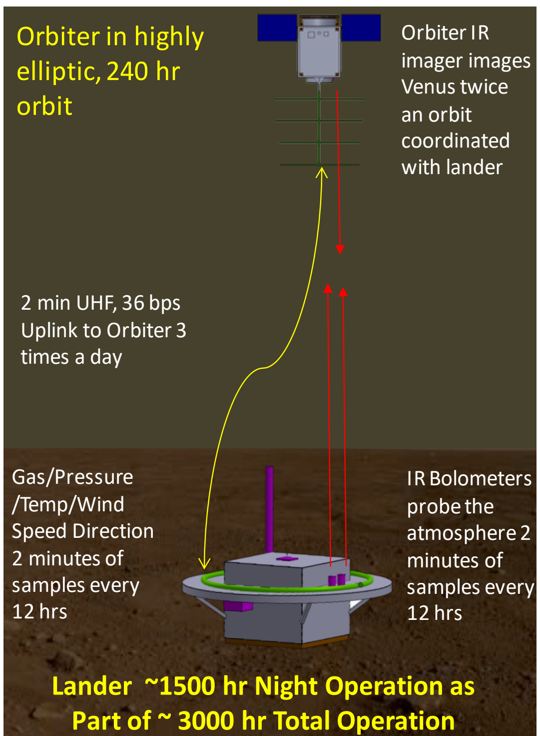

Figure 1. V-BOSS Coupled Orbiter-Lander Concept.

The V-BOSS study produced a point design to show an example of the quality of science with a paired orbiter/lander that can be done with a cost cap between SIMPLEx and Discovery.

Mission Overview: Figure 2 shows a graphic overview of the concept.

Launch and Delivery:

Secondary launch from a moon directed mission with V-BOSS on an ESPA Grande ring containing a lander and orbiter. Lunar phasing/powered Earth flyby enables Venus transit.

Deploy lander/EDL 30 days before Earth-viewed orbiter capture into 10 day inclined Venus orbit.

Lander enters atmosphere in sight of orbiter and lands 55°S at night.

Operations:

Lander Science: lander gathers IR, temperature, pressure and chemical data during descent and for an entire Venus night/day. At the surface, the wind sensor gathers 2 minutes of data and transmits every 12 hours to orbiter using 100 MHz link at 36 bps.

Orbiter science: orbiter takes IR images co-incident with lander IR data uplink, caches data and transmits to Earth daily at 200 to 2000 bps.

Mission Elements:

Lander: ~15 kg, ~20 cm cube with drag flap, high T electronics and battery, UHF communications through 1/3 wavelength loop antenna.

EDL System: ~12 kg, 0.5m aeroshell, passive separation systems, lander provides telemetry.

Orbiter: 200 kg Smallsat with ~90 kg monopropellant to provide burns at Earth and to capture at Venus (total ~1000 m/s), UHF uplink from lander, X-band data return to earth

Science Return: The Science Theme targets a coupled orbiter-lander approach to uniquely investigate mineralogy and surface atmosphere interactions over extended duration of a full Venus solar day. The Science Goals, Measurements, and Instruments for the orbital, descent, and surface themes are shown in Table 1. Orbital mapping of the surface with diffraction-limited horizontal resolution of ~60 km can distinguish major differences in surface mineralogy by utilizing an IR emissivity imaging camera on the orbiter and then calibrating those images based on the IR flux measurements from the lander. V-BOSS would cover the majority of the surface and observe examples of all of the major geological landforms. Using this scheme, new and relevant insights regarding the mineralogy of Venus' crust may be obtained. Moreover, access to newly recorded surface maps can be compared to the IR measurements obtained from previous missions, and provide critical data needed to interpret the composition of specific high priority geologic targets such as tesserae or coronae.

Table 1. V-BOSS Goals, Instruments, & Measureents

Mission Goals	Instrument	Measurement
Orbiter		
Constrain surface mineralogy	4 channel Multispectral IR Emissivity Mapper	Radiant flux at 4 target wavelengths
Probe (Descent: Data Collection at < 20 km)		
Determine atmospheric composition at lower scale height	Atmospheric Chemical sensor suite: fO_2, CO, SOx, H_2O, OCS, HCl, HF, NO, Pressure, Temp	Vertical T, P profile Abundance profile of major and trace species and oxygen fugacity.
Radiance profiles with altitude. Correlation w. Orbiter meas.	IR radiance Bolometers: 2 looking up and 1 looking down	Upward and downward IR radiant flux, bands matching orbiter.
Probe (Landed)		
Constrain surface-atmosphere interactions	Long duration Atmo. Chemical sensor suite: fO_2, CO, SOx, H_2O, OCS, HCl, HF, NO, Pressure, Temp	Monitoring of chemical comp. at surface, variability of abundances with T & P
Measure wind speed and direction over months	Long-duration wind sensor	Long term wind speed and direction measurements
Constrain the atmospheric radiance energy over time	IR radiance Bolometers 2 up-looking and 1 down-looking down	Upward and downward IR radiant flux in specified bands
Measure surface mineralogy reactions	Microsensors that monitor selected standard samples for reaction chemistry	Reaction chemistry via electrochemical measurements (IV,CV)

Additional detail on chemistry and composition of the landing site may be accomplished by completing in-situ reaction chemistry experiments of known samples using contemporary advancements in solid state chemistry. This testing will provide essential data to investigate and define mineral stability regimes at the surface and the effect of the Venus atmosphere on known geological materials.

