Topic: N161-011

Prime Photonics, LC

Turbomachinery Distortion Characterization by Non-intrusive Measurement Methods
Filtered Rayleigh Scattering (FRS) provides a completely nonintrusive method of full annulus airflow characterization. It uniquely characterizes pressure, density and temperature as well as provides flow speed and angle. During engine operations, complex distortion profiles that cannot be mimicked in a ground test environment are experienced. There is currently no method of characterizing these profiles. FRS, once fully mature, will fill this technology gap as well as enhance ground test measurements. Unlike other current techniques, FRS proposes no obstruction to the flow nor introduce particles into the flow. The target initial platform for this technology is an advanced fighter aircraft. During the Phase I, mean velocity, temperature and pressure measurements were resolved to within acceptable limits for both uniform and distorted flows of a free jet in a laboratory environment. Prime Photonics is a technology company focused on bringing innovative products to the marketplace. Our focus areas include sensor and materials technologies for test & measurement, inspection, control and health monitoring of commercial and military equipment, structures and turbomachinery.

Technology Category Alignment:

Aircraft Propulsion, Power and Thermal
Energy & Power Technologies
Engineered Resilient Systems (ERS)
Sensors
Propulsion

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SYSCOM: NAVAIR
Contract: N68335-18-C-0002
Corporate Brochure: https://navystp.com/vtm/open_file?type=brochure&id=N68335-18-C-0002

Department of the Navy SBIR/STTR Transition Program

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NAVAIR JSF18-945

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WHO

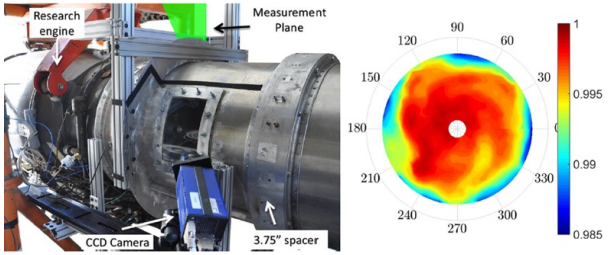
SYSCOM: NAVAIR

Sponsoring Program: Joint Strike Fighter

Transition Target: Advanced Fighter Aircraft

TPOC:
(301)757-0443

Other transition opportunities: This technology can easily reach across all aircraft with inlet distortion phenomena.



Notes: Characterization of distortion at the inlet of fans and compressors is done early during development stages. The intrusive nature of currently used measurement techniques have the potential to cause domestic object damage (DOD). Within the engine operating envelope complex distortion profiles are experienced due to aircraft maneuvers or environmental effects. These complex distortion profiles are not all currently tested during development due to their stochastic nature. As a new and completely non-intrusive test method, FRS sensing technology provides an avenue for testing these complex profiles on in service engines without compromising performance due to probe blockage or potential for DoD.

WHAT

Operational Need and Improvement: The capability to characterize and assess inlet distortion using non-intrusive methods in-flight is not currently available. Determining the root cause of performance or structural issues is critical, and to have the ability to quantify the severity and intensity at the inlet of the affected compression system will allow us to avoid critical inlet flow distortions that negatively affect the operability, performance, and structural integrity.

Specifications Required: The FRS sensor should be accessible from the turbomachinery exterior and simple to install on multiple engine platforms without adversely affecting the flow stream, performance or becoming a source for DOD. It will have the ability to characterize the distortion parameters (pressure, angle, temperature) as well as data acquisition and processing systems. The system will also convert the data into numerical distortion descriptors used in computational models.

Technology Developed: Filtered Rayleigh Scattering (FRS) provides a completely nonintrusive method of full annulus airflow characterization. It not only characterizes pressure, density and temperature but also provides flow speed and angle. It uses a system of lasers and cameras outside of the flow path to determine these measurements. During the Phase I, mean velocity, temperature and pressure measurements were resolved for both uniform and distorted flows of a free jet in a laboratory environment using the FRS technique.

Warfighter Value: Unlike using rakes which are placed in the direct flow path thereby distorting the flow, FRS is completely nonintrusive. While rakes can only give point-wise data, FRS can resolve information across the entire cross section of the flow. Unlike other laser based techniques, FRS does not require flow seeding and can measure velocity, temperature, pressure and density of flows simultaneously. This technology can also be used to determine flow angle, which is currently not measured due to measurement complexity, by measuring the 3D velocity vector. The FRS technique is widely applicable not only in the military aircraft engine application, but also in commercial, ground based, marine, power generation, automotive and other areas, where distortion plays a significant role in reduced performance and operability.

WHEN

Contract Number: N68335-18-C-0002 **Ending on:** March 5, 2019

Milestone	Risk Level	Measure of Success	Ending TRL	Date
Successful Demonstration of Sensor on a JT15D engine with an inlet distortion screen attached	Med	measurements fall within acceptable range and match previous well know measurement technique results	3	November 2018
Adaptational test of sensor at the CARL facility	Med	measurements fall within acceptable range and match previous well know measurement technique results	3	December 2019
Functional test of sensor at the CARL facility	High	measurements fall within acceptable range and match previous well know measurement technique results	3	July 2019
Successful Demonstration of sensor at the CARL facility	High	measurements fall within acceptable range and match previous well know measurement technique results	4	October 2019

HOW

Projected Business Model: Prime Photonics plans to manufacture and initially sell FRS products into the ground-based T&E market. For the flight test systems, we expect to supply hardware to engine OEM(s) and grant licenses for required software, however all options are open for commercialization including licensing the system to an airframer, engine OEM or other Navy contractor.

Company Objectives: The first product planned for the FRS system will be an inlet and exhaust flow distortion Test & Evaluation (T&E) system for ground test applications. It will be marketed to engine OEMs, airframers, Navy/DoD personnel, land-based gas turbine operators and universities and test houses using existing T&E user contacts. Initial sales will be performed by our Director of Sales. Low-Rate Initial Production (LRIP) is expected to begin late 2020 at which time prototype product launch will start and systems will be field tested at partner facilities. Our facility is well-equipped to produce and test the product at production levels up to a few hundred units per year. Higher manufacturing volume could be achieved through additional outsourcing of subassemblies, contract manufacturing, or through facility expansion.

Potential Commercial Applications: As a member of the Propulsion and Instrumentation Working Group Steering and Advisory Board (PIWG SAB), we have direct access to a wide range of customers/users and will further market the resulting product through direct sales, marketing at conferences and tradeshows and publications. Throughout the Phase II, we will work to further explore and develop additional markets for the product in military, industrial and medical applications. Major OEMs have already shown interest in our product and we hope to further that relationship by inviting them to our TRL 3 and 4 demonstrations to illustrate the usefulness of FRS sensors in new engine development programs as well as existing engine performance testing.

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