3.3.1.4

Institutional Effectiveness: Research

The institution identifies expected outcomes, assesses the extent to which it achieves these outcomes, and provides evidence of improvement based on analysis of the results in each of the following areas:

3.3.1.4 research within its mission, if appropriate.

Judgment

☑ Compliance   ☐ Partial Compliance   ☐ Non-Compliance   ☐ Not Applicable

Narrative

Tennessee Technological University (TTU) is engaged in the scholarship of discovery and creativity, the application of knowledge to create new opportunities, the integration of knowledge to find new solutions, the transfer of knowledge and products for societal benefits, and students' engagement in the learning process. Toward this end, TTU articulates its research outcomes in relation to its mission through several different initiatives and entities described further below.

The University's Research Initiative

As the only technological university in Tennessee, TTU works to project a robust research and innovation profile. One of the broad trends in higher education is interdisciplinary research/collaboration that produces technological innovation, which is the focus of most funding agencies. TTU's Carnegie Classification is Master's Large, Research high [1].

Because TTU is a comprehensive university, research is defined broadly in terms of all creative works that contribute to the enhancement of knowledge. The University's mission has a research component. "The University is engaged in scholarly activity, especially basic and applied research, creative endeavors, and public services, with special emphasis on community and economic development" [2].

Research outcomes in relation to the University's mission are articulated through and within several related and interdependent initiatives and entities that include

- The **Office of Research and Economic Development (ORED)** that coordinates and supports campus-wide research
- The University's strategic plan, which is called the **Flight Plan**
- The **Research Centers** that were established and maintained to promote research in critical areas of national need
- The **Agreement on Responsibilities** that each faculty member negotiates and signs each academic year in which differential percentages of research can be indicated by the faculty member in agreement with the faculty member's supervisor
- The **academic colleges and departments** that set goals and monitor research outcomes on a college and departmental level

The institution identifies expected outcomes for the research component of its mission, assesses the extent to which it achieves these outcomes, and provides evidence of improvement based on analysis of the results.

Office of Research and Economic Development

Research activities are coordinated and supported through the ORED, which is responsible for achieving University-wide research outcomes. The ORED supports the University's mission in three broad areas:

- Sponsored and Scholastic Research: Support, inspire, incentivize faculty to pursue sponsored and scholastic research and grow sponsored research programs
- Innovation: Develop and inspire innovation and entrepreneurial culture on campus involving students and faculty
- Economic Development: Play a support role in economic development of the Upper Cumberland region and the state through research developed in the University

The ORED is responsible for and oversees all University research and creative activities through the following objectives, assessments, and outcomes.

Table 1. ORED Objectives, Assessments and Outcomes.

Objectives	Assessments	Outcomes
Goal 1. Develop and encourage activities to increase extramural funding; develop and strengthen strategic alliances in pursuit of research and creative activities	• Number of proposals submitted • Amount requested in proposals submitted • Number of award activations • Amount of externally sponsored research and creative activities funded	• Conducted several proposal development workshops • Hosted webinars on grants and contracts • Subscribed to several funding and proposal development resources (Research Development and Grant Writing News, FoundationSearch, Federal and Foundation Assistance Monitor, InfoEd Global Suite) • Formed alliances with universities, government, industry, and private agencies, nationally and internationally, in pursuit of research and creative activities. Examples of alliances established include, but are not limited to, The Automotive Research Association of India, The Technology University of the Philippines, Oak Ridge National Lab, Tennessee Valley Authority, Eastman Chemical, and TheraChem Company.
Goal 2. Develop infrastructure to support higher level of research;	• Infrastructure developed to support existing and emerging research.	• The iCube has been developed for students and faculty to collaborate, conceptualize, inspire, and innovate while using immersive visualization reality technologies. • Enhanced the Environmental Quality Lab of the Center for the Management, Utilization and Protection of Water Resources to provide faculty and students the use of cutting-edge water quality analysis technology.

Goal 3. Ensure that units operate in a fiscally responsible manner and comply with federal, state, agency, Tennessee Board of Regents, and university policies and guidelines. Ensure operating policies and procedures are clearly written and communicated to appropriate university units and personnel	• Level of compliance with federal and state policies and guidelines related to awards • Number of training workshops conducted • Internal and external audit reports	• Reviewed and revised policies, procedures and training so that all units are in compliance with current Office of Management and Budget Circular (2 CFR, Chapter I, Chapter II, Part 200 et al.) which was implemented on Dec. 26, 2014. These policies provide government-wide framework for awards management to minimize fraud, waste, or abuse. • Hired more staff to provide training to faculty and staff in award management, assist in formulating budgets for proposals, and monitor budgets and financial commitments on awards. • Established schedule for the review and revision of operating policies and procedures.
Goal 4. Develop and encourage activities that enhance innovation.	• Number of inventions disclosed • Number of patents and copyrights filed • Number of inventions licensed and/or commercialized	• Provided initiation grants for innovative research ideas that might result in invention disclosures. • Provided funding for filing patents and copyrighted materials. • Sought opportunities to inform angel investors and venture capitalists of inventions in the University's intellectual property portfolio.
Goal 5. Provide support to and collaborate with public and private sectors in economic development activities.	• Number of inventions licensed and/or commercialized	• Publicized the intellectual capital that exists at the University. • Collaborated with local business in holding workshops in workforce training and development. • Sought economic development grants related to job creation/retention.

The ORED participates in and provides leadership in the development and assessment of University-wide research

outcomes through the operation of the University Research Advisory Committee (URAC). The URAC was established to advise the President and the Provost regarding strategies to stimulate growth in research and externally funded scholarly activities within the University community, and to develop a comprehensive structure and network of activities to foster externally funded scholarly activities [3]. The URAC meets five times a year to review assessment data on research activities and make recommendations regarding intellectual and infrastructure needs to increase and/or enhance research productivity. Of particular note is that recommendations of the URAC helped form the basis for strategic goals identified in the Flight Plan.

