

# Advanced CMC Manufacturing & Machining Process Development

## PROBLEM / OBJECTIVE

Improve the fuel efficiency and reduce the weight of the UH-60 Black Hawk and AH-64 Apache helicopters through the use of lighter weight, higher temperature capable, and more durable Stage 1 and Stage 2 ceramic matrix composite (CMC) shrouds, replacing metal components in the T700 family of engines.



CMC Shroud

SH-60 Seahawk

## ACCOMPLISHMENTS / PAYOFF

**Process Improvement:** This project demonstrated improved manufacturing and processing of CMCs used in aviation propulsion and power generation. Demonstrated processes include:

- Affordable robust manufacturing processes
- Manufacture full-scale prototype components
- Validate process capabilities to MRL 6+
- Increased efficiency of tow coating for Type S SiC fibers
- Low cost methods for fabricating shroud preform shapes
- Leaner machining fixturing and cutting processes for CMC materials
- Developing Cost Effective Methods for Applying and Repairing Environmental Barrier Coatings (EBC)

**Implementation and Technology Transfer:** GE Aviation has conducted a full engine test program which has successfully demonstrated the use of CMC shrouds in a CT7 turboshaft engine. The improved manufacturing parameters and demo shrouds were delivered to PM Common Engine in April 2015. The Navy is funding development to implement CMC shrouds in the T700-401C engine for Seahawk. This program will provide a range of benefits to the Warfighter including weapon systems availability, durability, efficiency, logistical support and O&S costs.

## Benefits and Warfighter Impact:

Process	Measure	Program Objective (reductions)	Final Status (reductions)	Final MRL
In-Line Tow Coating	Labor	70%	70%	6
Tape Processing	Labor	20%	43%	6
Layup & Debulk	Labor	50%	75%	6
Preforming	Labor	50%	75%	6
Machining	Labor	20%	20%	6
Environmental Barrier Coating (EBC)	Labor	75%	94%	6

In addition to meeting the metrics listed above, there were a number of other potential performance benefits associated with using CMC shrouds in the T700 engine application that were identified at the onset of the program. These achievements include:

- ~0.5% improvement in engine Specific Fuel Consumption
- >1 pound of weight reduction (per engine)
- Reduced engine part count
- Reduced environmental emissions of CO<sub>2</sub>
- Reduction of front-line fuel transportation convoys

## TIME LINE / MILESTONE

Start Date Sept 2010  
End Date April 2015

## FUNDING

U.S. Army ManTech \$10.65M

## PARTICIPANTS

U.S. Army RDECOM Aviation and Missile Research, Development and Engineering Center (AMRDEC)  
Redstone Arsenal, AL  
GE-Aviation, Cincinnati, OH  
Tiburon Associates, Inc.