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2014 IN REVIEW

TWO BAD DAYS
Questioning conventional wisdom after Antares, Virgin Galactic/Page 4

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Fueling exploration

by Bryan Palaszewski

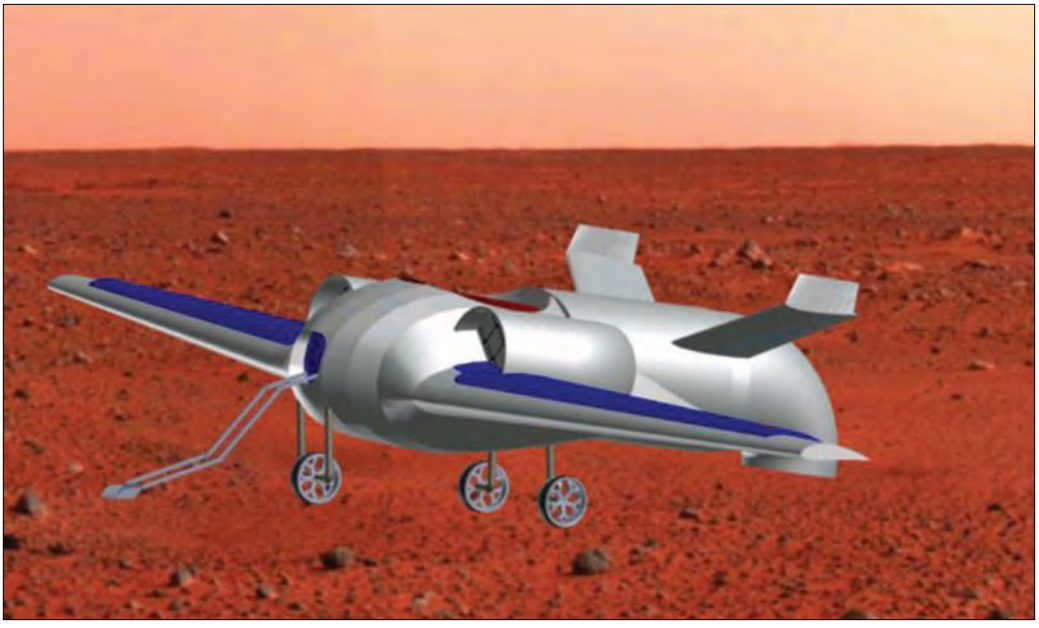
*The **Nuclear and Future Flight Propulsion Technical Committee** works to advance the implementation and design of nonchemical, high-energy propulsion systems other than electric thruster systems.*

NASA's Glenn Research Center has developed preliminary designs for robotic **aerospacecraft**, powered by gas core nuclear rocket engines, that would mine helium 3, helium 4 and hydrogen from the atmospheres of Uranus and Neptune to make fuel for smaller unmanned exploration aircraft. A study of aerial vehicle reconnaissance and exploration options was presented at AIAA Propulsion and Energy 2014 in July.

Mission analyses for the exploration vehicles assessed one-way, round-trip, multiple observations, loitering at a phenomenon of interest and other options. Unmanned aircraft designs that would accommodate both short and long missions were proposed. The times to travel between various areas of Uranus and Neptune were assessed, including distances of 10 to 90 degrees (latitude or longitude) and using aircraft velocities of 100 to 400 meters per second. For Uranus, it would take approximately 111.5 hours to traverse 90 degrees at 100 meters per second. At 400 meters per second, the travel time would be 27.9 hours. The travel times at Neptune would be slightly lower, given the planet's slightly smaller diameter. For example, at Neptune, a flight at 100 meters per second for the 90-degree traverse would be 108.1 hours; the time to traverse 90 degrees at 400 meters per second would be 27 hours.

For an unmanned aircraft observing a storm, circumnavigating the entire storm is an advantageous approach that would enable detailed studies of anomalous behavior, winds or other unique features. Time for circumnavigation of storms was computed and included a 100-kilometer standoff distance from the edge of a circular storm. At an unmanned aircraft speed of 300 meters per second, the time to circumnavigate a 0.05 Earth radius storm (319 kilometers in diameter) is just under 91 hours. These analyses suggest that there may be several avenues for using the gases of the outer planets effectively on future exploration missions. The vast reservoirs of fuels at Uranus and Neptune are more readily accessible than those at Jupiter and Saturn and, with the advent of nuclear fusion propulsion, may offer the best option for the **first practical interstellar flight**.

The University of Miami conducted a preliminary feasibility study for a proposed multimission Mars explorer craft — the Mars Aerial Nuclear Global Landing Explorer, or **MANGLE**. Using nuclear propulsion to fly in the Martian atmosphere, this aerial and land robotic system would take off and land vertically. The craft would use the planet's atmosphere, which is mostly carbon dioxide, as propellant for an air-breathing engine heated by a fission nuclear reactor based on an open Brayton cycle. To achieve vertical takeoff and landing the craft would use a lifting fan and the vectored nozzle of the engine. The engine would generate both thrust and auxiliary power. MANGLE would cruise at Mach 0.4. The engine's power requirements would be 2.1 megawatts at takeoff and landing, and 0.4 megawatts at cruise. The system's total mass would be 899 kilograms.



AIAA

This artist's rendering depicts the Mars Aerial Nuclear Global Landing Explorer taking a soil sample.

The craft's weight is low because it carries no propellant or radiator, and because of the extremely high power and energy density of nuclear fission. MANGLE's blended-wing-body design uses a co-flow jet airfoil. This innovative ultra-high-lift flow control airfoil would provide a cruise lift coefficient of 3.5 — five to 10 times greater than that of a conventional airfoil. MANGLE would not only perform a science mission to investigate the Martian atmosphere, but would also land to examine soil samples at locations of interest observed from the aerial survey.