NATIONAL CENTER FOR MANUFACTURING SCIENCES

Breakthroughs in Composites and Advanced Material Sustainment

While composite materials have been used for thousands of years, technological advancements in modern composites have produced exceptional benefits: corrosion resistance, design flexibility, durability, strength, stiffness, light weighting, and low maintenance costs. Since the development of fiberglass, one of the first modern composites, in the 1930s, composites have been used in cars, trucks, boats, trailers, aircraft, spacecraft, wind turbine blades, bridges, buildings, bathtubs, swimming pools, storage tanks, countertops, sporting goods, solar cells, sensors, lasers, and many more items.

Created by merging two or more materials with different chemical or physical properties, without dissolving or blending those materials into each other, composites produce a new material with superior properties. Reinforcement materials (particles, flakes, or most commonly fibers made of carbon, glass, aramid, or boron) are embedded into a matrix (generally ceramics, metals, or most frequently polymers) that serves as an adhesive by binding the fibers together and lending solidity to the material. Many new types of composites are produced through alternating layers of different materials. By carefully choosing the matrix, the reinforcement, and the manufacturing process, engineers can tailor composite properties to meet needed requirements.

For several decades, the National Center for Manufacturing Sciences (NCMS) has facilitated collaborations with industry, academic, and government partners that have advanced high-performance composite design and manufacturing processes. In the early 2000s, an NCMS project team assisted the DOD with repairing composite materials by establishing a standardized methodology to enable depot and field repair facilities to determine suitable substitute materials for weapon system repair and remanufacture. This project provided immediate benefit to warfighting capability during missions in Afghanistan, Kosovo, and Iraq.

In the 2010s, NCMS organized a collaboration to solve a significant problem the DOD has faced in the production and repair of composites: over 10% of engineering time is spent resolving cure cycle and heat transfer issues, which cost millions of dollars each year in scrapped parts and lost time. To help to save both money and time, an NCMS project team developed and tested tools to manage heat transfer for ovens and autoclaves used in the production

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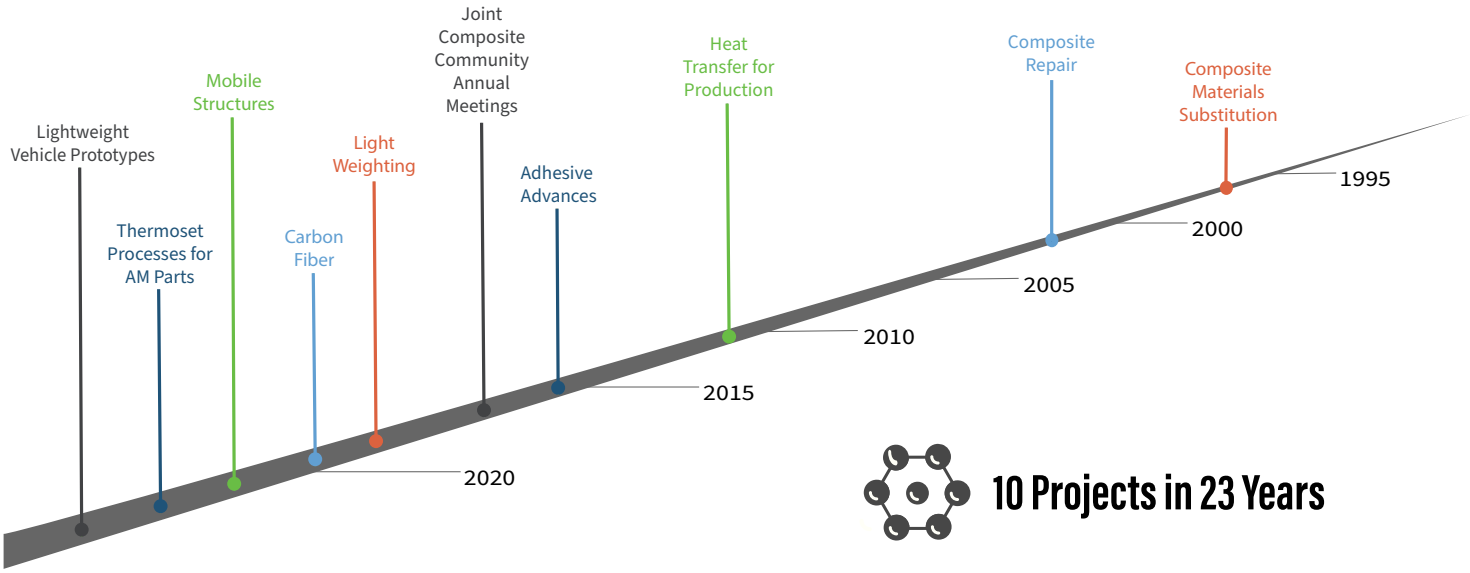
Timeline of Developments

In Composites and Advanced Material Sustainment



and repair of composites. This project installed control hardware and software, optimizing manufacture and repair processes for several facilities that produce substantial composite hardware for the DOD.

