

WHO

SYSCOM: NAVAIR

Sponsoring Program: PMA 261 H-53 Heavy Lift Helicopters

Transition Target: Any air-frame that requires one to machine and countersink fastener holes in composite structures for aircraft components such as the CH-53K, F/A-18, and F-35

TPOC:

Other transition opportunities: Other platforms that require countersunk fastener holes in carbon and glass fiber laminate composite materials like the CH-47 Chinook and MH-60R

Notes: Composite panels are being implemented on the CH-53K helicopter and other aircraft to decrease weight and increase performance. Third Wave Systems is developing drilling process simulation and adaptive process optimization to minimize damage during the drilling of countersunk fastener holes, improve panel quality, and drastically reduce cost.



U.S. Marine Corps Photo, available at <https://www.candp.marines.mil/portals/216/images/03%20Programs/04%20ver=2018-04-25-114019-047>

WHAT

Operational Need and Improvement: Fiber reinforced polymer (FRP) composites are a key enabling material in several U.S. military aircraft; however, the highly abrasive nature of carbon, glass, and aramid fibers reduces tool life of traditional tungsten carbide drill bits, necessitating their frequent changing, and affects hole diameter as the drill bit is abraded by the material. The frictional heat generated by the drill bit can cause severe damage to the polymer matrix, resulting in a loss of strength that can be extremely difficult to detect and FRP materials are prone to delamination due to improper drilling technique.

Specifications Required: The solution shall be a process modeling and optimization tool to enable the control of mechanical and thermal damage in the composite material as the tool wears. Cutting forces and the resulting mechanical and thermal damage in the composite material surrounding the countersunk hole will be modeled. Adaptive process optimization will maximize hole making rate while accounting for progressive tool wear to maintain hole quality. The modeling and optimization software will be adaptable to different composite ply stacking strategies and advances in drilling and countersink tooling.

Technology Developed: Third Wave Systems is developing Finite Element Modeling technology to simulate the interaction of the drill and countersink tooling with the composite material. The model captures the inter- and intra-laminar behavior of the composite material to accurately predict the resulting mechanical damage (e.g. delamination) from the drilling forces and the thermal damage in the material resulting from the heat that is generated during the drilling and countersink process. These simulations are insights that are then used for adaptive process optimization, which accounts for the high rate of tool wear that occurs when drilling carbon fiber composite materials. The process modeling and optimization accounts for the increasing forces and heat that result as the tool wears and enables the process parameters to be adjusted to maintain optimal hole-making rate and quality.

Warfighter Value: The technology will reduce aircraft production costs by preventing damage that could cause panel rejection or decreased service life, which would lead to premature panel replacement. The proposed technology will improve hole quality by reducing thermal & mechanical damage, which will improve part performance while increasing the hole making rate and decreasing tooling cost. The modeling and optimization approach we are developing will allow "virtual" trial and error to decrease the development time with less material and labor costs.

WHEN

Contract Number: N68335-20-C-0254 **Ending on:** December 18, 2021

| Milestone | Risk Level | Measure of Success | Ending TRL | Date |
|---|------------|---|------------|---------------|
| Predict and validate key physics using orthogonal cutting tests | Med | Satisfactory agreement between simplified cutting simulation and experiments | 6 | August 2020 |
| Develop countersink drilling modeling capabilities | Med | Satisfactory agreement between drilling simulations and experiments | 6 | February 2021 |
| Develop optimization technologies | Med | Demonstration of technology to minimize mechanical and thermal damage | 5 | April 2021 |
| Develop adaptive modeling and optimization technology | Med | Satisfactory demonstration of adaptive modeling through comparison with simulation and test results | 5 | December 2021 |

HOW

Projected Business Model: Our business model is to sell the process modeling and adaptive modeling technology to the Primes and their suppliers. Third Wave Systems' approach to commercialization will mirror the successful supply chain deployment strategies used for metals machining, coupled with additional machine tool and/or controller partnerships. To a large extent, these distribution channels already exist. The ability to manufacture machined parts faster and for lower cost holds the promise of increased long-term viability for prime contractors and will simultaneously promote a healthier supplier network. Presently, over 100 DoD suppliers are using TWS' physics-based machining models for their machining processes.

Company Objectives: We anticipate the Navy SBIR/STTR Transition Program will facilitate additional connections with Government and Industry that are facing challenges in creating high-quality fastening holes in composite panels while reducing production costs. Our short-term objective is to secure a Phase III project to improve the modeling accuracy and computational performance and to further develop the adaptive optimization capabilities to compensate for tool wear and composite panel variations. Our long-term objective is to fully implement process modeling and adaptive optimization as a tool in the aerospace composite supply chain to eliminate scrap rate due to poor-quality holes and to maximize cost savings.

Potential Commercial Applications: This technology will be directly applicable to commercial aerospace structure applications where composite panels are attached via countersunk faster holes. In addition, the technology can be an effective and efficient machining and cutting tool for various components in both the military and commercial sectors such as automobile, and marine. TWS will continue to expand their library of composites that they can both model and machine, which will increase the number of industries that they can target.