Venus Atmospheric Maneuverable Platform (VAMP) – Pathfinder Concepts.

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Introduction: Northrop Grumman Aerospace Systems has been developing an innovative and versatile new class of vehicle that will serve as an atmospheric rover for exploration of planets and moons of the solar system that have atmospheres. The new class of vehicle is called Lifting Entry Atmospheric Flight (LEAF), which provides a new way to enter an atmosphere from space and transition to flight within the atmosphere. Additionally, the LEAF system is semi-buoyant and the on-board propulsion system provides the capability to adjust altitude on command and travel in specified directions. It is also robust to failures since it can safely float at full buoyancy should it lose power. The LEAF system further reduces mission risk by deploying prior to entry at a relatively slow pace and gently enters the atmosphere; thereby easing "eight minutes of terror" into "30 minutes of trepidation." Moreover, the omission of a heavy aeroshell and the gentle nature of atmospheric entry enable the vehicle to accommodate a large science payload mass, which maximizes the science that can be achieved with LEAF.

A planet well-suited for exploration with a system such as LEAF is Venus. Our Venus atmospheric rover is called Venus Atmospheric Maneuverable Platform (VAMP). Over the past several years, we have been developing the VAMP concept that supports the VEXAG Goals Objectives and Investigations (GOIs) I and III [1]. In 2015, we formulated low risk VAMP pathfinder concepts that are analogous to the Mars Rovers development.

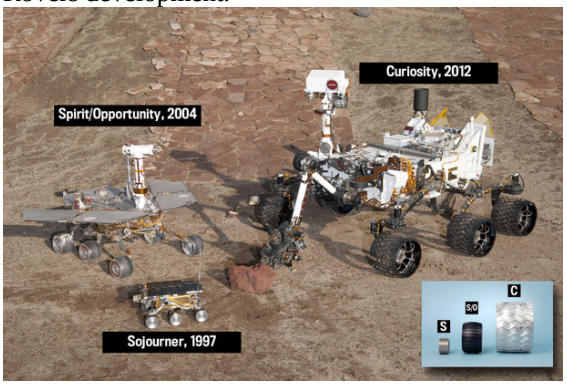

Figure 1. Mars Rover Evolution [Image Credit: NASA]

Just as the Mars Rovers started with the small, less capable Sojourner (11.5 kg mass and 30 sols designed lifetime) [2], to the more capable Spirit/Opportunity (174 kg and 1 km intended driving distance) [3], and ultimately to the current Curiosity (900 kg and 19 km intended driving distance) [3], the Venus atmospheric rover can be developed starting with a small rover that would validate technology and concepts of operation, to larger, more capable atmospheric science platforms as shown in Figure 2.

	Low Altitude (Small)	Mid Altitude (Mid-Size)	High Altitude (Large)
Float Alt	48 km	50 km	52 km
Minimum Power	100 w (day); 20 w (night)	300 w (day); 100 w (night)	8,000 w (day); 100 w (night)
Wing Span	6 m	30 m	59 m
Mass	90 kg including instruments	450 kg incl. 10 kg of instruments	880 kg incl. 50 kg of instruments
Tech	• Simple inflation-based deployment • TPS material for lifting entry • Sulfuric acid resistant skin material	• Mechanical plus inflation-based deployment • Autonomous navigation and hazard avoidance • Enhanced night time power • Limited propulsion capability	Next generation versions of pathfinder technologies

Figure 2. Low Risk VAMP Concepts

In this presentation we provide an update on the air vehicle design and plans for analyses and prototyping to advance and refine the concept. More specifically, we discuss various VAMP configurations and atmospheric science operations, including potential instruments and traceability to the VEXAG GOIs. Additionally, we discuss how the low risk (i.e., small and mid-size rovers) can complement other Venus missions.

References:

[1] Herrick, R. et al. (2014) *Goals, Objectives, and Investigations for Venus Exploration*. [2] Wilcox, B. and Nguyen, T., (1998) *SAE Technical Paper* 981695. [3] Watson, T. (2008) *USA Today 2008-4-14*.