The goals, objectives, and action plans of the ORED were developed by the URAC with input from the academic deans. Further, the goals and objectives are aligned with the University's current Flight Plan to enhance research and innovation and support the economic development of the Upper Cumberland Region, and the state. The URAC's strategic plan, including objectives and action plans, and its activities since its formation in FY2009/10 are summarized and published (with detailed minutes) in ORED annual reports [4]. The assessment instruments were selected and are monitored annually to provide quantitative measures of research outcomes, with data available in ORED annual reports [4].

Example data showing number of proposals submitted and awards received for six fiscal years are provided in Figure 1, and total external funding for the previous six fiscal years broken down by colleges and departments is provided in Table 2. Complete data on these metrics for the University are available through the ORED's annual reports [4].
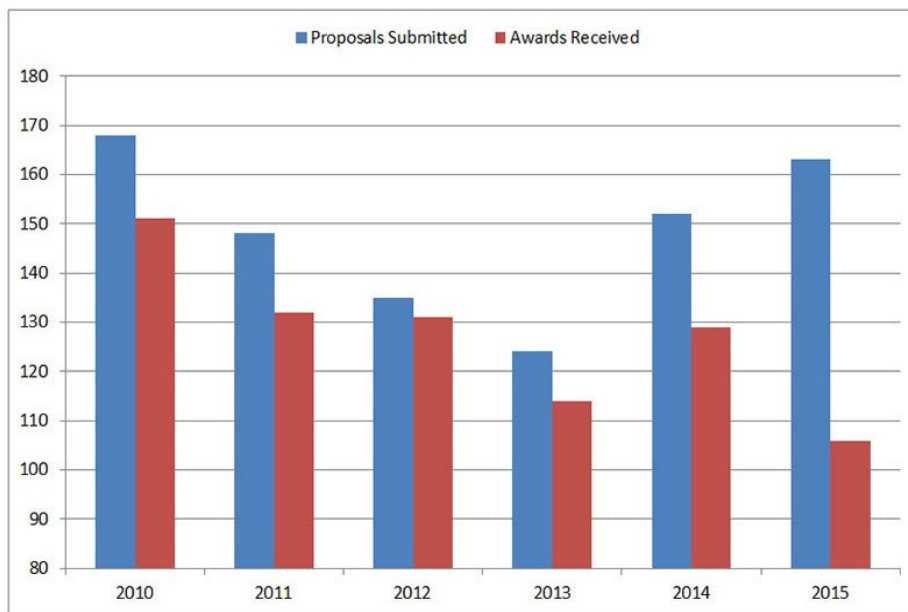

Figure 1. University grant proposals submitted and received for six fiscal years.

Table 2. External Funded Projects by Department of Project PI.

PI's College	PI's Department, Center, or Unit	Total Funding					
		FY 2009/10	FY 2010/11	FY 2011/12	FY 2012/13	FY 2013/14	FY 2014/15
Agricultural and Human Sciences	Agriculture	$153,792	$184,361	$305,169	$187,583	$109,759	$152,150
	Human Ecology	$1,101,885	$1,021,786	$674,548	$499,700	$464,790	$182,328
	Dean's Office	$33,500	$150,000				
Arts and Sciences	Biology	$571,013	$473,641	$434,860	$276,246	$158,720	$180,286
	Chemistry	$25,000	$70,000	$144,919	$114,200	$90,000	$644,875
	Cooperative Fisheries Research Unit	$369,306	$668,950	$588,913	$289,771	$251,252	$156,605
	Earth Sciences				$127,350		
	English			$77,516	$47,980	$34,033	
	Foreign Languages	$3,000					
	History			$15,000	$15,000		
	Mathematics	$413,425	$277,847	$157,886	$156,113	$215,458	
	Physics	$144,149	$97,000	$245,791	$235,794	$454,136	$540,175
Business	Business Administration			$24,396			
	Business Media Center	$713,756	$859,621	$901,501	$1,088,925	$1,238,352	$1,603,933
	Decision Sciences and Management	$123,300	$123,300	$123,300	$99,772	$91,772	
	Economics, Finance and Marketing				$5,000		$1,700
	Small Business Development Center	$77,696	$151,251	$60,605	$129,965	$125,997	$136,420
Education	Academic Development	$3,000					
	Administration						$33,264
	Art					$9,000	
	Counseling and Psychology	$260,943	$506,831	$634,611	$694,697	$663,854	$28,320
	Curriculum and Instruction	$1,481,250	$1,040,695	$2,012,076	$1,289,564	$918,126	$612,534
	Education Administration	$320,000					
	Exercise Science, Physical Education, Wellness	$15,000	$15,000				
Engineering	Basic Engineering	$761,611	$184,910	$47,500			
	Chemical Engineering	$366,860	$129,404	$105,243		$381,057	$298,063
	Civil and Environmental Engineering	$431,985	$376,166	$466,207	$717,878	$521,323	$253,980
	Computer Science	$12,491	$383,500	$408,605	$249,332	$699,937	$485,727
	Electrical and Computer Engineering	$706,539	$92,624	$38,781	$100,950	$629,605	$795,419
	Manufacturing and Industrial Technology	$65,637	$90,717	$213,589	$34,500	$60,000	$47,192
	Mechnical Engineering	$638,627	$586,302	$945,365	$524,970	$719,544	$580,988
	Engineering Administration	$33,515	$44,444	$41,462	$43,059	$68,709	$190,474
Centers of Excellence	Energy Center Appropriation	$883,400	$896,700	$866,000	$880,700	$919,300	$898,500
	Energy Center Other	$843,009	$180,464	$16,525	$11,175	$3,850	$0
	Manufacturing Center Appropriation	$1,492,200	$1,512,400	$1,460,000	$1,482,900	$1,541,100	$1,506,300
	Manufacturing Center Other	$2,243,783	$1,242,412	$523,967	$462,523	$249,831	$265,436
	Water Center Appropriation	$1,171,400	$1,188,000	$1,215,549	$1,161,300	$1,205,600	$1,178,300
	Water Center Other	$380,625	$326,251	$133,651	$319,482	$108,462	$179,596
Interdisciplinary Studies	Extended Educaton		$500,000				
Other	Academic Affairs					$140,000	
	Athletics					$500	
	Counseling Center	$7,780	$3,619	$2,725	$3,450		
	Facilities and Business Services	$1,221,240			$250,000		
	Student Affairs	$720					
	STEM Center		$400,000	$198,706	$475,000		$68,101
	University Police		$6,227				
Total	All Units	$17,071,437	$13,784,423	$13,084,966	$11,974,879	$12,074,067	$11,020,666

*Colleges and Departments not listed did not having funding activity during the fiscal year.

