



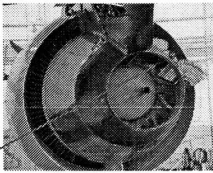
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 (a) NASA GRC, (b) Cleveland State University, (c) NASA DFRC, (d) Ohio Aerospace Institute, (e) Tytrin Corporation

**Objective:**

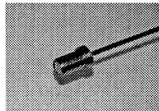
Develop Advanced Sensor Technology and rotordynamic structural diagnostics to address existing Aviation Safety Propulsion Health Management needs as well as proactively begin to address anticipated safety issues for new technologies

**Microwave Blade Tip Clearance / Tip Timing Sensor**

- Blade Tip Clearance to monitor blade growth & wear
- Blade Tip Timing to monitor blade deflection & vibration
- Goal is to detect precursors to faults and prevent a blade / disk "event" before it happens



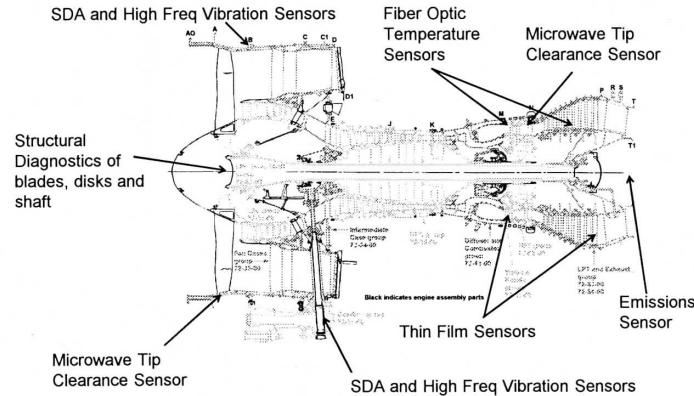
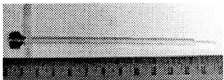
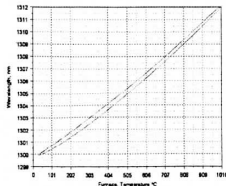
Engine Failure Incident June 2, 2006



Microwave Tip Clearance Probe

Fiber optic sensors mitigate potential reliability & performance issues associated with conventional sensors and have integration advantages

Developed & demonstrated high temperature optical sensors operational at 1000 C for up to 1000 hours



**Emissions Sensors** to Quantify composition of critical constituents in turbine engine exhaust products, E.G., CO, CO<sub>2</sub>, NOX, O<sub>2</sub>, HC (unburned Hydrocarbons)



CO Sensor



SiC Hydrocarbon Sensor

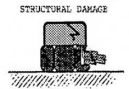
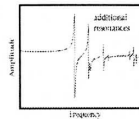


CO2 Sensor

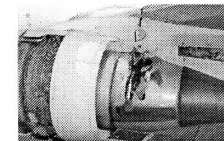
**Vehicle Integrated Propulsion Research (VIPR) engine tests (2011 to 2013)** as a part of Technology Development

- **Engine testing is a necessary and challenging component of VHM technology development.**
- **Test Objective:** Demonstrate multiple structural and gas path health management sensors in an operating engine environment. Integrate sensor / detection technologies with Structural and Gas Path diagnostics.
- **Approach:** Perform engine ground tests using commercial derivative engine. Conduct normal engine operations and also operations that have seeded mechanical and gas path faults (simulated).

**Self Diagnostic Accelerometer:** For mission critical decisions, such as an engine being shut off due to anomalous acceleration readings, ensuring sensor health is critical.



**On-Component Thin Film Sensors** for monitoring degradation and damage that develops over time in hot section components



PdCr strain sensor to T=1000°C

**Rotordynamics for Structural Health Management Diagnostics - Crack Signatures** obtained through Subscale Engine Disk Spin Rig

