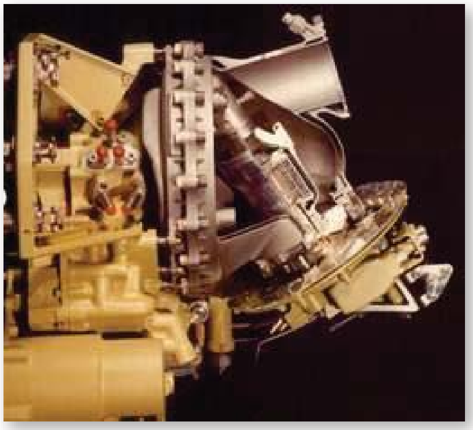
Active Project (2013 - 2014)

Green Applications For Space Power Project

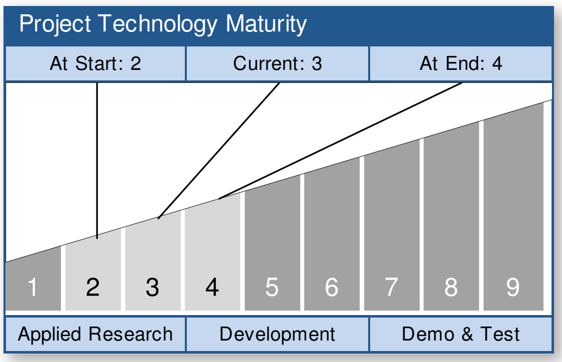
Center Innovation Fund: MSFC CIF Program

Space Technology Mission Directorate (STMD)

National Aeronautics and Space Administration



A Cutaway of the APU Used on the Shuttle Orbiter



ABSTRACT

Spacecraft propulsion and power for many decades has relied on Hydrazine monopropellant technology for auxiliary power units (APU), orbital circularization, orbit raising/lowering and attitude control. However, Hydrazine is toxic and therefore requires special ground handling procedures to ensure launch crew safety. The Swedish Company ECAPS has developed a technology based upon the propellant Ammonium Dinitramide (ADN) that offers higher performance, higher density and reduced ground handling support than Hydrazine. This blended propellant is called LMP-103S. Currently, the United States Air Force (USAF) is pursuing a technology based on Hydroxyl Ammonium Nitrate (HAN, otherwise known as AF-M315E) with industry partners Aerojet and Moog. Based on the advantages offered by these propellants, MSFC should explore powering APU's with these propellants.

Due to the availability of space hardware, the principal investigator has found a collection of USAF hardware, that will act as a surrogate, which operates on a Hydrazine derivative. The F-16 fighter jet uses H-70 or 30% diluted Hydrazine for an Emergency Power Unit (EPU) which supplies power to the plane. The PI has acquired two

...***Read more on the last page.***

Technology Area: In-Space Propulsion Technologies TA02 (Primary)
Launch Propulsion Systems TA01 (Secondary)

ANTICIPATED BENEFITS

To NASA unfunded & planned missions:

This GRASP proposal links directly to the CIF technology themes of a) advanced in-space propulsion technologies and l) small spacecraft systems and enabling technologies. For in-space applications, reducing the size of the spacecraft significantly impacts launch costs. Use of propellant that is denser than Hydrazine (>25% denser for LMP-103S, 40% for

