Topic: N141-082

ATA Engineering, Inc.

Non-Linear Behavior Models for Design of Carbon-Carbon Composite Components

ATA Engineering, Inc. (ATA) has developed a computational toolset for simulating complex thermo-mechanical responses of woven carbon-carbon (C/C) composite materials. The toolset, COMPAS(TM), is fully integrated within the ABAQUS finite element analysis environment to provide a novel capability for assessing the design of C/C thermal protection system (TPS) components used on spacecraft, reentry systems, and hypersonic vehicles. From partial information about constituent materials and limited mechanical test data, COMPAS extracts material model parameters (e.g., stiffness, strength) along with associated statistical distributions. As ATA completes comprehensive validation of the toolset's predictive accuracy through comparison with a variety of experimental test data, we seek opportunities to utilize the technology in providing modeling and simulation services to DoD, NASA, and contractors developing flight systems for extreme environments.

Technology Category Alignment:

High-Speed/Hypersonics
Corrosion
Power and Energy

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SYSCOM: SSP
Contract: N00030-16-C-0238

Corporate Brochure: https://navystp.com/vtm/open_file?type=brochure&id=N00030-16-C-0238

Department of the Navy SBIR/STTR Transition Program

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SSP 8 Dec 2017

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WHO

SYSCOM: SSP

Sponsoring Program: Strategic Weapons Systems

Transition Target: Trident II D5 (ACAT I)

TPOC:
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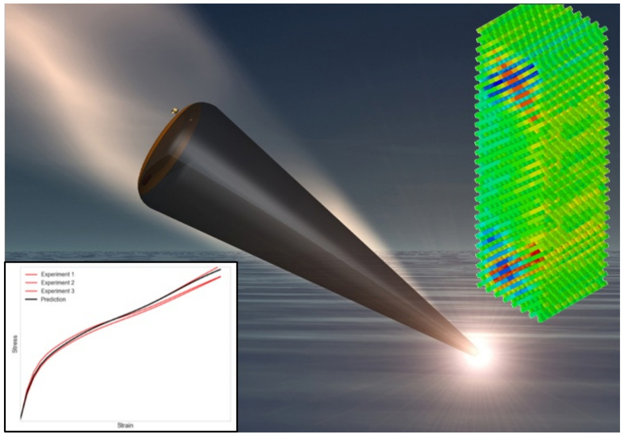
Other transition opportunities: Air Force reentry systems, hypersonic vehicles, hypervelocity projectiles, spacecraft planetary entry systems



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WHAT

Operational Need and Improvement: There is a critical need to reduce the time needed to assess the viability of a new material system for use in flight vehicle thermal protection systems (TPS). Continually changing raw material availability presents a challenge for designing and delivering TPS for ongoing reentry body life extension programs (LEP), upgrades, and future systems. Navy and prime contractors must expend tremendous effort in analysis and testing to certify new replacement material systems. The Navy seeks a numerical simulation approach utilizing non-linear finite element analysis (FEA) to predict the performance of candidate material systems while reducing the reliance on experimental characterization.

Specifications Required:
•Develop a methodology for TPS component design that accounts for onset and development of material non-linearity under complex thermo-mechanically induced load conditions.
•Evaluate fidelity of response prediction against measured data (including standard coupon protocols, complex load configurations, room and elevated temperature).
•Evaluate applicability to a notional nosetip reentry environment.

Technology Developed: ATA's COMPAS computational toolset predicts the thermo-mechanical response of ceramic matrix composite materials (CMCs) and carbon/carbon (C/C) composites, including orthogonally woven 3D materials. Implemented in SIMULIA's Abaqus FEA environment with graphical user interfaces for ease of use, COMPAS accurately extracts material model parameters, such as stiffness and strength properties, along with their associated statistical distributions using only a limited set of test data and constituent material information. Underlying technologies include a novel modeling formulation, known as the Enhanced Binary Model (EBM), and machine learning algorithms coupled with statistical methods that serve as ultra-efficient surrogates for FEA solutions.

Warfighter Value: COMPAS provides the engineer with reliable material model parameters even when comprehensive characterization data is unavailable. This capability has the potential to accelerate the adoption of new material systems that will enable more lightweight and capable TPS designs.

WHEN

Contract Number: N00030-16-C-0238 **Ending on:** July 1, 2018

Milestone	Risk Level	Measure of Success	Ending TRL	Date
Validate accuracy of modeling framework	Low	Acceptable correlation between analysis prediction and extensive thermo-mechanical test dataset	5	October 2017
Full-scale simulation of representative nosetip structure	Med	Perceived accuracy of predicted material response as assessed by subject-matter experts.	6	December 2017
Simulation of complex thermomechanical load cases (combined loading)	Med	Confirmed simulation accuracy through comparison with measured responses	7	March 2018
Productization of software tool	Low	Delivery of software package and documentation	7	July 2018

HOW

Projected Business Model: ATA plans to transition this technology to industry by providing derivative engineering services to the DoD and NASA contractors developing reentry vehicles, hypersonic vehicles, and spacecraft. This approach mirrors our core business model and affords the prime contractors with on-demand, scalable access to the technology and ATA's experts in the field. In addition, ATA will license the COMPAS software toolset to these organizations for use by their own engineering teams.

Company Objectives: ATA endeavors to be a leading provider of modeling, simulation, and analysis (MS&A) solutions to the organizations developing next generation high-speed flight vehicles, spacecraft, and other aerospace systems. At the 2018 Navy FST, ATA seeks partners interested in exploring applicability of COMPAS to the engineering of their products.

Potential Commercial Applications: Advanced composite material systems, including aircraft engine exhaust hot section parts and racing car brake components

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