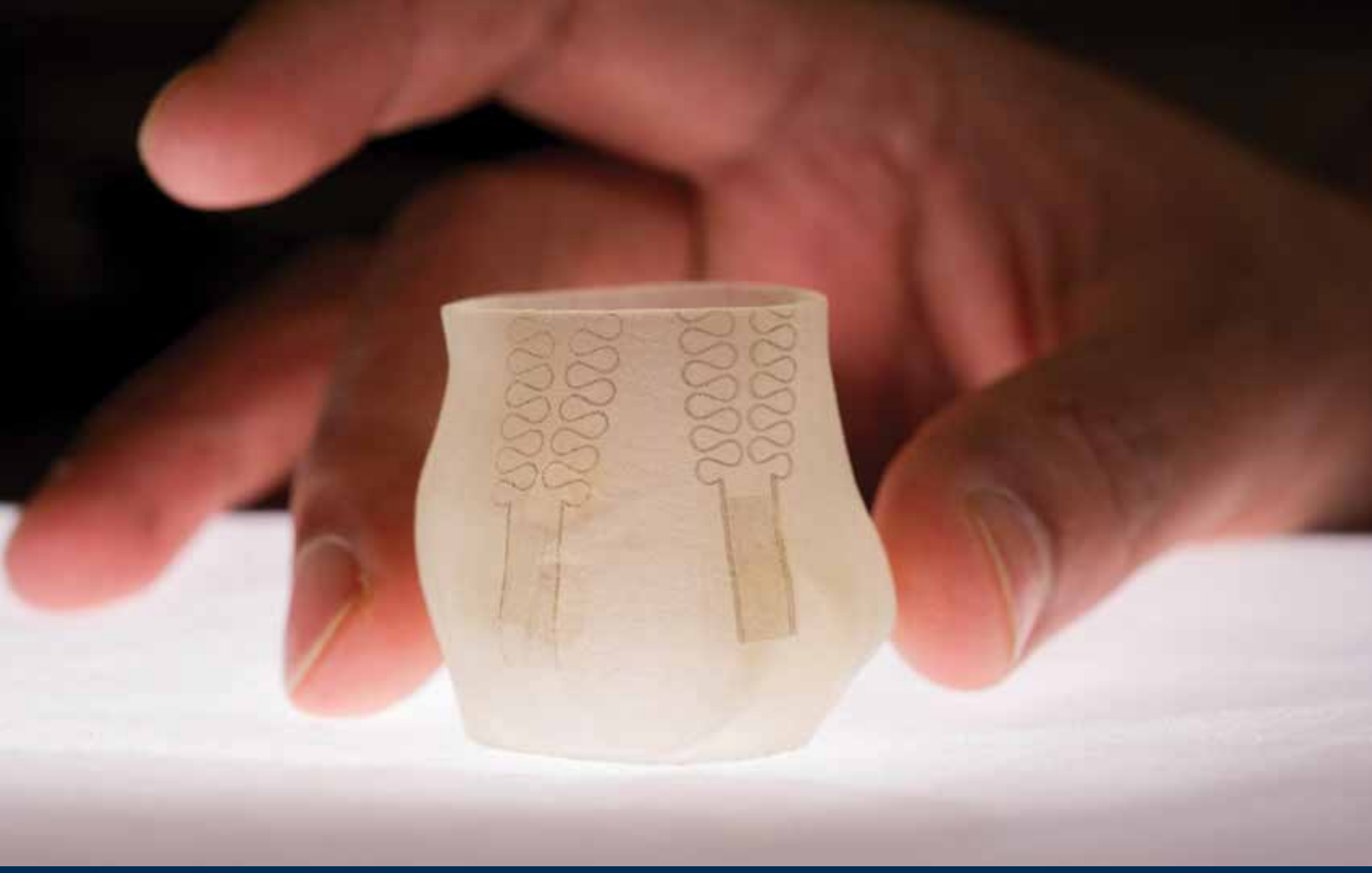
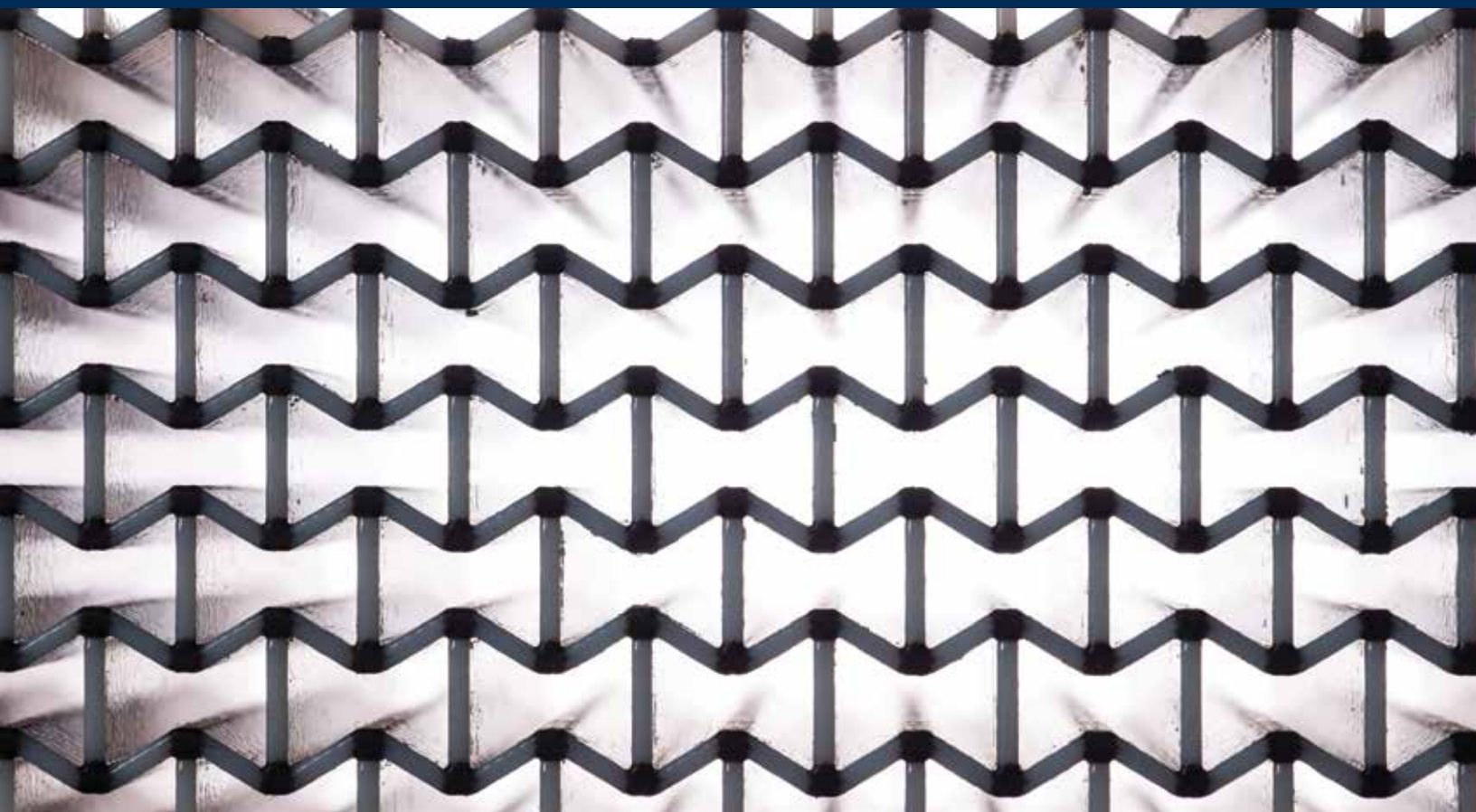
