

2019-2020: Manufacturing Research Center

Definition of Unit

Providing Department:

Manufacturing Research Center

Department/Unit Contact:

Ying Zhang

Mission/Vision Statement:

The Center for Manufacturing Research (CMR) was established in 1984 to leverage resources of the State of Tennessee, the University, industries, and government funding agencies into cooperative efforts to advance manufacturing research. The CMR's Mission stated below is driven by core principles from the College of Engineering's and the University's Mission.

CMR Mission

To advance and support scientific and engineering knowledge in areas related to manufacturing through fundamental research and technology transfer activities, and to impact the instructional program in those areas.

Research Areas

Using a strategic planning process that was based on national manufacturing roadmap strategies in alignment with the College of Engineering research focus areas, the Center for Manufacturing Research has identified two research areas: (1) Digital Design and Manufacturing including (a) additive manufacturing, (b) advanced robotics and controls, and (c) cybersecurity in manufacturing, and 2) Sustainable Materials and Manufacturing including (a) materials processing and modeling and (b) energy conversion / storage materials and devices.

Core Values

The CMR has established the core values listed below that define the behaviors we seek to reward and recognize.

1. Commitment to Personal and Scholarly Integrity
2. Teamwork
3. Commitment to Excellence
4. Commitment to Personal/Professional Development
5. Valuing Partnerships, Cooperation, and Collaboration

6. Commitment to Continuous Improvement

Goal 1. Increase national and international recognition for TTU manufacturing research

Define Goal:

Increase research activity in the CMR by increasing total funding requests through proposals submitted to external sources, and thus, increase funding impact at the University and State levels. The CMR is continuing to invest in faculty members in the College of Engineering who conduct research in manufacturing research areas. In addition to this investment, it is our goal that our external proposal activity and externally funded research will increase as a result of the efforts of the faculty and increased Center activities.

Intended Outcomes / Objectives:

Objective 1. Increase externally funded research annually.

Objective 2. Increase proposal funding requests annually.

Goal 2. Increase student, faculty, & staff capabilities

Define Goal:

Increase the participation and capabilities of students, faculty, and staff in manufacturing related research and education via external funding, professional activities, and outreach programs.

Intended Outcomes / Objectives:

Ensure productivity of the CMR in scholarly work and graduates.

Enhance professional development of faculty and staff.

Goal 3. Increase resources of the CMR to allow for research expansion

Define Goal:

Increase the amount of income (resources), both internally and externally, that can be used to expand research in the CMR research focus areas and improve staff support for research activities.

Intended Outcomes / Objectives:

Potential sources of additional income for the CMR comes from release time of personnel, graduate student support from externally funded research, gifts, testing/service income, F&A return, and equipment grants or gifts.

Objective: Enhance research infrastructure and acquire state of the art equipment.

Assessment Tool #1: Project Activations

Goal/ Outcome/ Objective:

Goal 1 and Goal 2 and Goal 3

Type of Tool:

Tracking Spreadsheet

Frequency of Assessment:

Annually

Rationale:

a. Project activations indicate the productivity of both the Center faculty and faculty associates as well as the Center staff in attracting external funding from International, Federal, State, Industry, and Private sources. This is also the measure that the Tennessee Higher Education Commission (THEC) uses to measure the vitality of a Center of Excellence. b. Successful results will indicate annual increases as described. c. Project activations are a measure of the value associated by outside agencies to the manufacturing-related research conducted through our Center. Several faculty have been added to the college and the university has significantly invested to increase research productivity.

Assessment Tool #2: External Proposal Submissions

Goal/ Outcome/ Objective:

Goal 1 and Goal 2 and Goal 3

Type of Tool:

Tracking Spreadsheet

Frequency of Assessment:

Annually

Rationale:

a. Proposal valuations have been shown statistically to be a significant leading indicator of Project Activations. This will help to identify processes that can be implemented or modified to boost proposal activity. b. Successful results will indicate an annual increase as described above. c. Proposal valuations are a function of both the number of proposals as well as the size of larger collaborative proposals. As the College of Engineering increases their number of tenure-track faculty, the number of proposals should increase. As the College's research areas grow and become self-sustaining, the number of larger collaborative proposals should increase as well.

