Venus Flyer

Lifting entry could enable airborne exploration of other planetary bodies

NORTHROP GRUMMAN

VAMP would deploy inflatably and mechanically, then fly on solar power.

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A different way to enter a planet's atmosphere is behind Northrop Grumman's concept for a flying "rover" able to coast through the clouds of Venus for up to a year collecting atmospheric data.

A semibuoyant flying wing, the proposed Venus Atmospheric Maneuverable Platform (VAMP) is the first in a possible family of vehicles exploiting the lifting entry/atmospheric flight (LEAF) concept. VAMP is being explored as a potential candidate for a future NASA mission.

"This is a different approach to getting inside a planet's atmosphere and is based on an idea from the 1960s for returning an astronaut from orbit in an emergency," says Ron Polidan, manager of science systems at Northrop Grumman Aerospace Systems.

As the acronym suggests, LEAF involves drifting down from space "like a leaf from a tree." Instead of a high-speed atmospheric entry by a small, heavy craft protected by a heat shield, "if we have a big fluffy light thing it slows down fast, does not get very hot and there is not a lot of stress," he says.

"If you imagine throwing an air mattress into the atmosphere, it would slow very quickly. We have shaped that mattress into a very large, very lightweight aircraft," Polidan says. "And it is a lifting surface, so it further reduces heating and g-loading by using its lift capacity to fly into the atmosphere."

The LEAF approach could be used to enter the atmospheres of Mars, Titan or Earth, but Venus is an attractive first application because it has a dense atmosphere, which, in the upper cloud layer where the VAMP would operate, "is not far removed from Earth's," he says, adding, "we would not deep dive."

In Mars's thin atmosphere a LEAF vehicle would not sustain level flight, but could be used to deploy a surface lander. At Titan, the challenge is the low temperature and low sunlight for solar power. "Our focus is on Venus because it offers the most unique science opportunity," says Polidan. "Nothing else can sample the atmosphere for a long duration. Probes just rush through."

Working with deployable space systems specialist L.Garde on internal funds, Northrop is developing a core design architecture with variants for each of the four target bodies. "They have noticeable differences, but in each LEAF does the work, from lifting entry to transition to horizontal flight," he says.

This year the team plans to fly small radio-controlled prototypes, starting with 1-2-ft. scale models, then getting bigger. "We'll begin glide tests in the next month or so," says Polidan. Wind tunnel tests and, potentially, drop tests from high-altitude balloons are also in the cards. "We are working on deployment systems with L.Garde. The way we will deploy the platform is a bit different," he says, likely a hybrid of mechanical deployment of structural elements and hard surfaces with inflation. Northrop has experience with deployable structures and L.Garde with inflatable systems.

The flying wing will fully deploy in space to enable a gentle lifting entry, and use either aerobraking or a small kick motor to drop down into the planet's atmosphere. The platform will be subsonic at 95 km altitude and heating is expected to peak at 1000-1500C—"which is gentle by most standards," he says—and load factor at just over 2g. After a couple of days descending, the solar-powered propellers will deploy "and now it is a flying aircraft."

With a maximum speed of around 100 kph, VAMP "is no race car." It will be able to fight the polar winds to fly north-south, but will not use the east-west winds, Polidan says. As it is blown around Venus, the solar-powered platform will spend 3-4 days in daylight and 3-4 days in darkness, which will size the batteries, although "we are looking at novel approaches to power at night," he says.

A key feature of the design is its buoyancy, which reduces the power needed to stay aloft while increasing the ability to survive a failure. VAMP will be fully buoyant at 52-55-km altitude, where atmospheric pressure is around 1 bar, similar to Earth. "Turn on the props to give it some velocity and lift and the platform will climb at 1-1.5 kph to 65-68 km. As long as there is power it can stay there, but at that altitude it is 9% buoyant—turn off the props and it will drop down," he says.

"That's why semibuoyancy is a major advantage. If it was a true aircraft and there was a safety problem, there would be minimal time to recover. This is designed to be fault-tolerant. If there is a problem, it can float down and wait for help," Polidan says.

A potential issue for LEAF is the wider-than-expected variation in atmospheric density, experienced by Europe's Venus Express orbiter in 2006 during aerobraking. This will influence the design of the VAMP's control surfaces. "We are just starting to work with the Venus Express data to model the variability," he says. "The nice thing is that Earth densities are similar so a lot of the risk factors can be tested here."