

Definition of Unit

Definition of Unit: Center for Manufacturing Research

Reporting Year:

Providing Department:

Manufacturing Research Center

Department/Unit Contact:

Ying Zhang

Mission/Vision/Goal 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 three research areas: (1) Advanced Manufacturing, (2) Materials and Devices for Energy Storage and Conversion, and (3) Networking and Algorithm for Big Data in Manufacturing.

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/Objective/Outcome

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 1a. Increase externally funded research by a minimum of 5% annually.

Objective 1b. Increase proposal funding requests by 5% 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. Increase of 5% annually is targeted.

Assessment Tools**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: Income Generation

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 must rely on supplementing State appropriations with release of salaries from external projects, testing and service income, 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 requiring Center faculty to claim more release on their funded projects.
- c. Sampling includes all sources of additional income. The data comes directly from internal working spreadsheets and data readily available through BANNER.

Results

Goal 1: Results/Outcomes/Accomplishments

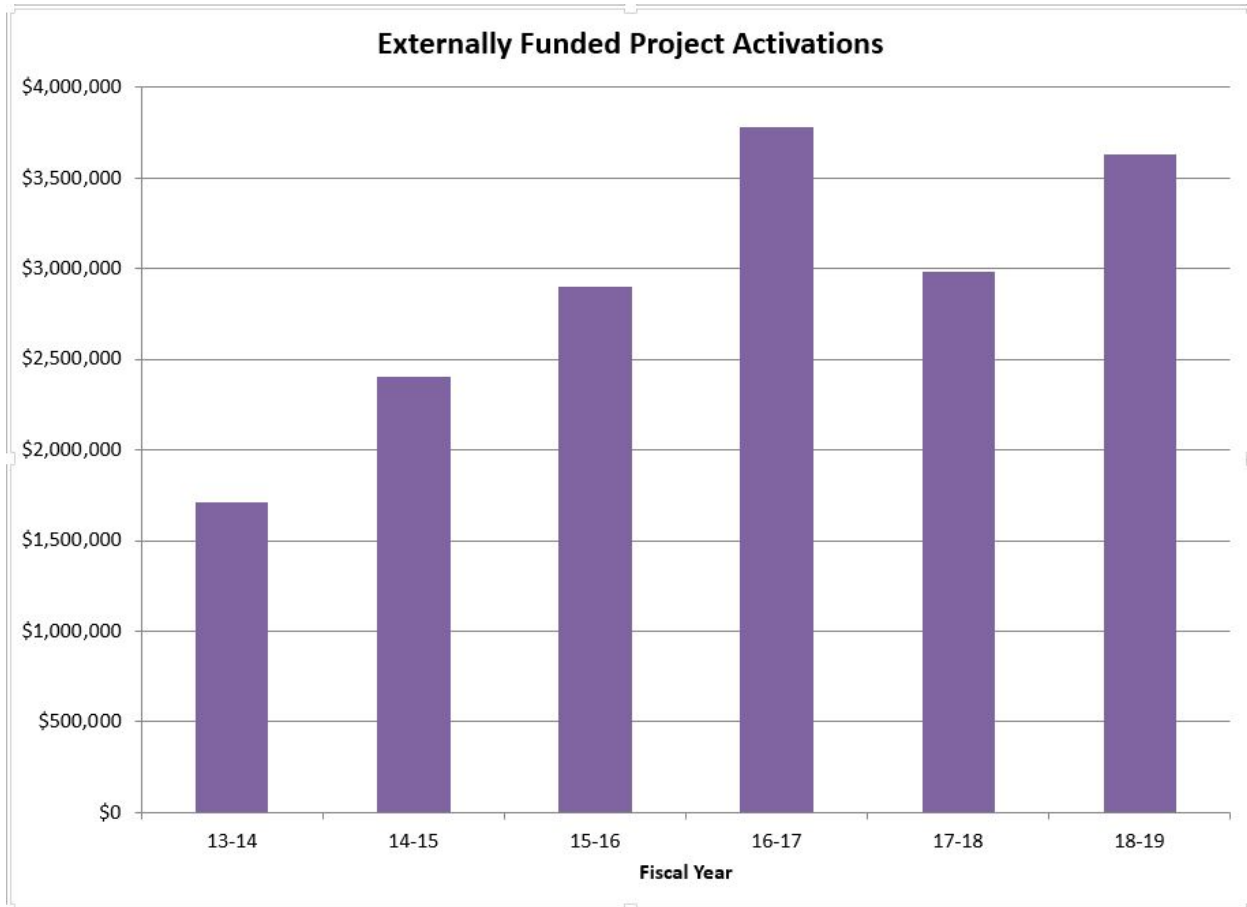
Goal/Objective/Outcome Number:

