John Delvaux

Education
BEME Auburn University 1985
MSME University of Florida 1994

Career
Technical Leader Ceramic Matrix Composites – 2009+
Aeromechanics Growth Leader – 2005
Technical Leader Gas Turbine Technology Lab - 2000
Agilis Technical Leader – 1998
Pratt and Whitney Senior Design Engineer - 1985

Technical expertise
Turbine Design and Test
Turbine Airfoils Aeromechanics

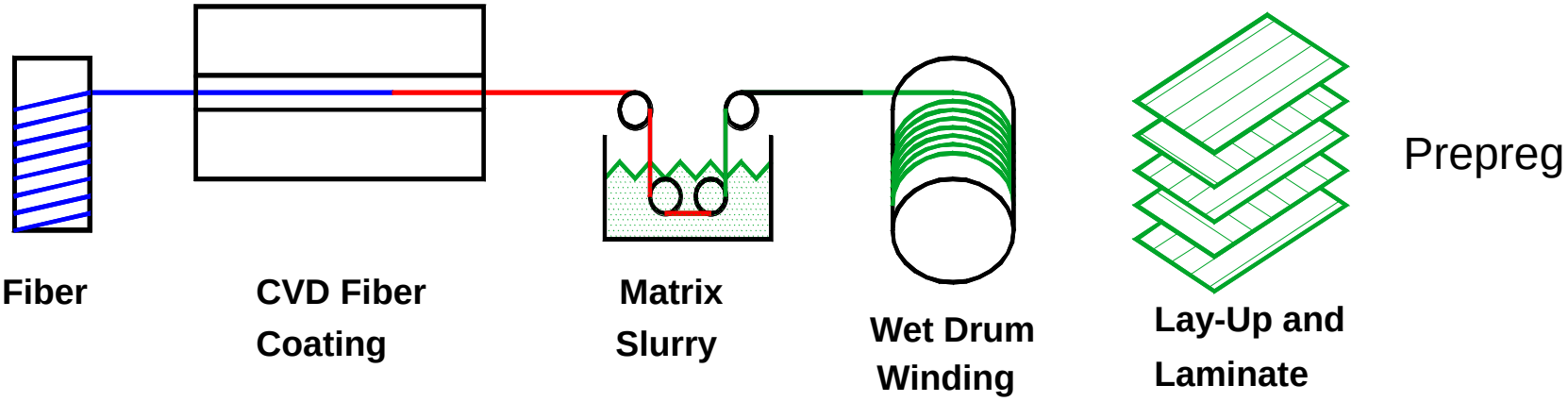
Accomplishments:
CMC Field Endurance Record
F-Class GT Durable Compressor
F135 Fan Blade Design
F136 Compressor Blade Design
AS907 Low Pressure Turbine Blade Design
Board Certified Mechanical Engineer
Six Sigma Black Belt
Significant Invention Disclosures
Clemson University Capstone Coordinator

Activity
Hiking
Motor Sports
Auburn University Engineering Advisory Board

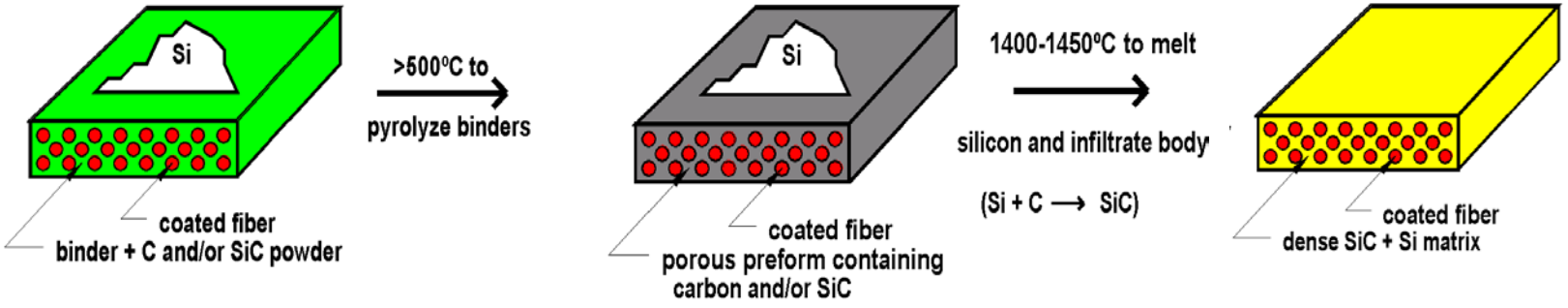
- **GE CMC**
- **Accomplishments**
- **GEA**
- **GE Power Nozzle**

