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Budget battles, test flights, lawsuits...

2013 IN REVIEW

PREEMINENCE AT RISK
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Empowering exploration

by Bryan Palaszewski

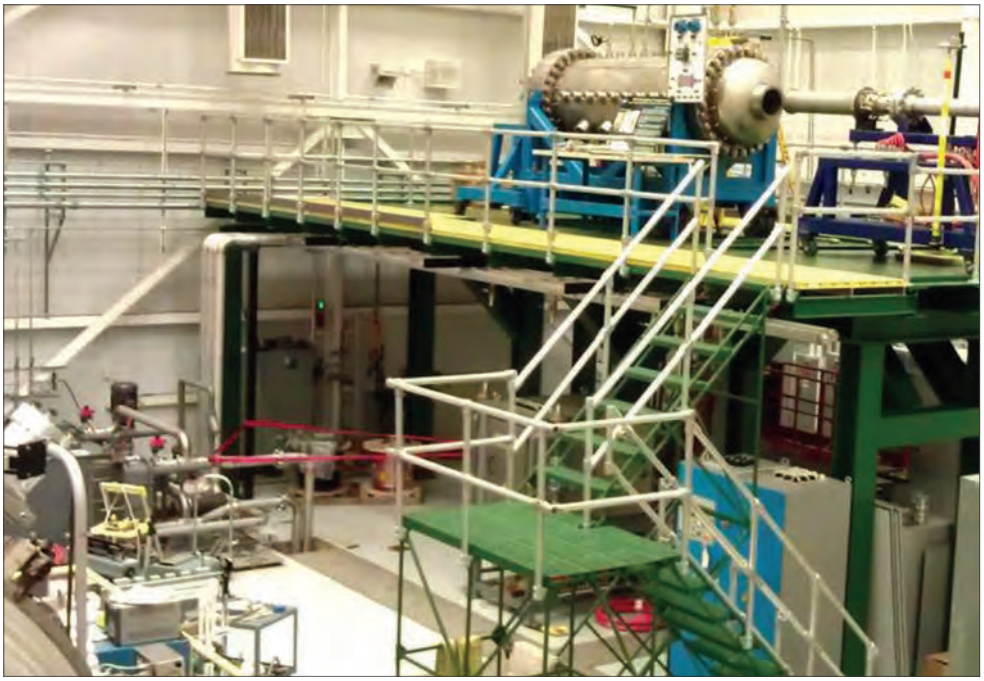
*The **Nuclear and Future Flight Propulsion Technical Committee** works to advance the implementation and design of nonchemical, high-energy propulsion systems other than electric thruster systems.*

Research at NASA Glenn investigated atmospheric mining in the outer solar system as a means of producing fuel for high-energy propulsion and power. **Fusion fuels** such as helium 3 and hydrogen could be wrested from the atmospheres of Uranus and Neptune and either returned to Earth or used in-situ for energy production or propulsion. **Helium 3** and hydrogen (also deuterium, an isotope of hydrogen) were the primary gases of interest, with hydrogen the main propellant for nuclear thermal solid core and gas core rocket-based atmospheric flight.

A series of analyses were completed to investigate the resource-capturing aspects of atmospheric mining in the outer solar system. In capturing helium 3, large amounts of hydrogen and helium (helium 4) are produced. With these two additional gases, there is potential for fueling fleets of exploration and exploitation craft. Aerospacecraft, unmanned aircraft, or rockets could fly through the outer planet atmospheres to conduct cloud formation dynamics studies, global weather observations, localized storm or other disturbance investigations, wind speed measurements, polar observations, and similar activities. Deep-diving aircraft built to withstand many atmospheres of pressure, and powered by the excess hydrogen or helium 4, could be designed to probe the higher density regions of the **gas giants**. Nuclear ramjet vehicles could use the raw atmospheric constituents and fly for long periods.

Concept studies identified several classes of probes and unmanned aircraft that could significantly augment future atmospheric exploration. Probes that use free fall or parachutes as they take data in the atmosphere, as Galileo did for Jupiter, are the first and most mature options. A more aggressive approach to probe- or aircraft-based exploration would be a rocket-assisted craft. Because it can take many hours to access the deeper parts of the atmosphere, the concept studies considered a **rocket assist** to accelerate the probe to great depths. A rocket return was also studied. Taking advantage of more traditional unmanned aircraft designs would provide many operational benefits as well. For example, remote sensing instruments on subsonic winged aircraft could provide extensive data on outer planet winds, cloud dynamics and localized atmospheric composition.

At NASA Marshall, the non-nuclear fuel element test rig called **NTREES**, or Nuclear Thermal Rocket Element Environmental Simulator, is being investigated for testing simulated reactor fuel elements to close conditions of operation, without the radiation environment. The test site is licensed to handle natural and depleted uranium. The fuel element is heated with an induction heater inside a pressure vessel with a nitrogen ambient environment. Hydrogen propellant flows through the element as in the engine, with the same flow rates and pressures. The facility was designed to handle up to 5-MW input power to test the material compatibility, thermodynamics, material properties and endurance of various fuel element designs. Designs that show acceptable test results from NTREES can then be tested in radiation environments to examine the effects.



The Nuclear Thermal Rocket Element Environmental Simulator would test reactor fuel elements. Credit: NASA.

Material issues for cermet and graphite **fuel elements** were compared at NASA Glenn. In particular, two issues in nuclear thermal fuel element performance are being studied: ductile to brittle transition in relation to crack propagation, and providing the proper orifice sizing of individual coolant channels in fuel elements. Their relevance to fuel element performance is supported by considering material properties, experimental data, and results from multidisciplinary fluid/thermal/structural simulations.

Learn more in the paper, ***"Solar System Exploration by Lunar and Outer Planet Resource Utilization"***

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