NASA Facts

National Aeronautics and
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Marshall Space Flight Center
Huntsville, Alabama 35812

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Next Generation Propulsion Technology:

Integrated Powerhead Demonstrator

NASA, the U.S. Air Force and leading aerospace industry contractors have joined forces to develop the Integrated Powerhead Demonstrator, a risk-reduction effort to develop engine technologies that could, within decades, power the next generation of America's space fleet.

The Integrated Powerhead Demonstrator, or IPD, is a joint venture between NASA's Exploration Systems Mission Directorate, managed for the Agency at the Marshall Space Flight Center in Huntsville, Ala., and the Integrated High Payoff Rocket Propulsion Technologies (IHPRPT) program, managed for the Department of Defense by the U.S. Air Force Research Laboratory at Edwards Air Force Base, Calif.

The project is the first phase of the Integrated High Payoff Rocket Propulsion Technologies program's effort to develop a flight-rated, full-flow, hydrogen-fueled, staged-combustion rocket engine in the 250,000-pound thrust class. This would be the first engine of its kind, capable of doubling the performance of state-of-the-art booster engines. The Integrated Powerhead Demonstrator engine will employ dual preburners that provide both oxygen-rich and hydrogen-rich gases for the staged combustion engine. This innovative approach is expected to keep critical components of future engines cooler during flight, achieving better reliability and improved safety.

The project is intended to address two major technological challenges -- turbine life and bearing wear -- that traditionally have limited performance among rocket engines. By sending all of the propellant flow through the turbine, the same amount of energy can be extracted with a lower-temperature gas -- thus reducing the likelihood of material fatigue caused by sustained high temperatures.

The high-performance turbomachinery of the demonstrator also will include hydrostatic bearings that fully support the rotor of both the fuel and oxidizer pump. Because the hydrostatic bearings actually cause the rotor to float on a layer of liquid during operation, bearing wear only occurs for a few seconds during engine startup and shutdown. Rocket turbomachinery, in comparison, typically uses ball bearings or roller bearings, which rub continuously whenever the rotor is spinning. Minimizing operational contact eliminates bearing wear as a major life-limiting factor for the turbomachinery.

Unique component technologies

The Integrated Powerhead Demonstrator's liquid-hydrogen fuel turbopump is designed to raise the pressure of hydrogen entering the rocket engine above the pressure in the thrust chamber. The turbopump extracts energy from the hot gases flowing through the turbine, causing the turbopump rotor to spin very rapidly. As it spins, an impeller -- a rotating device used to force fluid in a desired direction -- attached to the other end of the shaft pumps the hydrogen to pressures greater than 5,000 pounds per square inch.

Developed for NASA and the Air Force by the Boeing Company's Rocketdyne Propulsion and Power Division of Canoga Park, Calif., the turbopump's design addresses key life limitations common to the Space Shuttle main engine. In comparison, the Shuttle main engine turbomachinery requires maintenance and refurbishment after 10 flights; the Integrated Powerhead Demonstrator engine is intended to fly 100 times between maintenance periods. Engineers also are seeking development of a 200-mission lifespan for the new engine – more than double that of the Shuttle main engine.

Boeing-Rocketdyne also is responsible for development and testing of the demonstrator's oxygen pump, main injector and main combustion chamber.

Developed and tested for NASA and the Air Force by Aerojet Corp. of Sacramento, Calif., the oxidizer preburner -- which initiates the combustion process -- is designed to generate oxygen-rich steam for use by the oxygen turbopump's turbine. The preburner burns a large quantity of liquid oxygen with a small quantity of hydrogen to produce this steam, which then mixes with additional hydrogen fuel to be burned in the main combustion chamber.

The oxidizer preburner is the first flight-capable, oxygen-rich preburner developed in the United States for a large-scale engine. The Space Shuttle main engine makes use of a preburner that generates hydrogen-rich steam -- the only American rocket engine to do so. But whereas the Shuttle main engine burns only a small amount of oxygen prior to entry into the main combustion chamber, all the oxygen used in the demonstrator engine system will be sent through the preburner.

The use of oxygen-rich steam to power the demonstrator's oxygen turbopump is intended to dramatically increase safety of engine system operation, limiting seal failure between the pump and the turbine that could leak extremely hot gases into the turbine and cause them to burn prematurely.

Aerojet also is responsible for development of the demonstrator engine's fuel preburner, designed to supply the fuel turbopump's turbine with hot, hydrogen-rich steam. The Aerojet team also has designed, fabricated and tested the channel wall nozzle, a component that directs the rocket engine's exhaust.

Boeing-Rocketdyne will lead overall system integration for NASA once component-level development and testing is complete. Integrated system testing of the demonstrator is scheduled to begin in 2005.

More about the project

The Integrated Powerhead Demonstrator is a cornerstone of the Integrated High Payoff Rocket Propulsion Technologies program, which seeks to double the performance and capability of today's state-of-the-art rocket propulsion systems while decreasing costs associated with military and commercial access to space. The intended full-flow engine cycle is a key component in achieving this goal.

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