GE Ceramic Matrix Composite (CMC) Processing

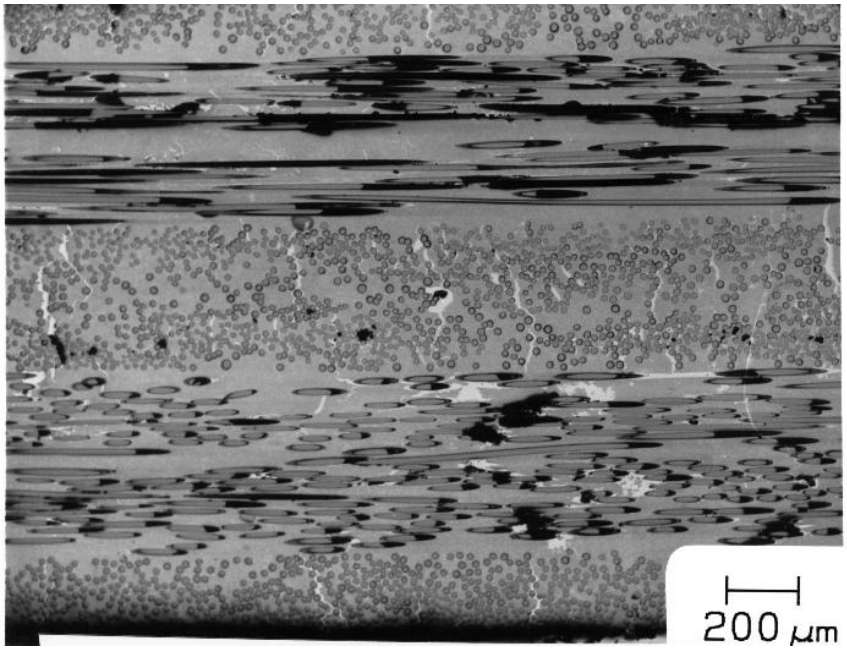
Preform Fabrication

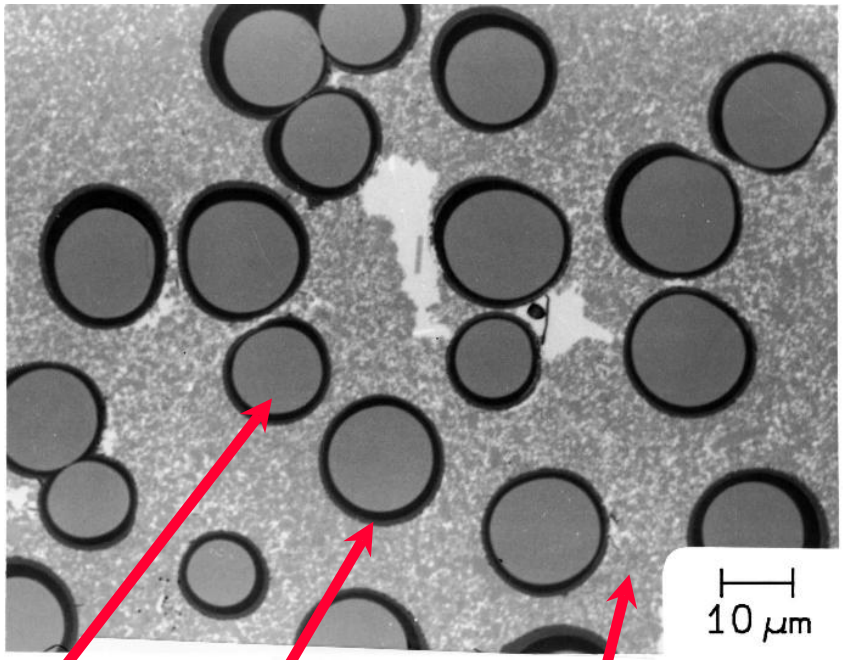


Melt Infiltration



Microstructure of Prepreg MI Composites





Fiber

Fiber Coating

SiC-Si Matrix

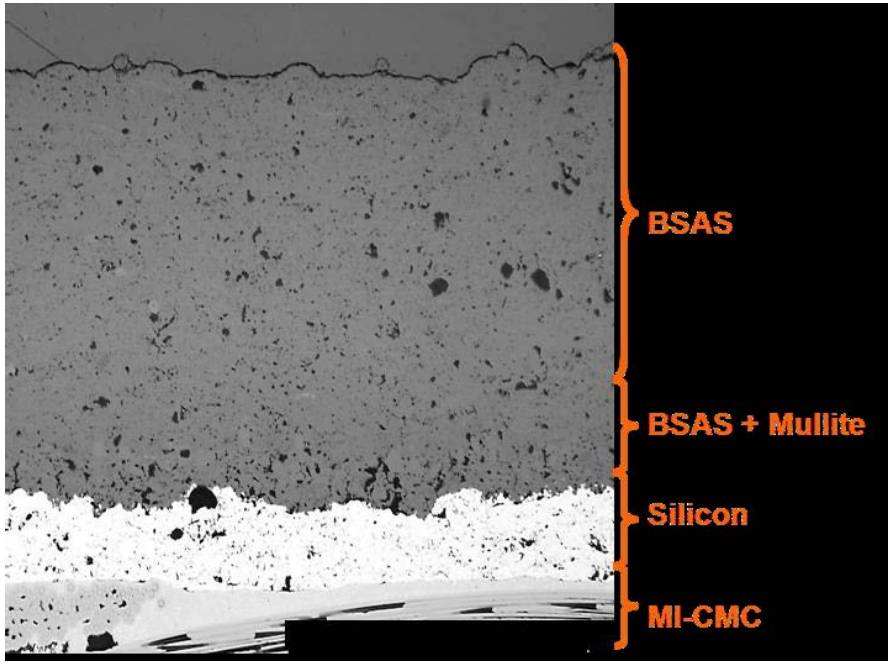
- Fibers Homogeneously Distributed; Vf = ~25%
- Separated Fibers and Fiber Coatings
- ~2-3% Matrix Porosity

Environmental Barrier Coating (EBC)

EBC needed for turbine applications to prevent silica volatilization and surface recession from water vapor in combustion gas

$SiO2 + H2O \rightarrow Si(OH)_x$ (gas)

Baseline System

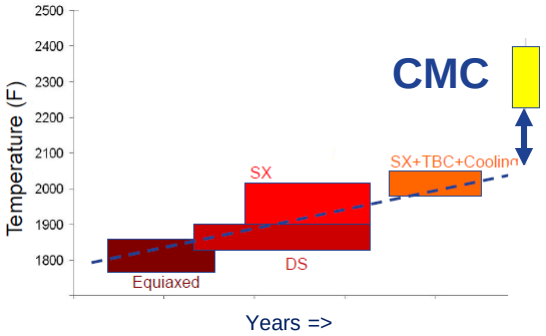


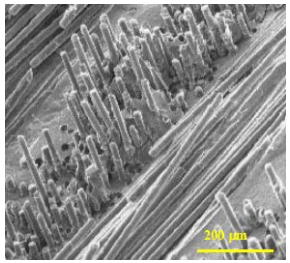
Advanced system

- Retain Si bond coat
- RE silicate layers
  - ☐ CTE match
  - ☐ recession resistance