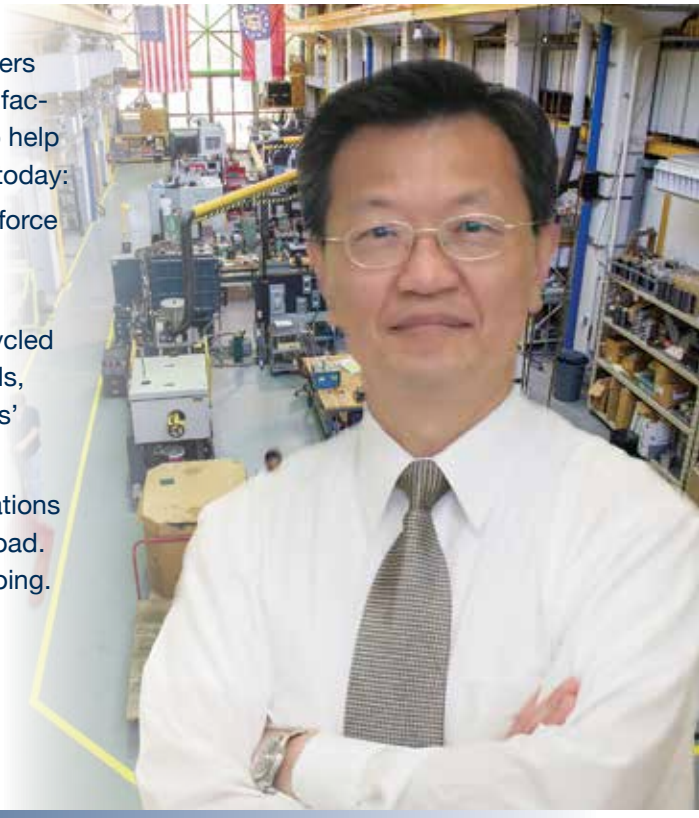


