Poster #37

Embedded Multiplexed Fiber-Optic Sensing for Turbine Control and Prognostics & Health Management

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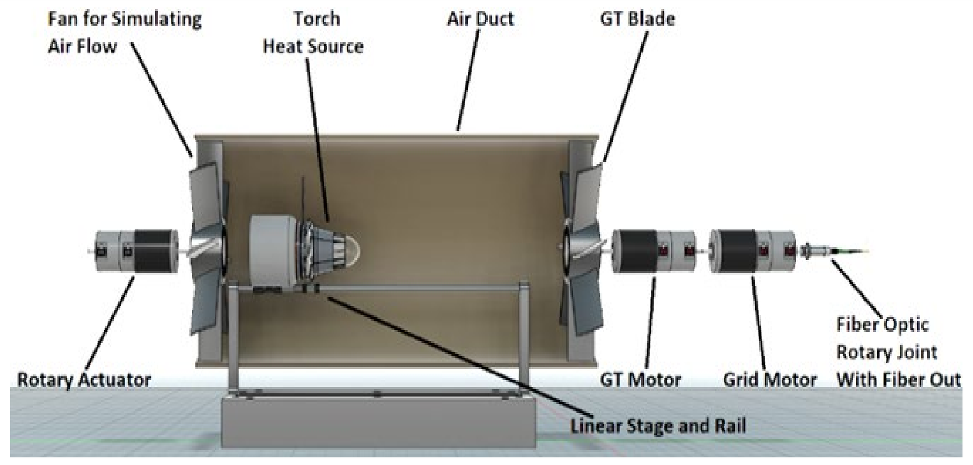
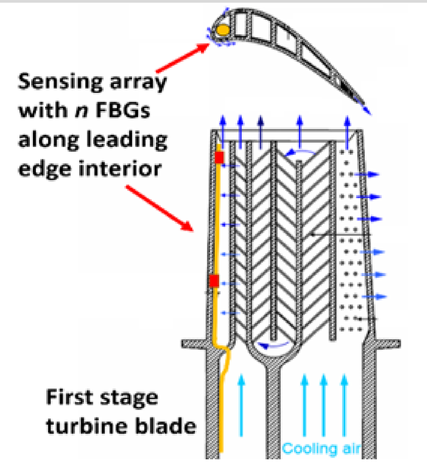
INTRO/APPROACH/DATA

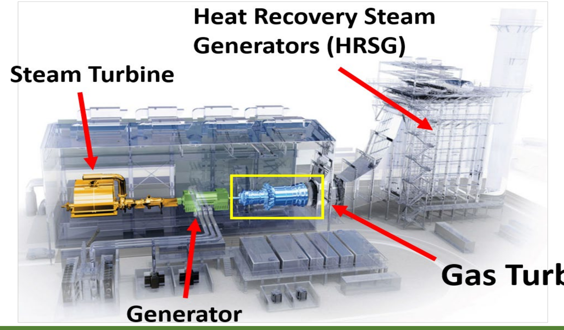
Next-generation plant management requires better sensors and analytics to collect and process data from the harshest portions of gas turbine (GT) engines, especially high-temperature first-stage turbine blades immediately aft of the combustor. Conventional instrumentation approaches have limitations that will prevent them from providing expanded control and health monitoring capabilities. IFOS' *Turbine*Sense*™ technology platform leverages major photonic and optoelectronics system innovations to overcome the challenges faced by conventional electronic sensors. A single hair-thin, sensor-instrumented optical fiber is attached to the interior wall of the blade leading edge to provide temperature and strain/stress measurements. Turbine*Sense™ has no electrically active components in the turbine blade or shaft; all signal processing and post-detection electronics are situated on stationary modules in a controlled, remote environment, eliminating the need for expensive, high-temperature electronics.

