



**Sensatek**  
*Propulsion Technology, Inc.*

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**Extreme (-302F to 3732F) Passive Wireless Resonant Sensors:  
Ground Test to Commercial Flight Instrumentation**

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850.321.5993

www.sensatek.com





Who I am?



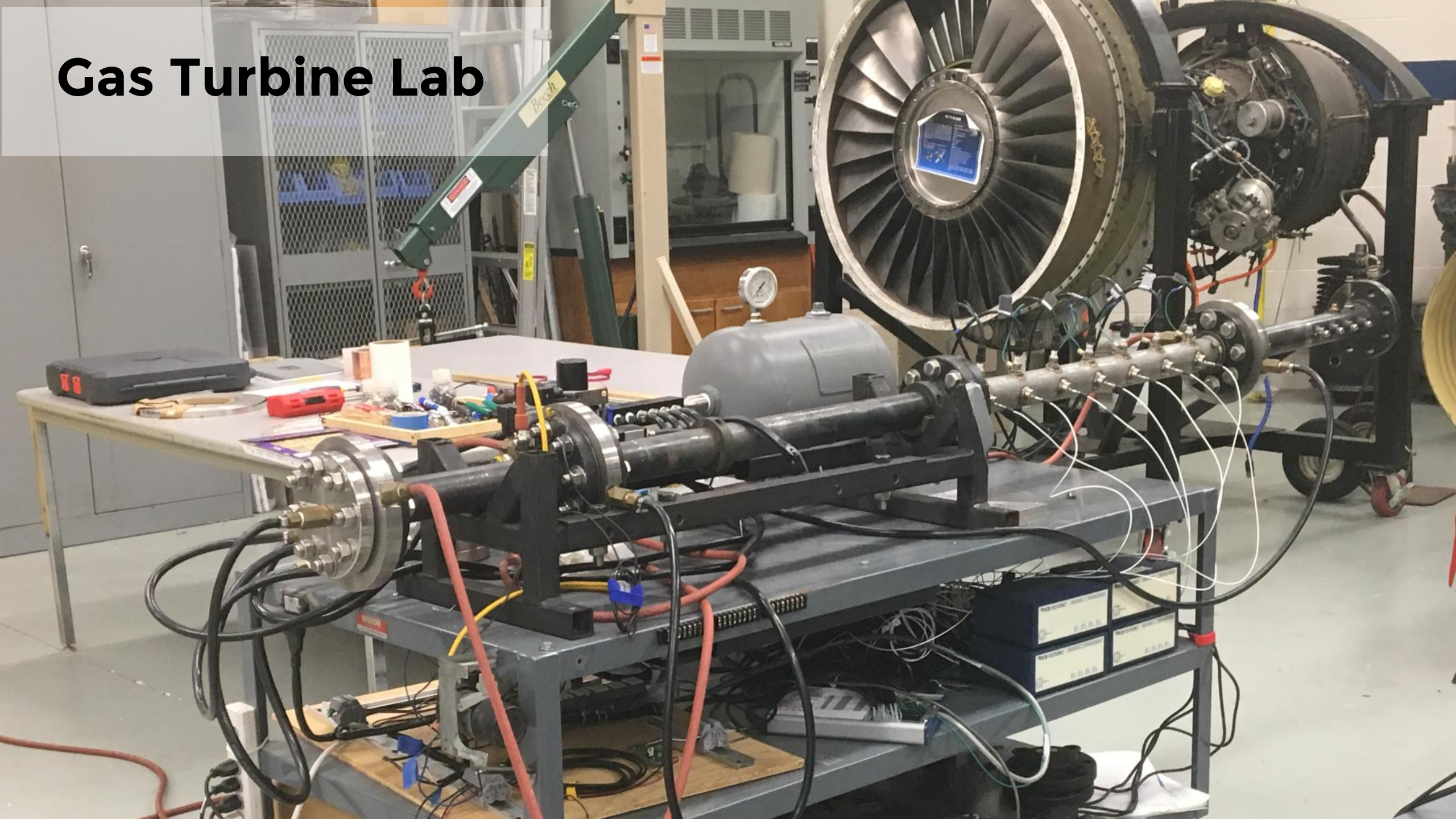




