



# Innovation

**SBIR Topic Number:**  
AF03-257

**SBIR Title:**  
Non-intrusive Optical  
Smoke Meter for Turbine  
Engines

**Contract Number:**  
FA9101-04-C-0034

**SBIR Company Name:**  
Advanced Fuel Research,  
Inc., East Hartford, CT

**Technical Project Office:**  
Arnold Engineering  
Development Center,  
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.



**Air Force engines require modern technology for accurate smoke measurements. The clean burning F-22 Raptor engine was first ground tested at AEDC, sponsor of this SBIR project.**

## Real-Time Optical Smoke Monitoring System Helps Minimize Exhaust Signatures in Jet Engine Development

- Future jet fighters need to burn fuel cleanly in order to minimize both jet engine exhaust signature and environmental pollution
- This monitoring system will assist in advanced engine development programs such as the F135, F119, VAATE, and IHPTET
- The technology developed under this SBIR program utilized a low-power visible laser beam in a new, fast, and efficient method for monitoring exhaust gas smoke
- Other applications include the commercial aircraft engine, electric power generation, heavy-duty diesel engine, and fire early-warning/prevention industries

2008-232

**A**

DISTRIBUTION A:  
Approved for public  
release; distribution  
unlimited.

## Air Force Requirement

The U.S. Air Force requires future fighter jet engines to burn fuel cleanly in order to minimize pollution released into the atmosphere and also to minimize exhaust signatures that could be detected by enemy surveillance. Therefore, the Air Force pays particular attention to the measurement of smoke particles in the exhaust of new fighter jet engines under development. The traditional industry-accepted practice to measure the level of exhaust smoke is a time-consuming, labor-intensive method that requires the use of an extractive probe, sample lines, flow rate measurement apparatus, smoke collection apparatus, filter paper and an optical reflectometer in order to produce a measurement. Consequently, the Air Force needs a new, faster and more efficient method for measuring smoke since: 1) the traditional practice has a high total cost due to the combined cost of test facility operation, test apparatus, fuel usage, engine wear, and labor required; and 2) the traditional practice has limited accuracy for smoke measurements in advanced clean burning engines being developed for the future fighter force.

## SBIR Technology

Under this Air Force SBIR program, Advanced Fuel Research, Inc. (AFR) developed and demonstrated an optical system for measuring engine smoke that provides real-time data while requiring very little operator attention. This technology monitors the extinction (attenuation) of a low-power visible laser beam directed at a photon detector located on the opposite side of the engine exhaust. When jet exhaust passes through the beam, the smoke particles absorb and scatter a portion of the light resulting in a reduction of photons at the detector. The amount of light extinction measured may be related to the particulate level in the exhaust gas stream. Judicious design has resulted in a smoke measurement system that meets performance goals for operational stability, smoke sensitivity, and insusceptibility to gaseous exhaust interference. This SBIR-developed technology has been demonstrated to provide the needed improvements in precision, sensitivity, and measurement time as compared to the traditional practice of collecting smoke on filter paper for subsequent off-line measurement.

## Potential Air Force Application

The new smoke monitoring system provides benefit to advanced fighter engine development programs such as the F135 (used in the F-35 Joint Strike Fighter), the F119 (used in the F/A-22 Raptor), the Versatile Affordable Advanced Turbine Engines (VAATE) program, and the Integrated High Performance Turbine Engine Technology (IHPTET) program. Advanced engine development testing can be carried out with assurance that smoke levels are being monitored efficiently and accurately with state-of-the-art technology to ensure that these engines meet low emission and surveillance signature goals.

## Company Impact

Under a previous Air Force SBIR program, AFR had been focused on technology development for the rapid, continuous measurements of gas-phase species in jet engine exhaust. That previous work resulted in multiple units of an optical-based product being delivered to the Air Force. This product was commercialized by an AFR spin-off company that was subsequently bought by a large U.S. sensor manufacturing company. The opportunity provided by this current Air Force SBIR program has allowed AFR to expand its technology base in optical diagnostics and measurements. Future product development applications are envisioned in the commercial aircraft engine industry, the electric power generation industry, the heavy-duty diesel engine industry, and the fire early-warning/prevention industry.



# SBIR/STTR

Air Force SBIR Program  
AFRL/XP  
1864 4th Street  
Wright-Patterson AFB OH 45433

AF SBIR/STTR Program Manager: Augustine Vu  
Website: [www.sbirsttrmall.com](http://www.sbirsttrmall.com)  
Comm: (800) 222-0336  
Fax: (937) 255-2219  
e-mail: [afrl.xppn.dl.sbir.hq@wpafb.af.mil](mailto:afrl.xppn.dl.sbir.hq@wpafb.af.mil)

