BLIMPLANE- A CONCEPTUAL HYBRID UAV FOR VENUS EXPLORATION Kumar Ashish[1],Mofeez Alam[2], Sanjay Limaye[3], [1]IIT Kharagpur,(WB,721302, India, krashon@gmail.com), [2]IIST, Trivadrum(KL, 695547, India, mofeezalam786@gmail.com),[3]SSEC, UW-Madison(WI, 53706, USA, sanjay.limaye@ssec.wisc.edu)

Introduction: Planet Venus is considered as Earth's sister due to its similar size, mass and gravity. However it possesses a hostile environment with strong zonal wind of around 100 m/s (at 70 km altitude) - faster than the planet's rotational speed and a mean surface temperature of 735 K. [1] Acquisition of scientific measurements in this region of high winds and sulfuric acid cloud particles with unknown ultraviolet absorbers is of immense interest and useful to understand why Venus is so different from Earth with its immense greenhouse effect with presence of liquid water on its surface in its past, it is therefore valuable to know how Venus evolved differently, so that we may have a better notion of Earth's future climate. Previous probes have not been able to sample the cloud top region of Venus and thus the desire for exploring the feasibility of an unmanned aerial vehicle (UAV) exists.

Approach: The Aerodynamic design of a "BlimPlane", (hybrid of Blimp and Airplane) for future insitu exploration of Venusian atmosphere in 60 to 80 km altitude range has been addressed. The airplane is powered by solar panels installed on its top and bottom surfaces. It is assisted by buoyancy for unpowered operations. The analysis is done by Computational Fluid Dynamics (CFD). Reynolds-averaged Navier-Stokes models- k-ε and SST k-ω are used to simulate different turbulent levels. Operational Reynolds number range is $-1x10^6$ – $20x10^6$ with respect to fuselage length and Mach number range is 0.2-0.7. Glide Ratio and Pitching moment are taken into consideration while estimating the aerodynamic efficiency. High wing loading near the central portion due to lifting fuselage configuration assists the BlimPlane flight sustainability against a head wind, which in turn simplifies station maintenance by gaining increased lift due to the relative motion with respect to wind.[2]

Result: The Blimplane showed good aerodynamic performance in the low turbulent regions. The pitch stability was appreciable and it was not affected by turbulence. This design fulfills all the aerodynamic requirements for station-keeping as well as surveillance missions for altitude range of clouds i.e. 45-64 km. Due to very low density of the atmosphere at 80 km altitude the power requirements could not be met with the given aerodynamic characteristics. The alternative method proposed for meeting the energy requirement was to perform altitude change maneuvers. The change in turbulence level significantly decreases the glide ratio and increases the power consumption. [2] Figure.1 shows the requirment of V^2*Cl, it was found from this graph and power availability curve that a vehicle with 10 m wingspan is adequate for desired performace.

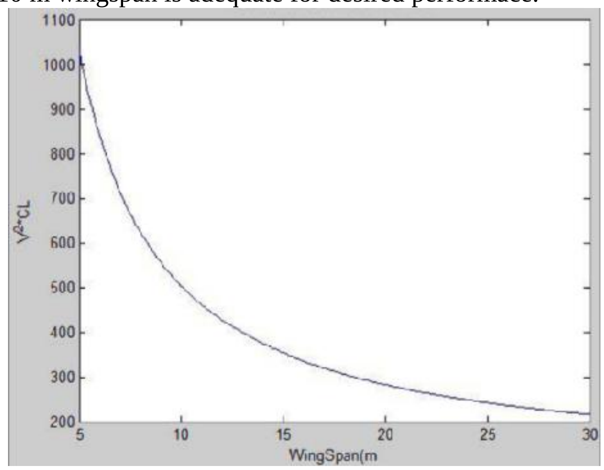

Fig.1 V^2*Cl requirement for levelled flight vs Winspan at 60 km altitude

Due to very efficient steady-levelled performance in such a turbulent atmopshere it has a high paylaod fraction. It can take a payload of 100 kg with a power availability of 150 W. The bottom surface of the blimplane offers a relativity quite flow feature for in-situ measurements of pressure, characteristics of the isotopes of gases, aerosols concentrations. It is capable of carrying instruments and other objectives descriped in the Goal identified by the Venus Exploration Group (VEXAG)[3]. Thus, detailed observations of the surfaceusing a miniature Synthetic Aperture Radar are possible. Data relay to Earth will need an orbiter, preferably in a low inclination orbit, depending on the latitude region selected for emphasis.

Future Scope: It is an interesting as well as challenging multidisciplinary optimization problem which can only be tackled if other parameters like Structures, Thermal Safety, Energy and Propulsion- are considered simultaneously. We can then go ahead with comparatively low error band while accessing the whole flight envelop.

References: [1]The Venus International reference atmosphere- COSPAR, Advances in Space, Volume 5, Number 11, 1985. [2] Mofeez Alam, et al. Aerodynamic Analysis of Blimplane- a Conceptual Hybrid UAV for Venus Exploration, 2014 IEEE Aerospace Conference.[3]Goals, Objectives and Investigation for Venus Exploration : 2014