THE UNIVERSITY OF TENNESSEE AT CHATTANOOGA

CENTER OF EXCELLENCE

IN APPLIED COMPUTATIONAL SCIENCE AND ENGINEERING

Annual Report to the Tennessee Higher Education Commission Fiscal Year 2014-2015

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Executive Summary

During 2014-15 the Center of Excellence in Applied Computational Science and Engineering (CEACSE) celebrated its first decade of operation and service to the State of Tennessee and beyond. Through the Center's effective research and educational outreach efforts, the financial support of the Tennessee Higher Education Commission, and CEACSE's other valued partners has been utilized to the benefit of new and ongoing innovative computational applications.

Building on strong foundations and reputations for excellence in research, both CEACSE and the SimCenter: National Center for Computational Science and Engineering operated effectively and met established goals and objectives during this period. This was accomplished despite a number of key personnel changes. In July, 2015, several of the faculty and administrators directing the Center's work retired, and there were also changes in the support staff of both CEACSE and the SimCenter.

Effective July 1, 2015, Dr. Reinhold Mann, a senior scientist well-known for his leadership and scholarship in association with research facilities including Oak Ridge National Laboratory, Pacific Northwest National Laboratory, and the Brookhaven National Laboratory, was named Interim Director of the SimCenter. Dr. Mann's expertise and breadth of administrative skills are welcomed and have already been very effective in continuing the excellent work by CEACSE and the SimCenter. In the current year Dr. Mann will direct the engagement of new opportunities for expanded research and sustainable funding sources. Dr. James Newman, III, a long-term member of the

SimCenter faculty, has graciously accepted the post of Interim Department Head and Assistant Director for the SimCenter Graduate School of Computational Science and Engineering. Dr. Newman's continued service in these key roles is welcomed and will help ensure that transitions anticipated in the academic instruction and administration components of the Center will go smoothly.

Over the past ten years, a culture of the securing external funding as an outcome of seed research funding provided by CEACSE has been fostered. One issue is the necessity to promote and stimulate grant competition from a broader spectrum of individuals and technological areas. This is affected by current teaching demands, which impact capabilities and time required for research and proposal development and paths. There are continuing issues as well including the national economic environment, levels of external monies committed to research and development funding, and increased externally competitive environments. These ongoing challenges are being addressed through strengthened focus on developing new partnerships, and a retooling of the academic components of the Center's work.

CEACSE continues to enhance the educational aspects of its mission and objectives though the Ph.D. and M.S. graduate programs with The University of Tennessee at Chattanooga and its Graduate School of Computational Science and Engineering within the College of Engineering and Computer Science. Both graduate and undergraduate students have participated in various research activities undertaken as a result of CEACSE funding. Because of those research activities, area companies continue to have

interest in the educational programs impacted by CEACSE initiatives. In the current year the Center will broaden its efforts to partner with companies in our region and beyond. Because of the nature of computational research, the efforts of researchers and the SimCenter will continue to serve as research anchors attracting students from across the nation and internationally.

The reporting year proceeded with the awarded research funds being expended in fulfillment of THEC's purposes for the establishment of Centers of Excellence. In support of those purposes, CEACSE's particular goals and objectives have been effectively addressed. Through the awards directed by the Center, researchers and associated academic units have maintained external funding from various agencies, companies, and governmental entities. CEACSE monies from the 2014-15 period as well as from years past continue to provide returns, reaping benefits through additional awards/grants.

As presented in the figure which follows, THEC through the funding of CEACSE's mission and activities brings together productive and innovative research partners from many key areas responsive to changing needs and demands of energy and the environment, health and biosystems, and manufacturing.