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

Results:

The CMR secured thirty-one externally funded projects for a total amount of \$3,627,332, resulting in an approximate 21% increase from the previous year. This is the second highest year of external funding since the center's inception in 1984. These activations included \$526,095 of Indirect Costs to be processed through the University. A total of thirty-three research proposals in the amount of \$9,754,283 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 23.7% decrease from the value of proposals submitted in 2017-2018.



Included in the externally funded grants this past year were:

- Thirty-one different research projects were activated for a total of \$3,627,332 from various funding agencies, i.e., U.S. Department of Energy, National Science Foundation, National Institute of Health, Air Force Office of Scientific Research, Oak Ridge National Laboratory, etc. In addition, 33 externally funded research proposals in the amount of \$9,754,283 were submitted by 21 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 2018 Center of Excellence by the U.S. Department of Energy (DOE). This award places the IAC as the top-ranking center out of 28 centers nationwide. \$346,687 in Year 3 funding was awarded by DOE. The IAC has been in existence at Tennessee Tech since 2006.
- CMR Faculty Associate Dr. Ambareen Siraj (Director, Cybersecurity Education, Research and Outreach Center, CEROC) continues to serve as PI for the Tennessee CyberCorps: Scholarship for Service Program with Dr. Douglas Talbert serving as Co-PI. Year 4 funding from the National Science Foundation (NSF) was awarded to

continue supporting the efforts for this Program. NSF provided additional funding of this Cybersecurity Program by awarding two separate supplemental components: 1) Bootcamp Funding Supplement for \$45,015 and 2) Community College Inclusion for \$106,714. Dr. Siraj was also awarded third-year funding from the National Security Agency for \$134,925 for GenCyber Camp and funding from the Department of Defense for Cybersecurity scholarships. This combined 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.

- Dr. Ismail Fidan, CMR Faculty Associate, was awarded \$278,234 for the third year of a three-year NSF grant entitled "AM-WATCH: Additive Manufacturing - Workforce Advancement Training Coalition and Hub". The primary goal of AM-WATCH is to bridge the gap between industry needs and future workforce skills via the enhancement of high school and community college curriculum with additive manufacturing practices. This will be accomplished through the development of curriculum and the delivery of professional development.
- Dr. Jiahong Zhu, CMR Faculty Associate, was awarded total funding of \$181,348 for Year 2 of the DOE grant entitled "Development and Validation of Low-Cost, Highly-Durable, Spinel-Based Contact Materials for SOFC Cathode-Side Contact Application". As a collaborative research effort between TTU (the leading research institute) and FuelCell Energy (FCE, the subawardee), this project focuses on developing and validating the low-cost, highly-durable, spinel-based material for SOFC cathode-side contact application utilizing a unique environmentally-assisted reactive sintering process to lower the sintering temperature.
- CMR Faculty Associate Steven Anton was awarded \$135,561 for the third year of a three-year grant entitled "Self-Powered in Vivo Force and Implant Wear Sensing in Knee Arthroplasty" from the National Institute of Health. This research will help to determine if sensors can be used to record force and wear data, which in turn could develop better surgical procedures and implant designs in order to improve surgical outcomes and ultimately better public health.
- Dr. Steven Anton, CMR Faculty Associate, received \$120,000 for Year 3 of the Young Investigator Research Program (YIP) award from the Air Force Office of Scientific Research (AFOSR) for his work entitled "Continuous Real-Time State Monitoring in Highly Dynamic Environments." This research focuses on developing novel sensing systems for structures experiencing rapid changes by extending conventional electromechanical impedance-based structural health monitoring (SHM) concepts to structural systems experiencing rapid changes in state (e.g. boundary conditions, interfaces, structural damage, etc.) in order to identify those changes on the microsecond to millisecond time frame.
- The National Science Foundation awarded CMR Faculty Associates, Dr. Mohamed Mahmoud and Dr. Syed Hasan \$119,424 for Year 1 of a three year program to host a REU Site - Secure and Privacy Preserving Cyber Physical Systems at Tennessee Tech this summer for a ten-week period from June 3 to August 9, 2019. This REU Program focused on research related to security and privacy in cyber physical systems such as