**EMBRY-RIDDLE**  
Aeronautical University



# Gas Turbine Lab





# Overheated Components



PDE Rings

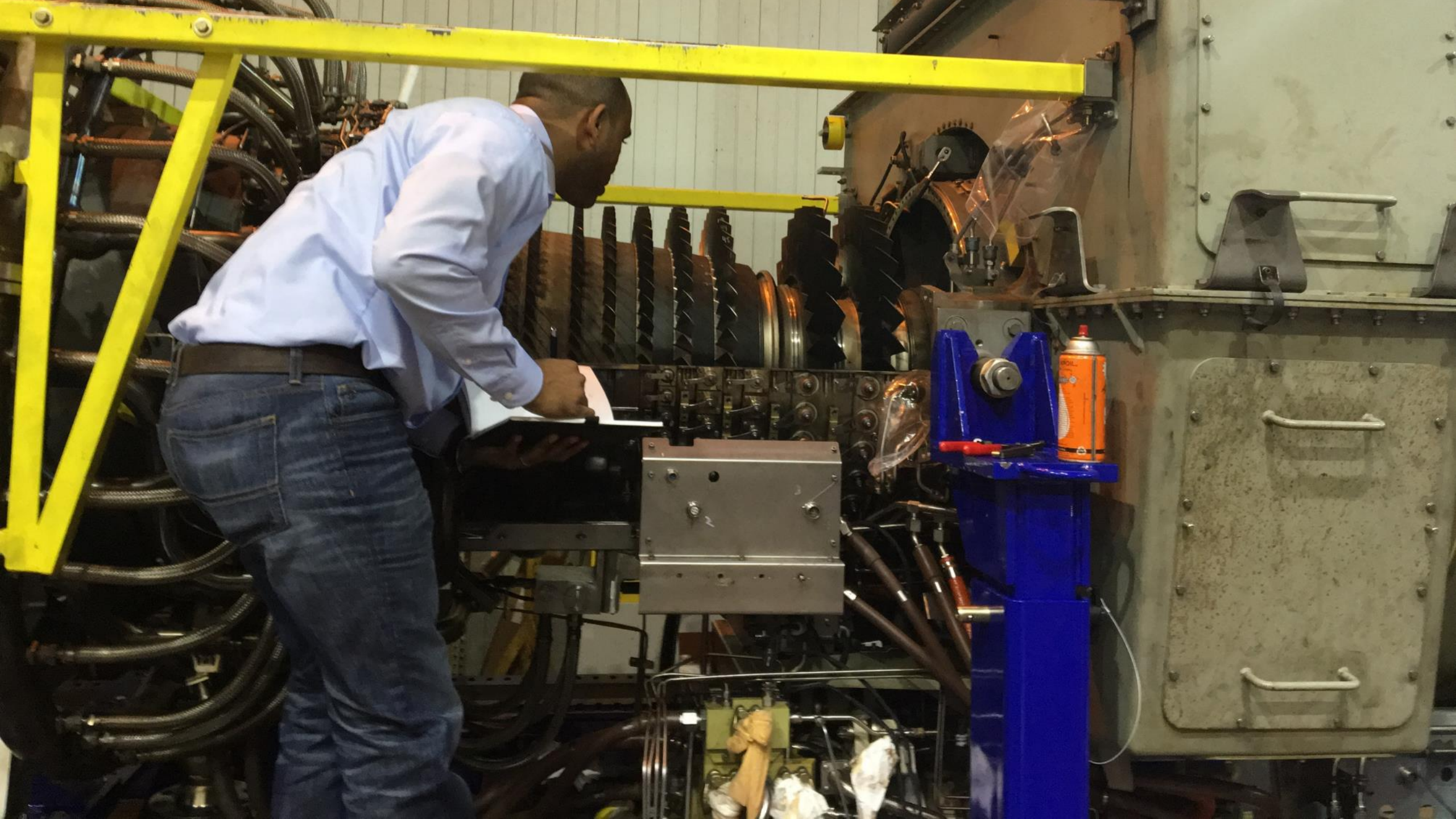


Blades



Combustion Chamber









**I WANT YOU**

**FOR**  **CORPS**  
NSF Innovation Corps

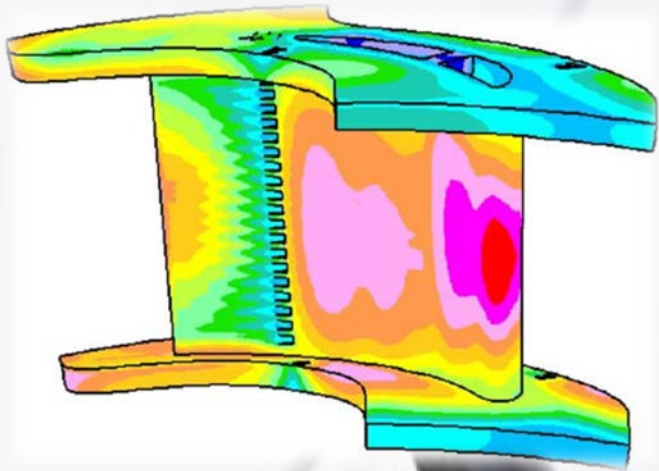
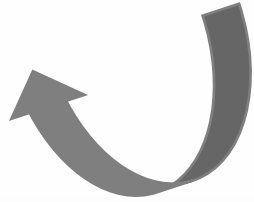
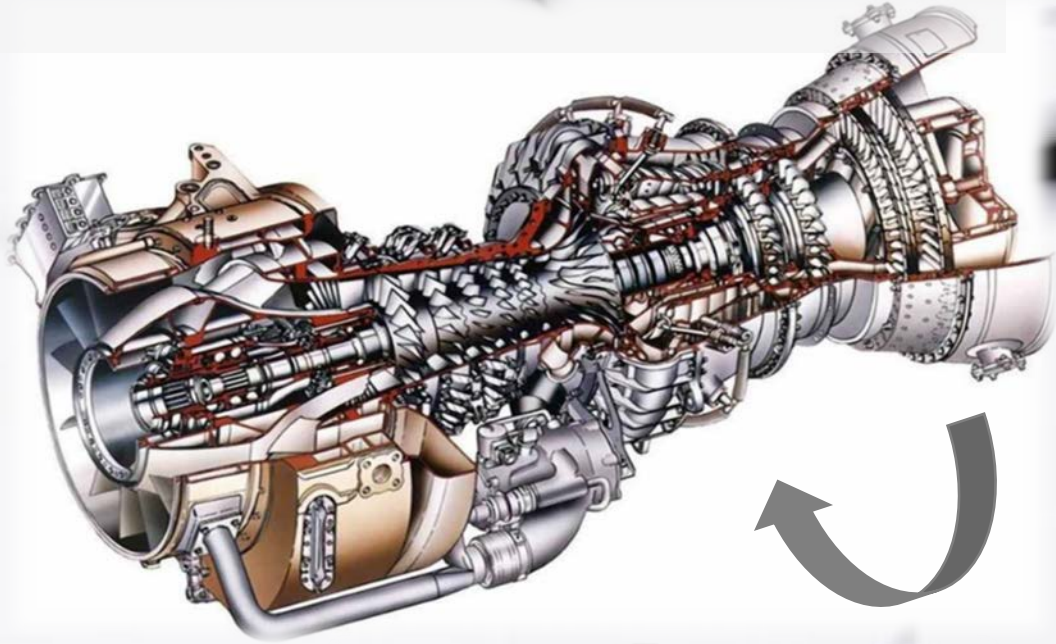
**NEAREST RECRUITING STATION**