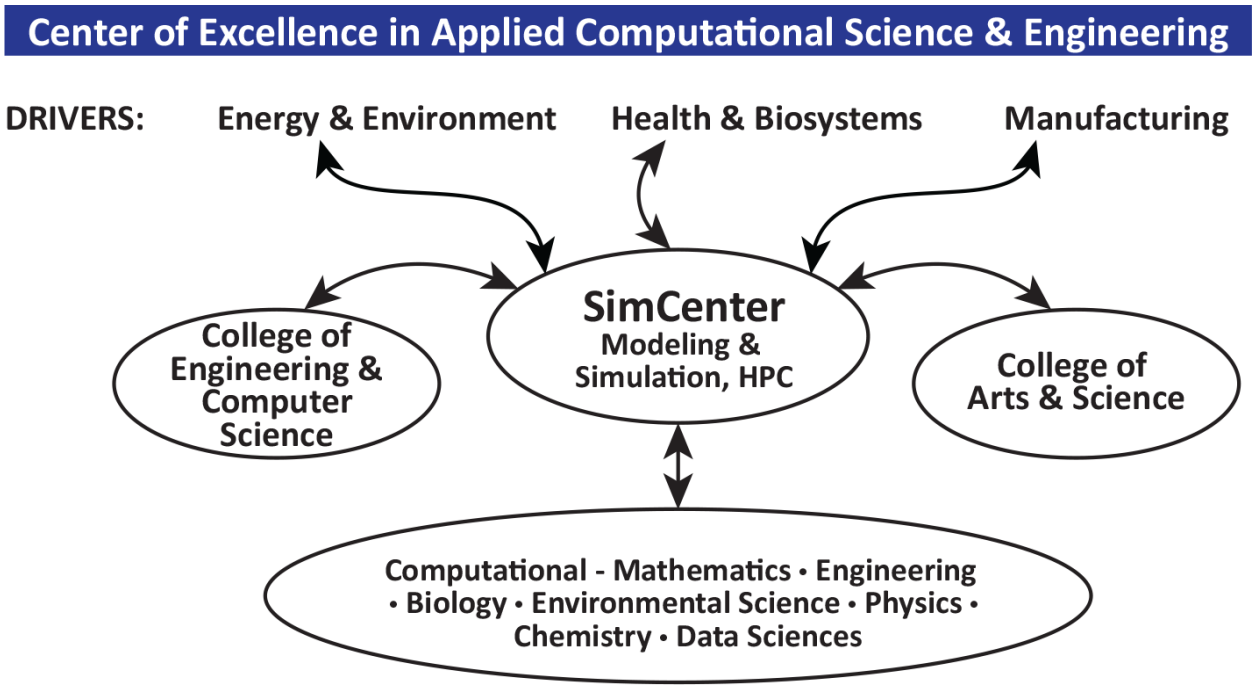

Figure 1

As noted in previous reports, an aspect of funding research activities of the Center and securing external funding assists in promoting companies to continue to develop enterprises in the Chattanooga region. During the period of this report, new engagements were established with the organizations including the Chattanooga Business Development Center, the Tennessee Association of Manufacturers, and the Greater Chattanooga Chamber of Commerce.

The following is the Annual Report for Fiscal Year 2015 of CEACSE activities and efforts. As we look forward to our continued work together during 2015-16 and beyond, on behalf of the Center, the College of Engineering and Computer Science of the University of Tennessee at Chattanooga, and the Center's community partners, thanks are extended to THEC for the Commission's decade of support.

Introduction

Consistent with the enabling legislation establishing the THEC Centers of Excellence in 1984 et seq., the THEC Center of Excellence for Applied Computational Science and Engineering (CEACSE) presents opportunities to capitalize on the successful initiative of the SimCenter: National Center for Computational Science and Engineering and on the substantial transformational enabling investments made by public/private community partnerships.

CEACSE utilizes the expertise of established researchers, graduate students, and the faculty of the College of Engineering and Computer Science of the University of Tennessee at Chattanooga and other Colleges within the University to broaden and deepen the concept of a computational modeling and simulation center. The Center strives for involvement in a wider array of practical problem areas in science and engineering including opportunities in the fields of cyber security, biology and medicine, environmental sciences, and energy science and technologies. CEACSE's activities involve the use of advanced computational methodologies to solve complex problems in practical applications.

The particular applications focus on areas of need and interest to local, regional, national industries, and state and federal agencies. Funding from the Center seeds these activities, with expectations, whenever feasible and applicable, that additional funding would result from federal grants and contracts awarded to researchers for further development. In this report year, funding for research was expanded into the medical field (e.g., Exposure

Prediction in Infectious Disease Epidemics, Rupture Predictions for Aneurysms, Airflow in Bronchial Systems). Predictable additional funding from agencies and business concerns previously "untapped," will lead to the betterment of medical science and patient care. New FY 2015 initiatives by the researchers supported by CEACSE have broadened the Center's capability to address other problems of national interest.

New FY 2015 initiatives by the researchers supported by CEACSE have broadened the Center's capability to address problems of national interests with regards to energy independence, national security, and human health. A complete list of these projects may be found in the *Research Activities Funded by the Center* section. Some notable examples include *in silico* certification of drag reduction devices for Class-8 trucks, disaster management system for hazardous material releases, and the development of tools for an automated fall risk assessment system for post stroke patients.

