

# Department of the Navy SBIR/STTR Transition Program

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Topic # N141-082

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

ATA Engineering, Inc.

## WHO

**SYSCOM:** SSP

**Sponsoring Program:** Strategic Weapons Systems

**Transition Target:** Trident II D5 (ACAT I)

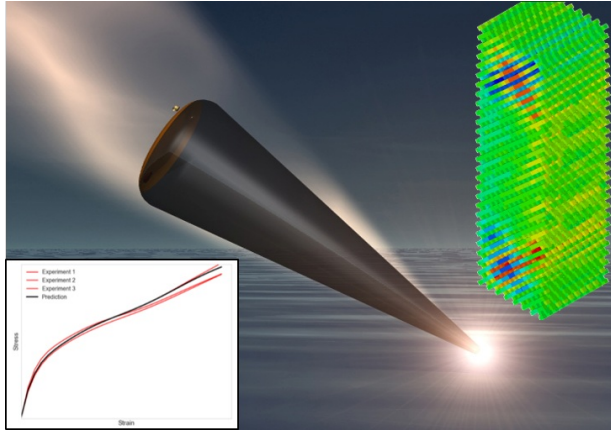
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**Other transition opportunities:** Air Force reentry systems, hypersonic vehicles, hypervelocity projectiles, spacecraft planetary entry systems



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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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