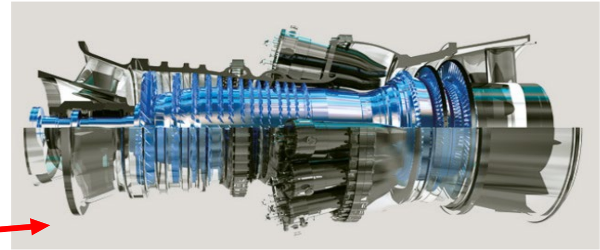




NEED

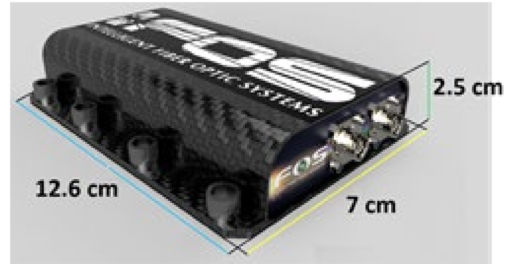
GTs today are most commonly operated in "combined-cycle" mode. The combined-cycle power plant can thereby produce 50% more electricity from a given amount of GT fuel than "simple-cycle" (GT only) plants. This implies that a given supply of electricity can be achieved with 50% less fossil fuels than simple-cycle plants. Combined-cycle plant operation brings clear plant-level efficiency benefits, but it also increases the cost of GT downtime – the number of assets idled due to GT downtime is greater than those for simple-cycle plants – and the risk of cascading failure across interconnected turbines and generators. These failures and the resulting generator downtimes increase the overall cost of ownership (CoO) and levelized cost of electricity (LCOE). Therefore, the impact of health monitoring, intelligent diagnostics, and prognostics for enhanced reliability is significant.





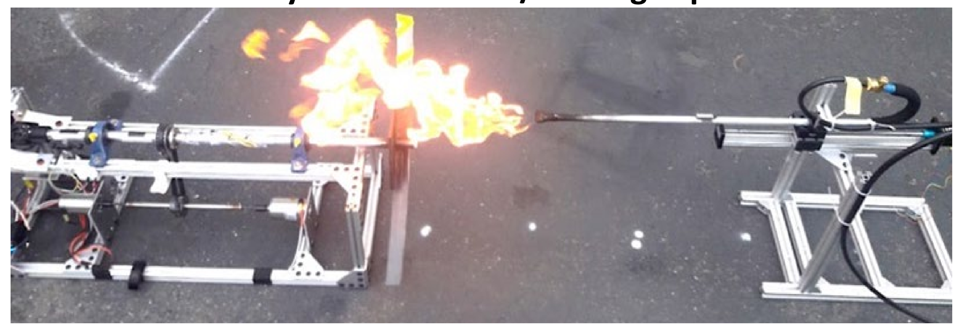
APPROACH

The Phase I approach was to demonstrate technical feasibility of the key precision photonic sensing and optoelectronic system innovations of the Turbine*Sense concept. These include multiplexable fiber Bragg gratings (FBGs), fiber-optic rotary joint (FORJ, analogous to electrical slip-ring), and simulated turbomachinery components and control system. IFOS planned to establish feasibility by first testing the individual components, then integrating them into higher fidelity subsystems for benchtop testing. In parallel, interaction with leading GT OEMs would refine the application requirements technology transition roadmap to commercial systems in both energy and aviation.



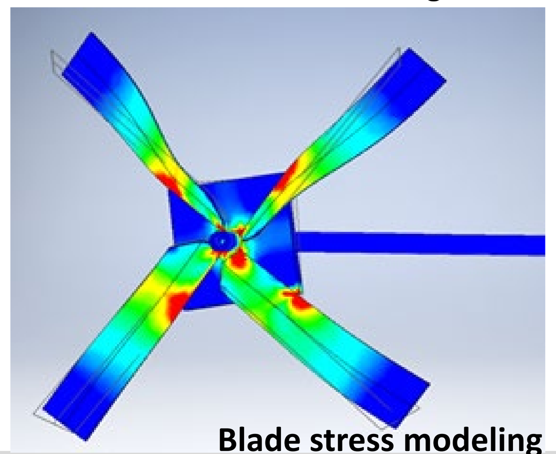
Miniaturized optoelectronic interrogator