This report summarizes the research programs supported by CEASCE funds in FY2015 and the outcomes achieved by these programs in support of the Center of Excellence goals. Upon the retirement of founding director Dr. Henry McDonald, Dr. Neslihan Alp, Interim Dean of the College of Engineering and Computer Science at UTC, was appointed Interim Director of CEASCE.

Strategic Goal

The overarching goal of CEACSE supports the original enabling legislation and builds upon the UTC's established academic strengths and community partnerships in applied computational science and engineering. The Center's evolution into and recognition as a national 'Center of Excellence' and a premier multidisciplinary research and education center for computational science and engineering is evidenced by the body of research and its applications over the past decade. For example, seminal research and development by the Center include:

- High-fidelity modeling of drag reduction devices for Class-8 trucks; including rotating wheel and ground plane effects
- Fluid-thermo-elastic analysis, sensitivity analysis, and design of Solid Oxide and Proton Exchange Membrane Fuel Cells
- Evacuation strategy assessment via coupled simulations of airborne contaminant release and agent-based modeling for traffic routing
- Temporally and spatially higher-order accurate algorithms for multidisciplinary and multiphysics applications

CEACSE utilizes the expertise and infrastructure of the SimCenter staff and its computing resources. CEACSE seeds new research activities, expands previously supported research activities, and undertakes supporting activities that lead to additional sources of funding. Appropriate faculty across the entire University, particularly those in science, engineering, and business are encouraged and solicited to be involved. With expansions into key areas such as medicine and cyber security, the research portfolio over

the report year includes broaden research contributions. Those contributions enhance the educational and economic development mission of The University of Tennessee at Chattanooga and the communities it serves.

Center Research Focus

CEACSE is strategically focused on synergistic new programs that advance the state of the art in computational simulation in solving complex problems utilizing scientific supercomputing. During the report year and in 2015-16, the research focus was/is being reexamined with an emphasis on strategic local, regional, and national needs; sustainable funding; and expansion of relationships with additional academic departments and units across the educational spectrum of UT Chattanooga.

This focus encompasses research on computational simulations for analysis of the physical processes embedded in real world problems, as well as computational approaches that synthesize these simulation capabilities into efficient and effective low-cost solution tools and capabilities across multiple disciplines. Complex problems in the physical sciences are frequently multidisciplinary and require a synthesis of physical sciences, engineering, mathematics of computation, and scientific computing. The mission, objectives, and outcomes of CEACSE are designed effectively address such complex problems.

The Computational Approach

One of the major strengths of CEACSE is the SimCenter with its expertise in computational engineering and applications methodologies that are broadly applicable to both new and evolving problem areas and other non-engineering disciplines. CEACSE is advancing science, technology, education, and workforce development by supporting cross-disciplinary teams of researchers and educators. The Center has been developing core capabilities in modeling, simulation, and the associated applied mathematics and computer science in close collaboration of scientists and engineers in several disciplines, with a particular focus on effective use of high-performance computing systems.

The Center initiates research activities in new areas of focus and in other disciplines combining experienced computational experts with scientists who are expert in the required discipline, i.e. physics, chemistry, and biology, medical research, computer science. These efforts can be very effective in generating opportunities for attracting new funding, advancing science and technology, and providing exciting new opportunities for education and training.

The core computational expertise of the SimCenter is leveraged via CEACSE support to foster interdisciplinary collaborations between SimCenter researchers and collaborators who are experts in other disciplines or particular application areas.

Objectives, Activities and Uses of Center Funding

CEACSE pursues goals and objectives that establish the necessary and on-going foundation for recognition as a premier center of excellence for computational applications. The Center's objectives, activities and use of funding are outlined as follows.

Objectives

The primary objectives of the Center are:

- *to expand the demonstrated capability of the University in the area of Computational Science and Engineering*
- *to seed research and educational activities that broaden and expand the Center's base of research expertise*
- *to utilize the Center's base of research expertise and demonstrated success to attract new sustainable research funding.*

A high-performance computing cluster of processors with associated significant storage capacity has been serving the computational needs of CEACSE activities to date. While this facility will continue effective operation for some time, we are in the process of realizing an opportunity to connect to the world-leading high-performance computing environment at the Oak Ridge National Laboratory (ORNL) via a 10Gbit/s network that is expandable up to 100Gbit/s as the need develops. By placing a cluster into the CADES (Computing and Data Enabling Science) environment at ORNL we advance the CEACSE computational infrastructure with the environment developing

at ORNL, a US Leadership Computing Facility on the path to exascale computing, and a major contributor to the US Exascale Computing Initiative.

