LOW ALTITUDE VENUS AIRSHIP FOR ATMOSPHERIC AND SURFACE EXPLORATION. L. G. Lemke[1], E. Z. Dobrea[1], D. W. Hall[2], R. Deedon[2], and A. Brecht,[3], [1]Planetary Science Institute, 1700 East Fort Lowell, Suite 106, Tucson, AZ, 85719 (lemke@psi.edu), [2]DHC Engineering, 1576 Marina Court Suite H, San Mateo, CA, 94403 [3]NASA Ames Research Center, Moffett Field, CA, 94035

Introduction: We study the feasibility of a variable-buoyancy dirigible for exploration of the lower atmosphere and surface of Venus capable of repeatedly cycling between the near surface and high altitude (≈ 30 km). This concept is distinct from other Venus lighter-than-air mission concepts [1, 2] which have no capability for direct maneuvering, and distinct from high altitude airship mission concepts such as High Altitude Venus Operational Concept [3] and Venus Atmospheric Maneuverable Platform [4] which envision operations solely above the cloud deck. Exploration of the lower atmosphere (0-40 km) and surface of Venus has long been inhibited by the extreme temperatures and pressures that exist near the surface of the planet and by the thick cloud deck found between 50 and 70 km altitude. The extreme near-surface temperature has traditionally limited the lifetime of landers to < 90 minutes. An altitude cycling dirigible mission would be able to alleviate this problem by periodically ascending from the surface to higher altitudes where more solar energy is available for power and atmospheric temperatures are significantly lower, allowing the airship to cool down. The greater abundance of solar power and cooler temperatures at high altitudes is expected to allow the use of actively cooled scientific instruments on the descent to the surface to perform near-surface measurements and to acquire vertical profile data as it descends. Such a dirigible would embody many unique capabilities: 1) It could visit multiple sites for high resolution or in-situ analyses, 2) It could perform repeated vertical profiles of the lower Venusian atmosphere, 3) It could use solar panels for power instead of more exotic (e.g., nuclear) sources, 4) It could remain buoyant at a survivable altitude while the winds transport it across the night-time hemisphere of the planet, requiring little maintenance power, and 5) Mission duration would be limited by the lifetime of the mechanisms and not by temperature or power constraints. Given the low airspeed needed for flight near the Venusian surface, it is also conceivable that such an airship could make one or more takeoffs and landings during its mission. The core technical component that enables such an airship is a reusable buoyancy cell constructed using thin-walled stainless steel bellows. This technology was demonstrated at sub-scale by JPL in its Low Altitude Balloon (LAB) study [5].

Because of square-cube law mass relationships, the performance of airships improves monotonically with size. This is in distinction to square-cube scaling laws for heavier-than-air craft which generally place an upper practical limit on size. This strongly suggests that such an airship—if possible—should be designed for the largest feasible size. Two technical developments on the horizon which are critical for the feasibility of this concept are the SpaceX Starship—capable of delivering ≈ 100 tons and 1100 cubic meters of payload to Venus' orbit and the Adaptive Deployable Entry Placement Technology (ADEPT) entry system being developed by NASA Ames Research Center. The ADEPT deployment approach allows very large planetary atmosphere entry vehicles to be folded and stowed inside launch vehicle shrouds and then be unfurled to provide low ballistic coefficient, lifting entries into planetary atmospheres. ADEPT was specifically designed to accommodate Venus atmosphere entries.

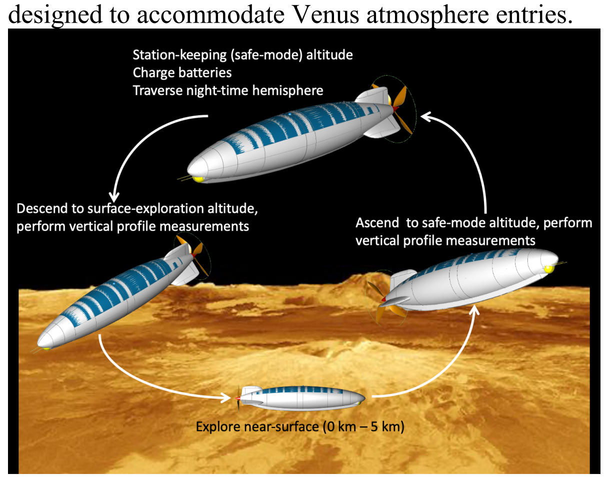

Figure 1. Conceptual mission profile.

We have conducted a conceptual design study to define a notional point design variably buoyant airship capable of repeatedly cycling between ≈ 30 km altitude and the surface in the lower atmosphere of Venus based on use of the SpaceX Starship launch vehicle, ADEPT entry vehicle technology, and JPL-developed LAB technology.

Significant work has gone into the development of generic spacecraft subsystems and components capable of surviving and operating in the conditions of the Venusian near-surface under the NASA Glenn HOTTECH program. These subsystems and components include batteries, electromechanical actuators, electronics, solar cells, sensors, and microprocessors. Where appropriate, it is assumed that HOTTECH components would be utilized in the airship design. For example, preliminary calculations indicate that Low Intensity High Temperature (LIHT) Solar Cells being developed by HOTTECH may be sufficient to power an airship.

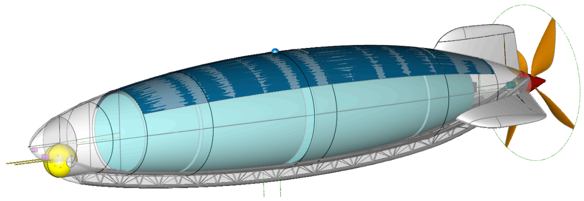

Figure 2. Conceptual Low Altitude Venus Airship, Cutaway View

Our study produced a point design that closes with the following design parameters:

- Length—17.2 m
- Diameter—3.0 m
- Gross Mass—530 kg
- Buoyancy Ratio—95%
- Solar Power available, 30 km—9.94 kW
- Flight Speed, 30 km—4.3 m/s
- Cruise Power Required @ 30 km —1.45 kW
- Flight Speed, 0 km—1.7 m/s
- Cruise Power Required @ 0 km—0.43 kW
- Time to Descend (30 to 0 km)—5.4 hr
- Time to Ascend (0 to 30 km)—4.5 hr
- Science Payload Mass—27.6 kg

References:

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