Continuous improvement and modifications. The Office of Research was reorganized as the ORED to more effectively focus on research, innovation, and economic development. Several initiatives were undertaken to (a) develop and strengthen strategic alliances and relationships with federal and state agencies, industry, and private sector companies to further enhance the acquisition of grants and contracts; (b) strengthen existing and develop new research

center/institutes and interdisciplinary teams in response to emerging national research priorities; and (c) provide pre- and post-award sponsored program logistics as well as compliance support. These initiatives resulted in (a) the establishment of the Center for Healthcare Informatics; (b) the development of collaboration between Thermofield, LLC, the Business Media Center, Chemical Engineering, Healthcare Informatics, and Electrical Engineering; (c) the spin-off company of Cumberland Health Informatics, which is under development; (d) the development of a project for medical devices with two University of Alabama-Birmingham faculty members; (e) the development of a software project on clinical informatics in collaboration with Vanderbilt University; and (f) the development an Innovation and Learning Center that is now located in the Angelo and Jennette Volpe Library.

As a result of a satisfaction survey, the ORED is providing more training to faculty on proposal development and preparation and has added one staff to assist faculty and staff with the development of proposal budgets and another staff member to assist faculty with writing proposals.

Improvements to assessment plan. Several improvements have been made as a result of the ORED's assessment measures. They include the following:

- The number of proposals submitted to funding agencies was tracked instead of the total number of faculty who submitted proposals because several faculty contribute to proposal development as co-PIs, senior personnel, and support personnel.
- The number of faculty who received proposal preparation assistance will be tracked instead of the number of faculty that participated in proposal development workshops because the outcome of proposal development workshops is the number of faculty who required proposal preparation assistance.
- The value of proposals submitted was added as an assessment tool.
- Tracking the number of patents issued was added as an assessment tool.
- The number of faculty who participate in training in research compliance, such as responsible conduct of research, human subjects, animal care and use, and export controls will be added as a tool in assessing research compliance.
- The frequency of assessment was changed from each semester to annually to more accurately capture activities that occur during the summer and to coincide with the period of the annual reports.

The assessments have led to several improvements in research, the following of which are a few specific examples:

- Several research-active faculty members have been hired in targeted focus areas where the University has core competencies.
- The Faculty Research Grants Committee (see below) has revised its guidelines to stimulate research and creative activities and increase extramural funding by providing initiation grants under three tracks for individual and interdisciplinary research projects, and by helping faculty with proposal preparation through workshops and training.
- A noticeable improvement in both number of proposals submitted by the University and number of successful awards obtained has occurred (See Figure 1).
- The Undergraduate Research and Creative Activity (URECA!) Grants Program (see below) was enhanced to permit more undergraduates to participate in research and creative activities and to travel to conferences to present their work.
- The Students' Research Day (annually in April) was enhanced through the participation of government and industry representatives, sharing insights on grant opportunities and strategic initiatives. Student participation has grown as a result.
- An automatic electronic notification system was implemented to alert faculty of the availability of funding opportunities in their respective areas of expertise, thereby eliminating the time and effort expended by faculty, staff, and students in searching for funding opportunities.
- The Collaborative Institutional Training Initiative (CITI), an online training program on responsible conduct of research, human subjects research, export controls, biosafety and biosecurity, and animal care and use was implemented to train faculty, staff, and students so that they are current and compliant with regulatory requirements.
- The eCustoms Visual Compliance Software was also implemented to assist with faculty training in export controls.
- The number of online subscriptions and journals in research has increased.
- An incentive research pay system was instituted in order to incentivize research.

The ORED also provides executive leadership to the Faculty Research Grants Committee, which was established to stimulate interest in research on the part of the faculty, to establish and administer policies and standards in connection with faculty research funds from which assistance may be provided to faculty members who wish to undertake research projects, and to assist in the dissemination of information developed in faculty research projects through the publication of research results in appropriate media. Faculty members submit proposals to the Faculty Research Grants Program in an annual solicitation in January. The proposals are reviewed by the Committee and are approved or declined, and the reviews are used by the faculty for improvement and refinement for resubmission or for submission to external funding agencies.

The ORED also provides executive leadership to the Intellectual Property Advisory Committee [5], which was developed to advise and assist the President in all matters involving patents, trademarks, and copyrights. Table 3 is evidence of the

tracking that this committee performs in fostering the development of patents and other intellectual property. The ORED encourages activities to enhance innovation by providing initiation grants for innovative ideas that could result in invention disclosures, by providing funding for patent filing and copyrighted materials, and by seeking opportunities to inform angel investors and venture capitalists of inventions in the University intellectual property portfolio. Other measures of success are the number of inventions disclosed, the number of provisional and utility patents filed, and the number of inventions that have been presented for commercialization. Transfer of technology for societal benefits results in economic development, which aligns with the mission of the University. In 2012-14, technologies developed at the University have resulted in the creation of two start-up companies, Robotic Technologies of Tennessee and Promethia Labs. Other technologies are being considered for commercialization and/or start-ups.

Table 3. Intellectual Property Activity.