Assessment Tool #3: Publications and Supported Graduate Student Degree Completion

Goal/ Outcome/ Objective:

Goal 1 and Goal 2

Type of Tool:

Other

Frequency of Assessment:

Annually

Rationale:

1. Publications 2. Outreach Activities 3. Graduate Students Completing Degrees 4. Awards & Recognition

Assessment Tool #4: Staff Participation in Research and Outreach

Goal/ Outcome/ Objective:

Goal 1 and Goal 2 and Goal 3

Type of Tool:

Tracking Spreadsheet

Frequency of Assessment:

Annually

Rationale:

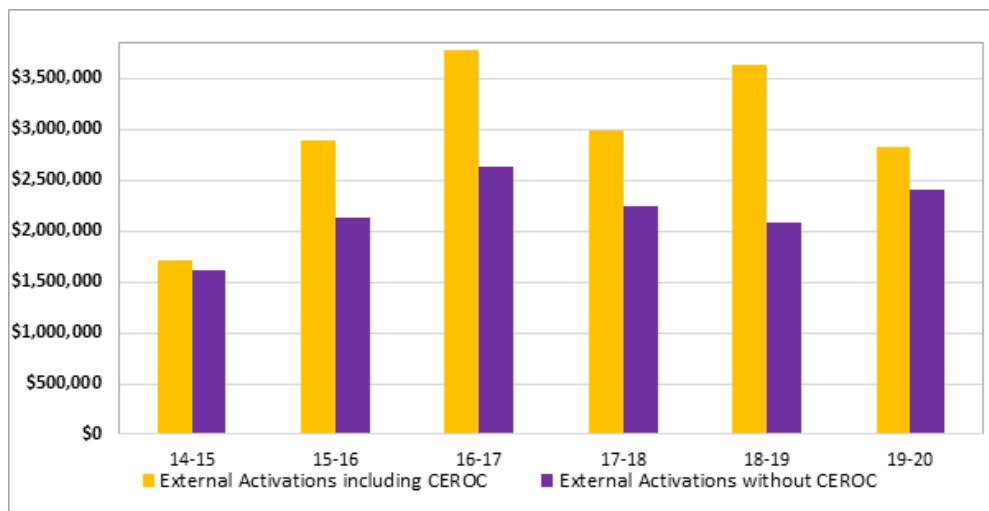
- a. The CMR uses its annual State Appropriation for basic resources including salaries, benefits, graduate assistantships and fees. In order to expand capabilities and increase seed funding in exploratory areas, the CMR needs to generate release of salaries from external projects, outreach activities and indirect return.
- b. This assessment tool is highly correlated to project activations and is less likely to change dramatically. There are specific activities and processes that can be instituted that will positively affect this measure including direct requests for gifts to support graduate assistantships, marketing testing and service capabilities, and anticipating Center staff to generate release on funded projects.

Goal 1: Results/Outcomes/Accomplishments

Results:

Objective 1: Increase externally funded research annually.

The CMR secured twenty externally funded projects for a total amount of \$2,830,562, resulting in an approximate 22% decrease from the previous year. These activations included \$456,442 of Indirect Costs to be processed through the University. If, however, you take out those projects that were for the Cybersecurity Education, Research, and Outreach Center (CEROC), then externally-funded projects increased in 2019-20 from \$2,090,724 to \$2,411,429, an increase of 14%.



Objective 2: Increase proposal funding requests annually.

A total of twenty-nine research proposals in the amount of \$7,427,305 were submitted to be considered for external funding, some of which will be funded during the next year. The total value of the proposals was a 24% decrease from the value of proposals submitted in 2018-2019. This reflects a decrease in proposal submission during the last quarter of 2019-2020 due to the Covid-19 pandemic.