**Get out of the building!**





# Life Cycle Costs





# Lengthy Lead Times



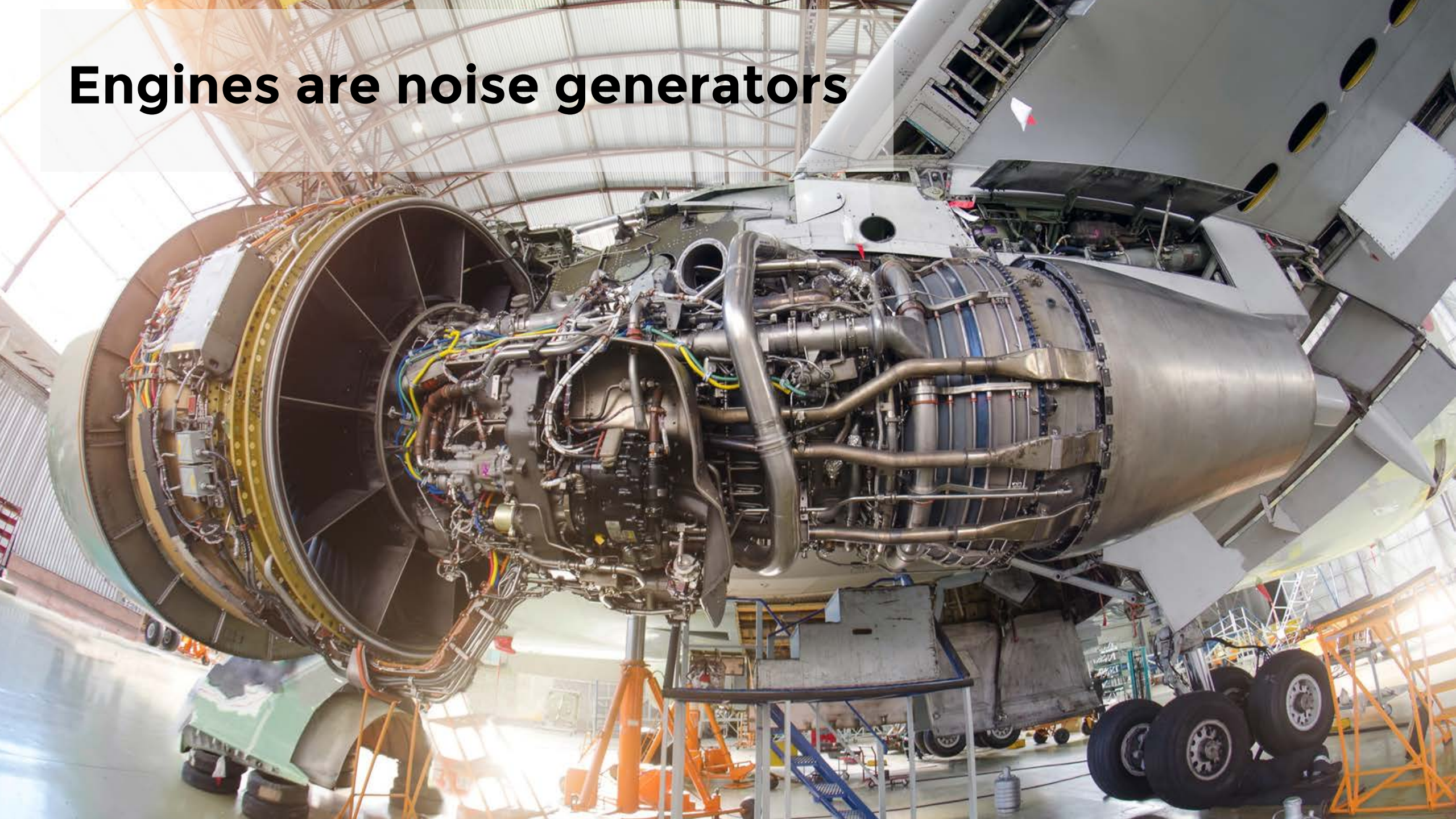


# Airline Performance





**Engines are noise generators**





**Engines are shrinking**



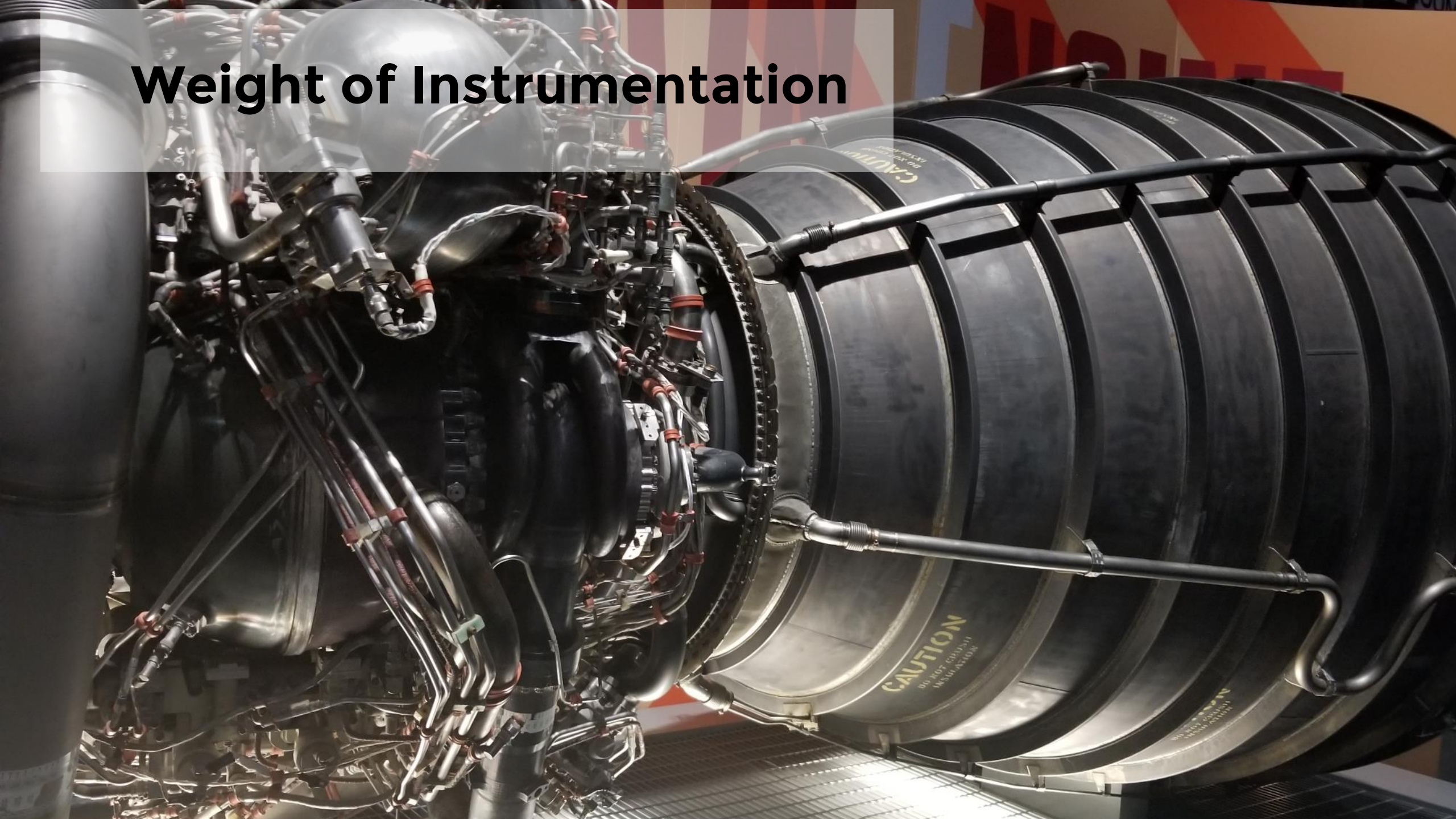


# Rocket Test Stand





# Weight of Instrumentation





# PATENTS AND PUBLICATIONS

(12) **United States Patent**  
Gong et al.