	FY 2009/10	FY 2010/11	FY 2011/12	FY 2012/13	FY 2013/14	FY 2014/15
Invention Disclosures	5	4	3	4	2	4
Provisional Patents Filed	4	2	1	3	2	2
Patents Pending Action	2		2	3	2	2
Patents Issued			1	1	1	0
Patents Licensed					2	1
Copyrighted Materials	1					0

An exciting development that is overseen by the ORED is the establishment, in Fall 2011, of the Undergraduate Research and Creative Activity (URECA!) program [6]. The URECA! program and ORED define undergraduate research as "a student-faculty collaboration to examine, create, and share new knowledge or works in ways commensurate with practices in the discipline." The official mission of URECA! is to provide monetary assistance for undergraduates who pursue research and creative activities at TTU through academic year mini-grants, summer grants with stipends, and travel grants for students and their accompanying faculty mentors. The Undergraduate Research Steering Committee accepts URECA applications for mini-grants, summer grants, student travel grants, and faculty travel grants each year. Grants range from $1,000 to $3,500 per year, per project. Since inception, 211 grant projects have been funded totaling more than $353,983 in undergraduate research. In 2013-14, the ORED created and appointed the faculty member position of Director of Undergraduate Research.

The ORED also routinely maintains and administers such institutional policies as the Institutional Review for the Human Subject Policy and the Animal Use Policy. Compliance reviews of pre- and post-award management are conducted annually by the TTU Office of Internal Audit and by state auditors. These audits are used for continuous improvement of the research enterprise.

These activities have produced a noticeable improvement in both the number of proposals submitted by the University and the number of successful awards obtained (See Figure 1). An automatic electronic notification system, InfoEd's Sponsored Program Information Network, has been implemented to alert faculty of the availability of funding opportunities in their respective areas of expertise. An online Collaborative Institutional Training Initiative (CITI) is now being implemented in proposal and faculty development training workshops to train on responsible conduct of research, human subjects research, export controls, and animal care.

Strategic Directions in Research in the TTU Flight Plan

Invigorating faculty to collaborate and explore research opportunities is an essential component of the University's new strategic plan, the Flight Plan [7]. In 2012-13, the Flight Plan Steering Committee identified 10 executive-level accountability metrics to include in a peer comparative gap analysis. One of these addresses the Research Focus Area of the Flight Plan (increase opportunities to enhance connection to industry and innovate), and this metric is Total Research Expenditures Per Full-Time Tenured Faculty, and the values are provided in Table 4 for the past five fiscal years (2009/2010 to 2013/2014).

Table 4. Research Expenditures per Full-Time Faculty.

	2009-10	2010-11	2011-12	2012-13	2013-14
Research Expenditures	11,972,147	11,491,266	9,703,179	9,594,263	9,503,256
Full-Time Tenured Faculty	262	270	267	243	243
Research Exp. Per Full-Time Tenured Faculty	45,695	42,560	36,341	39,483	39,108

In preliminary Flight Plan data gathering, including robust collaboration with the URAC (described above) and other campus stakeholders, faculty teams expressed a need for resources to incubate high-potential, interdisciplinary research ideas to ready opportunities for external funding.

Flight Plan Focus Area 3 identified the following strategic improvement directions that articulate the research mission of the University:

- Expand research and faculty scholarly activity
- Support faculty collaboration and development
- Evaluate structure where appropriate to promote cross-disciplinary and integrated programs and scholarship
- Improve graduate recruitment, incoming student quality, enrollment, and degrees conferred
- Provide undergraduate research opportunities

Based on the gap analysis [8], one of the 12 priority actions to enhance research undergoing development in 2014 was the proposed establishment of the Innovation for Distinctiveness in Education and Applied Sciences, an incubator to cultivate promising and distinctive research opportunities. Its primary objective is to expand funded research by surfacing prospects for new, distinctive research opportunities. Annual metrics for this project include the number of cross-appointments for faculty members and number of projects funded through the incubator.

The URECA! program that was originally established in Fall 2011 to foster undergraduate and graduate research has been infused with additional funding as a Flight Plan initiative.

Another priority action in Flight Plan is the 2014 initiative to offer new graduate degrees in high-demand fields. Graduate degree programs in targeted areas will increase the research emphasis of the institution and provide more STEM-related offerings to students. After reviewing the Bureau of Labor Statistics (BLS) report [9] on economic and employment projections for 2012-2022, the College of Graduate Studies (CGS) identified several key areas as offering program growth opportunities for the University. New programs in the fields of environmental studies, STEM, and healthcare are opportunities to meet the national needs of the employment market. With this knowledge and a review of the expertise within the colleges, the CGS assisted the colleges of Education and Interdisciplinary Studies in completing all of the paperwork for TBR approval of several new programs. The new programs recently introduced center around STEM-related fields and include:

- Professional Science Master's (PSM): Environmental Informatics
- M.A., Exercise Science, Physical Education and Wellness: Sport Management
- Ph.D., Exceptional Learning: STEM Education
- M.A., Curriculum and Instruction: Educational Technology

The Research Centers

The research mission of the University is further supported by research centers, which include the Millard Oakley STEM Center and the university's three interdisciplinary Accomplished Centers of Excellence. The Centers of Excellence are:

- Center for Manufacturing Research (CMR)
- Center for the Management, Utilization and Protection of Water Resources (CMUPWR)
- Center for Energy Systems Research (CESR)

These centers of advanced scholarship within state-supported universities were founded and received special funding through the State of Tennessee Centers of Excellence program. In 1984, Governor Lamar Alexander's administration designated three of 20 new Centers of Excellence at TTU. By formally establishing the three Centers for Excellence in 1985, continued opportunities for cooperation and collaboration exists between interdisciplinary research teams of faculty and students from departments, schools, and research units throughout the campus.

Each Center strives to use present educational resources to achieve excellence; to support economic development in the state; to enhance the intellectual, cultural, and social climate for Tennessee citizens; to use external sources to improve research; and to attract nationally and internationally recognized faculty to Tennessee institutions.

