Topic: N12A-T004

M4 Engineering, Inc.

Bonded Joint Analysis Method
M4 Engineering, an aerospace and mechanical engineering analysis and consulting company, is creating an advanced modeling tool for adhesive bonds that allows faster introduction of new material systems through better analysis and reduced testing. The Abaqus-based tool will reveal the real-world response of bonded joints for a broad range of mechanical and environmental loading conditions to give higher operational reliability and design robustness. The software tool builds upon the unique world-class polymer model developed by Sandia National Labs1 over a decade and interfaces directly with Abaqus, the premiere nonlinear finite element analysis program from SIMULIA. The goal is to have the tool adopted by the designers and analysts throughout the DoD labs as well their prime contractors in the aerospace and mechanical engineering fields.

Technology Category Alignment:
Fixed Wing Vehicles (includes UAS)
Fixed Wing Vehicles (includes UAS)
Structures and Protection
Modeling, Simulation & Test Infrastructure

Contact:
Daniel Hammerand, Ph.D.
dhammerand@m4-engineering.com
(562) 981-7797234
http://www.m4-engineering.com/
SYSCOM: NAVAIR
Contract: N68335-16-C-0176

Corporate Brochure: https://navystp.com/vtm/open_file?type=brochure&id=N68335-16-C-0176

Department of the Navy SBIR/STTR Transition Program

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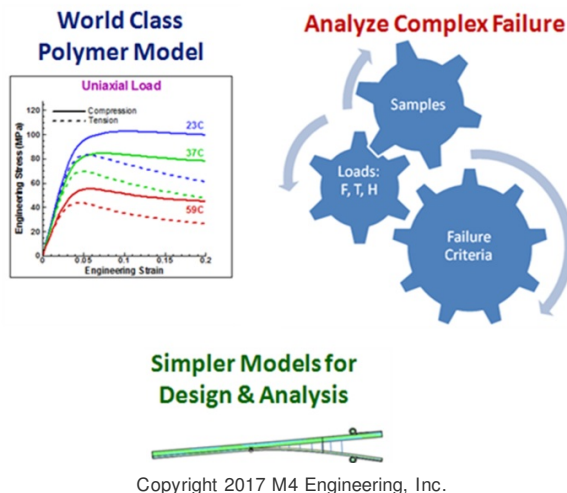
Bonded Joint Analysis Method

M4 Engineering, Inc.

WHO

SYSCOM: NAVAIR

Sponsoring Program: PMA-208
Navy Aerial Targets & Decoys

Transition Target: SSAT

TPOC:
(760)939-3638

Other transition opportunities:
Navy aircraft. Air Force. Commercial primes including Boeing, Lockheed Martin, Raytheon, Orbital ATK. Electronics manufacturers.

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WHAT

Operational Need and Improvement: Because of weight/cost benefits, bonded joints are becoming much more common in fielded and proposed systems. Streamlined approaches for introducing new/better adhesives and bonded joint designs for optimal reliability in operational environments will provide programmatic time and budget advantages.

Specifications Required: The objective of this topic is to advance the state of the art by identifying a failure theory with a basis in basic material properties that can be employed during structural analysis and will result in quantified margins of safety for bonded joints. The combined failure theory should include, at the minimum, the full range of complex loading, a finite element analysis application tool or plug-in, the test methods required to generate the needed material properties, and finally the validation of the method through the analysis and test of complexly loaded bonded structures. It should include all of the potential failure modes like adhesive failure, cohesive failure, and first-ply delamination of the composite adherands.

Technology Developed: An analysis software tool that combines advanced surrogate models for bonded joint response which is based upon a world-class polymer model originally developed by Sandia National Laboratories.[1] This tool interfaces directly with industry standard analysis tools and can be adopted quickly.

Warfighter Value: Faster introduction of new material systems through reduced testing and better analysis. Higher confidence in operational reliability and robustness will account for the complete range of mechanical loads and directly incorporate operational environments (temperature, moisture and their histories) in the structural analysis.

[1]Sandia National Laboratories is a multi-mission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA-0003525.

WHEN

Contract Number: N68335-16-C-0176 **Ending on:** July 27, 2018

Milestone	Risk Level	Measure of Success	Ending TRL	Date
Modeling Demo	N/A	Predicts bond response for representative loads/environments	3	January 2014
Prototype Tool	N/A	Input deck driven tool capturing range of bond responses	4	October 2016
Baseline Evaluation & Validation	Med	Model results compare well for simple bond tests with multiple adhesives & composite adherends	5	October 2017
Component Evaluation & Validation	Med	Model results compare well for component tests	6	March 2018
Integrated Software Tool	Med	Full GUI based tool released to NAVAIR & validated for components/environments	7	July 2018

HOW

Projected Business Model: M4 Engineering will commercialize the software tool via licensing. Both term-limited and non-expiring options will be offered. Direct sales to the government and its primes will be sought, as appropriate.

Company Objectives: During the Forum for SBIR/STTR Transition, M4 Engineering will develop additional customer interest outside of PMA-208. Throughout the remainder of Phase II, M4 will pursue additional government resources for further technology development. M4 will lay the foundation for a comprehensive bond modeling tool well suited for design and analysis activities, especially following integration with M4's optimization and uncertainty quantification framework. Additionally, M4 will continue to expand its commercial analysis business in the US aerospace industry.

Potential Commercial Applications: The advanced bond modeling tool will enable commercial aerospace firms to develop and incorporate improved bonded joint designs, new and refined adhesive materials, and bonded patch repairs more rapidly.

Contact: Daniel Hammerand, Ph.D., Senior Engineer, R&D
dhammerand@m4-engineering.com   562-981-7797 x234