The Center encourages at least one external proposal be developed for each seed funded activity and submitted to a funding agency for continuation and expansion of the CEACSE funded research or related research.

In some instances, multiple years of funding are necessary to mature a technology, especially in emerging strategic focus areas. The availability of sustaining support has proven to be very beneficial to the successful completion of several key research initiatives.

In this report year CEACSE granted funding to twenty-eight new research initiatives. The initiatives included research performed in support of requests received from external funding agencies, efforts to find external funding opportunities for a number of the CEACSE funded projects, and research activities undertaken by the Center's Staff and the faculty of the University of Tennessee at Chattanooga.

Table 1

CEACSE Seed Funding Committed for FY 2014-2015 Research Activities

Project Title	Budget	One-Year Extension	Expenses	Proposal Submitted	Externally Funded	External Funding Source(s)
Extension of Reduced Order Modeling Capabilities for Stability Derivative Evaluation and Computational Design	$22,000	N	$20,608	Y	N	
Numerical Simulations of Airflow and Particle Transport in a CT-Based Human Airway Model	$55,000	N	$54,018	Y	N	
Rupture Predictions for Aneurysms	$33,000	N	$31,154	N	N	
Utilization of Computational Design Optimization Technology for Sub-Model Parameter Optimization	$30,000	N	$27,798	N	N	
Electromagnetic Simulation and Optimization of Metamaterials	$55,000	N	$55,374	N	N	
An Application for on Demand Plume Tracking for Evacuation Planning	$40,000	N	$33,976	N	N	
Research into Tetrahedral Grids Produced From Physics-Based Point Placement	$40,000	N	$31,381	N	N	
Travel for Presentations and Networking at the Pointwise User Group Meeting	$5,500	N	$855	N	N	
A Robust Network Design in Cognitive Radio	$45,000	Y	$30,942			
Exascale Computing Leadership Class Machines Using FUNSAFE Framework	$25,000	N	$23,712	Y	N	
Harnessing the Power of Big Data in Arial Network Authentication and Medical Analysis and Predictions	$50,000	Y	$38,765			
Higher-Order Adaptive-Overset Dynamic Grid Development	$55,000	N	$40,776	Y	N	
A Prototype Disaster Management System for Hazardous Material Releases	$55,000	N	$55,343	Y	N	
Algorithms for Index Case Identifications and Exposure Predistion in Infectious Disease Epidemics	$22,000	N	$20,940	N	N	
Standards for Numerical Simulations of Drag Reduction Devices for Class 8 Trucks	$30,000	N	$29,422	Y	Y	Smartrucks $10,000
Improvement in the Thermodynamic Performance of Steam Turbines	$14,000	N	$13,734	N	N	
Mitigating Wind Effect on Air Cooled Condensers	$14,000	N	$12,610	N	N	
Combined Spectral Element/Pseudo-Spectral Method for Complex Three-Dimensional Geometries	$30,000	N	$26,657	N	N	
Towards Accurate and Efficient Hybrid RANS/LES Modeling for Acoustic Noise Prediction Using High-Order Multi-scale Finite Elements	$50,000	N	$51,412	Y	N	
Large Scale Simulation of Low-Pressure Compression System of the Energy Efficient Engine	$14,000	N	$12,483	N	N	
Extending Stall Margin of Axial-Flow Turbomachines Through the Energy Efficient Engine the Use of Passive Flow Control Devices	$40,000	N	$35,708	N	N	

Project Title	Budget	One-Year Extension	Expenses	Proposal Submitted	Externally Funded	External Funding Source(s)
Fully Conservative Semi-Lagrangian Methods for Viscous the Energy Efficient Engine Flow Simulations	$14,000	N	$14,444	N	N	
Development of Free Surface Interface Models for Higher-Order Finite Element Methods	$30,000	N	$31,778	N	N	
Development of a Fully-Coupled Fluid-Structure Interaction Approach for Hydrodynamic Application	$30,000	N	$29,537			
Securing Internet of Things by Capability-Based Access Control	$50,000	N	$49,417	Y	Y	NSF $914,780, NIH $384,747
Big Data Solution for Improved Mental Health Management	$55,000	N	$48,536			
Spectral and Energy-Efficient Distributed Multicast Algorithms for WSN	$50,000	N	$47,271			
Trust Propogation and Distrust in Web of Trust and Airborne Networks Authentication	$50,000	Y	$15,703	Y	N	
TOTAL	**$1,003,500**		**$884,354**			