GE & DOE Advancing Development of CMC Material for Power Generation

Increased material temperature capability …
… efficiency, output, reduced COE





laminate structure

toughness demo

High-temp material testing; 100,000 hrs …
… & toughness demonstrations

Field service demonstration …
… >20,000 hrs on 7FA shroud set

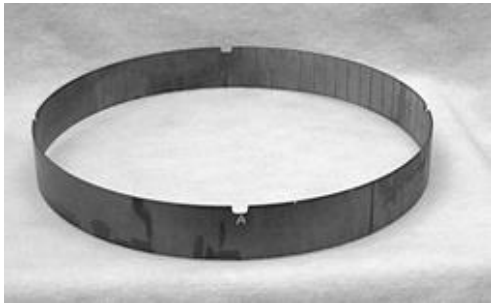

GE 7FA Shroud Installation


Reference: Aviation CMC nozzle

DOE 2014 phase 1 award …
… High Temp CMC Nozzles

Nearly 44000 hrs of CMC Field Experience

Stage Shroud Ring
47cm dia
1000 hrs
2 MW Machine
2000



Combustion Liner
~30 cm dia x 27 cm length
12,855 hrs, 45 cycles
Solar 5 MW gas turbine
2005 - 2006

First Shroud Demo 160 MW machine
5366 hrs, 14 cycles
2002-2003

Shroud Durability Test 1
2930 hrs, 552 cycles
2006 - Continuing

Shroud Durability Test 2
21740 hrs, 126 cycles
2011 - 2014

Shroud
~8 cm x 15 cm first stage shroud
96 per full set – 160 MW machine

First GE Power Application

CMC Stage 1 Shroud for 7F

CMC Technology

Ceramic Matrix Composite (CMC) represents a major step in material capability for gas turbines. With the strength of metals and the temperature capability of ceramics, this advanced material system enables the next generation of gas turbine performance. GE is a global leader in CMC technology development, with a pioneering research and development effort spanning nearly 20 years.
GE has accumulated over 24,000 hours of experience on CMC shrouds in 7F gas turbines, and has achieved FAA certification of CMC hot-section components on the LEAP* engine, the next generation of the CFM56* aircraft engine. This rigorous and thorough technology development path has culminated in the first commercial offering of CMC hardware in the industry.

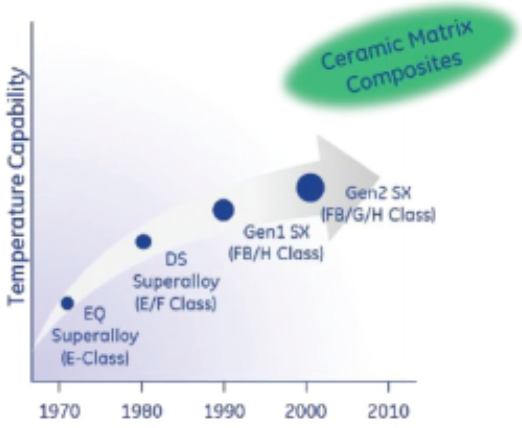


Figure 1 – CMCs represent the next generation in materials

Product Benefits

The 7F CMC shroud provides incremental output and heat rate improvements to the 7F Advanced Gas Path. The product can be applied to a new unit (7F.04, 7F.05) or as an option to a full AGP upgrade. CMC combines unique strength and durability characteristics, resulting in less turbine cooling flow requireme less thermodynamic and aerodynamic losses in the gas path, a higher performance.

Benefits

- Up to 0.6% gas turbine output increase
- Up to 0.2% gas turbine heat rate reduction
- 32,000 Factored Hour/1250 Factored Start Maintenance Inte
- Install as part of AGP upgrade or as a separate enhancement existing AGP configuration

This upgrade can be applied to the following unit configurations:

- 7F.01/.02/.03 with Advanced Gas Path
- 7F.04
- 7F.05

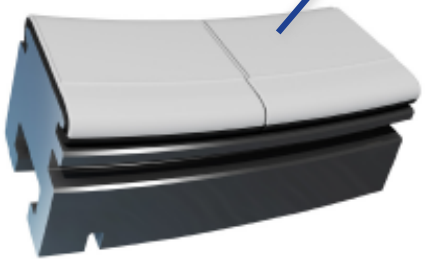
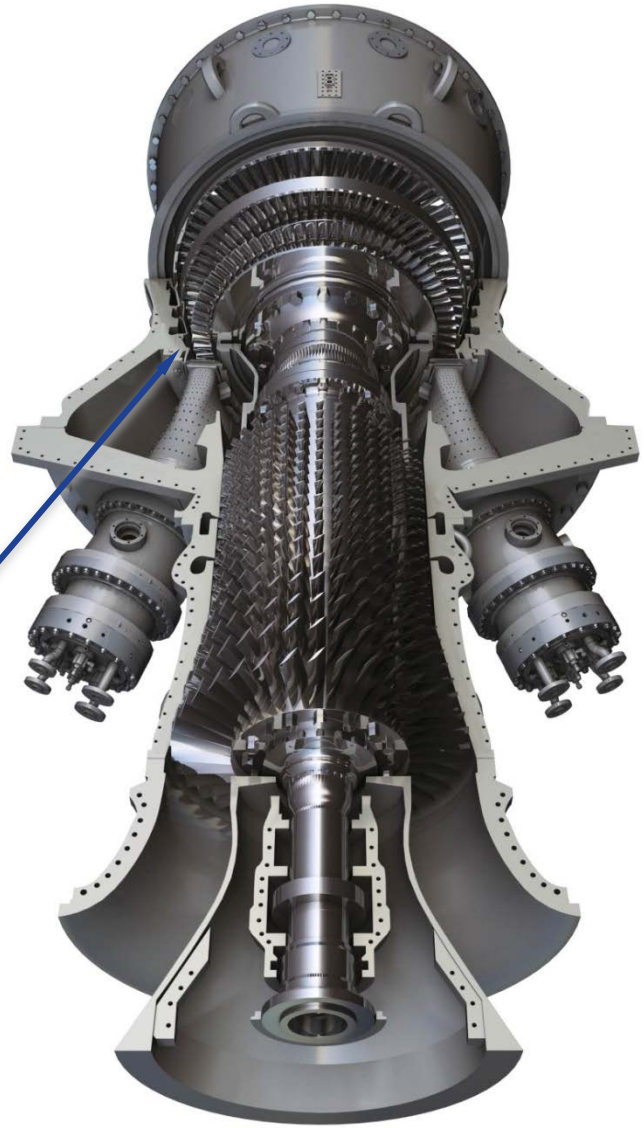