US 8,558,705 B2

(54) **TERMINAL SENSORS FOR WIRELESS SENSING**

(75) Inventors: Xun Gong, Orlando, FL (US); Linan An, Orlando, FL (US)

(73) Assignee: University of Central Florida Research Foundation, Inc., Orlando, FL (US)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 557 days.

(21) Appl. No.: 12/821,090

(22) Filed: Jun. 23, 2010

(45) Pub. Publication: US 2010/021181 A1



US 2010/021181 A1

(12) **United States Patent Application Publication**  
Gong et al.

(54) **INTEGRATED CAVITY FILTER/ANTENNA SYSTEM**

(75) Inventors: Xun Gong, Orlando, FL (US); Yanli Yang, Orlando, FL (US)

(73) Assignee: University of Central Florida Research Foundation, Inc., Orlando, FL (US)

(21) Appl. No.: 13/012,389

(22) Filed: May 26, 2011

(45) Pub. Publication: US 2012/0293279 A1

(54) **INTEGRATED CAVITY FILTER/ANTENNA SYSTEM**

(75) Inventors: Xun Gong, Orlando, FL (US); Yanli Yang, Orlando, FL (US)

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(75) Inventors: Xun Gong, Orlando, FL (US); Yanli Yang, Orlando, FL (US)

(73) Assignee: University of Central Florida Research Foundation, Inc., Orlando, FL (US)

(21) Appl. No.: 14/039,489

(22) Filed: May 26, 2014

(45) Pub. Publication: US 2015/0028889 A1

(54) **LOW-PROFILE WIRELESS PASSIVE RESONATORS FOR SENSING**

(75) Inventors: XUN GONG, ORLANDO, FL (US); LINAN AN, ORLANDO, FL (US)

(73) Assignee: University of Central Florida Research Foundation, Inc., Orlando, FL (US)

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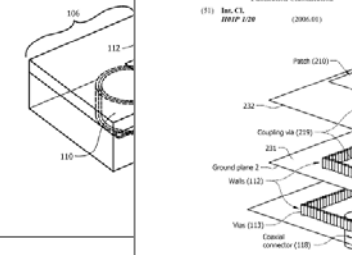
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IEEE SENSORS JOURNAL, VOL. 15, NO. 3, MARCH 2015

1073

## Wireless Passive Temperature Sensors Using Integrated Cylindrical Resonator/Antenna for Harsh-Environment Applications

Haitao Cheng, Student Member, IEEE, Xinhua Ren, Member, IEEE, Siamak Ehsadi, Student Member, IEEE, Yanhan Chen, Linan An, and Xun Gong, Senior Member, IEEE

**Abstract**—Wireless passive temperature sensors for harsh-environment applications based on cylindrical microwave cavity resonators are presented herein. Such antennas are in sensors with zero additional volume. The resonant frequency of the sensors are determined by the dielectric of the ceramic materials, which monotonically increase with temperature. Silicon nitride (SiN<sub>2</sub>) resonators which are very robust inside harsh environment high temperatures and corrosive gases, are optimal for reducing dielectric losses and increasing accuracy. A robust interrogation antenna is wirelessly measured the sensors up to 1300 °C. Tests on SiN<sub>2</sub> and SiC<sub>3</sub>N<sub>4</sub> ceramics are measured up to 1300 °C, respectively, with a sensitivity of  $\sim 0.75$  1000 °C. This type of wireless, passive, and robust be used for many harsh-environment applications.

**Index Terms**—Cavity resonators, high-temperature microwave sensors, hot antennas, temperature wire

of 10 °C is desirable. There are no commercially-available temperature sensors that are able to carry out in situ measure-



Evanescent-mode-resonator-based and antenna-integrated wireless passive pressure sensors for harsh-environment applications

Haitao Cheng<sup>1,\*</sup>, Gang Shao<sup>2</sup>, Siamak Ehsadi<sup>3</sup>, Xinhua Ren<sup>4</sup>, Kyle Harris<sup>1,5</sup>, Jian Liu<sup>6</sup>, Chengyu Xu<sup>1</sup>, Linan An<sup>1</sup>, Xun Gong<sup>1,6,7</sup>

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<sup>2</sup> School of Mechanical and Aerospace Engineering, University of Central Florida, Orlando, FL 32816, USA

<sup>3</sup> Department of Mechanical and Aerospace Engineering, University of Central Florida, Orlando, FL 32816, USA

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<sup>6</sup> Advanced Materials Processing and Analysis Center (AMPAC), University of Central Florida, Orlando, FL 32816, USA

<sup>7</sup> Department of Mechanical and Aerospace Engineering, University of Central Florida, Orlando, FL 32816, USA

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<sup>†</sup> E-mail address: hcheng@pegasus.com (H. Cheng), xun.gong@ucf.edu (X. Gong).

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Wireless passive high-temperature sensor based on multifunctional reflective patch antenna up to 1050 degrees centigrade