2014 GTMI Annual Report

Georgia Tech Manufacturing Institute



From the GTMI Executive Director



The Georgia Tech Manufacturing Institute brings together top researchers and thought leaders from the many varied disciplines that shape manufacturing — science, engineering, policy, robotics, and management — to help define and solve some of the greatest challenges facing U.S. industry today:

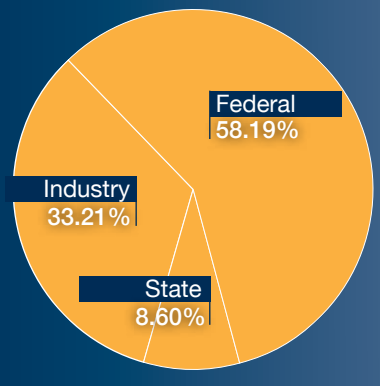
- Creating quality jobs and developing a highly skilled U.S. workforce
- Ensuring global competitiveness
- Advancing economic and environmental sustainability.

We focus on the complete innovation value chain — from raw and recycled resources to prototypes and finished products — and develop materials, systems, processes, education, and policies that impact manufacturers' performance in the marketplace.

This 2014 Annual Report highlights the progress of our many collaborations across the Georgia Tech campus, the state, the United States and abroad. My colleagues and I welcome all opportunities to share what we are doing. You can always call or email us. Also, be sure to visit our website (www.manufacturing.gatech.edu) frequently for news and updates.

Ben Wang,
Executive Directer, GTMI
ben.wang@gatech.edu or 404.894.9100

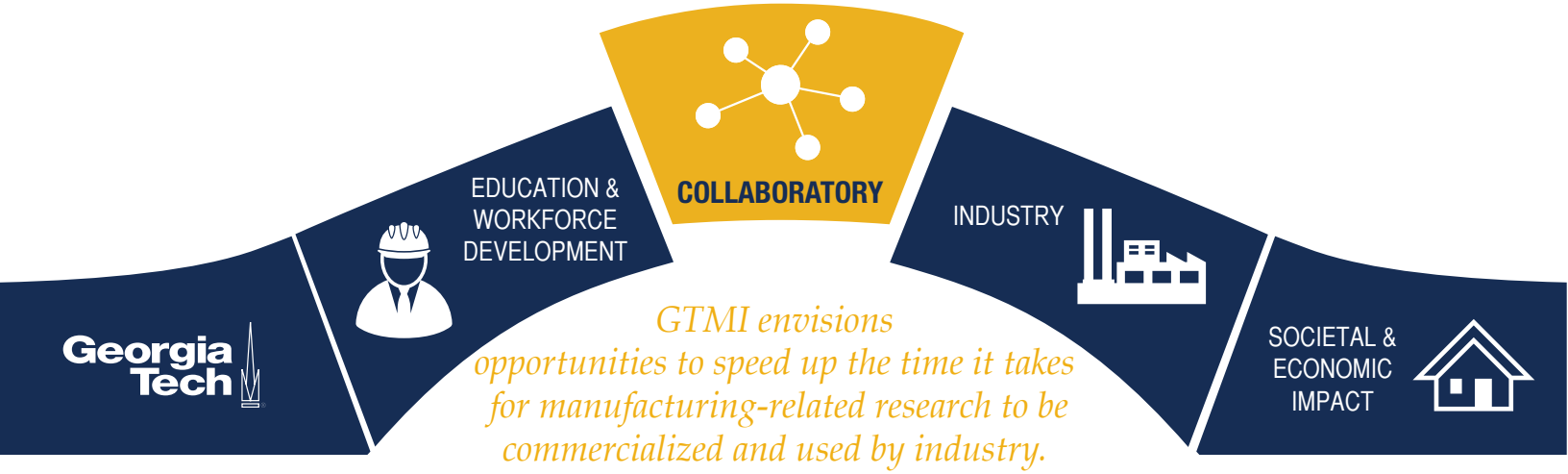
Financials - (Funding for January-December 2014)



GTMI Industry Partners

Workforce Development: Preparing Students and Professionals for Manufacturing Innovation

Intently focusing on enhancing the preparation of students through manufacturing coursework, research and innovation, GTMI's educational programs give students the critical knowledge and hands-on experience necessary to succeed in a highly competitive, multidisciplinary manufacturing environment. We offer the following programs: Graduate Assistant Opportunities; Manufacturing Education Program (MEP), consisting of the Manufacturing Certificate, International Option, and Manufacturing Scholarships; Language, Culture and Advanced Manufacturing Summer Immersion Program; REVAMP NSF REU; and Undergraduate Research Opportunities. In 2014, GTMI hosted its first class of Research Experience for Student Veterans in Advanced Manufacturing and Entrepreneurship (REVAMP) students. The program is funded by the National Science Foundation (NSF) as a Research Experience for Undergraduates (REU) summer site. The program trains undergraduate students in the fundamental principles of advanced manufacturing science and technology, and about the transition of basic discoveries in manufacturing science into innovative commercial products and processes. Pictured at right are the 2014 participants. Among them are four veterans, three women, and they represent three ethnic groups.