Each of these Centers conducts ongoing, data-driven assessment resulting in continuous improvement. In general, the

metrics established by TBR for the Centers have been to increase recognition of the University and the state in certain well-defined research areas, and focus on return on state appropriation dollars garnered through external funding. The TBR requires all Centers of Excellence to report the total amount of project activations each fiscal year. This amount of project activations is used as a prime metric to assess goals and objectives in each Center, along with annual reporting of participating faculty's publications, presentations, and so forth.

The three Centers accomplish these research goals in distinct ways, as described below, but are tied together by overarching thrust areas set by the College of Engineering in 2012 (see section on College of Engineering below). The Centers of Excellence have been active participants in targeted faculty hires by serving on search committees and providing start-up funds for new faculty. The effective result in external funding may take several years for these new faculty to become successful.

The Center for Manufacturing Research (CMR). The CMR was created to draw together Tennessee resources, the University, industries, and government funding agencies into a cooperative effort to be on the leading edge of the latest technological advances in manufacturing. The CMR draws upon expertise from throughout the College of Engineering and various other colleges, departments, and the University, as appropriate, as well as resources outside the University. The CMR also employs dedicated faculty and staff who are responsible for enhancing and supporting the strategic research program. Staffing includes three faculty, one postdoctoral assistant, three research and development engineers, eight supporting office and laboratory staff, and numerous graduate research assistants.

Established in 1985, the CMR exceeded the state of Tennessee's benchmarks of performance and was officially recognized by the state as an Accomplished Center of Excellence in 1990. In 1998, the CMR was awarded a Level 2 Tennessee Quality Award for its focus on continuous improvement. In addition, the CMR has conservatively estimated that $3 in additional revenues have been returned to the state's economy for every state-appropriated dollar.

The CMR has identified goals that are in alignment with both the College of Engineering Strategic Plan as well as the university's Flight Plan, focusing on increasing national and international recognition for TTU manufacturing research. The Center annually collects data on metrics such as project activations and valuations, and income generated. Results are shared annually in August with TTU administrators, TBR staff, and CMR core faculty/faculty associates and staff. These results help drive strategic decision making within the CMR and are also used in evaluating the effectiveness of the Director.

Examples of how the CMR uses its data for continuous improvement are as follows. Results of assessments show that, although proposal activity has remained relatively stable and at historically high levels, conversion to activations of external funding had been steadily declining, leading up to the benchmark fiscal year 2011-12. The CMR responded by taking advantage of several university-level initiatives to assist faculty in writing proposals and workshops to educate faculty about components of winning proposals. The promising upswing in results can be seen in Figure 2, showing external funding activations for six fiscal years. The CMR is providing seed funding to new and existing faculty to visit with program managers at funding agencies and providing insight to larger, more collaborative proposals. One example is the recent (October 2013 submission) collaboration with four other southeast states on a proposal for a National Network of Manufacturing Institutes (NNMI) focused on Digital Manufacturing and Design Innovation (DMDI). The CMR led the state of Tennessee collaborative effort, securing approximately $7.5 million in state matching. Unfortunately, the proposal was not funded, but the southeast team was one of only four other proposals to pass on to the second phase of the proposal process. Continued collaborative efforts of this type will be crucial to dramatically improving conversion rates of proposals to external funding.
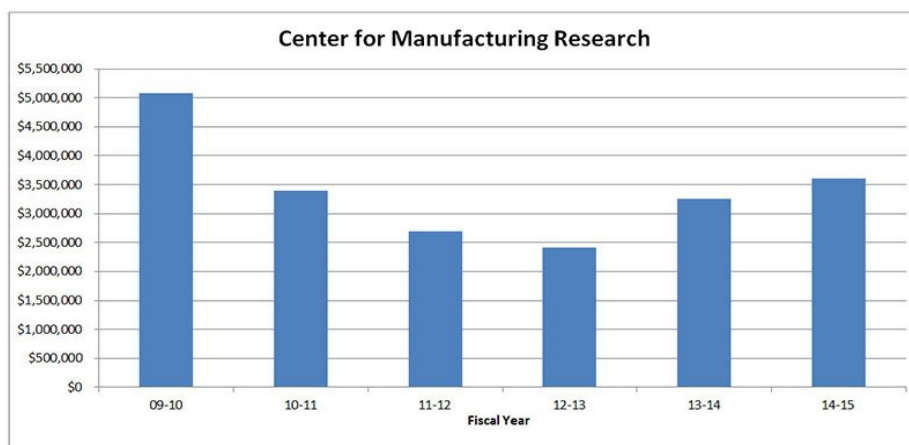

Figure 2. Center for Manufacturing Research externally funded project activations for six fiscal years.

In response to assessments, in 2012-13, CMR adopted a new policy that any new proposals and proposers that use CMR personnel/resources to conduct research activities should include release time and or reimbursement of supplies within their proposal budget. In addition, research and development engineers employed by the CMR are encouraged and measured on their performance evaluation based on the level of their salary return.

The Center for the Management, Utilization, and Protection of Water Resources (CMUPWR). The CMUPWR exists to enhance research by addressing diverse water-related problems in Tennessee, the nation, and the world; to enhance educational opportunities through research, university instruction, and educational outreach; and to enhance citizens' quality of life by providing technical assistance and technology transfer to peers, citizens, and industry. The Center director works with guidance from its Advisory Board and input from core faculty and associate faculty to establish strategic focus areas and set goals/objectives for the unit. The CMUPWR has chosen the Utah Water Research Laboratory as a benchmark. The CMUPWR's efforts in comparison to that facility are noteworthy since Utah State University is ranked at the Research University level, which is a higher Carnegie Classification level than TTU. Core faculty are required to file an annual activity report and are evaluated based on amount of external funding received, numbers of refereed papers published, and number of presentations.

