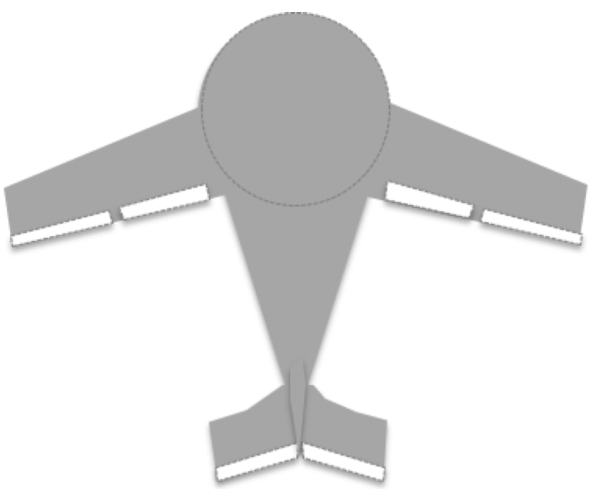
VENUS GUIDED AEROSONDE (VGA) FOR LANDING SITE RECONNAISSANCE. L. Matthies[1], J. Cutts[1], P. Tokumaru[2], and M. Pauken[1], [1]Jet Propulsion Laboratory, California Institute of Technology, [2]AeroVironment, Inc.

Introduction: The Venus highlands or tesserae are potentially important to study with a lander to gain insight into the early geologic history of the planet, including potential for there to have been abundant magmatic water[1]. However, these areas are very rough, and currently available remote sensing data is inadequate for identifying safe landing sites. The VGA concept extends previous Venus dropsonde concepts by adding a precise terrain-relative navigation capability, followed by a low-altitude, shallow glide to obtain high-resolution images and 3-D mapping data to scout potential landing sights.

Prior work: In the 1990s, a Venus Dropsonde concept was explored[2] that deployed an unguided vehicle from a balloon in the "temperate zone" of the Venus atmosphere at 55 km altitude. The Dropsonde fell rapidly to the surface of Venus, deployed a parachute a few kilometers above the surface, and acquired images over 10s of minutes covering on the order of 1 km^2 at < 1 m/pixel resolution.



VGA Guidance, Navigation, and Control: Imaging through the atmosphere of Venus is impaired by a thick layer of clouds and haze between 48 and 65 km altitude and by Rayleight scattering and gaseous absorption in the dense lower atmosphere. However, images of the surface can be obtained at a wavelength of about 1 μm with adequate quality for mapping from on the order of 1 km altitude and for navigation from altitudes of 10 to 20 km during the day and 30 to 50 km at night[3]. Radar images of the surface are available from the Magellan mission with resolutions better than 100 m over 98% of the planet.

In principle, onboard registration of optical images from the aerosonde to Magellan radar images can be used to initialize the position of the aerosonde once it gets through the cloud deck and to establish a target site for low-altitude, high resolution imaging. Registration of additional images during fast descent could be used to update the aerosonde position to navigate to the target. Registration of highly disparate imaging sensor modalities is done in medical imaging and Earth remote sensing with measures of the mutual information between patches from the two images to be registered. Proof-of-principle experiments have been done to apply this technique to navigating a balloon in the atmosphere of Titan by registering visible images from the balloon to radar or near-infrared images from an orbiter[4]. Inclusion of an IMU in the navigation system would enable smooth trajectory estimation and control between epochs of image registration. Guidance to within 1 km of the target should be possible. Similar techniques could be used on a later mission to guidance lander to a landing site chosen with aerosonde data.

An airplane-like airframe would provide control surfaces for steering during a steeply diving, rapid descent and for leveling out and steering for low-altitude imaging. A pressure vessel in the nose would house avionics, one or two cameras, and a radio to communicate images and state data to the balloon for relay to Earth. H_2O-NH_3 phase change material would extend lifetime by intercepting heat flow into the probe.

References: [1] *Vision and Voyages for Planetary Science in the Decade 2013-2022*. [2] Cutts, J. et al. (1999) *AIAA Balloon Technology Conference*. [3] Moroz, V. I. (2002) *Planetary and Space Science, 50*, 287-297. [4] Ansar, A. and Matthies, L. (2009) *IEEE/RSJ Int'l Conf. Intelligent Robots and Systems*.