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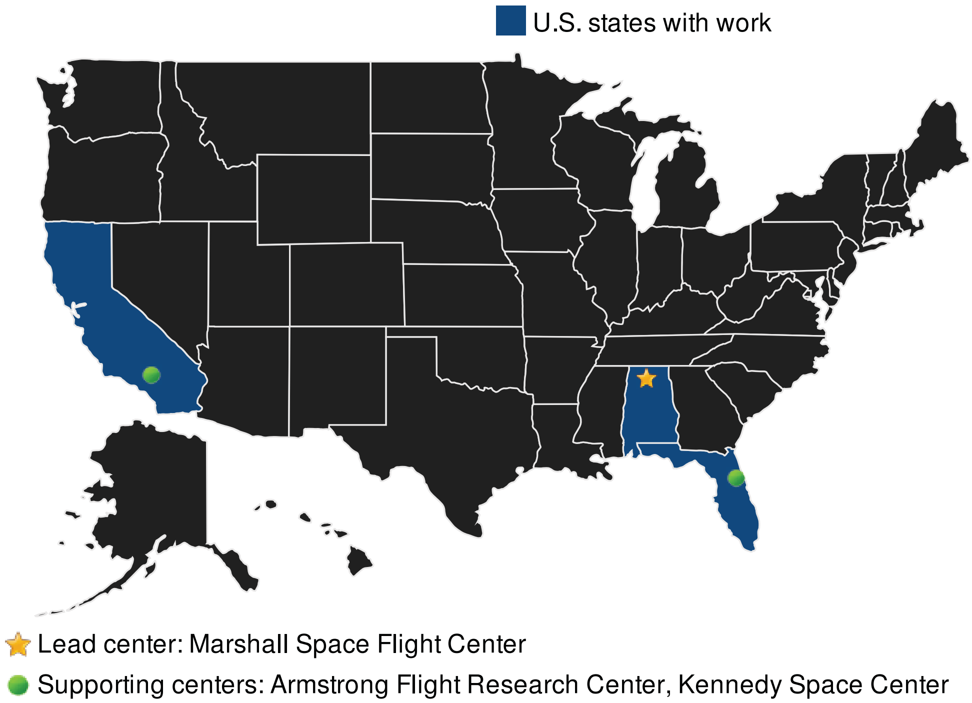
Read more on the last page.



DETAILED DESCRIPTION

A key technical difference (aside from the differences in toxicity) between Hydrazine and the green propellant alternatives is the combustion temperature. Both types of propellants are dispensed from their feed tanks through a catalyst material. The catalyst decomposes (reacts) with each propellant and creates the high temperature exhaust gases that are used to either provide thrust (in the application of a rocket engine) or to spin the turbine which provides power to an APU or EPU. Hydrazine decomposes at 900 deg C while the green propellants decompose at 1600 deg C. However, the existing H-70 catalyst (Shell 405) works best with dual-bonded nitrogen mixtures. Both ADN and HAN offer this dual-bonded feature. Although the green propellants may burn hotter with their own proprietary catalyst material, they will burn cooler with the Shell 405 product.

Additionally, both propellants are mixed with water and the water content can be increased to further reduce combustion temperatures. For this proposal, KSC will ship their green sensors (either for ADN or HAN) to MSFC and we in turn would instrument the EPU dedicated to that propellant. Following completion of one month of testing the EPU instrumented with leak detection sensors, the hardware would be shipped to DFRC for a ground test inside an F-16 aircraft. For the chosen aircraft, the existing H-70 system would be temporarily replaced with the MSFC provided green propellant EPU and the

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MANAGEMENT

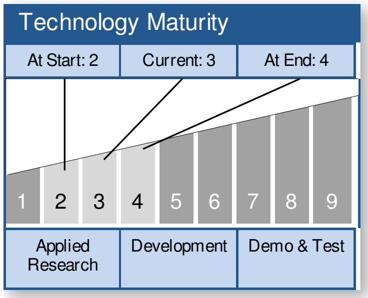
Program Manager:
John Falker

Project Manager:
Andrew Keys

Principal Investigator:
Joel Robinson

TECHNOLOGY DETAILS

Green Space Power



TECHNOLOGY DESCRIPTION

Green Space Power

This technology is categorized as a hardware assembly for manned spaceflight

- Technology Area
    - TA02 In-Space Propulsion Technologies (Primary)
    - TA01 Launch Propulsion Systems (Secondary)

CAPABILITIES PROVIDED

Propellant materials that are safer for the environment and users than current propellants

POTENTIAL APPLICATIONS

For in-space applications, reducing the size of the spacecraft significantly impacts launch costs. Use of propellant that is denser than Hydrazine (>25% denser for LMP-103S, 40% for AF-M315E) allows for spacecraft designers to use smaller tanks to contain the APU propellant, thereby decreasing dry mass. For small satellite applications (commonly known as ride share or secondary payloads), they are limited in using Hydrazine by their primary payload due to safety restrictions and risks. Besides the advantage of density, which is paramount for small satellite applications, both themes are benefited by the reduced ground handling requirements and safety features the propellants have demonstrated.