Included in the externally funded grants this past year were:

- Twenty different research projects were activated for a total of \$2,830,562 from various funding agencies, i.e., U.S. Department of Energy, National Science Foundation, National Institute of Health, U.S. Department of Defense, Oak Ridge National Laboratory, etc. In addition, 29 externally funded research proposals in the amount of \$7,427,305 were submitted by 23 different CMR faculty associates to be considered for funding.
- The Industrial Assessment Center (IAC), led by Dr. Glenn Cunningham and Dr. Ethan Languri, CMR Faculty Associates (Mechanical Engineering), was awarded Year 4 funding of \$315,462 by the U.S. Department of Energy (DOE). The IAC has been in existence at Tennessee Tech since 2006. The IAC has trained 190 students with 68 receiving DOE certification, and conducted 229 energy assessments for industry.
- Dr. Ping Chen, CMR Faculty Associate, was awarded \$476,703 for Year 1 of 3(total award \$779,819) from the Department of Energy for “Developing an Electric Vehicle Demonstration Testbed in the Upper Cumberland Region of Tennessee, an Economy Distressed Rural Region”. This project will create a proof-of-concept demonstration testbed for EVs and charging infrastructures in the Upper Cumberland region. Comprehensive data will be collected and analyzed to report the operation cost, issues and performance of EV to help potential fleet owners and the public at large make informed decisions in EV adoption for rural areas before making significant financial investment.

- CMR Director Dr. Ying Zhang and CMR Faculty Associate Dr. Jiahong Zhu were awarded a grant of \$580,821 from the Department of Energy for Year 1 of 2 of the project “Development of Corrosion- and Erosion-Resistant Coatings for Advanced Ultra-Supercritical Materials”. The total award is \$999,999. This work focuses on balancing the corrosion and erosion properties of the electro-codeposited coatings to protect steam turbine blades in advanced ultra-supercritical pulverized coal fired power plants.
- The Office of Naval Research awarded Dr. Ying Zhang a DURIP grant of \$315,000 for a High-Performance Laboratory-Scale Gas Atomizer for Materials and Coatings Research. The gas atomizer will enable fabrication of high-quality metal powders with unique compositions and properties for emerging applications. The new equipment will have a direct impact on TTU research and education capabilities in disciplines important to DoD missions, especially in the areas of advanced coatings, additive manufacturing (AM) of new metals and alloys, and energy conversion devices. In spite of the potential that metal AM offers, to date, most applications rely on existing materials for feedstocks, which have not been designed/optimized for AM processes. There is a clear need for development of new feedstock materials that are created with AM in mind to provide advanced material properties capable of meeting next-generation design requirements and product applications.
- Dr. Ali Alouani, CMR Faculty Associate, was awarded \$111,000 from the Tennessee Valley Authority to design and build an Intelligent Robot for TVA Substation Inspection. The total award is \$424,258. The objective of Tennessee Technological University (TTU) for this research is to design an intelligent robot to collect relevant data while autonomously traveling across a substation for the Tennessee Valley Authority (TVA). The robot automatically communicates pertinent data to a maintenance team/control center/operator via a dashboard. Furthermore, the robot has onboard intelligence and learning capabilities, utilizing sensors data fusion to detect abnormal patterns and alert the appropriate individual/group in real-time. It will also detect visible wear and tear of a piece of equipment in the substation by analyzing acquired images. The robot is to be utilized in different substations of different sizes and topologies.
- CMR Faculty Associate Dr. Ambareen Siraj continues to serve as PI for the Tennessee CyberCorps: A Hybrid Program in Cybersecurity with Dr. Douglas Talbert serving as Co-PI. NSF provided additional funding of this Cybersecurity Program by awarding two separate supplemental components: 1) “A Series of Cyber Encounters to Address Gap in High School Cyber Education” for \$358,583 and 2) Community College Inclusion for \$93,154. This funding for Cybersecurity research continues to make Tennessee Tech one of the highly visible cyber defense education programs in the country as well as designation by both NSA and the Department of Homeland Security (DHS) as a National Center of Academic Excellence in Cyber Defense Education (CAE-CD) through AY 2021. The total award is \$5,058,651.