GTMI envisions opportunities to speed up the time it takes for manufacturing-related research to be commercialized and used by industry.

GTMI Strategic Plan

In July 2014, a team of GTMI stakeholders were named to a Strategic Planning Committee to develop a strategic plan. The GTMI External Advisory Board and Internal Advisory Board provided input on the plan. The committee will incorporate their thoughts into the plan, which will be in the implementation phase over the next five years. As the plan develops, updates can be found at www.manufacturing.gatech.edu.

GTMI Vision

GTMI will be the world's premier institution anticipating needs and providing solutions on the frontiers of manufacturing research, application, and deployment.

GTMI Mission

To pursue knowledge and skills to accelerate the translation of manufacturing-related research into high impact products and manufacturing systems.

A Major Outcome

As a result, we will be leaders in major technological, social, and policy decisions that address critical manufacturing challenges.

Thought Leadership

GTMI engages current stakeholders and prospective stakeholders in broadening the scope and understanding of manufacturing and manufacturing challenges in a number of ways:

AMP 2.0 - Leaders from Georgia Tech participated in the release of the President Obama's Advanced Manufacturing Partnership (AMP 2.0) final report. This was a one-year endeavor to outline a roadmap to secure U.S. manufacturing competitiveness. Georgia Tech President G.P. "Bud" Peterson served on the 19-person AMP 2.0 Steering Committee and numerous faculty and staff put in many hours serving on various workstreams that focused on different aspects of manufacturing competitiveness. GTMI worked to support Dr. Peterson, Dr. Steve Cross, and other faculty with their AMP endeavors.

Industry Partners Symposium - Each year, GTMI hosts a symposium devoted to addressing manufacturing challenges. In November 2014, GTMI welcomed more than 250 stakeholders to hear from Dr. Reinhold Achatz, head of technology and innovation at ThyssenKrupp, on the next industrial revolution. The afternoon was filled with presentations on: industry, government and academia collaboration; the Internet of Things; next generation electronics; and using additive manufacturing in biomedical settings. Participants also heard the results of a comprehensive survey of Georgia manufacturers on how their businesses are doing, what kind of partnerships are most valuable to them, and their insights on the future of manufacturing in the state. *Pictured at right are (l to r) Thomas Felis, vice president of innovation at ThyssenKrupp Americas; Dr. Steve Cross, Georgia Tech executive vice president for research; Dr. Reinhold Achatz, head of technology and innovation at ThyssenKrupp, who gave the distinguished lecture; Dr. Bud Petersen, Georgia Tech president; and Dr. Ben Wang, GTMI executive director.*

Socket Optimized For Comfort With Advanced Technologies (SOCAT)

Problem: The trial and error system used in fitting and customizing the socket that the residual limb will fit into, as well as how naturally the prosthetic moves, can last weeks or months and cause great discomfort to amputees. Healthcare providers haven't had a system to collect hard data from patients on how the prosthetic feels and/or works in order to make proper adjustments quickly.

Solution: GTMI, in collaboration with Florida State University, Advanced Materials Professional Services, Prosthetics and Orthotics Associates, Quantum Motion Medical and St. Petersburg College, developed SOCAT. As part of a $4.4 million U.S. Department of Veterans Affairs VA Innovation Initiative, SOCAT addresses prosthetic socket design on behalf of military amputees. By developing a socket system that simultaneously measures socket pressure, temperature and moisture, the inner socket environment can be quantified. By merging this internal socket measurement system with external sensors on the prosthesis, profile settings can be created and associated with gait activities such as level surface ambulation, stair and ramp ascent or descent. The profile settings can then be correlated to subjective amputee feedback (i.e. comfort).

Benefits: For patients, the SOCAT design improves comfort, gait, mobility and functional capacity. For practitioners, the embedded printed electronic sensors communicate needed data on issues that arise within the socket. Additionally, practitioners and insurance providers can use this data to ensure proper treatment plans and minimize insurance ambiguities.

