A COMPACT DRONE-BASED INSTRUMENT SONDE FOR VENUS BALLOON MISSIONS

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Brief Presenter Biography: Dr. Benjamin Cameron is a Research and Development Engineer at Creare LLC in Hanover, NH, where he leads the autonomous systems group. He conducts research across a wide range of technology areas including fluid thermal systems, aerodynamics, hydrodynamics, autonomous systems, computational fluid dynamics, and mass and heat transfer. He also develops aerial drones, rovers, and underwater vehicle autonomous systems for specialized applications in earth observations, planetary exploration, and terrestrial commercial markets.

Introduction: NASA is currently developing concepts for controlled variable-altitude balloons for study of the Venusian atmosphere at altitudes ranging from 52 to 62 km. Creare is developing an instrumented drone, the Venus Sonde, to support these future balloon missions and extend mission capabilities. The drone extends the effective operating altitude of the balloon by flying above and below the platform and performing a range of possible missions.

Missions: The drone launches from the balloon platform under horizontal fixed-wing flight and returns to redock with the balloon platform under vertical flight (hovering). Once redocked to the balloon, the drone recharges for the next mission and transmits scientific data through a high-bandwidth connection.

The Venus Sonde can fly multiple missions to and from the balloon platform while profiling the atmosphere above and below the balloon altitude using a suite of miniature sensors for pressure, temperature, and concentrations of selected atmospheric species. Further, the drone can descend below the cloud deck to an altitude of about 46 km and directly image the surface in the near infrared during the Venusian night. This surface imaging is not possible with the balloon platform alone.

Other relevant drone missions include (1) inspection of the balloon platform and the skin for signs of degradation from the corrosive atmosphere, and (2) rendezvous and retrieval of physical samples from a surface ascent system and transfer to the more sophisticated analysis tools on the balloon.

Drone Platform: Creare's Venus Sonde design combines vertical flight (needed for docking with the balloon platform) with the extended range and high-altitude capabilities of a fixed-wing aircraft in horizontal flight. The overall drone has a mass between 2 and 10 kg, and a wing diameter between 0.3 and 1.0 meters depending on mission requirements. The Venus Sonde concept is based on a ring-wing design developed by Creare (Figure 1) for terrestrial applications and a planetary exploration vehicle for Titan.

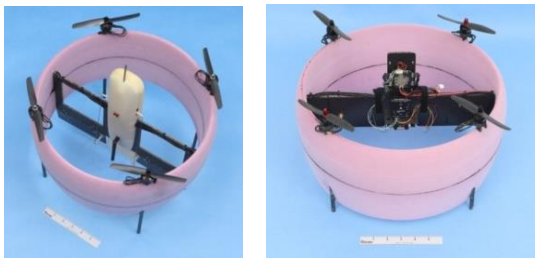

Figure 1. Terrestrial Ring-Wing Drone Prototypes

The drone configuration utilizes a quadcopter propeller arrangement and a nonplanar wing design to improve flight control characteristics and structural rigidity. This configuration creates a highly maneuverable drone capable of rapidly transitioning between vertical and horizontal flight (Figure 2).

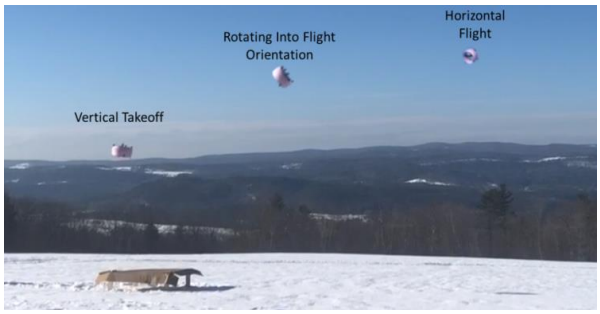

Figure 2. Ring-Wing Vertical to Horizontal Flight

The Venus Sonde design concept includes a central pod supported by the ring wing through multiple connecting struts. The volume in the central pod contains batteries, the thermal management system, avionics, and instrumentation. Avionics support is needed for basic flight activities, including a flight controller, power management, communications, vision, and sensor subsystems. The key constraints are the overall size, weight, and power budget and ambient temperature range of -43°C at 70 km and 112°C at 45 km. Fortunately, this temperature is within the range of high-reliability rad-hard electronics. The thermal management system protects more sensitive components, e.g., the batteries and imaging sensor, when exposed to elevated temperatures below the cloud deck.