CMR Faculty Associates and R&D engineers have published 35 journal papers, 45 conference papers, and four book chapters during the past year.

Twelve CMR-supported students graduated with their Master's degree and four with their Ph.D.

Goal 2: Results/Outcomes/Accomplishments

Results:

During this past year the CMR has achieved the following results for enhancing faculty, staff and student capabilities:

- The CMR supported a total of 36 graduate students: 19 M.S. and 17 Ph.D. This accomplishment was possible with the Center's revenue provided from externally funded projects that was designated for graduate student support.
- During this past year, degrees were awarded to four Ph.D. students and 12 M.S. students who were supported by the CMR, both from State Appropriations and externally funded grants.
- The CMR received total funded allotments of \$315,462 this past fiscal year from the Department of Energy to continue the outreach to students and Tennessee industries via the Tennessee 3-Star Industrial Assessment Center (IAC) which has been in existence in the Center and at Tennessee Tech since its inception in 2006. A total of 190 students have been impacted by the IAC Program, with 68 of them receiving DOE certificates of achievement. To date, 229 no-cost energy efficiency assessments have been performed by the students and faculty for companies of all sizes and industries in and around Tennessee. The IAC also offers services such as water and wastewater assessments, consulting in Smart Manufacturing, ISO 50001 energy management systems, and cybersecurity assessments in collaboration with the Cybersecurity Education, Research, and Outreach Center (CEROC) at Tennessee Tech.
- CMR-supported graduate students presented their research to their peers at a "Lightning Round" seminar series. The top student, based on peer rankings, was awarded a travel stipend to attend a conference.
- CMR staff, graduate and undergraduate students actively support the iMaker Space with extensive student use across campus.
- Travel funding has been provided to various faculty associates and graduate students to attend and present at national conferences. Due to travel restrictions as a result of the pandemic, travel to international conferences was limited.
- In addition to all training required by the University, CMR staff received additional training to enhance their capabilities in furtherance of Center goals. Materials Science Lab manager Wayne Hawkins received special operational and applications training on the new Hitachi SU7000 High Resolution Scanning Electron Microscope and training on practical quantitative analysis, metallography of powder metallurgy alloys, and thermal analysis.
- The Center Faculty Associates and R&D engineers have published 35 journal papers, 45 conference papers, and four book chapters during the past year.

Several faculty associates, staff, and students of the CMR have received significant honors and awards this past year with some of them being the direct result of successfully manufacturing related research and education supported via external funding.

- CMR Faculty Associate Dr. Ismail Fidan (Manufacturing & Industrial Technology), CMR R&D Engineer Dr. Nan Guo, and CMR Outreach Coordinator Michelle Davis were

awarded the Leighton E. Sissom Innovation and Creativity Award for their work with the Golden Eagle Additively Innovative Virtual Lecture Series. This award was established to recognize innovation and creativity in scholarship, methodology, invention, technique, processes, or other unique contributions demonstrating innovation and creativity.

