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The drive to Mach 5

Lewis pushes technology toward hypersonic flight

By Kristin K. Wilson

PUSHING an aircraft engine beyond its performance limitations is a risky proposition. For a team of researchers at NASA Lewis, going to such extremes is all in a day's work.

The team recently completed a series of tests inside the Center's Propulsion Systems Laboratory (PSL) to evaluate the operability of a General Electric J85-21 turbojet engine run at Mach 3, 1-1/2 times faster than its maximum flight speed of Mach 2.

The tests were part of an overall program, supported by NASA's Hypersonics Office, to develop a turbine-based combined-cycle (TBCC) propulsion concept that may one day propel aircraft and spacecraft from take-off to hypersonic speeds of more than 5 times the speed of sound. To put this in perspective, the SR-71 "Blackbird," considered the fastest operational aircraft, has a recorded top speed of 2,193 miles per hour or approximately three times the speed of sound. The NASA Lewis concept could revolutionize high performance aircraft and ultimately make space exploration more affordable by using air-breathing propulsion.

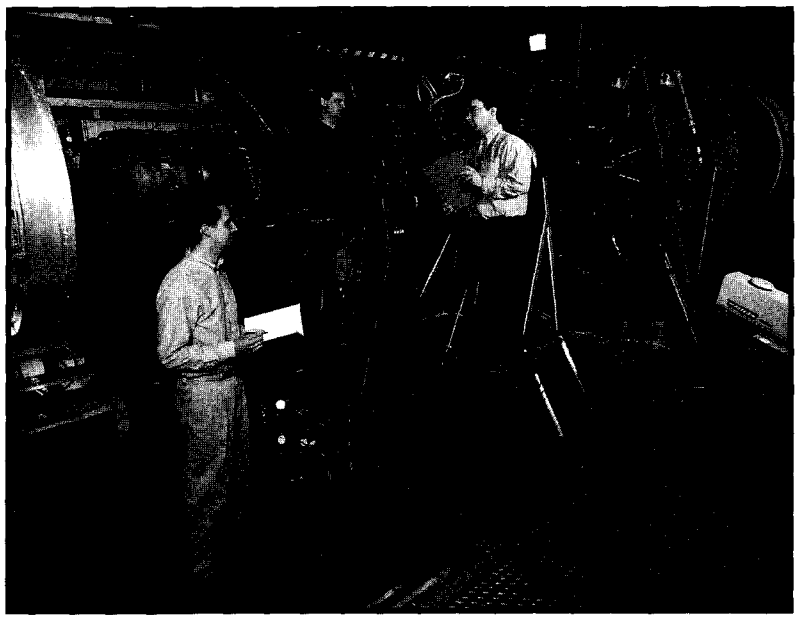

Photo by Tom Jares

James Walker (left), Rick Sorge (center), and Scott Thomas perform a final check of the J85-21 engine prior to testing inside NASA Lewis' Propulsion Systems Laboratory.

"Combined cycle systems represent a major breakthrough in propulsion technology," said NASA Lewis task manager James Walker, Engine Systems Technology Branch. "In practice, an air-breathing propulsion system such as TBCC may one day lower the high launch costs associated with rocket-powered space vehicles. It's an ideal candidate for a hypersonic cruise vehicle or the first stage of a two-stage-to-orbit launch vehicle."

Combined cycle systems integrate two or more different engine types into a single propulsion system to enhance operating capability. Practical designs, however, must minimize redundancy and mechanical complexity to reduce the size, weight, and overall cost of the propulsion system. The focus of the NASA Lewis program is to combine a currently available turbine engine with a ramjet flowpath to provide the required performance for hypersonic flight.

An air-breathing system of this type is designed to function in several different modes to propel a vehicle from take-off to hypersonic speeds. First the turbine engine operates without the ramjet at take-off and subsonic speeds. Then the ramjet flowpath is opened at approximately the sonic speed to permit additional air through the propulsion system. The two engines operate simultaneously up to about Mach 3. Such speeds are considered the limit of current state-of-the-art turbine engines

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ISO 9000—Ready or not, it's coming to Lewis

THE time has come to get serious about the implementation of ISO 9000 and a first rate business management system at NASA Lewis.

We are T - 436 days and counting from July 12, 1999. That's the day Det Norske Veritas, our registering body, will visit NASA Lewis to test us and our new business management system. Passing this rigorous exam will represent the first step towards improving our business management and our image as a world-class research and technology organization.

Implementing an improved business management system, as opposed to ISO 9000 alone, will not be easy. Based on the Center's analysis of its

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PSL puts hypersonic component to the test

Photo by Tom Jares

Engineers and technicians run a test of the J85-21 engine from the control room at the Power Systems Laboratory.

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and the point where ramjets can produce sufficient performance to accelerate the vehicle up to hypersonic speeds. Past Mach 3, the turbine engine is shut down and isolated from the flow path to protect it from the extreme air temperatures experienced at higher flight speeds.

On location at PSL—the only NASA ground test facility capable of providing true altitude simulation for the direct connect testing of full-scale, air-breathing gas turbine engines—the J85-21 turbojet was put to the test up to Mach 3. The J85-21's high thrust-to-weight ratio and small size makes it ideal for TBCC demonstration tests including ground-based experiments and potentially X-Vehicle flight validation. The main challenge facing NASA Lewis engineers and technicians was to extend the operating envelope of the engine past its originally designed flight speed of Mach 2.

With assistance from General Electric, the NASA Lewis team identified water injection as a low cost method to increase the maximum flight speed of the engine and improve engine thrust.

The new water injection system installed at PSL incorporates commercial spray nozzles to inject atomized water upstream of the engine to promote evaporation. The evaporation process cools the air prior to it reaching critical parts of the engine, enabling the engine to operate at Mach 3. In addition, the engine can accept more air flow to produce greater thrust because of the higher air density corresponding with the lower air temperatures.

"We're extremely pleased with the results of the tests," Walker said. "Rick Sorge, the lead test engineer, and the PSL team have done an excellent job designing and implementing the new systems necessary to successfully complete the tests."

As the program progresses, many of NASA Lewis' key research facilities will be used for critical testing. In the Engine Components Research Laboratory, sub-scale tests of the integrated engine system will evaluate system performance. In addition, the Inlet Technology Branch identified inlet technology that would require the use of the 1x1 and 10x10 supersonic wind tunnels for validation testing. The final phase of the technology program includes full-scale tests in PSL and/or the 10x10 supersonic wind tunnel where the complete TBCC propulsion system would be demonstrated with the use of the J85-21 turbojet engine. ●

Editor's Note: *The TBCC concept is part of NASA Lewis' Aero Base R&T Hybrid Hyperspeed Propulsion (HHP) project. The primary emphasis of the project is ejector-ramjets, known to most of us as Rocket-Based Combined-Cycle (RBCC). The Center has been seriously investigating these types of systems since late 1994, and the RBCC air-breathing propulsion idea is the centerpiece of NASA Lewis' Trailblazer project within HHP.*