Table 2. Technology readiness for V-BOSS systems

Technology	Current TRL
Electronic circuits (SiC): sensors and data handling	4-5
Electronic circuits (SiC): power management	4
Communications (100 MHz)	3-4
High-Temperature Battery	5
Entry System (Heritage/HEEET)	6
MIREM Spectral Imager	4
Wind Sensor	4
Temperature Sensor	5
Pressure Sensor	4
Chemical Sensors	5
LLISSE Bolometer	3-4
V-Rad (V-BOSS IR Bolometer)	3-4
V-Lab (V-BOSS Surface Reaction Measurement)	3-4

V-BOSS is a paradigm-shifting small mission class, that allows for easy scaling and different instrument configurations to address cost, mass, or other constraints, or different science measurement goals. V-BOSS leverages newly demonstrated (LLISSE) and developing technologies. Readiness of technology (Table 2) is a driving aspect for a V-BOSS "Bridge" or Technology demonstration class mission. All technologies have funded or fundable paths to TRL-6 by a mission PDR.

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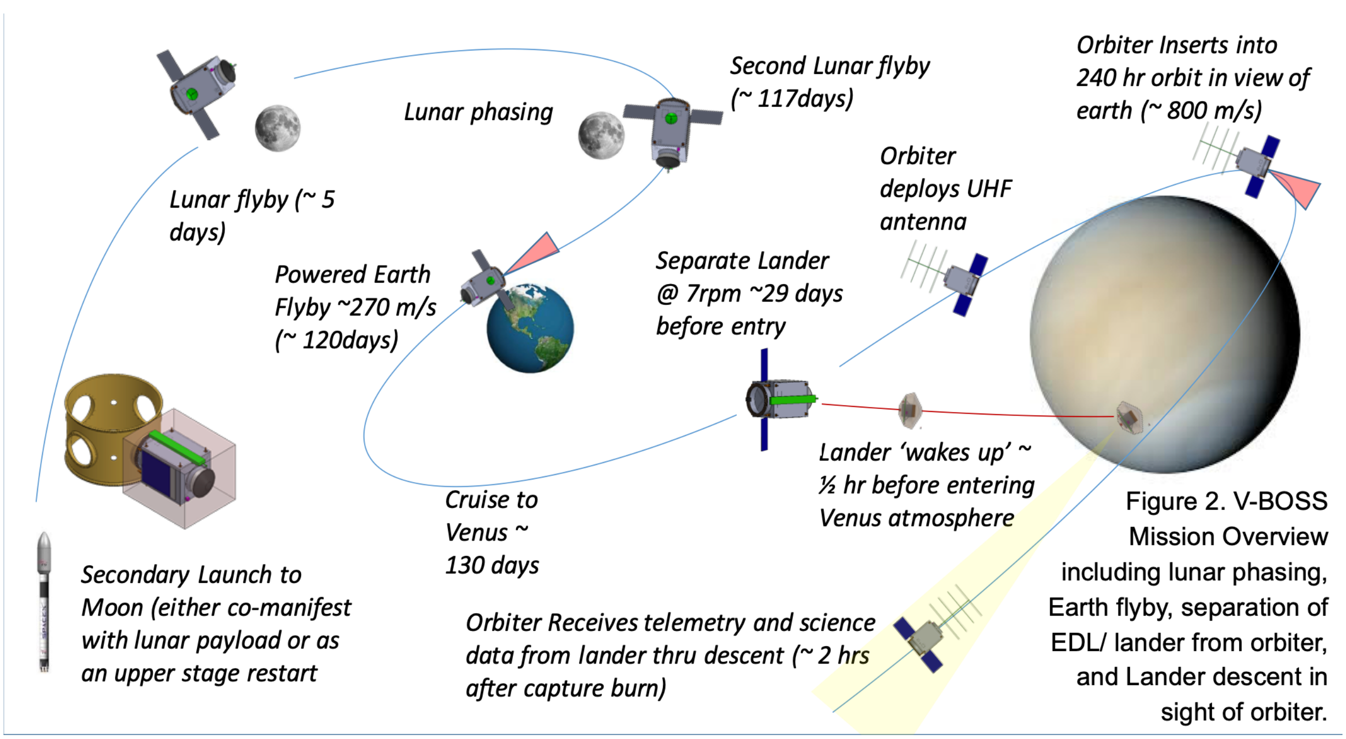

Figure 2. V-BOSS Mission Overview including lunar phasing, Earth flyby, separation of EDL/ lander from orbiter, and Lander descent in sight of orbiter.