VENUS AERIAL PLATFORMS STUDY: J. A. Cutts[1] and Venus Aerial Platform Study Team, [1]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive Pasadena, CA 91109, James.A.Cutts@jpl.nasa.gov.

Introduction: The Venus Aerial Platform Study has been assessing the technologies for exploring Venus with aerial vehicles in order to develop a Venus Aerial Platform Roadmap for the future exploration of the planet. Two Study Team meetings were conducted in May and December of 2017. The first Study Team meeting in May addressed the scientific opportunities offered by aerial platforms at Venus, their operating environments, and a technical review of possible aerial platforms. The second meeting in December addressed the technologies needed for operating in the severe Venus environment. Here we focused on the technologies needed to fully exploit the potential of aerial platforms capable of operating in the altitude range 45 km to 65 km.

Key Aerial Platform Technologies: Beyond the technologies of achieving mobility in a planetary atmosphere, other key capabilities are localization of the platform, communications of data, and instrumentation.

Localization: Determining the position of the vehicle is critical to operation of the mission and to acquisitions of certain types of scientific information such as the magnitude and time variation of zonal and meridional winds. When the platform is on the Earth-facing side of Venus, extremely accurate measurements of position and velocity can be made with the Very Long Baseline measurements. A constellation of CubeSats in orbit at Venus can provide comparable information for the side of Venus facing away from the Earth and can reduce the use of ground assets through the mission.

Communications: Transmitting data from the aerial platform to Earth is also critical. Transmission directly to Earth is only practical when the aerial platform is on the Earth-facing side of the planet. Even then, this is not an efficient approach in terms the power consumed on the platform as well as the DSN antenna time that must be dedicated to data transfer. Orbital relay is an alternative, and a SmallSat in a near circular orbit can provide a substantial enhancement in data return. Trade studies indicating dependence of data return on orbital parameters were examined. This indicated that aerial platforms inserted in the equatorial regions will remain near the equator indefinitely. A complementary vehicle in a high-inclination orbit would support communication with aerial vehicles, if they drift to high latitudes. However, solar-powered aerial platforms will have limited lifetimes at latitudes more than 70° from the equator.

Instrumentation: The limited payload mass of aerial platforms of 10 to 20 kg means that instruments that are or can be miniaturized define the science that can be performed. For investigating the physics and chemistry of the atmosphere, a range of mass spectrometers, tunable diode spectrometers and nephelometers will make it possible to characterize both the active gases and the haze and cloud particles that constitute the atmosphere. For investigating the crusts and interior, a range of infrasound and electromagnetic techniques are also feasible. The capabilities of these different instrument capabilities for meeting VEXAG's Venus exploration science goals was examined.

Venus Aerial Platform Implementations – Implementations concepts range from Fixed Altitude Balloons, Variable Altitude Balloons, Solar Aircraft, and Hybrid Airships. The Fixed Altitude Balloon like the Russian VeGa balloons, operating at 55 km would be the lowest risk option. More science would be accomplished by Variable Altitude Balloons implemented via bellows or phase-change techniques. The Solar Airplane and the Hybrid Airship would provide 3-D control, but with significant increases in coat and complexity. Variable Altitude Balloons occupy a "sweet spot" with enhanced science return at a modest increase in cost and risk.

Next Steps: NASA and VEXAG have commissioned a parallel Venus Lander Platform Study that addresses current science objectives and the state of the technology for exploring Venus' surface with lander and probes and how additional technical capabilities could enable new science objectives. Both studies will enable a development of the updated VEXAG Roadmap and Technology Plan and for the future exploration of the Venus that will be addressed in a Venus Flagship Mission Study as well as white papers for the next Planetary Decadal Survey.

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