Performance Metrics		
Metric	Unit	Quantity
Propellant Density	g/cc	TBD

PROJECT LIBRARY

Images

- Image 1

  (https://techport.nasa.gov/fetchFile?objectId=3976)

ABSTRACT (CONT'D)

EPU's from planes slated for destruction at the Davis Monthan AFB.

This CIF will include a partnership with 2 other NASA Centers who are individually seeking seed funds from their respective organizations: Kennedy Space Center (KSC) and Dryden Flight Research Center (DFRC). KSC is preparing for future flights from their launch pads that will utilize green propellants and desire a low-cost testbed in which to test and calibrate new leak detection sensors. DFRC has access to F-16's which can be used by MSFC & KSC to perform a ground test that demonstrates emergency power supplied to the jet.

Neither of the green propellant alternatives have been considered nor evaluated for an APU application. Work has already been accomplished to characterize and obtain the properties of these 2 propellants. However, the spacecraft are using existing leak detection sensors that are typically used for Hydrazine. Using these green propellants for the APU application requires decrementing their TRL down to 3. This task would aim to establish a TRL of 4 at conclusion by showing a proof of concept with a KSC-instrumented EPU asset at the MSFC Component Development Area (CDA). The task to accomplish this is called Green Application for Space Power or GRASP.

ANTICIPATED BENEFITS

To NASA unfunded & planned missions: (CONT'D)

AF-M315E) allows for spacecraft designers to use smaller tanks to contain the APU propellant, thereby decreasing dry mass. For small satellite applications (commonly known as ride share or secondary payloads), they are limited in using Hydrazine by their primary payload due to safety restrictions and risks. Besides the advantage of density, which is paramount for small satellite applications, both themes are benefited by the reduced ground handling requirements and safety features the propellants have demonstrated.

To the commercial space industry:

This GRASP proposal links directly to the CIF technology themes of a) advanced in-space propulsion technologies and l) small spacecraft systems and enabling technologies. For in-space applications, reducing the size of the spacecraft significantly impacts launch costs. Use of propellant that is denser than Hydrazine (>25% denser for LMP-103S, 40% for AF-M315E) allows for spacecraft designers to use smaller tanks to contain the APU propellant, thereby decreasing dry mass. For small satellite applications (commonly known as ride share or secondary payloads), they are limited in using Hydrazine by their primary payload due to safety restrictions and risks. Besides the advantage of density, which is paramount for

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ANTICIPATED BENEFITS (CONT'D)

small satellite applications, both themes are benefited by the reduced ground handling requirements and safety features the propellants have demonstrated.

DETAILED DESCRIPTION (CONT'D)

aircraft would be suspended off the ground (jacked) to simulate an engine failure and resultant use of the EPU. The objective would be to show that the landing gear could be deployed and aero control surfaces would properly move to pilot commands.

Alternative approaches to providing power to an APU include an external gas blowdown system, a Lithium Ion battery driven motor or a thermal battery driven motor. All of these approaches have some drawbacks. An external gas blowdown system may employ the use of a stored gas, most likely Helium, to drive the APU turbine. The primary disadvantage to this system is the mass and volume required to store the compressed gas. A similar approach that would minimize the mass and volume is to use gaseous Hydrogen tapped off a liquid propellant rocket engine. However, APU checkouts would be problematic without the engine in operation. An additional system would be required to provide the gas for checkout purposes. In addition, future launch system elements may not have direct access to the liquid rocket engine and would require a disconnect for staging adding to its complexity. Lithium Ion batteries require many cells that must be matched which drive the weight and costs. The disadvantage of thermal batteries lies in its operation or turnaround. For APU checkouts, an external power source is required and in the event of a launch abort or scrub, these batteries must be replaced. These green propellants provide a high power density packaged power source that can be started multiple times with minimal effects on turnaround from issues presented. In addition, this propellant could not only provide a propellant source for APU’s but also launch vehicle roll control.