MAID (Magnet-Assisted Intubation Device)

Problem: During intubation, when a breathing tube is inserted into a patient's airway, there is great potential for injury to the patient's teeth, vocal cords and more; risk of infection; and failure of the procedure. The main cause of these risks is the device commonly used to help guide the breathing tube into place, called a laryngoscope.

Solution: A student team from Georgia Tech competing in the 2011 InVenture competition discovered a way to potentially minimize injuries and risks. MAID guides the intubation tube into place using magnetic force. A removable, magnet-tipped stylet is placed within a breathing tube. With a strong magnet placed outside the body by the patient's Adam's apple, the tube is steered into proper position. The new device eliminates the need to visualize the airway and thus the laryngoscope. MAID won second place and went on to capture top honors in Georgia Tech's Business Plan Competition, as well as a $50,000 grant from the Georgia Tech Research Institute (GTRI). Today, it remains a viable candidate for commercialization. GTMI has helped simplify the design and manufacturing of an improved prototype.

Benefits: For patients, the use of MAID can minimize the risk of broken teeth or bones, tissue injury, infection and more because it doesn't rely on a bulky metal device to insert the breathing tube and it takes less time to insert. For practitioners, MAID will improve intubation success rates while minimizing complications and required training.

Consortium Seeks Answers to Major Challenges in Using Cell Manufacturing to Fight Cancer and Other Diseases

Problem: Scientists know how to manufacture very specific cells that can be injected into a patient to fight certain cancers, but the treatment can cost anywhere from $12,000 to $40,000 or more per injection. This is out of reach for many patients. Contributing to the high cost are: the limited availability of raw material (adult cells), the lack of widely accepted industry standards for cell characterization, and the lack of robust, reproducible manufacturing processes to mass produce therapeutic human cells, e.g. T cells and stem cells.

Solution: Georgia Tech received a grant this year from the Advanced Manufacturing Technology Consortia (AMTech) Program of the National Institute of Standards and Technology to create a roadmap that addresses these challenges. The Cell Manufacturing Consortium (CMC) will initially be composed of five universities and four companies engaged in cell manufacturing.

Benefits: Through collaboration with its stakeholders, CMC will develop a roadmap for how to proceed with technological innovations in cell manufacturing, and find ways to accelerate the use of cell-derived products in the health care market. This will provide affordable and readily available stem cell or immune cell-based treatment options for more patients.

Consortium for Accelerated Innovation and Insertion of Advanced Composites (CAIIAC)

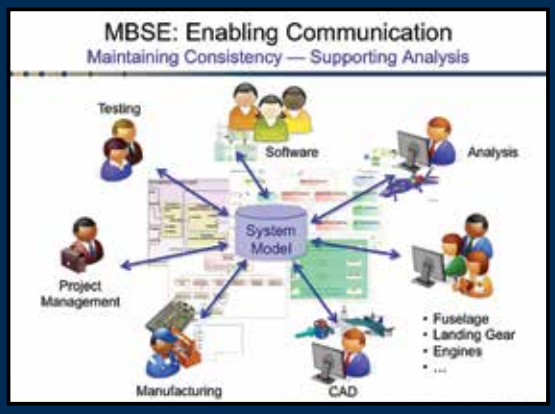
Problem: The potential business benefits of the next generation of advanced composites are compelling; however, no single company has the financial resources or the technical depth to make it a reality.

Solution: With a National Institute of Standards and Technology (NIST) grant, GTMI, in collaboration with Advanced Materials Professional Services, Florida State University, and the University of Dayton, created the Consortium. As many as 45 companies and government laboratories representing the aerospace, automotive, energy, and medical device sectors have committed to participating in CAIIAC. Starting with an industry-led roadmapping process, the new consortium aims to:

- Create a domestic, innovative manufacturing ecosystem to accelerate innovation and industry adoption of advanced composite products.
- Significantly shorten composite development cycles and provide "right-the-first-time material yields."
- Enable rapid technology transfer with advanced technologies and an improved understanding of business environments.

Benefits: The CAIIAC roadmap will provide a plan to speed up the time it takes to apply research on advanced composites to solve U.S. manufacturing challenges and improve the economic viability of U.S. companies of all sizes.

Model-Based Systems Engineering (MBSE)

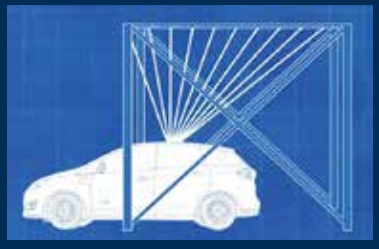


Problem: Modern factories and supply chains are becoming highly engineered systems, with real-time control systems driven by "big data" and analytics. The challenge today is that these systems historically have evolved in a largely ad hoc manner with almost no "engineering" tools to support their design. Rather, system design decisions have been driven by intuition, occasionally supported by hand-built optimization or simulation models. As a consequence, decisions that have a long-term impact on system performance are often not adequately supported by analyses.