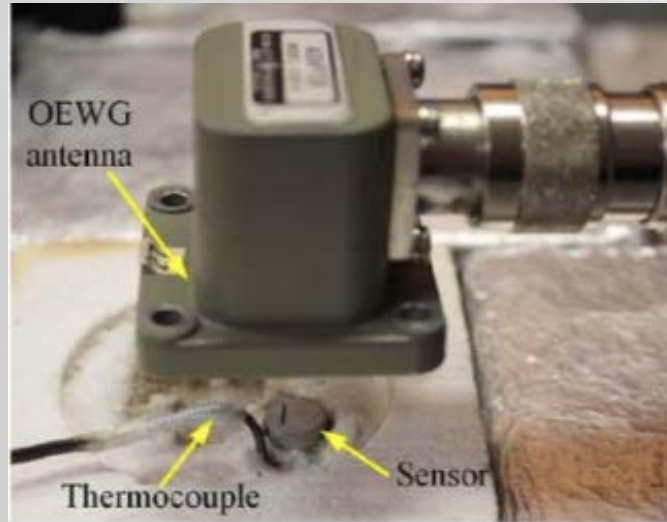
Haitao Cheng<sup>1,\*</sup>



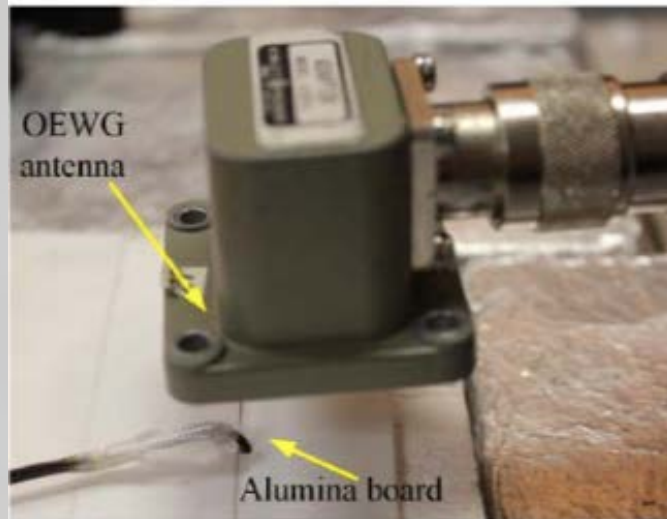
# WIRELESS HIGH-TEMPERATURE CERAMIC SENSOR

Published in IEEE Sensors Journal March 2015

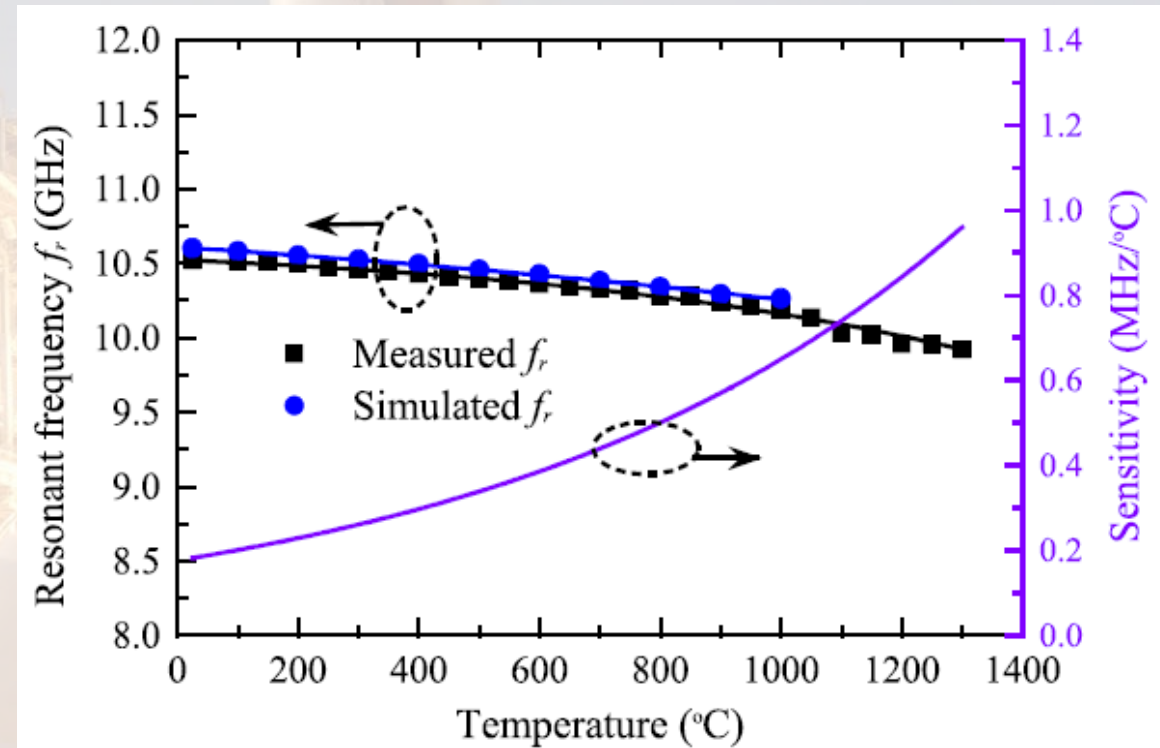
High-Temperature measurement using  
heat pad and X-band OEWG antenna



(a)



(b)