Figure 2 – CMC shroud for the 7F

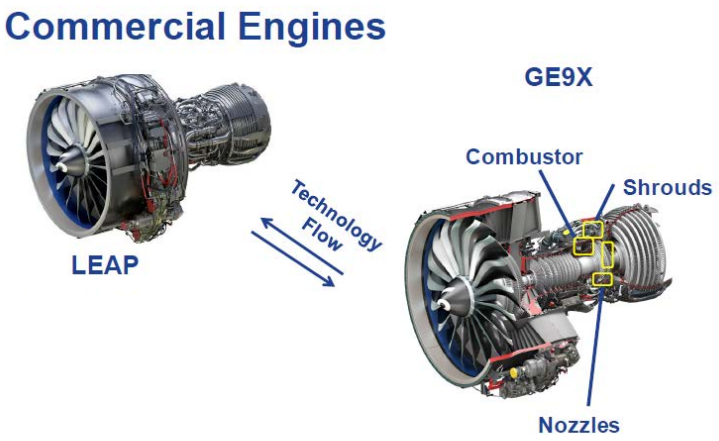
Typical Customer Brochure



Typical 3-stage F-class Turbine

DoE funding for CMCs… Big Impact

Aviation



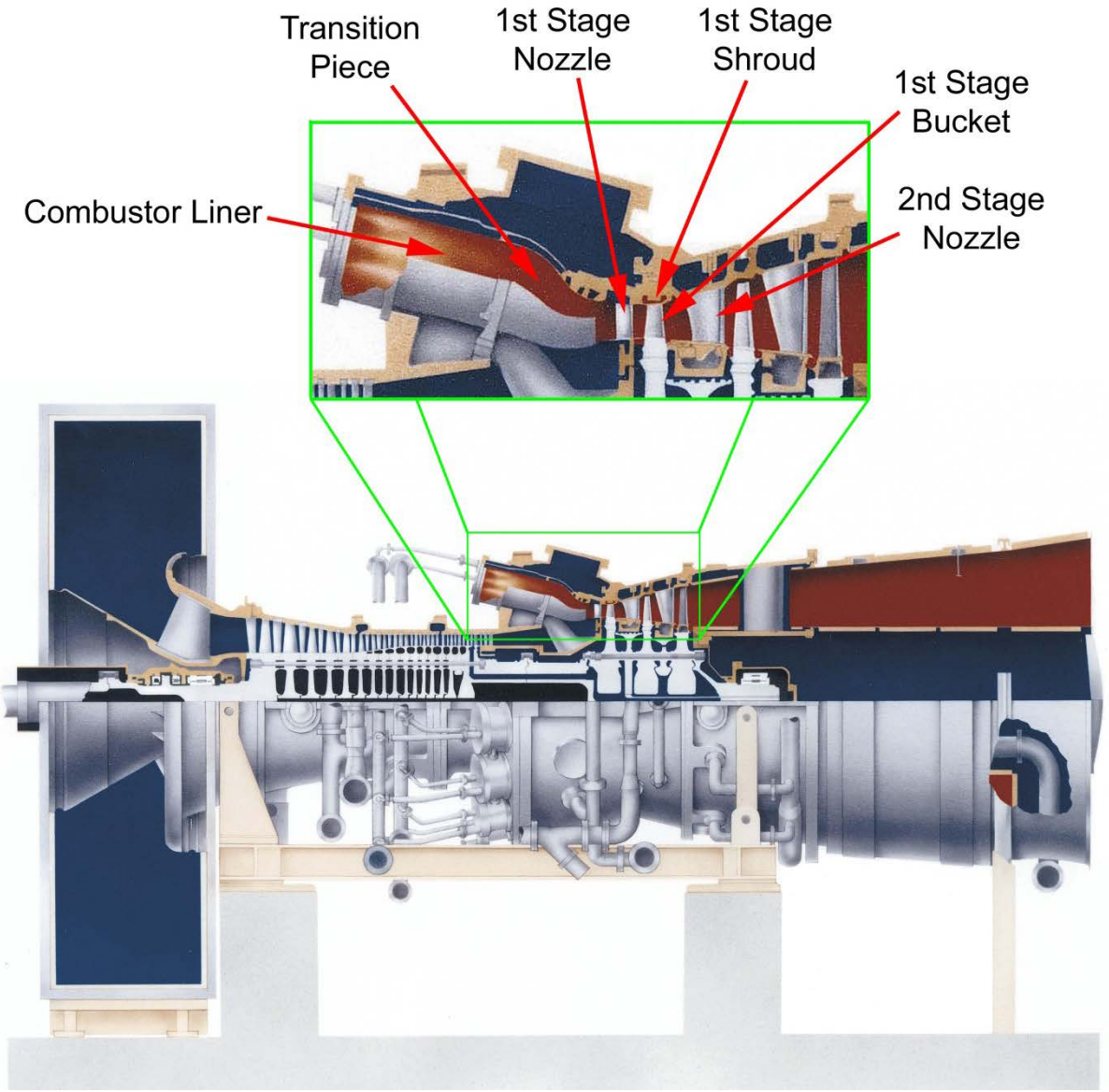
- Engine Orders
- Build Factories
  - ☐ Raw Fiber
  - ☐ Fiber Coating & Tape

Correa said. For GE, “this is very much past the science experiment and engineering marvel”

