

Innovation

Air Force SBIR/STTR Innovation Story

SBIR Topic Number:

AF04-288

SBIR Title:

Innovative Thermal Barrier Coating (TBC) Blade Imaging System for Surface Temperature Mapping

Contract Number:

FA9101-05-M-0036

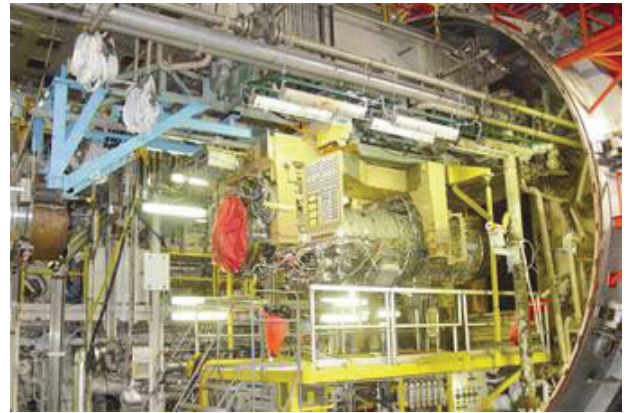
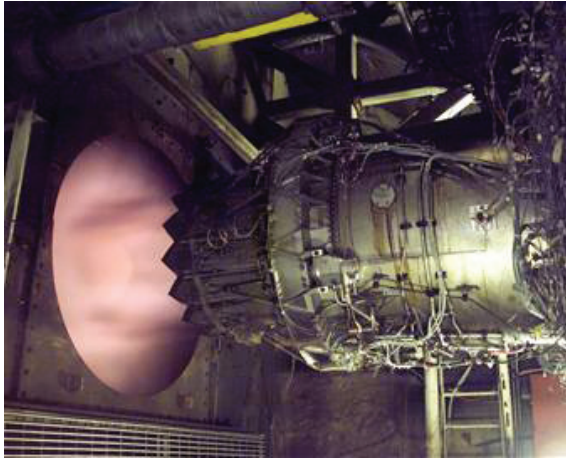
SBIR Company Name:

Advanced Fuel Research, Inc. (AFR), East Hartford, CT

Technical Project Office:

Arnold Engineering Development Center (AEDC), Arnold AFB, TN

This Air Force SBIR/STTR Innovation Story is an example of Air Force supported SBIR/STTR technology that met topic requirements and has outstanding potential for Air Force and DoD.



Engine testing at AEDC

Innovative Thermal Barrier Coating (TBC) Imaging System

- Air Force required a new sensing capability be developed to map and monitor the surface temperature and health of ceramic TBC on first stage turbine blades during engine testing
- SBIR project led to development of a long wavelength infrared (LWIR) optical system to capture on-engine thermal images of high-speed TBC turbine blades
- Project success was result of collaborative efforts of AEDC, Pratt & Whitney, and AFR
- Advanced fighter jet engines that implement TBC to protect metal turbine blades can run hotter for more thrust and improved performance

AEDC/2007-116

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Air Force Requirement

Aircraft gas turbine engines for the development of the nation's most vital aerospace weapons systems are tested in the Engine Test Facility (ETF) of the Arnold Engineering Development Center (AEDC) at Arnold Air Force Base, Tennessee. Sensors that monitor critical engine parts are essential during advanced engine tests in the ETF.

In this SBIR project, the Air Force required a new sensing capability to be developed to map and monitor the surface temperature and health of ceramic thermal barrier coating (TBC) on first stage turbine blades during engine testing. TBC is a vital component of advanced engines under development for protecting the metal alloy turbine blades from the extreme combustion temperature. TBC must be proven as a reliable means to prevent blade failure. The Air Force requires the following for the new on-engine sensor:

- Whole blade thermal map spatial resolution of less than 0.125 inches
- Non-intrusive; no wires or paints to put on blades
- Image integration time no longer than 1 microsecond
- TBC temperature accuracy goal per turbine revolution +/- 10 deg F (+/- 5.5 deg C) to above 2200 deg F (1204 deg C) to 2500 deg F (1371 deg C)
- Real-time diagnostic of cooling schemes of TBC blades
- Flag potential loss of TBC during engine operation
- Self-monitoring for maintaining calibration
- Compatible with a current on-engine probe and access port

Without this measurement capability, AEDC test engineers and engine manufacturers have no early warning of TBC conditions that may lead to a complete blade failure. Shut-down of a test engine before a catastrophic failure occurs has an enormous impact on minimizing both engine repair costs and delay to the test schedule.

SBIR/STTR Technology

Under a previous Air Force SBIR project (contract number F40600-90-C-0022), Advanced Fuel Research, Inc. (AFR) developed and delivered an innovative optical bench top instrument to AEDC for measuring the thermal spectral properties of TBC and other materials at high temperatures. Laboratory measurements on TBC samples supplied key information to the current project developing a long wavelength infrared (LWIR) optical system to capture on-engine images of high-speed TBC turbine blades to meet the Air Force specifications listed above.

Early work produced a LWIR lens system within the dimensional constraints of a Pratt & Whitney (P&W) turbine-case-mounted probe. When coupled to a LWIR focal plane array, whole-blade imaging of torch-heated parts in the laboratory were successful for demonstrating thermal-mapping capability and for distinguishing TBC defects.

The advanced sensor now in development for on-engine use includes custom LWIR optics integrated into a P&W engine probe for obtaining temperature maps of both sides of in-service TBC blades. The high performance thermal imaging camera provides the short sampling period needed to capture fast-moving TBC blades. Important temperature and condition information will be provided for both sides of each TBC blade on the turbine wheel.

Potential Air Force Application

Advanced fighter jet engines that successfully implement TBC to protect metal turbine blades can run hotter for more thrust and improved performance, thus providing an advantage to the war fighter. The Phase II deliverable supplies the Air Force with a truly unique measurement capability to validate and optimize operational specifications for TBC performance and survivability during flight simulation testing at AEDC. The innovative TBC blade imaging system for surface temperature mapping will provide essential data to expedite advanced engine development programs, and accordingly help to bring new, high performance propulsion engines to bear for national security.

Company Impact

AFR's prior commercialization successes resulting from its involvement in the SBIR program include creating spin-off companies that manufacture and sell products, licensing of software and patents, and providing unique measurement services and equipment. AFR today supplies contract research, product development and analytical services to industrial, government, and academic clients throughout the world.

Projects that are to result in on-board sensors for developmental aircraft jet engines are particularly challenging since subjecting the engine to new risk is intolerable. The sensor must add value without compromising engine performance or test objectives. As result of the collaborative efforts of AEDC, P&W, and AFR, on-engine demonstration of the new measurement capability was possible. P&W provided proven on-engine hardware for securing the new system, and valuable guidance during design, development and testing.

James R. Markham, CEO
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SBIR/STTR

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