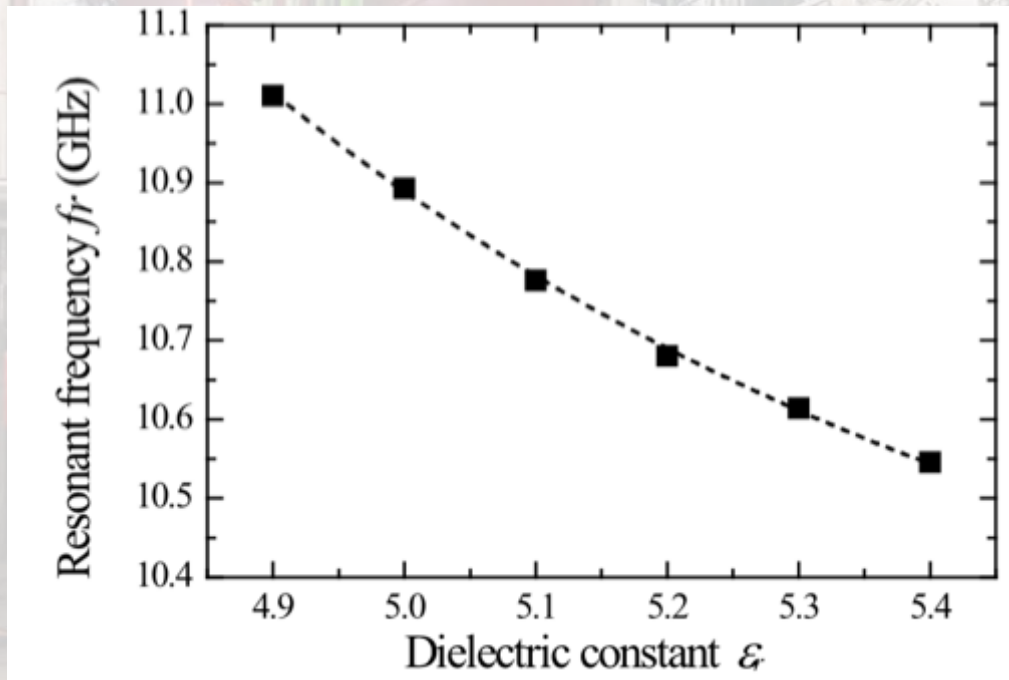
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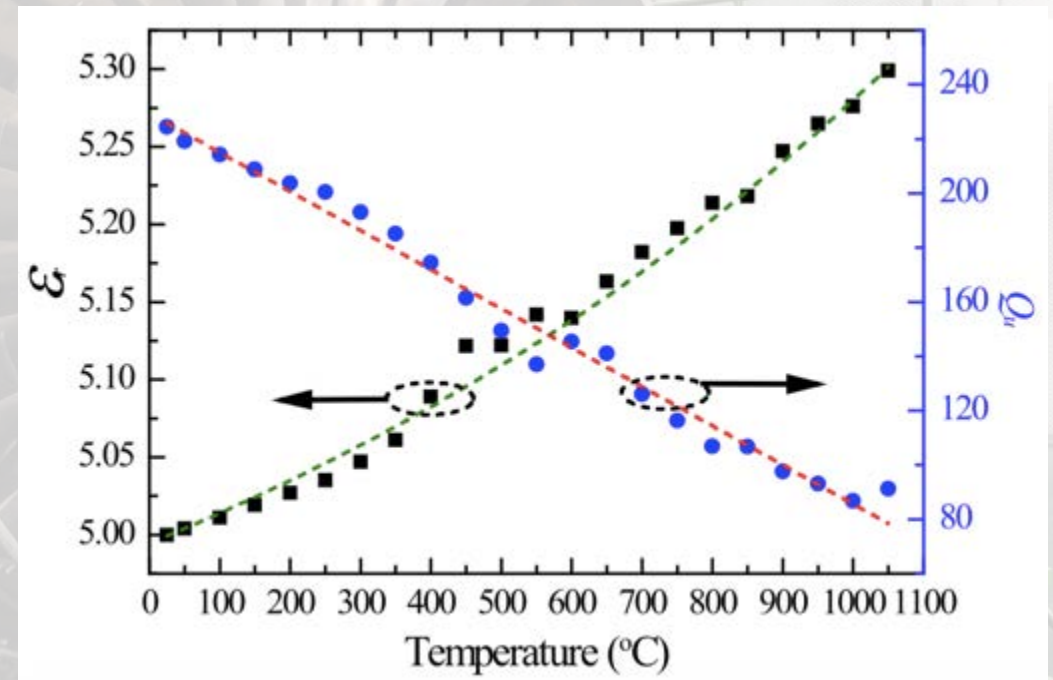
**Step 1** → Detects Resonant Frequency, **RF**

**Step 2** → Compares **RF** to Characterized Data

Measured **RF** Versus Dielectric Constant



Characterization of Ceramics at High Temperatures



**Step 3** → Determines Temperature

Resonant Frequency is inversely proportional to Dielectric Constant,  $\epsilon_r$



$$f_{TM010} = \frac{cp_{01}}{2\pi a\sqrt{\epsilon_r}}$$

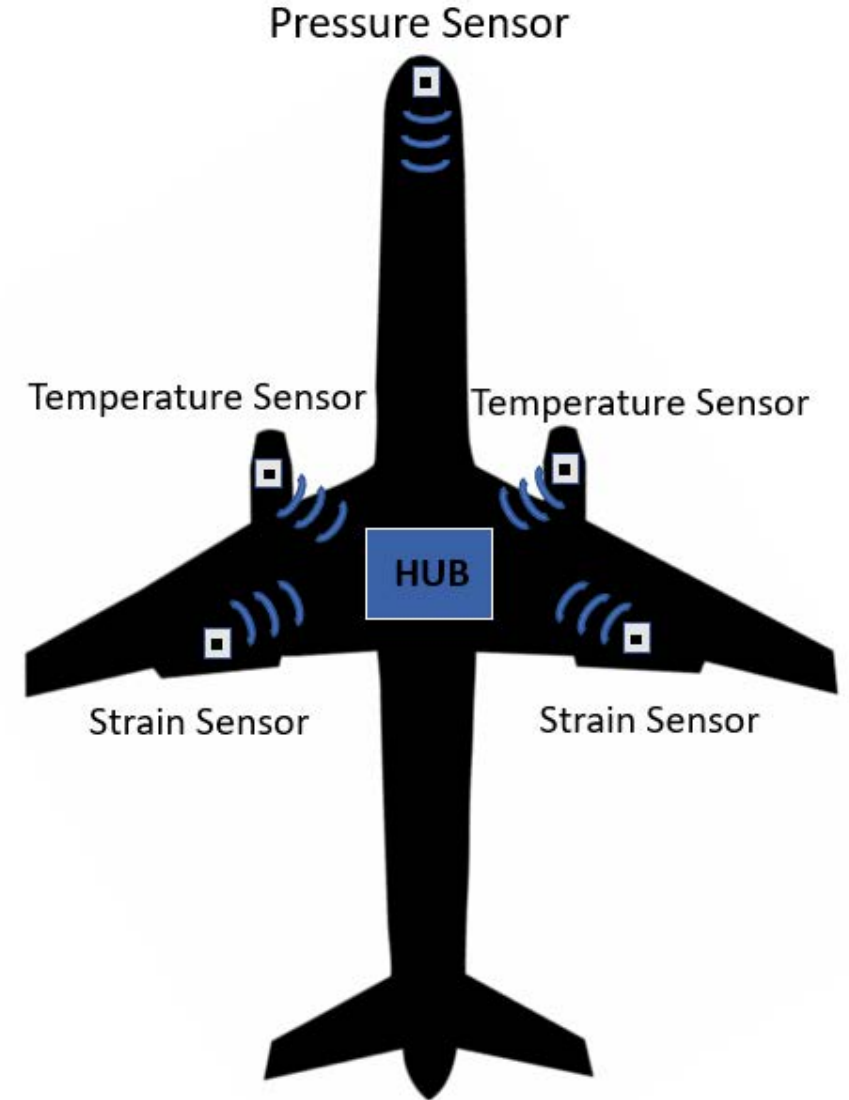


## Wireless Aviation Intra-Communications (WAIC)

- Local Radio communication between avionics components and systems on-board the same aircraft.
- Only safety and flight operations related applications, not for passenger communication.
- Low Transmission Power (10 dBm)

