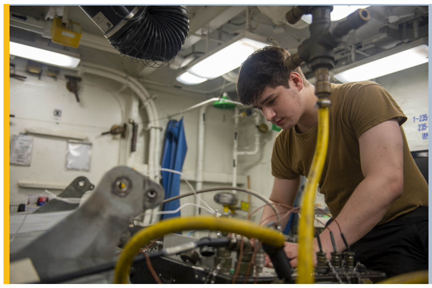
TOPIC NUMBER: N141-082 | **SBIR INVESTMENT:** $1,149,284 | **PHASE III FUNDING:** $2,998,211

DEPARTMENT OF THE NAVY

NAVY SBIR/STTR SUCCESS STORY



NON-LINEAR BEHAVIOR MODELS FOR DESIGN OF CARBON-CARBON COMPOSITE COMPONENTS

Through SBIR, ATA Engineering met the Navy's objective to improve non-linear materials behavior models for the design of Carbon/Carbon thermal protection components.

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THE CHALLENGE

Navy reentry bodies are subject to intense aerodynamic heating rates and surface ablation during descent. A Thermal Protection System (TPS) is used on the outer surface of the body to control erosion and minimize heat transmission to the underlying structure. TPS systems for current and future Navy hypersonic reentry bodies include flight critical components fabricated from 2D and 3D woven carbon-carbon (C/C) composite materials which need to perform across a vast temperature range of 70-5,000 °F. TPS component designs are validated by Finite Element Analysis (FEA) during pre-flight Preliminary and Critical Design Reviews. The Navy sought computational power/resources in developing new and improved methods for thermo-mechanical design validation of 2D and 3D C/C TPS components.

THE TECHNOLOGY

ATA evolved its improved non-linear materials behavior model for the design of 3D woven C/C composite TPS components. Phase I was a conceptualized approach for improved design methodology for non-linear FEA of 2D and 3D C/C, and Phase II expanded and refined a C/C material modeling toolset which enabled more complex geometries analysis, multidirectional stress states, and alternative material systems. A validation test campaign produced key points from thermo-mechanical coupon tension, compression, and shear testing of a next-generation material system at temperature providing insight into material performance under complex loading conditions.

THE TRANSITION

The Navy Strategic Systems Programs (SSP) awarded a Phase III contract for extension of the toolset developed and validated under its Phase I/II SBIR funding. This includes: toolset extension to be compatible with select solvers, validating the approach's predictive accuracy, select materials ablation prediction, developing and evaluating predictive approaches against test data to identify the best approach, extending the approach to a broad range of Navy reentry TPS materials families, creating workflows from the toolset, and validating virtual allowable predictions, i.e., A and B basis allowables.

THE NAVAL BENEFIT

Previously, pre-flight design validation for current generation TPS materials was required before full characterization data and material model coefficients became available. Output of the material model was limited to stress/strain state and gave no indication as to the onset or extent of damage within the material or critical failure mode within the cell structure of the material. This technology enables a more robust and complete analysis of 2D and 3D C/C materials, which will result in improved performance and longevity of the thermal protection systems used for Navy reentry bodies. To achieve greater realism in computational modeling for these extreme environments, ATA's technology enables coupled co-simulation using best-in-class software codes across multiple domains. This and other technologies developed by ATA will help U.S. government agencies and contractors achieve a critical national security priority: leading the world in hypersonics

THE FUTURE

As the Navy is preparing to develop the next generation of attack and ballistic/cruise missile submarines, the tools resulting from this project will be well timed to support the extensive modeling and analysis efforts associated with these new classes. FEA will be employed in these design activities to an extent not seen before, and definitive modeling standards will be necessary to achieve accurate, cost-effective, and robust analyses. In other applications, 3D reinforced composite materials have many potential uses in space, air transport, and automotive applications. Improved methods for design validation of these materials would be beneficial in a variety of scenarios including Missile NoseTips, Missile Launch Abort Systems, Throttling Divert and Attitude Control Systems (T-DACS), and TPSs for hypersonic vehicles.

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