Even with their great benefits, composites still suffer wear and damage over time. Making repairs to composites with the same materials used in the first manufacturing process has generally proven to be unsuccessful. This is because the interactions of repair materials with the original materials is never as cohesive as the original materials. As a result, alternate repair materials and procedures have been needed.

For this reason, the composite community has sought a detailed sustainment technology strategy to ensure community-wide unity of effort. The goal is to better utilize commercial and government resources toward boosting the efficiency and effectiveness of composite maintenance and sustainment.

To meet this need, in 2016 NCMS reconfigured the Composite Maintainers Technical Interchange Meeting (TIM) into the Joint Composite & Advanced Materials Sustainment (JCAMS) Annual Meeting. This meeting continues to bring together government and military officials, industry leaders, manufacturers, engineers, and other technical experts who focus on issues facing the manufacturing, tooling, deployment, and repair of advanced composite materials in a defense setting.

JCAMS addresses the unique challenges for composite materials, repairs, tooling, processing, storage, and facilities. Their working groups have, for instance, solved issues in obtaining materials needed for repairing composite parts for several different assets; assembled a resource list for available training; and catalogued the skills, tools, equipment, techniques, materials, and analysis found to optimize sustainment.

In addition to the JCAMS initiatives, several NCMS collaborations have assisted the DOD transition to lightweight composite metals for industrial applications, resulting in enhanced performance, lower costs, and reduced fuel usage. Lightweight materials, such as composites, aluminum, and magnesium alloys do present a challenge: they cannot be fastened in the same way as traditional metals. They require special adhesives and other methods for joining separate parts, rather than bolts and welds.

NCMS has brought together initiatives that repair and maintain adhesive-intensive joints in a production setting using specification-compliant products. This includes making a survey of currently used joining materials used in the three largest Army depots and publicizing a list of specification-compliant replacement materials for obsolete adhesives and sealants. NCMS partners also found success in developing high-strength, high-elongation adhesives with low-temperature cure.

Another team of government and industry partners developed a reversible thermoplastic adhesive system by which a combination of steel, aluminum, and glass-fiber reinforced composite segments of vehicle components can be repaired. This work will facilitate faster, more effective maintenance of vehicles, vessels, and aircraft.

As the global transportation industry has increasingly sought to reduce carbon emissions, several NCMS collaborations have focused on using composites for vehicle light weighting, which is a primary strategy to reduce fuel consumption. One project team is developing a domestic source of mesophase pitch-based carbon fiber and lightweight composites to produce lightweight composite wheel rims and other components for commercial and military trucks.

Another collaboration has used an out of autoclave (OOA) composite manufacturing methodology, an alternative to the traditional high-pressure autoclave curing process commonly used to manufacture composite materials. This project has demonstrated efficient manufacturing processes for military ground vehicle structures, which has resulted in lightweight prototypes that are economical to produce.

Additional research on composites has upgraded the mechanical performance of additively manufactured (AM) parts used in vehicles that operate in austere, harsh environments. All these efforts have accelerated the development and transition of a wide range of composite materials into the commercial transportation industry, which will reduce corrosion, maintenance costs, and fuel consumption.

NCMS partners are also advancing new composite technologies and design processes to improve the functionality and lifecycle of rigid wall shelters. Using the Joint Warfighter Shelter of the Future—a DOD initiative—as a surrogate to prove out this new technology, this collaboration aims to determine whether composites can be used in a wide range of mobile shelters, freight containers, and other storage devices across commercial industries and DOD organizations. The use of composite materials for

these structures will reduce transportation and maintenance costs in many different industries. Moreover, utilizing composites will reduce the carbon footprint by 90 percent, when compared to standard building materials.

The future of composites is extremely bright, with proven technologies—including liquid resin infusion, compression molding, OOA thermoset molding processes, and thermoplastic composites—being adapted to meet the fast-evolving needs of many industries, especially aerospace, automotive, defense, marine, and wind turbine. NCMS looks forward to continuing in its role of facilitating further advances in this critical industry sector.

About NCMS

The National Center for Manufacturing Sciences (NCMS) is a cross-industry technology development consortium, dedicated to improving the competitiveness and strength of the US industrial base. As a member-based organization, it leverages its network of industry, government, and academia partners to develop, demonstrate, and transition innovative technologies efficiently, with less risk and lower cost.

NCMS enables world-class member companies to work effectively with other members on new opportunities – bringing together highly capable companies with providers and end users who need their innovations and technology solutions. NCMS members benefit from an accelerated progression of idea creation through execution.