- CMR Manager Suzanne Henry was awarded the College of Engineering's Outstanding Staff Award. Suzanne has worked for the CMR for twenty-nine years.
- CMR Faculty Associate, Dr. Steven Anton (Mechanical Engineering), was awarded the Brown-Henderson Outstanding Engineering Faculty Award which rewards accomplishments that most closely reflect the mission of the College of Engineering – preparing graduates through a blend of education, research, and service.
- Dr. Mohamed Mahmoud, CMR Faculty Associate in Electrical and Computer Engineering, was awarded the 2020 Kinslow Engineering Research Award which is given for the best paper written by a TTU engineering faculty member and published in a refereed professional journal. The paper is entitled "Efficient Privacy-Preserving Ride Sharing Organization for Transferable and Non-Transferable Services", published in the IEEE Transactions on Dependable and Secure Computing (TDSC), 2019.
- CMR-supported Electrical and Computer Engineering (ECE) graduate student Tolulope Odetola won the ECE Graduate (Masters) section of the Tennessee Tech Research and Creative Inquiry Day. Mr. Odetola's paper was entitled "WORDA: A "6/3" Winograd Offline-Runtime Decomposition Algorithm for Faster Inference".
- In the Manufacturing and Engineering Technology (MET) section of the Tennessee Tech Research and Creative Inquiry Day, CMR-supported student Hao Lu won the Graduate (Masters) section with his paper "Mechanical Characterization of Low-Cost Metal Material Extrusion" and Ankit Gupta won the Graduate (PhD) section with his paper "Development of Methacrylate-Based Denture Reinforced with Short Glass Fibers Using the Fused Filament Fabrication Process".
- CMR-supported student Eric Nolan won the Mechanical Engineering Graduate (Masters) section of the Tennessee Tech Research and Creative Inquiry Day with his paper, "Electromechanical Impedance Based Structural Health Monitoring During a Dynamic Event".

Goal 3: Results/Outcomes/Accomplishments

Results:

- The CMR secured twenty externally funded projects for a total amount of \$2,830,562, resulting in an approximate 22% decrease from the previous year. However with CERO projects removed, there was a 14% increase in external funding.
- A portion of this external funding in the amount of \$157,179 was secured for graduate students' stipends and fees. This level of external funding supported 37% of the CMR's students for this past year.
- A total of \$304,220 of external funding was in the areas of F&A Return, Testing Services Income, Graduate Student Support and Equipment Usage. CMR Staff also generated \$129,844 Release Time by actively engaging in various research and outreach efforts. This supplemental income allowed the CMR to expand capabilities and resources.

- The CMR received revenue in its Testing Services Account income in this past year of \$3,203. Due to the expanded research capabilities, certain Testing Projects became Research Projects with well-defined research objectives and tasks. Recently, the CMR revised the Research Service Rates and the new rates have been approved by the University. The CMR will use these rates going forward for the services the Center offers to Tennessee industries.
- The CMR enhanced its research infrastructure with the hiring of a part-time IT staff to meet the needs of CMR research labs. The CMR's Material Science Laboratory (MSL) was updated with a new Hitachi ultra-high-resolution scanning electron microscope (FE_SEM SU7000) for nano surface structural analysis. The SU7000 is equipped with EDAX Octane Elect Detector and APEX software for qualitative and quantitative analysis of a variety of specimens and their material compositional elements. Scanning Transmitting Electron Microscopy (STEM) Detector capabilities are also available. Tennessee Tech is the first university in North America to receive the Hitachi SU7000.
- Other improvements to physical research resources include: 1) Renovation of above Materials Science Lab to accommodate the new SEM, 2) acquisition of a new hardness tester, 3) acquisition of pump and renovation of lab area to accommodate its installation

New Modifications and Continuing Improvement to Goals/Objectives/Outcomes Item

Goal/Objective/Outcome Number:

Goal 1 and Goal 3

Program Changes and Actions due to Results:

The CMR will pursue an effort to continue to allocate financial and infrastructure resources to provide required cost-sharing commitments for externally-funded research projects. This effort will hopefully increase both proposal submissions and external funding for the CMR.

New Modifications and Continuing Improvement to Goals/Objectives/Outcomes Item

Goal/Objective/Outcome Number:

Goal 3: Increase resources of the CMR to allow for research expansion

Program Changes and Actions due to Results:

For the coming year (2019 - 2020) we will be adding an objective to enhance research infrastructure and acquire state of the art equipment to facilitate expanding the CMR's research capabilities.

Link to 'Tech Tomorrow' Strategic Plan:

Research, Scholar, Intellect, and Creativity