Smart Cities infrastructures and provided undergraduate research experiences for a total of ten interns from eight different universities.

- Dr. Stephen Canfield, CMR Faculty Associate, continued to lead the Innovation Corps Sites Training Grant at Tennessee Tech during the third year. Funding of \$99,956 was awarded for Year 3 to support this research effort.
- The CMR Faculty Associates and R&D engineers have published 46 journal papers, 59 conference papers, and four book chapters during the past year.
- The CMR had two Visiting International Researchers at Tennessee Tech during the past year. Dr. Yuliang Zhang joined the Center's Wireless Communications/Networking Systems Research Group. Also, Professor Yongtang Li visited Tennessee Tech to discuss potential research collaboration in the area of casting-rolling compound forming of metallic rings.

Attachments:

Goal 2: Results/Outcomes/Accomplishments

Goal/Objective/Outcome Number:

Goal 2. Increase student, faculty, and staff capabilities

Results:

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

- Tennessee Tech University achieved a higher level of recognition under the Carnegie Classification to a R2 university - "Doctoral Granting University, High Research" (previously classified as "Doctoral Granting, Limited Research"). This recognition is in large part due to the increase in the number of PhD degrees awarded by the College of Engineering, which in turn has been largely supported by the research grants and state appropriation supporting the graduate students through the Centers of Excellence.
- The CMR supported a total of 33 graduate students: 18 M.S. and 15 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 six Ph.D. students and five M.S. students who were supported by the CMR, both from State Appropriations and externally funded grants.
- The CMR received total funded allotments of \$346,687 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 180 students have been impacted by the IAC Program, with 55 of them receiving DOE certificates of achievement. To date, 230 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.

- The IAC provided assistance to the Tennessee Valley Authority (TVA) in achieving certification to the ISO 50001 Energy Management Standard for their Magnolia Combined Cycle Power Plant in Mississippi. This will be the first power plant in the country certified to this rigorous standard.
- The National Science Foundation awarded CMR Faculty Associates, Dr. Mohamed Mahmoud and Dr. Syed Hasan \$119,424 for Year 1 of a three year program to host a REU Site - Secure and Privacy Preserving Cyber Physical Systems at Tennessee Tech this summer for a ten-week period from June 3 to August 9, 2019. This REU Program focused on research related to security and privacy in cyber physical systems such as Smart Cities infrastructures and provided undergraduate research experiences for a total of ten interns from eight different universities.
- CMR Faculty Associate, Dr. Stephen Canfield, continued to lead the Innovation Corps Sites Training Grant at Tennessee Tech during the third year. Funding of \$99,956 was awarded for Year 3 to support this research effort.
- Faculty associates Dr. Ambareen Siraj and Dr. Doug Talbert continue to administer the Tennessee CyberCorps: Scholarship for Service Program for the fourth consecutive year. This program and funding from the Department of Defense provide scholarships for undergraduate students. In addition, NSF provided additional funding for two separate supplemental components to enhance this Cybersecurity Program: 1) Bootcamp Program for \$45,015 which funds a 2-day camp designed to offer new students with tips and resources to supplement their technical learning at their respective programs, and 2) the Community College Inclusion for \$106,714 which will allow students at community colleges to have interactions with a Tennessee Tech liaison to ensure seamless transition into the Tennessee Tech program and will provide continuous monitoring of their progress.
- 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.
- A Capstone grant funded for \$15,000 was awarded from UT/CIS. This grant allowed students the opportunity to correlate their innovative ideas with various industries in a classroom environment.
- 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 international conferences.
- In addition to all trainings required by the University, CMR staff received additional training to enhance their capabilities in furtherance of Center goals. Michelle Davis, Outreach Coordinator, was re-certified as an ISO 50001 Energy Management Systems Lead Auditor. Wayne Hawkins, Material Science Lab Manager, received training on the 3D Optical Profiler enabling non-contact surface measurement and characterization of micro- and nano-scale surface features.

