HYBRID ENTRY-SHIP: A CONCEPTUAL ENTRY-DESCENT AND SURVEILLANCE PLATFORM FOR VENUS ATMOSPHERE, Mofeez Alam1, Kamal Saroha1, Pankaj Priyadarshi1, Sanjay Limaye2, 1Indian Institute of Space Science and Technology(IIST), Trivadrum(KL, 695547, India, mofeezalam786@gmail.com), kamalsrh@gmail.com, pankaj.priyadarshi@gmail.com, 3SSEC, UW-Madison(WI, 53706, USA, sanjay.limaye@ssec.wisc.edu

Introduction: The direct sampling of the clouds has been possible only below about 62 km, whereas the recent Venus Express observations indicate that the cloud tops extend from about 75 km in equatorial regions to about 67 km in polar regions[2]. For in-situ sampling of the cloud top region of Venus, platforms other than entry probes or balloons are desired. Different concepts for sampling the atmosphere have been proposed - e.g. Landis et.al[3] proposed a folding-wing airplane which will enter in an aeroshell. This concept did not take benefit of the high density of the atmosphere of Venus and was limited in the payload it could carry due to several constraints. Recently, a large airship, HAVOC (High Altitude Venus Operational Concept) has been studied by NASA/LaRC. HAVOC needs inflation to such a large volume that the high dynamic pressure poses a challenge to the structural integrity of semi-rigid structure. We present here a hybrid entry cum airship concept which will enter from a low Venus orbit.

Concept: We present a hybrid entry cum airship concept which will enter from a low Venus orbit. It will undergo a series of changes in its configuration to achieve an optimal Entry-Descent and Surveillance(EDS) sequence. From trajectory analysis, it is seen that this concept encounters very low g-load (~2-3g). The maximum heat loads over the whole entry time is substantially less than conventional module entry due to very low ballistic coefficient and enabled by an ablating Thermal Protection System (TPS). Preliminary aerodynamic performance in the entry phase has shown that the drag is very high for this concept which helps in decelerating the vehicle in low density region and hence is good for structural stability due to low dynamic pressure. While in the atmosphere, the vehicle utilizes appropriate proportion of aerodynamic and buoyant lift in order to perform both surveillance and station keeping missions[4]. Simulations show that the proposed aerial configuration performs nicely in airspeed range of 30-120 m/sec which translates to maximum of 10 m/sec of ground speed. With the inherent stability it can withstand gusts and zonal-wind loads without much loss in aerodynamic performance. It is powered by solar panels placed on top and bottom surfaces of the vehicle in Specified sections in the vehicle with low vibration, low local turbulent regions are being considered for sensitive instruments like Laser Induced Breakdown Spectroscopy (LIBS/Raman), Light detection and ranging (LIDAR) which could provide valuable information about the nature and identity of the ultraviolet absorber(s), global atmospheric circulation, aerosols and small-scale vertical motion which are some of the major science priorities identified by VEXAG[1]. It can house payloads upto 200-300 kg which is 6% of the mass of the vehicle while surveillance. The nominal power of 250 W is available to the payloads.

Future Plans: We plan to finalize the design of the concept with the help of tools from different disciplines in order to produce the best solution as a whole.

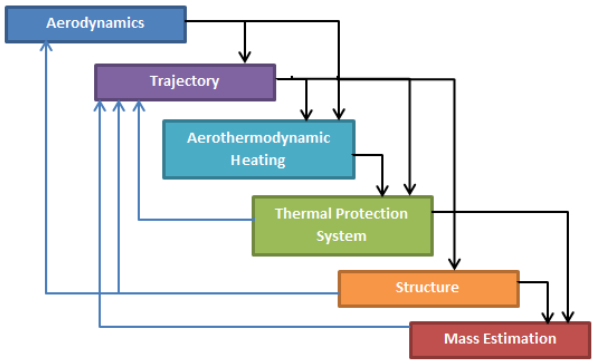

Fig.1: Control Flow of the design process with Feedback loops.

References: [1]Goals, Objectives and Investigation for Venus Exploration : 2014,
[2] Sanjay Limaye, Kumar Ashish, Mofeez Alam , Geoffrey Landis , Thomas Widemann , and Tibor Kremic, "*Sampling the Cloudtop Region on Venus*" EGU General Assembly 2014, 27 April -2 May, 2014 in Vienna, Austria, id.8720,
[3]Landis, G.A., A. Colozza, C.M. LaMarre, *Atmospheric flight on Venus.* NASA/TM—2002-211467,AIAA2001-0819June-2002,
[4] Mofeez Alam, et al. *Aerodynamic Analysis of Blimplane-a Conceptual Hybrid UAV for Venus Exploration*, 2014 IEEE Aerospace Conference.