Figure 3 shows the external funding generated by the Center over a period of six years. The Center's objective to increase external funding and return on dollars funded by state appropriations and analysis of historical funding data have caused it to establish and strengthen funding to certain thrust research areas, such as the impact of climate change on water resources and endangered animals, and proteomics.
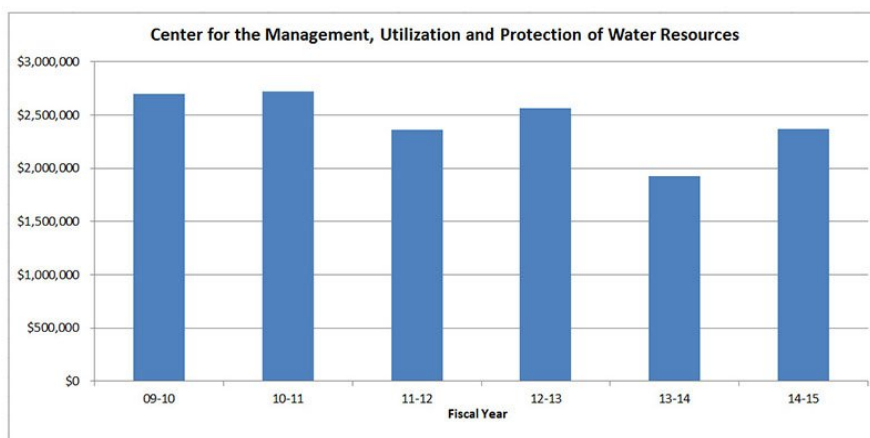

Figure 3. Center for the Management, Utilization and Protection of Water Resources
externally funded project activations for six fiscal years.

The Center for Energy Systems Research (CESR). The CESR was established to advance and apply scientific and engineering knowledge and academic programs associated with energy systems, and in particular with electric power, while supporting the instructional program of the University. Research efforts are focused on solving current and anticipated problems associated with energy systems with special emphasis to the needs of the electric power industry.

The goals are derived from the mission of the Center, and set by the Center Director with input from a small group of the CESR faculty. Numerical targets are determined to allow for an anticipated annual growth of 10 percent. Data is gathered from annual reports of participating faculty and includes numbers of external grants activated, amount of funding, journal publications and presentations, and bachelor's, master's, and doctoral graduates and supported students. Figure 4 shows external funding earned over the past six fiscal years.
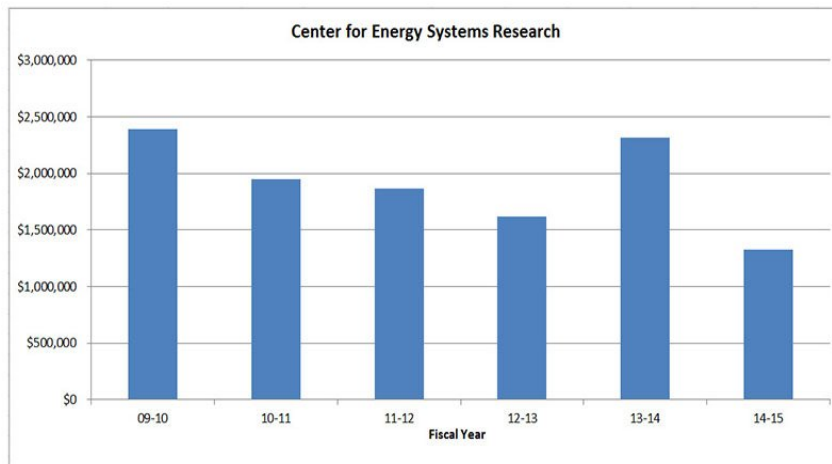
Figure 4. Center for Energy Systems Research externally funded
project activations for six fiscal years.

The CESR has fallen short of its goals primarily because presently the Director position is occupied by an Interim Director, and three faculty positions fell vacant. A search to hire a new director is in process. It is expected that a new director will join before the beginning of the next academic year (August 2015). Three new faculty members were hired in the 2012-13 fiscal year and two more in the 2013-14 fiscal year. It is expected that their efforts will lead to increased grants in the future years.

Based on results of assessments of 2012-13, the Center has chosen to place more emphasis on preparation and submission of collaborative research proposals, to increase support for undergraduate research projects, and increase outreach activities. Publication in refereed journals and more selective presentations during prestigious conferences will be emphasized.

The Millard Oakley STEM Center. The research mission of the University is further supported by the newly established Millard Oakley STEM Center that supports innovative teaching and dynamic learning in science, technology, engineering, and mathematics. The STEM Center enriches pre-kindergarten through college (P-16) student STEM learning with hands-on inquiry, enhances the STEM preparation of new and practicing pre-kindergarten through high school (P-12) teachers, models innovative instructional design and learning environments, conducts rigorous STEM education research, and collaborates with industry and organizations to strengthen STEM education initiatives across the region, state, and nation.

A vital activity of the STEM Center is learning research, and one of its stated goals is to support TTU campus faculty in the development and dissemination of STEM education research activities. For purposes of its research mission, the Center maintains a semesterly facility-use log, and annual grant and communications logs. This assessment data is currently shared with a STEM Steering Board consisting of mostly on-campus stakeholders. However, a more broadly conceived Advisory Council model is projected for formation in the 2014-2015 fiscal year, consisting of university faculty, K-12 education teachers and administrators, industry, business and community organizations with STEM interests, government agencies, and legislators. The Council will meet annually in November to receive an annual report and give input on Center goals and outcomes. Thus, the STEM Center's new process for assessment-driven continuous improvement is under development. Figure 5 shows the external funding the STEM Center has received over the past six fiscal years.
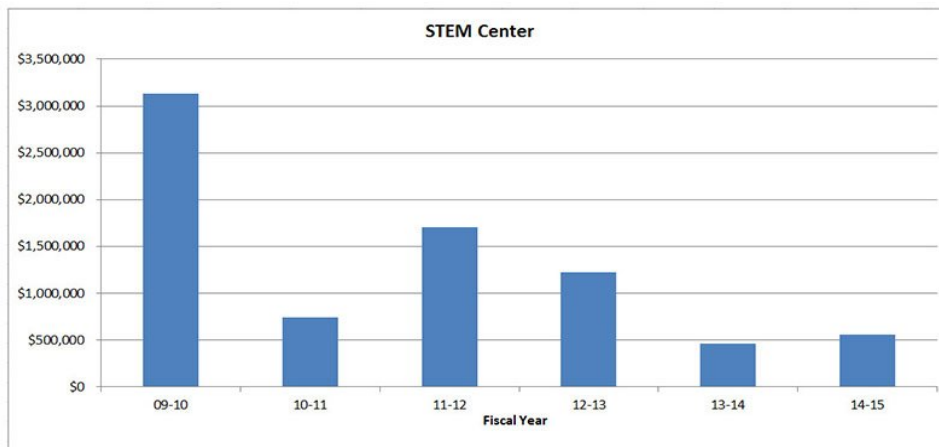
Figure 5. Millard Oakley STEM Center externally funded project activations for six fiscal years.