### Motivation & Advantages:

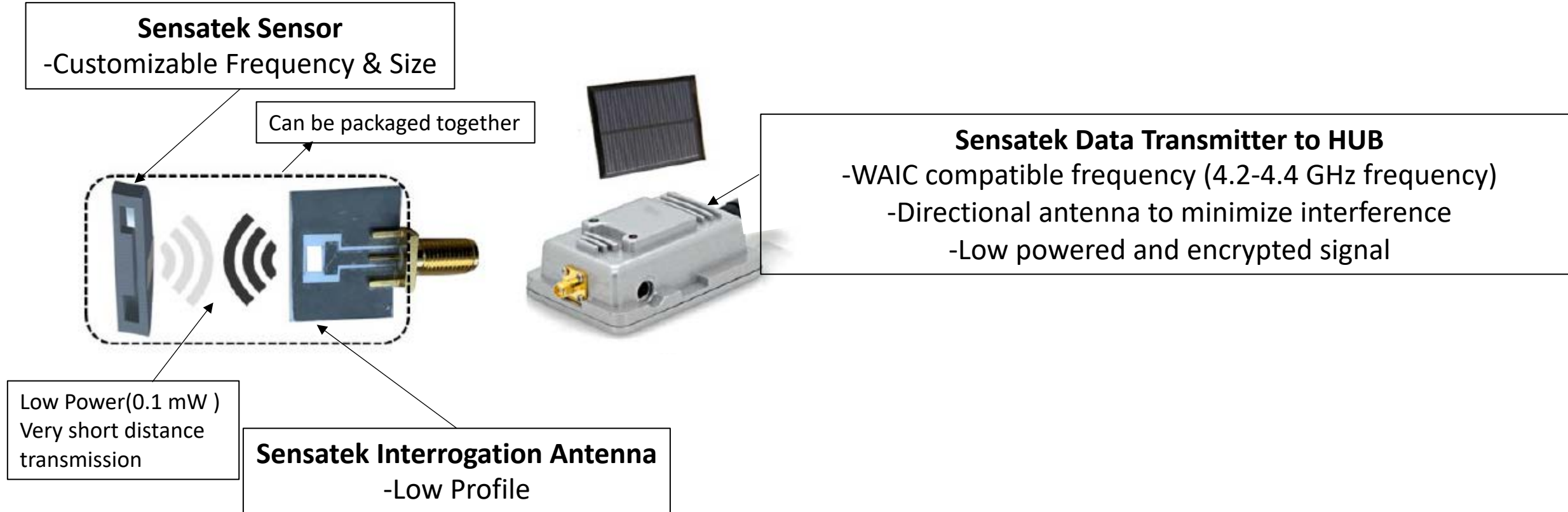
- 30 % of wires are potential candidates for replacement.
- Aircraft wiring usually features double, triple redundancy through different route.
- Having wireless communication enables redundancy while mitigating risk of single point of failure.
- For space missions, increases useful payload capacity, improves economy for commercial aviation applications.



*Sensatek Sensors Suite enabling WAIC*



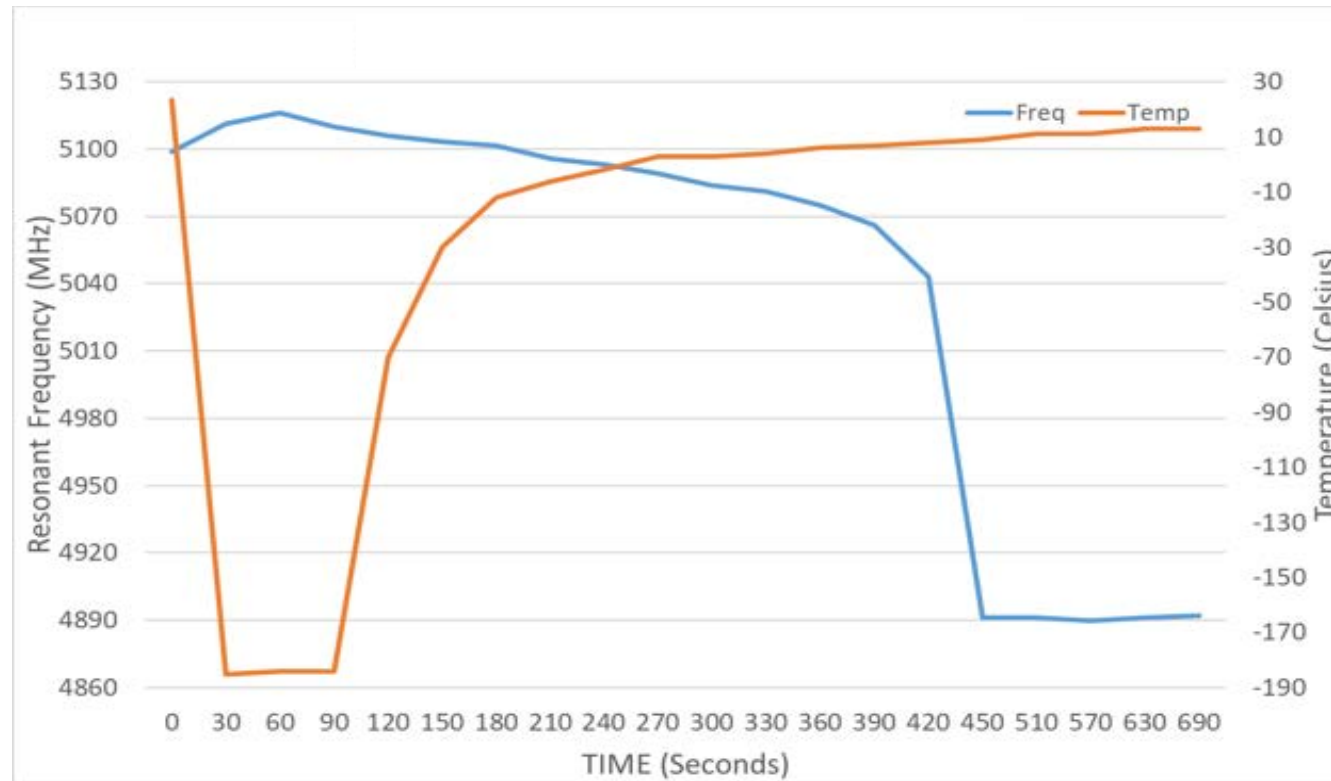
## Sensatek Sensor System for WAIC applications





## Cryogenic Testing

- Quick Proof-of-concept test using Liquid Nitrogen
- Liquid Nitrogen Poured over sensor placed on an Inconel component in a Pyrex Container
- Temperature recorded wirelessly for sensors using waveguide and independently using K-type thermocouple attached to DAQ
- Test duration was 12 minutes, readings recorded every 30 secs.