Solution: Researchers in GTMI's Model-Based Systems Engineering Center have developed methods, models, and algorithms to enable a standardized description of large scale factories and supply chains, and to automate the translation from this standard description into optimization and simulation models. The approach involves the development of a comprehensive reference model (or meta-model) for the application domain, the creation of appropriate re-usable analysis component libraries, and the development of a transformation methodology based on "software factory" concepts from software engineering.

Benefits: This novel factory and logistics systems modeling framework developed at GTMI can be used to facilitate engineering design of these systems, with automated access to sophisticated analysis tools. By using a formal modeling framework, the analysis model development time is reduced, and the quality of system design decisions is improved: consistent system models and simulations result in better and faster decision-making.

New Solar Car Concept Shines

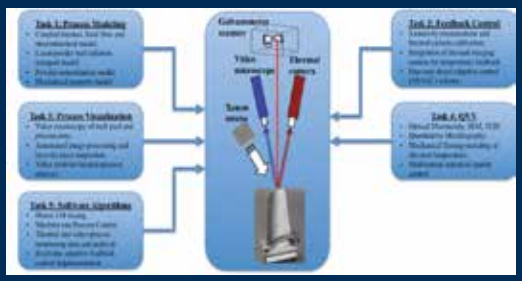


Problem: Conventional solar panels cannot absorb enough energy to fully charge a vehicle, thus leaving drivers dependent on the electric grid for a full charge.

Solution: Through a Ford-led collaborative project with Georgia Tech and San Jose, Calif.-based SunPower Corp, the C-MAX Solar Energi Concept was developed. Ford and SunPower co-developed the solar panel for the roof of the vehicle. The central idea was to harness the power of the sun by parking under a special concentrator that acts like a magnifying glass, directing intensified rays from the sun onto solar panels on the parked vehicle's roof below. The Georgia Tech Sustainable Design and Manufacturing Lab modeled the size and dimensions of the concentrator needed to get to 8 kWh per day. It uses special Fresnel lenses similar to what lighthouses use to amplify a small light and direct it onto the solar panels on the vehicle's roof.

Benefit: The concept car can store enough solar power to deliver the same performance as Ford's comparable plug-in hybrid. Ford estimates that the technology will reduce the annual greenhouse gas emissions from a typical car owner by four metric tons.

Cyber-Enabled Direct Digital Manufacturing of Gas Turbine Engine Hot-Section Components



Problem: High temperature materials such as nickel-based super-alloys are commonly used in the hot-section components of gas turbines on aircraft propulsion systems and in industrial power generation. High operating temperatures may cause severe damage to the integrity of hot-section components. They are also difficult to repair because the hot-section alloys cannot be welded. Replacing the components is expensive and causes down time for both military and commercial aviation, marine turbine engines, and for land-based power generators.

Solution: Supported by the Cyber-Enabled Manufacturing Systems for Direct Digital Manufacturing Program of the Office of Naval Research, the GTMI Direct Digital Manufacturing Lab is developing Scanning Laser Epitaxy (SLE), a technology platform to repair gas turbine engine hot-section components using laser additive repair and additive manufacturing. Researchers have already successfully created defect-free deposits in a range of common, but non-weldable, hot-section alloys.

Benefits: Non-repairable components could be restored to service condition, improving fleet sustainment, reducing down time, and sparing expense. There are fewer processing steps and the cost is lower when using direct digital manufacturing, the digital data created and feedstock powders. The process enables the use of additive manufacturing technologies using advanced materials and microstructures to create next generation, higher-performance components.

Researchers at GTMI's Factory Information Systems (FIS) Center Develop Innovative Software and Hardware Solutions to Boost Efficiency

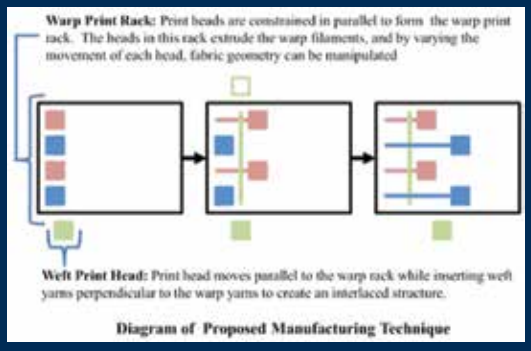
Problem: Some companies are not fully using the power of technology to improve their manufacturing processes.