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. Stephen Canfield (Professor of 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. Stephen Canfield was also awarded the 2019 Kinslow Engineering Research Award which is given for the best paper written by a TTU engineering faculty member and published in a referred professional journal. The paper is titled “Controllability Ellipsoid to Evaluate the Performance of Mobile Manipulators for Manufacturing Tasks”, published in the ASME Journal of Mechanisms and Robotics, October 12, 2017.
- Dr. Dale Wilson (Mechanical Engineering), CMR Faculty Associate, was awarded the 2019 Leighton E. Sissom Innovation and Creativity Award. This award was established to recognize innovation and creativity in scholarship, methodology, invention, technique, processes, or other unique contributions demonstrating innovation and creativity.
- CMR-supported Manufacturing and Engineering Technology (MET) graduate students Aslan Nasirov and Shane Terry tied for the MET Graduate (Masters) section of the Tennessee Tech Research and Creative Inquiry Day. Mr. Nasirov’s paper was titled “Prediction of Mechanical Properties of Fused Deposition Modeling-Made Parts using Computational Models” and Mr. Terry’s was titled “Innovating the FDM Process – Metal Powder PLA Printing”. Mahdi Mohammadzadeh won the MET Graduate (PhD) section of the Tennessee Tech Research and Creative Inquiry Day with his paper titled “Thermomechanical Investigation of Continuous Fiber Reinforced Additively Manufactured Components”.
- In the Mechanical Engineering section of the Tennessee Tech Research and Creative Inquiry Day, CMR-supported student Nathan Ghattas won the Undergraduate section of the Tennessee Tech Research and Creative Inquiry Day with his paper “Investigation of Mechanical Boundary Conditions on Impedance-Based Structural Health Monitoring in a Biomedical Environment”. In the Graduate (Masters) section, Farzin Mashali won with his paper “A Particular Nanodiamond Suspension for Thermal Management”. In the Graduate (PhD) section, Mohsen Safaei won for his paper “Finite Element Simulation of High Frequency Electromechanical Impedance Measurements for Structural Health Monitoring”.
- The Center Faculty Associates and R&D engineers have published 46 journal papers, 59 conference papers, and four book chapters during the past year.

Attachments:

Goal 3: Results/Outcomes/Accomplishments

Goal/Objective/Outcome Number:

Goal 3. Increase Resources of the CMR to Allow for Research Expansion

Results:

- The CMR secured thirty-one externally funded projects for a total amount of \$3,627,332, resulting in an approximate 21% increase from the previous year. This is the second highest year of external funding since the center's inception in 1984.
- A portion of this external funding in the amount of \$287,144 was secured for graduate students' stipends and fees. This level of external funding supported 53% of the CMR's students for this past year.
- A total of \$412,454 of external funding was in the areas of F&A Return, Testing Services Income, Graduate Student Support and Equipment Usage. CMR Staff also generated \$86,717 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 \$23,888. 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. CMR also upgraded the research equipment in its key laboratories, such as purchase of a new precision abrasive sectioning saw, a new sample mounting press, a new pump for the mechanical testing system, and repair of the Hitachi S-4500 scanning electron microscope.

Attachments:

New Results Item

Goal/Objective/Outcome Number:

Results:

Attachments:

Modifications and Continuing Improvement to Goals/Objectives/Outcomes

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

Goal/Objective/Outcome Number:

Program Changes and Actions due to Results:

Link to Assessment:

Link to 'Tech Tomorrow' Strategic Plan:

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

Goal/Objective/Outcome Number:

Program Changes and Actions due to Results:

Link to Assessment:

Link to 'Tech Tomorrow' Strategic Plan: