Return to Menu

Green Application for Space Power

Project Manager(s)/Lead(s)

Joel Robinson/CS10
(256) 544–3513

Sponsoring Program(s)

Space Technology Mission Directorate
Center Innovation Fund
Space Launch System Advanced Development

Project Description

Most space vehicle auxiliary power units (APUs) use hydrazine propellant for generating power. Hydrazine is a toxic, hazardous fuel that requires special safety equipment and processes for handling and loading. In recent years, there has been development of two green propellants (less toxic) that could enable their use in APUs. The Swedish government, in concert with the Swedish Space Corporation, has developed a propellant based on ammonium dinitramide (LMP-103S) that was flown on the Prisma spacecraft in 2010. The United States Air Force (USAF) has been developing a propellant based on hydroxylammonium nitrate (AF-M315E) that is scheduled to fly on the Green Propellant Infusion Mission in the spring of 2016 to demonstrate apogee and reaction control thrusters. However, no one else in the Agency is currently pursuing use of green propellants for application to the APUs. Per the TA-01 Launch Propulsion Roadmap, the Space Technology Mission Directorate had identified the need to have a green propellant APU by 2015. This is our motivation for continuing activities.

The plan proposed by NASA Marshall Space Flight Center (MSFC) is to utilize existing F-16 and Space Shuttle hardware to provide a low-cost demonstration testbed for green propellant APUs. During preparation for the TDM12 solicitation, MSFC was able to acquire a solid rocket booster gas generator and an orbiter APU residing at White Sands Test Facility that were no longer needed by the Space Launch System (SLS). Since these test assets are limited in number, a Department of Defense equivalent asset was identified. The F-16 fighter jet uses H-70 propellant (30% diluted hydrazine) for providing the plane emergency power if the pilot loses engine power. Since there have been over 4,400 F-16 planes built, there are a number of these planes that have been retired and await destruction at the Davis Monthan Air Force Base in Tucson, AZ.

The feasibility testing funded by MSFC investment was to utilize a modified version of the USAF's green propellant to decompose with the F-16 gas generator, a main component within the emergency power unit (EPU) assembly. MSFC worked closely with engineers/chemists at the Air Force Research Laboratory (AFRL), adding water content to the AF-M315E to lower anticipated combustion temperatures. AFRL mixed the propellant, performed catalyst heating tests, and provided 5 gallons of propellant to MSFC for test operations. MSFC disassembled the EPU and configured the test setup shown in figure 1. A series of 64 pulse operations were performed over the course of 2 days.

Anticipated Benefits

Demonstration of green propellant with an alternative catalyst material could lead to cost savings across the F-16 fleet and SLS booster nozzle gimballing. This testing could further be extended to testing the other green monopropellant that has matured: LMP-103S. Both leading green propellants offer not only increase performance characteristics compared to hydrazine (density and impulse) but also are less hazardous. Safety testing reveals that SCAPE (self-contained atmospheric protective ensemble) suits are not required for transport, loading, and handling of the propellant, which would lower operations costs and allow for serial operations to occur for aircraft and spacecraft preparation.

Potential Applications

Besides the F-16 EPU and the SLS booster APU, the U-2 spy plane also uses a form of hydrazine for engine restart at altitude. Given further interest, there may be the opportunity to investigate that platform as well.

Figure 1: F-16 gas generator installed at MSFC Component Development Area Test Cell.

Notable Accomplishments

MSFC recently completed feasibility testing of an F-16 EPU gas generator using a variant of the AF-M315E (higher water content). MSFC demonstrated that the gas generator can develop 300 psi of pressure. What is unique about this accomplishment is that the propellant mixture was reactive with the hydrazine catalyst material (Shell 405). With additional testing, there could be a significant cost savings and safety improvement if the F-16 System Program Office decides to implement this propellant across the vast fleet of F-16 users. Likewise, SLS may consider transitioning from hydrazine-powered APUs to a green propellant alternative.

References

MSFC 2014 Center Innovation Fund Final Report, Green Application for Space Power, J. Robinson.