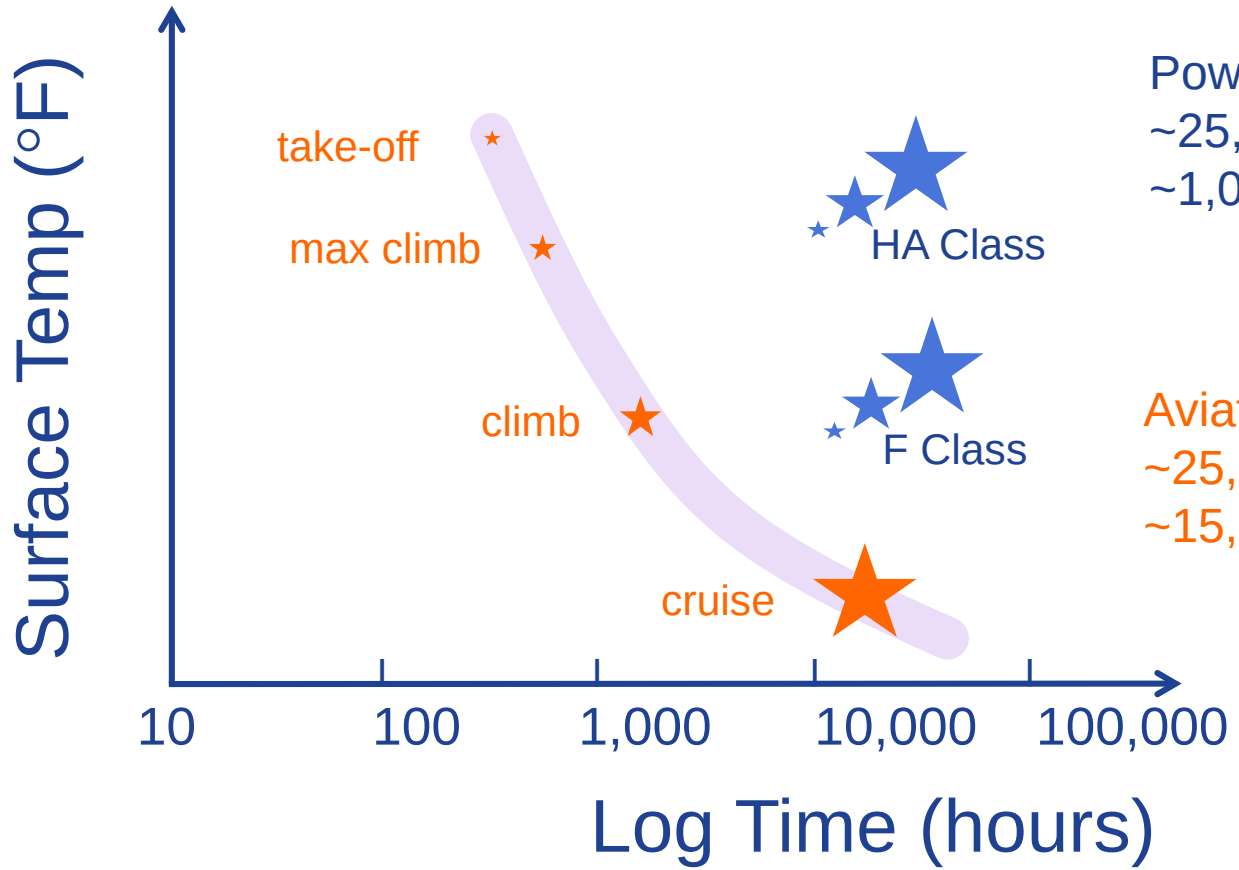
GE Power

Powering the world… opportunity for CMCs

Industrial Turbine Applications



Mission Uniqueness… GT Durability Challenge

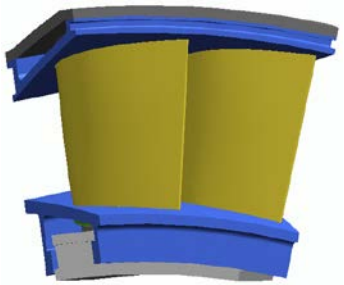


Power Gen
~25,000h
~1,000cy, 10-100h holds

Aviation
~25,000h
~15,000cy, 0.03-10h holds

Need to demonstrate capable designs

Nozzle Concepts



Select Attributes

Simple CMC airfoils… high yield

Sealing complexity… performance risk

Loaded CMC… life risk

Cantilevered CMC airfoil… low stress

Loaded metal… life risk

ID endwall gaps… performance risk

CMC… A key technology for the 65% efficient machine