Department of the Navy SBIR/STTR Transition Program
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Topic # AF19A-T021
Carbon-Carbon Composite Manufacturing Process Variability and Impact on Flight Performance
CFD Research Corporation

WHO

SYSCOM: SSP

Sponsoring Program: Navy SSP

Transition Target: Hypersonic Programs

TPOC: SSP.SBIR@ssp.navy.mil

Other Transition Opportunities: These composite processing models can also support development of emerging composite starting materials, processing steps, and approaches to fabricating multi-functional composites for electromagnetic interference and radiation shielding.

Notes: CFD Research is a 100% employee-owned small business with a 37-year heritage of innovative technology development and deployment, and a track record of successfully executing programs for the US Government. We specialize in engineering simulations and innovative designs for Aerospace, Biomedical, Defense, Energy, Materials, and other industries. Using our software and experimental facilities, we develop new hardware concepts, innovative designs, and prototypes.

CFD Research has previously developed complimentary modeling tools to predict how carbon-carbon (C/C) and other composites degrade in extreme operating environments.

Starting Materials | Processing Conditions

Porosity, Distortion — Mechanical Properties
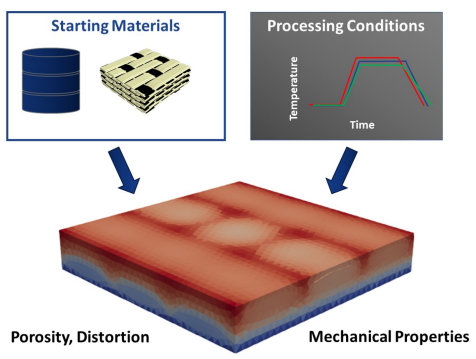
WHAT

Operational Need and Improvement: C/C composites with improved as-built mechanical properties, reduced variability, and known sensitivity to any changes in the starting materials are needed. Composite processing models that accurately predict final component geometry, density, mechanical and physical properties, and their variations within the component, will accelerate development and qualification of these composites. The model results need to be subsequently usable by downstream codes to analyze performance under various use cases.

Specifications Required: The composite processing models should accurately predict final component geometry, density, mechanical and physical properties, and variations within the component. The modeling architecture should be flexible enough to incorporate new processes and/or customizable to address new process steps. The starting composite architecture should be easily importable into the models, and the results should be exportable to design and analysis software.

Technology Developed: CFD Research is developing a C/C composite fabrication process model accounting for starting materials, fiber weave architecture, and process conditions that predicts the model composite response to each step. The model uses information from the molecular scale (detailed simulations of liquid resin entering/leaving spaces between individual fibers) to predict voids, stresses, and mechanical properties as the composite is fabricated. Data transfer and links will be established so that the process model results provide the starting composite state for CFD Research software to predict its mechanical properties, thermal performance, and degradation in operating environments.

Warfighter Value: The developed ability to predict C/C composite material performance variations resulting from process condition changes and supplier/material variability will accelerate the current "build and test" development process, saving the Navy and other DoD organizations significant time and expense. By providing an improved understanding of sensitivity to key inputs, composite manufacturers will be able to focus quality control efforts and more rapidly adapt to changes in source materials. The principal value to the warfighter is increased confidence in the quality and consistent, repeatable performance of these critical materials.

WHEN

Contract Number: N64267-23-C-0026　　　**Ending on:** Mar 25, 2025

Milestone	Risk Level	Measure of Success	Ending TRL	Date
Phase I model predictions of composite strength after process cycles	N/A	Agreement with published models and data	3	2nd QTR FY20
Validation against experimental data for a single infiltration-densification cycle	Medium	Predicted porosity distribution and sample coupon strength agree with measurements	4	1st QTR FY25
If Option exercised, link predicted as-manufactured composite to flight environment performance	Medium	Successful demonstration of process to vehicle scale (aeroshell) performance	4	4th QTR FY25

HOW

Projected Business Model: The commercialization approach will be based on a Products + Services = Solutions business model. The initial focus will be on services, applying the developed models for customers to develop process strategies for new composite architectures and starting materials, and to develop custom approaches to C/C composites fabrication to increase throughput or reduce variability. The associated application-driven development of the software will support preparation of a prototype for software sales and continued expert services.

Company Objectives: CFD Research is focused on commercializing advanced technologies; this includes transitioning technologies to government agencies and primes as well as through licensing, products, and spin-offs. Our corporate mission is to deliver innovative technologies, services, and products to empower out customers for success.

Potential Commercial Applications: Potential commercial applications include aiding in process development and quality control for other carbon fiber based composite material systems. The principal value proposition is better quality control and process repeatability, resulting in reduced scrap and fabrication costs.

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