Phase I dynamic rotation/heating experiment

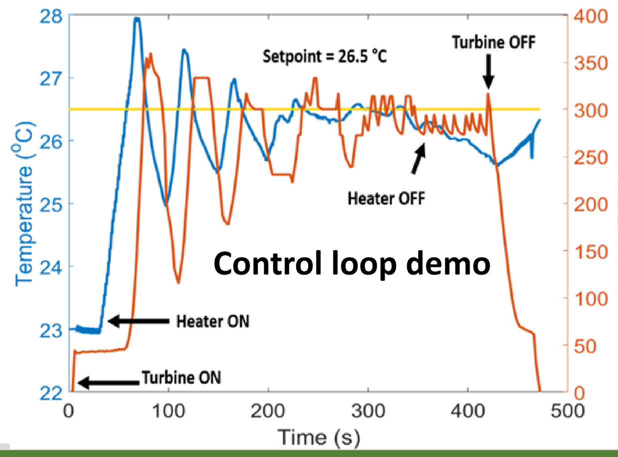


RESULTS

Phase I demonstrated technical feasibility of the foundational underpinnings of the Turbine*Sense™ concept including embeddable sensor arrays, optical rotary components, and controls integrability. IFOS recorded temperature and strain data with sensor arrays attached to the simulated turbine blades, with verification of measured data by conventional gold-standard reference resistive foil gauges. IFOS also developed a custom controller software program that was shown to guide turbine operating parameters to desired levels using the FBG sensor input data. Beyond demonstrating feasibility, an enabling achievement of Phase I was the close interaction with major GT OEMs. These frequent industrial interactions provided enhanced understanding of real-world industrial application requirements.

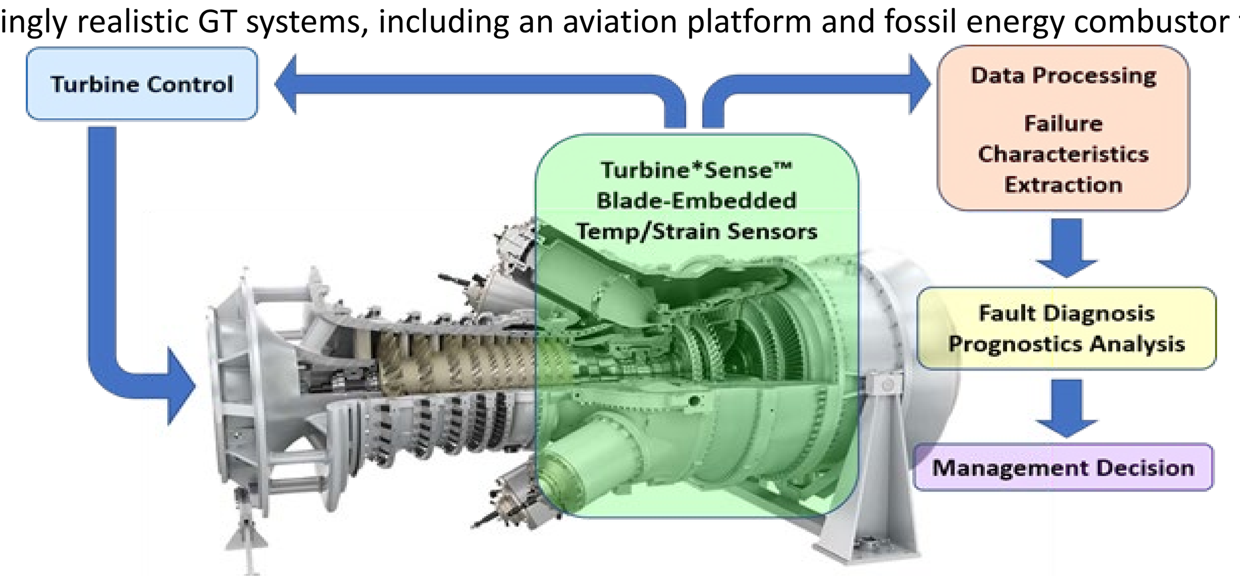


Blade stress modeling



BENFITS AND FUTURE WORK

Turbine*Sense™ technology stems from the accelerating and interrelated needs for increased electricity generator efficiency and reliability. Turbine*Sense™ system solutions will be marketed as both a development enhancement platform for design and validation of new turbine systems, and a production system enhancement to improve turbine control and unlock PHM methods for reduced CoO and LCOE. In Phase II, IFOS will demonstrate and validate Turbine*Sense™ measurements in increasingly realistic GT systems, including an aviation platform and fossil energy combustor testbed.



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