VENUS ALTITUDE CYCLING BALLOON. M. de Jong, Thin Red Line Aerospace, Chilliwack, B.C., Canada. Email maxim@thin-red-line.com

Introduction: NASA seeks capability to sustain long duration balloon probe flight in the cloud level region of Venus' atmosphere. Significant additional scientific benefit is derived from the capability to cycle float altitude from below the cloud layer to above. Innovative concepts and system-level solutions are sought for such an altitude cycling Venus balloon presenting a minimum cycling altitude of 45 km or lower, a maximum cycling altitude of 58 km or higher, a balloon large enough to carry a 100 kg payload, and a flight duration of at least 14 (Earth) days comprising both day and night conditions.

Mechanical Compression as Altitude Control Mechanism: Compression of a buoyant balloon's volume increases its density--ultimately leading to the vehicle's descent. Descent will continue with maintainence of a constant, compressive load of sufficient amplitude. However, when travelling through a significant range of altitudes the balloon's volume greatly varies in accordance with the change in altitude related atmospheric pressure and temperature: To be able to traverse the target 45 to 58 km Venus altitude region, a mechanically compressed balloon must accommodate a 4:1 range of volumetric compression.

UHPV[1] Altitude Control Balloon Architecture: The investigated altitude control balloon platform is based on Thin Red Line's UHPV architecture (Figure 1) that was originally developed for high shell load space habitats and Inflatable Aerodynamic Decelerators (IAD's). Key UHPV advantages validated in past NASA SBIR studies are scalability, structural determinism, and minimum mass.

Fig 1: Thin Red Line Ultra High Performance Vessel (UHPV)

[1] Ultra-High Performance Vessel

Multi-segment UHPV Balloon: As seen in Figure 2, left, the mechanical compression altitude control balloon comprises a modular 'stack' of 5 identical UHPV balloon segments connected to one-another at their respective polar regions. A tension cable connects the 'North' and 'South' poles to facilitate mechanical compression of the UHPV stack. Compression is performed by an electric motor installed at the bottom apex of the balloon.

Observations: The motor's retraction of the demonstration balloon's tension cable reduced volume by ~75% thereby fulfilling the volumetric requirements of the target 45 to 58 km Venus altitude region.

Further to the unique structural attributes of the UHPV architecture, simple mechanical compression is achieved through manipulation of a single axial tensile member. Varying the number of UHPV segments theoretically accommodates unlimited altitude range mobility. In practice, payload mass will diminish with increasing altitude range. This technology is also of interest for terrestrial applications.

Fig 2: UHPV altitude cycling balloon

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