Faculty Agreement on Responsibilities - Relationship to Research Outcomes

The research mission is extensively embedded within the academic and service units of the University and is largely conducted by individual faculty members and their students. Faculty are expected to engage in research/scholarly activity leading to new knowledge or creative works in their disciplines, and to mentor graduate and undergraduate students to offer learning opportunities that impart discipline-specific skills and knowledge. Generally speaking, faculty members in collaboration with their departmental chairs define research outcomes. A research component is listed in the Agreement on Responsibilities that each faculty member negotiates and signs each academic year (see Faculty Handbook [10])[11], in which differential percentages of research can be indicated by the faculty member in agreement with his/her supervisor. Each faculty member is then required to file an annual activity report with the departmental chair to be used for evaluation of how well these agreed responsibilities have been met. Faculty annual evaluation meetings with department chairs provide opportunities for reviewing the process for improvement and for making modifications in individual goals for continuous improvements. Having a research-active faculty keeps the University on the cutting-edge of new knowledge and able to impart real-world problem-solving skills to students.

Faculty research and scholarship contribute to and benefit the institution's research mission and are crucial components in hiring, promoting, and retaining faculty. It is the means through which the University distinguishes itself, enhances its reputation regionally and nationally, recruits high-caliber faculty, and attracts highly qualified students. TTU's visibility has been significantly enhanced through participation in several research and creative activities, and those accomplishments that benefit the university mission are documented in the annual reports of the academic units.

Periodic reviews of research and creative activities occur at the unit level due primarily to the comprehensive nature of the University. These reviews consist of annual evaluations of the research and scholarly productivity of the faculty and may result in awards at the unit level. For example, in the College of Engineering, the Dean has established a Teacher-Scholar model to set expectations and evaluate faculty relative to research productivity. Faculty are expected to secure external funding that supports graduate students and to publish in refereed scholarly journals in their disciplines. The College gives incentives for research accomplishments in terms of awards on the order of $10 thousand annually.

Exemplary Research Outcomes in Academic Colleges and Departments

As stated earlier, the research mission is extensively embedded within the academic departments of the University and is conducted by individual faculty members and their students. Here we highlight several examples of how individual colleges and departments have set research goals, how these are assessed, and modifications for continuous improvement.

College of Engineering (COE) – Research profile. The COE has aggressively sought to advance the research mission of the University [2]. The COE has its own strategic plan that aligns with the University Flight Plan. The Dean's Advisory Council for Engineering and the Strategic Planning and Implementation Subcommittee meets ever semester to set goals for the college, establish metrics, and review outcomes. The COE oversees two research-focused Centers of Excellence, the CESR and the CMR.

Examples of continuous improvement in the COE based on assessment are numerous. From 2007 through 2010, 10 research-active faculty left TTU to pursue positions of advanced responsibility either administratively or within larger research institutions. Coupled with several years of budget cuts, resulting in approximately a 30 percent reduction in budgets, and an elimination of congressionally directed spending, external funding witnessed a significant drop from

previous levels. In response, in 2012, the COE initiated a strategic planning effort that united the direction of departments and research centers and set Centers of Excellence focus areas around six major thrust areas, with the corresponding Center of Excellence responsible for coordination of activities in parentheses:

1. Advanced Manufacturing (CMR)
2. Energy Storage and Conversion (CMR)
3. Networking and Sensing (CMR)
4. Smart Grid (CESR)
5. Resilient Infrastructure (CESR)
6. Nanoparticles and Proteomics in the Environment (CWR)

Shortly after these research areas were selected (see the website given below [12] to review a presentation on how these areas were selected), the COE added 11 new faculty lines. All new faculty hires in the college have been in these strategic research areas, including a raise in new faculty starting salaries by 15 percent, and an increase in average faculty start-up package from $100 thousand to $350 thousand.

To reward research accomplishment, the COE has also established a merit-based teacher-scholar faculty award with significant one-time monetary compensation at the college level and has established departmental awards limited to 30 percent or less of faculty.

A result of Flight Plan and COE initiatives has been the establishment of an Institute for Modeling, Simulation, and Discovery (IMSD) that has campus-wide participation [13][14]. The primary focus of the IMSD is to provide the COE and University with resources and collaborations for meeting the scientific computing challenges facing researchers.

Dramatic gains have been made in graduate student recruitment by a new targeted graduate student recruitment advertisement, and visitation of campuses that only offer bachelor's degrees. As a result, Ph.D. applications are up by nearly 100 percent and M.S. applications are up by more than 130 percent compared to Fall 2013. Improvements have been made in processing applications, resulting in admission levels of 51 students to the Ph.D. program in Fall 2014 compared to 15 for Fall 2013.

The premium placed on research outcomes is evidenced by the realignment of the Associate Dean position as Associate Dean for Research and Innovation that focuses on research, graduate recruiting and funding, and innovation and entrepreneurship initiatives.

College of Education (COEd) – Research profile. As one of the larger colleges at TTU, the COEd strives to support the university's mission to offer high-quality instruction and learning experiences. The most appropriate approach to high-quality instruction and learning experiences is through research. Faculty members are expected to stay abreast of the latest research and participate in and conduct research in their respective fields. Faculty members in the COEd work closely with students to provide research opportunities whether through a research-based course or extracurricular activity.