Solutions: Here are a few ways that GTMI's FIS Center assisted companies:

- The client company needed to provide its services to a variety of customers around the world. GTMI FIS developed an innovative cloud application capable of communicating with a variety of hardware devices through the cellular network, displaying data from the devices, communicating with the appropriate individuals and sending messages to equipment for further action.
- Helped launch a startup company by assisting in the design of a mechanical pump, fabricating electronic controls, and developing monitoring software to maintain landfill leachate levels with the goal of optimizing decomposition and maximizing landfill gas to generate electricity. The company has sold almost $1 million worth of products in its first year.
- Provided software expertise to a same day delivery company to improve package delivery, enhance processing of business-to-business electronic data interchanges, and guide enterprise software strategy.

Benefits: Companies can realize tremendous savings in time and money, while increasing quality control.

Manufacturing Method Creates High Performance Composites Using Additive Manufacturing and Weaving Technologies

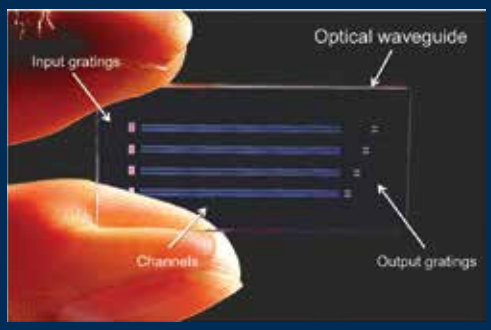


Problem: Conventional manufacturing techniques are unable to meet the anticipated future design requirements of the high performance composites industry, particularly with respect to aerospace and automotive applications. This is due to limitations in conventional manufacturing processes that make it difficult to manipulate fabric geometry, fiber orientation, and matrix/fiber materials within a composite structure to create a load-customized composite.

Solution: GTMI is developing a composite manufacturing method to fabricate interlaced hybrid composite structures with local internal variations of fabric geometry and matrix/fiber materials. This method combines additive manufacturing and weaving technologies to permit precise control of individual yarns during a simultaneous weaving and composite formation process. GTMI is collaborating with Cytec Aerospace Materials in developing a fiber-reinforced composite filament that can be used as the raw material for this process.

Benefits: Applications for this new process include the production of ultra-lightweight aircraft components (fairings, wing panels, etc.), as well as biomedical applications where part properties must match the organic component they are replacing.

Lumense Partners with GTMI to Improve Poultry Production



Problem: Lumense Inc. is an Advanced Technology Development Center (ATDC) Select Company that produces a variety of sensors for use in manufacturing settings. The core element of Lumense's sensor products is an optical waveguide that serves as a real-time chemical and biological sensor platform. Novel polymers coated on the waveguide channels greatly influence the sensitivity and determine the selectivity of the sensor. The current methods for applying polymer coatings are not reproducible, which results in significant variation in performance from device-to-device or unacceptable device yield. Further, these methods employ slow and manual deposition procedures that do not apply coatings of precise geometry and are the rate-limiting step for device manufacturing.

Solution: Lumense is partnering with GTMI on a six-month manufacturing research project to learn how to employ an in-house Aerosol-Jet printer to improve the coating manufacturing process. This would significantly improve the spatial-precision of the applied coating; rapid manufacturing for scalability; and enhance reproducibility/reliability of performance from device-to-device. The Agribusiness sector is the first target market for Lumense sensor products. Poultry growers can use the real-time monitoring of ammonia concentration to automatically and continuously optimize ventilation of grow-out-houses to improve poultry growth and yield while reducing feed and maintenance costs. The project is supported and co-sponsored by the Georgia Center of Innovation for Manufacturing and the Georgia Manufacturing Extension Partnership.

Benefit: Application of the research is anticipated to positively influence Lumense's commercial success and economic impact, particularly in rural areas of Georgia.

Small Businesses Get a Boost in Submitting Proposals

Problem: The Department of Energy (DOE) is dedicated to the successful commercialization of Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) funded technologies. But receiving a Phase I award is no small feat. The application process is difficult and requires a lot of time that many small businesses don't have.

Solution: GTMI has partnered with Dawnbreaker, a commercialization assistance company, to help facilitate the new DOE Phase 0 SBIR/STTR assistance program for targeted applicants to the DOE's SBIR program. With the help of the Dawnbreaker-led team, the U.S. DOE is funding its first ever Phase 0 program to assist eligible small businesses in navigating the complexities of the SBIR proposal process. With a full menu of services available to pre-approved applicants, small businesses that fall into three categories: 1) under represented states (e.g. Georgia); 2) women-owned; and 3) socially and economically disadvantaged, can now get the assistance they need to submit a compelling and successful Phase I SBIR/STTR proposal.

Benefit: Eligible small businesses that receive assistance will have a better chance to win DOE SBIR funding, thus stimulating company success and the economy. Companies can apply at www.dawnbreaker.com/doephase0/.

