DUAL BALLOON CONCEPT FOR LIFTING PAYLOADS FROM THE SURFACE OF VENUS. V. V. Kerzhanovich, A. H. Yavrouian, J. L. Hall and J. A. Cutts, Jet Propulsion Laboratory, 4800 Oak Grove Dr., Pasadena, CA., 91109, Viktor.V.Kerzhanovich@jpl.nasa.gov.

Introduction: Two high-rated Venus mission concepts proposed in the National Science Foundation Decadal Survey [1] require a balloon to lift payloads from Venusian surface to high altitudes: Venus Surface Sample Return (VESSR) and Venus In-Situ Explorer (VISE). In case of VESSR the payload is a canister with the surface sample plus a Venus ascent vehicle (VAV), which is a rocket that takes the sample into orbit for rendezvous with an Earth return vehicle. VISE is envisioned as a more limited precursor mission where the surface sample is only taken to high altitudes so that non time-critical analyses can be performed. From the balloon point of view, the only difference between these two missions is that the VESSR payload to be lifted is very much larger than VISE because of the inclusion of the VAV.

A key problem is that at the time the decadal survey was published, no high temperature balloon technology existed to implement either mission. Prior technology development efforts had concentrated on a single balloon that could operate across the entire 0-60 km altitude range, tolerating both the sulfuric acid aerosols and the extreme temperatures of -10 to +460 ºC. However, this problem was unsolved because no combination of sufficiently lightweight balloon material and manufacturing (seaming) technology was ever found to tolerate the high temperatures at the surface.

Two-Balloon Concept: In this paper the authors describe a solution to the problem based on the idea of using a two-balloon approach (Fig. 1). One balloon is optimized for high temperature service in the lower atmosphere, while the second is optimized for high altitude performance. Both balloons can be made from available materials with known fabrication technology. The near-surface balloon will be a metal bellows made of stainless steel or other suitable alloy. The relatively high mass of metal material is allowable in this architecture because only small balloons are needed to lift significant payloads in the dense lower atmosphere of Venus. The second, high-altitude balloon will be made of a more conventional Teflon-coated Kapton film. This much lighter material enables the large balloon volumes needed for expansion in the low density upper atmosphere while the Teflon coating simultaneously provides sulfuric acid protection throughout the ascent.

In operation, the metal bellows balloon will be inflated with either helium or hydrogen gas during the initial descent and landing of the overall vehicle. During the descent and the short stay on the surface, the second, high altitude balloon remains in a thermally insulated container along with the vehicle avionics and other sensitive components. Once the sample has been collected, the payload and the two balloons will be released from the lander and begin to ascend. At a crossover altitude of approximately 12 km, the temperature will be low enough (~370 C) to deploy the high-altitude balloon from its insulated container. The valve that connects the two balloons will then be opened to allow the buoyancy gas from the metal bellows balloon to transfer to the high altitude balloon. The metal bellows balloon will be released once this gas transfer is complete, and the remaining vehicle will ascend to its floating altitude of approximately 60 km while the bellow will float at much lower altitude.

Detailed calculations have been performed to design the two balloon vehicle and quantify its performance during all phases of the mission. The paper includes key results from these trade studies for balloon sizing and mass, crossover altitude, and payload temperature.

In addition to the analytical work, the authors conducted proof-of-concept high-temperature and inflation tests of a metal bellows and high-temperature test of Kapton film. These successful tests are also described in the paper and provide additional confidence in the feasibility of the two-balloon concept for these Venus missions.

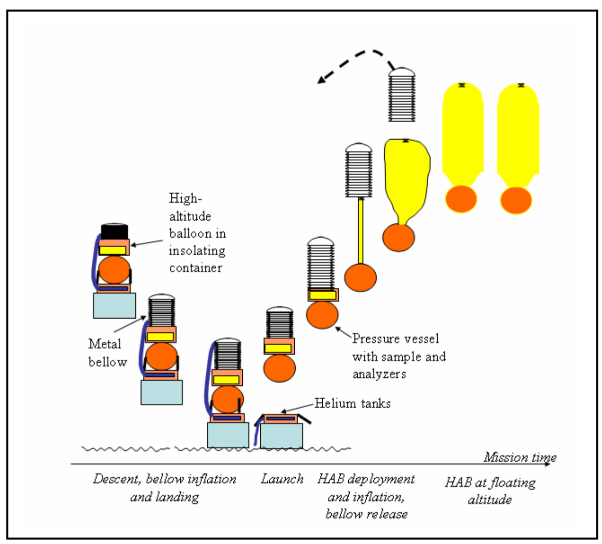

Fig. 1: Schematic diagram of Two-Balloon Concept

References:

[1] Solar System Exploration Survey Committee, Space Studies Board, Division of Engineering and Physical Sciences, National Research Council, National Academies Press, Washington D.C., *New Frontiers in the Solar System: An integrated exploration strategy*, 2003.