The COEd has articulated research outcomes in relation to its program goals and student learning outcomes. Faculty members identify research outcomes for their respective programs. For example, in the various master's programs in the Department of Curriculum and Instruction, faculty members have developed two sequences of research courses required for most programs. For students pursuing a quantitative research endeavor, they enroll in the following sequence of courses: FOED 6820, FOED 6920, and CUED 6900. For those pursuing a qualitative research endeavor: FOED 6820, FOED 6980, and CUED 6900. A student's faculty committee reviews and provides input and approves or disproves student work throughout the entire process. Research activities overseen by the COEd include guided student research projects, both formal via coursework and informal via shared student/faculty interest (e.g. URECA!, Student Research Day, and various scholarly conferences). Other research activities include internally and externally funded as well as unfunded faculty research projects.

While the COEd tracks the number of research outcomes (publications; grants funded or continuing; presentations at international, national, state, or regional professional organization conferences; manuscripts submitted for publication; grant applications submitted; and research in progress), departmental chairpersons work with faculty in terms of defining expectations. Student research outcomes are also tracked. For example, the Exceptional Learning Ph.D. program annually tracks student activity in grant proposals written, grant proposals submitted, in-service workshops, national and international presentations, book chapters, peer-reviewed publications, and peer-reviewed publications pending. The Department of Curriculum and Instruction annually tracks student outcomes in its various research courses.

The tables in the annual reports of the COEd provide ample evidence of its assessment of research outcomes [15]. Additional evidence of assessment activities for research in the COEd may be found in the respective Institutional Effectiveness (IE) reports for programs and departments in the COEd. The various programs and departments in the COEd conduct annual reviews for improvements. The respective IE reports are just one example of the various annual reviews. All licensure programs in the COEd undergo multiple reviews annually. Examples include National Council on Teacher Quality, Title II, Tennessee State Report Card for Teacher Preparation Programs, in addition to the various accreditation agencies for programs in the COEd (CACREP, CAEP, NASAD, NASM). Additionally, the COEd meets twice a

year, at the beginning of each semester, to review program data from the previous year and recommend any necessary changes based on the data.

All accredited programs and those that undergo Academic Audits via the TBR are required to demonstrate program improvement based on program reviews of expected outcomes and related data. Examples of where assessment results improved research within the COEd include the development of the research course FOED 6820. In reviewing data from the sequence of research courses in the master's program in the Department of Curriculum and Instruction, faculty found students to be underprepared in statistics and quantitative analysis. To remedy this disconnect between expectations and preparation, faculty developed FOED 6820. More refined rubrics for student assessment have been developed for this and other research-based graduate courses. Another example of continuous improvement is the Exceptional Learning Ph.D. program's development of EDU 7000, which among other things, directs students to set up an InfoEd Smart profile via the ORED, be introduced to IRB, and more.

For the last five academic years, external funding in the COEd has been driven, largely through the grant activity of the Department of Curriculum and Instruction. Table 5 is extracted from Table 2 and shows externally funded projects by the principal investigator in the Department of Curriculum and Instruction.

Table 5. Externally funded projects by Principal Investigator
in the Department of Curriculum and Instruction.

	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Curriculum and Instruction	$1,481,250	$1,040,695	$2,012,076	$1,289,564	$918,126	$612,534

Campus Labs **Planning Module for Institutional Effectiveness in Research**

IE reports for research are collected regularly and continually monitored by the office of Academic Affairs and the office of University Assessment [16]. A program *(Campus Labs)*, with planning tools for submitting reports efficiently [17] and consistently, was purchased and was implemented for collecting IE reports in the 2014-2015 academic year.

Conclusion

Research initiatives on campus are guided by principles following requirements of institutional effectiveness. Each unit within the ORED purview is tracked through its various objectives, outcomes, assessments, and plans for continuous improvement. As key areas for improvement are identified through these measures, steps are taken to make the changes needed. Specifically, the pursuit of the ORED's goal to develop and encourage activities to increase extramural funding, etc. (Goal 1), has led to more proposal development workshops and webinars, and alliances with universities, government, industry, and private agencies. The iCube, a three-dimensional learning and creating area on campus has been developed to allow faculty and students to conceptualize, inspire, and innovate while using immersive visualization technologies as part of the ORED's pursuit of infrastructure development that will support higher levels of research (Goal 2). On the fiscal side of research, more staff have been hired to provide training in award management and formulating budgets, etc., to ensure that faculty and students are operating according to state and university policies (Goal 3). Toward the end of enhancing innovation (Goal 4), faculty have been provided initiation grants for innovative research ideas, and funding has been provided for filling patents and copyrighted materials. Economic development grants related to job creation have been pursued and collaborations with local businesses have been enhanced through Goal 5, which initiates activities that enhance economic development through technology transfer. Each of the ORED's goals and the corresponding assessment methods has led to tangible effects that influence the university and improve its ability to pursue and attain externally funded research opportunities. Therefore, TTU is in compliance with Comprehensive Standard 3.3.1.4 (Institutional Effectiveness: Research).

Sources

[01] Carnegie_Classification

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[03] University Research Advisory Committee

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- [05] Intellectual Property Advisory Committee
- [06] URECA Program
- [07] Flight Plan
- [08] Flight Plan Overall Summary Report_August 2013
- [09] Bureau of Labor Statistics Economic and Employment Projections 2012_2022
- [10] Faculty_Handbook
- [11] Agreement on Responsibilities Rev Spring 2015
- [12] TTU COE Strategic Plan_01_2015
- [13] TTU_COE Strategic Research Areas Information Meetings October_2012
- [14] Institute for Modeling Simulation and Discovery
- [15] College of Education Annual Report FY 2014
- [16] Institutional Effectiveness
- [17] Rubric for Evaluating IE Plans w Exemplary Acceptable Developing
- SACSCOC Institutional Effectiveness
- TTU Assessment