Advanced Extreme Tribology

Problem: Manufacturers sometimes encounter challenges with tribological systems (lubricants, surface engineered materials) and need assistance in gathering reliable data where the conditions of operation, such as load or temperature, are extreme, resulting in significant material displacement or removal (e.g., machine tool interface).

Solution: Engineers within the GTMI Laboratory for Extreme Tribology and Diagnostics have been active in conducting research and providing expertise on advanced extreme tribology. At the core of the laboratory is an electromagnetic tribometer, capable of generating material contacts at acceleration rates of the order of 10^6 m/s^2, velocities of the order of 10^3 m/s, current densities of the order of 10^9 A/m^2 and magnetic pressures of the order of 10^8 Pa. The Office of Naval Research has served as a primary sponsor through its Electromagnetic Railgun Program.

Benefit: Using unique instrumentation, including high-speed and IR digital cameras, the lab has provided a fundamental understanding of the friction, wear, dynamics, and mechanics of sliding interfaces for customer use, while training a workforce of engineers and scientists skilled in tribology-related technologies through modeling and experimentation.

Industry Partnerships Fuel GTMI

Transforming world-class research into real-world value for industry partners is one of GTMI's most important goals. Much of our success comes from active collaboration with industry partners who help drive research outcomes to produce results that are readily implemented in the industrial sector. GTMI works with companies of all sizes on short- and long-term projects, ranging from several months to a few years. Research projects are defined in association with partner companies and when initiated, ongoing project interaction is maintained between the sponsoring company and GTMI. Our partners provide not only vital financial support, but they also play an active role in GTMI's strategy to efficiently deliver innovative concepts from the laboratory to the marketplace. In addition to strategic involvement in projects, GTMI's industry partners enjoy many benefits, including:

- Access to laboratories for demonstrations and visits prepared and scheduled through the partnership
- Meetings with GTMI faculty, students, and staff to discuss research problems
- Meetings with students to discuss opportunities for internships, co-op positions, and permanent employment
- Access to results of all non-proprietary research

In 2014, GTMI supported more than 65 companies and over 20 non-governmental organizations, academic and government organizations. One spin-off company was created, DHX Electric Machines.

Partnerships That Help Companies Grow and Products Find a Market

GTMI partners with the Enterprise Innovation Institute, including the Advanced Technology Development Center, Minority Business Development Agency, Georgia Manufacturing Extension Partnership, and VentureLab to help companies grow and prosper. We provide manufacturing expertise, networking opportunities, and access to core facilities and students. This strong partnership is a key component to accelerate the commercialization of new technologies and processes into the marketplace.

Collaboration with Technical Colleges in Georgia Aims to Better Prepare Technical College Graduates for the 21st Century Advanced Manufacturing Workforce

Georgia manufacturers are having difficulty hiring enough employees with the appropriate skills to be successful in highly technical jobs. A partnership between GTMI and the Technical College System of Georgia (TCSG) was formed to improve the preparation of Georgia's manufacturing workforce. A Manufacturing Competitiveness Committee (MCC) was formed to identify partnership opportunities that: 1) improve the competitiveness of Georgia manufacturers by enhancing the skill set and knowledge of the manufacturing workforce; and 2) identify pathways for enrollment of talented TCSG students into Georgia Tech engineering and other STEM-related programs. The program is leading the way in developing opportunities for technical college students to be exposed to higher-level training and knowledge and is creating a new channel from which manufacturers will be able to hire highly-skilled workers.

Georgia Tech-Boeing Strategic University Partnership Provides Model for Multi-Disciplinary Work

The Georgia Tech-Boeing Strategic University Partnership is a multi-disciplinary program that funds basic and applied research projects in manufacturing-related topics of interest to Boeing. The Strategic Universities program is run out of Boeing Research & Technology in St. Louis, Missouri. The partnership with Georgia Tech was established in 2007 and is managed by the GTMI. To date, this $10.3M+ program has supported research on a broad range of manufacturing topics, including systems-based design for manufacturing, advanced manufacturing processes, robotics, automated material handling, sensing, and materials aspects of manufacturing. Faculty participation in the program is drawn from several academic units in the College of Engineering, including Aerospace Engineering, Materials Science and Engineering, Mechanical Engineering, the College of Computing, and Industrial and Systems Engineering. In prior years, the program also supported faculty participants from Civil Engineering, Electrical and Computer Engineering, GTRI, and GTMI. The overarching goal of the program is to collaborate with Boeing on the research and development of next generation manufacturing technologies (both hardware and software), which will feed into the factory of the future for aerospace manufacturing.

On the cover: Pictured at top, a 3D printed aorta valve phantom with sensors currently in development; and at the bottom, a sample of a 3D printed material.