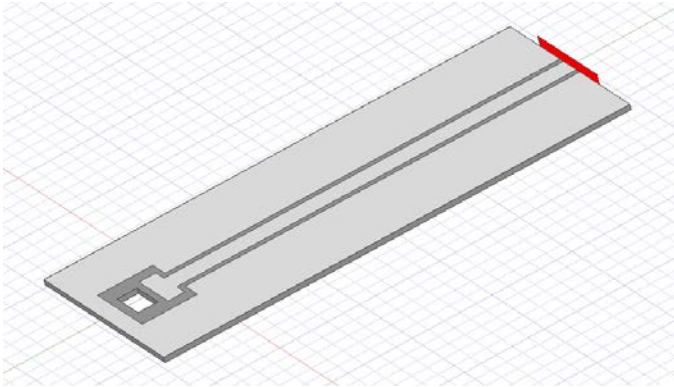


Sensor response for cryogenic temperatures.



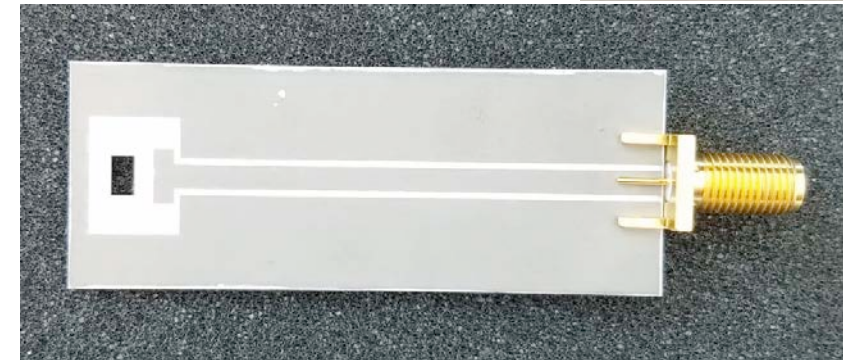
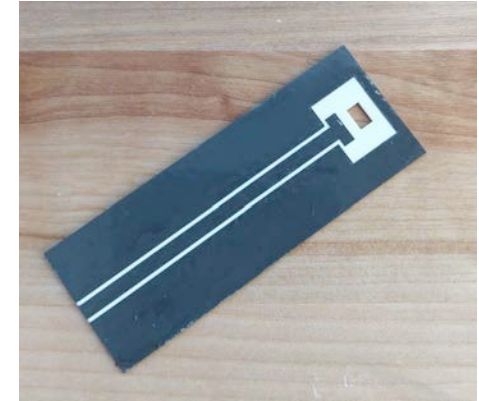
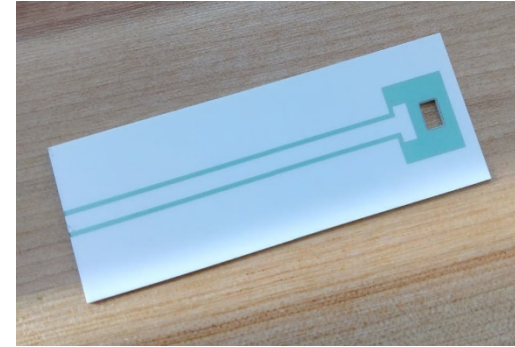
# Harsh Environment Antenna Design and Manufacturing

(1)



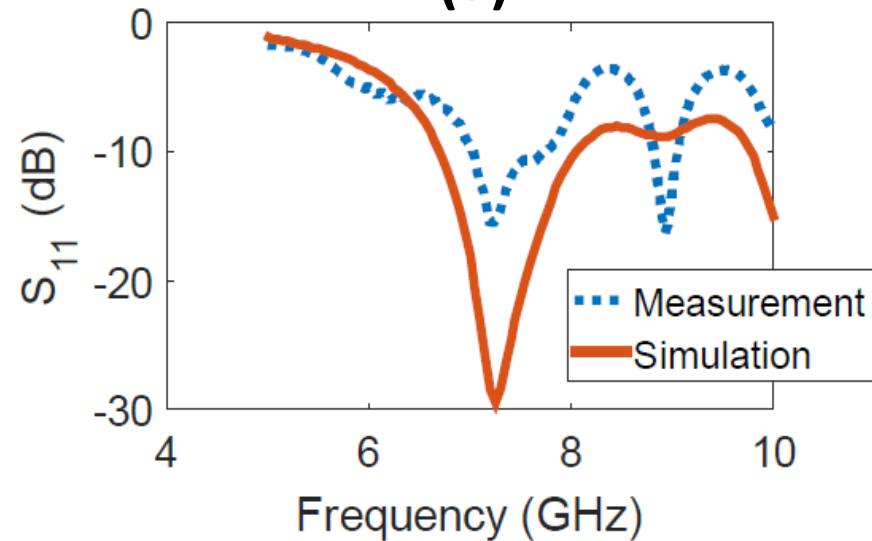
CAD Model of the antenna

(2)



Manufacturing Process of the antenna

(3)



Simulated Vs Manufactured



# Proof of Demonstration: Survivability on Rotating Microturbine Wheel









# Meet The Team



**Reamonn Soto**  
CEO & FOUNDER  
B.S. Physics  
M.S. Aeronautics



**Charles Cook, PhD**  
CHIEF TECHNOLOGY  
OFFICER



**Yogesh Pai**  
LEAD PROPULSION  
ENGINEER  
M.S. Aerospace Engineering



**Taofeek Orelekan, PhD**  
LEAD ELECTRICAL ENGINEER  
Wireless Power Transfer  
Expert  
PhD. Electrical Engineering



**Tanmay Naik**  
ELECTRICAL/RF ENGINEER  
M.S. Electrical Engineering



**Azryana Soto**  
MATERIALS RESEARCHER  
B.S. Molecular Cellular Biology



**Melinda Fix**  
MARKETING DIRECTOR  
B.S. Business Administration



**Yongho Sohn, PhD**  
MATERIALS SCIENTIST  
PhD. Materials Scientist



**Christian Pierre**  
Research Assistant

**Locke  
Lord**<sup>LLP</sup>

**GT** GreenbergTraurig

**JAMESON & COMPANY**

**James Moore**  
Certified Public Accountants and Consultants



**What's next?**