Table 2

CEACSE Seed Funding Carried Forward from FY 2013-2014 to FY 2014-2015 Research Activities

Project Title	Budget	One-Year Extension	Expenses	Proposal Submitted	Externally Funded	External Funding Source(s)
A Power Efficient Multicasting Scheme Using Compressive Sensing	$51,660	N	$51,659			
Quality of Service Assurance using GENI	$65,000	N	$50,977			
Communication and Data processing Tools for Automated Fall Risk Assessment System	$35,000	N	$35,407			
Data Acquisition and Communication in Smart Grid Networks	$85,000	Y	$71,980			
Zero-based Knowledge Authentication in Aerial Networks	$5,000	N	$3,996			
TOTAL	**$241,660**		**$214,019**			

Table 3
Summary of Funds Budgeted and Expended for FY 2014-2015

Expense	Budget	Expenses
SimCenter R&D Support	$291,965	$291,965
CEACSE Seed Funding for FY 2014-2015 Projects	$1,003,500	$884,354
CEACSE Seed Funding for FY 2013-2014 Projects Carried Forward	$241,660	$214,019
TOTAL	**$1,537,125**	**$1,390,338**

In order to ensure that the purpose and objectives of THEC's vital investment in CEACSE continue to be met, the financial progress of the projects is routinely tracked on a monthly basis via the UT financial reporting system, and the technical progress of the projects is monitored via short monthly progress reports, and final annual reports submitted to the Center by the Principal Investigators. *(All reports can be provided if requested.)* Subsequent external funding is also tracked, and where appropriate, is attributed to a specific Center project or groups of projects.

Recipients of CEACSE seed funding are required to provide copies of their submitted proposal and any subsequent information regarding awards or non-awards on external funding.

Secondary objectives of CEACSE are:

- *to increase the participation of additional faculty, graduate and undergraduate students in the Center's research efforts*
- *to assist in the recruitment of new faculty and students to the University*

- *to engage in activities that are directly or indirectly supportive of economic development initiatives which benefit the State of Tennessee, in particular, initiatives that create collateral opportunities for new research partnerships*
- *to seek appropriate opportunities for educational outreach activities which*

  a) help to create awareness and to stimulate interest in science and engineering among pre-college students, and

  b) help to stimulate interest in graduate study at UTC among undergraduate and graduate students.

CEACSE continued its efforts to broaden the scope of research through increased participation of additional faculty, graduate students and undergraduate students.

CEACSE awarded seed funding to support the research activities of sixteen faculty members from various disciplines, including computational engineering, computer science, engineering, business, and mathematics.

Each year the Center welcomes numerous visitors to discuss opportunities for research collaboration, and the Center sponsors presentations. The SimCenter has also initiated a speakers series offered at no charge to the participants, and open to the public. The speakers series is designed to bring scientists and scholars to share timely and topical information with the faculty of the University, area business leaders, local educators, and research personnel from other institutions. This new speakers series program supports CEASCE's commitment over the past ten years to foster effective

dialogue and exchange of ideas directly related to metropolitan engagement for the purpose of economic development, support of local businesses and government.

CEACSE sponsored research has created numerous opportunities for the education of graduate students, thereby providing students the potential to secure high-paying quality positions and to be able to remain within Tennessee.

In the summer of 2015, the Center once again hosted the participants in the Governor's School for Computational Physics. Fifty rising high school seniors accompanied by faculty and staff from Austin Peay State toured the SimCenter and learned about the educational preparation required for work in the field of computational science. This was the ninth year that the Center was included in the Governor's School program designed as an incentive to recruit and retain outstanding Tennessee high school students.

In addition to participation in the Governor's School curriculum, CEACSE and the SimCenter also sponsored visits by/workshops with students and faculty of area middle and high schools including:

- three workshop sessions for Brainerd High School students
- visits by Rhea County High School juniors and seniors
- two summer computing camps for middle school students and faculty
- visit by Gordon Lee High School students
- presentation at Career Day at Boyd-Buchanan School
- presentation and tour for Bledsoe County High School students and faculty

Center Plan for Achieving Objectives

The operation of the Center is guided by strategic planning to identify promising research avenues within the broad area of applied computational science and engineering. Some promising areas have been identified that leverage existing research capabilities into new and related areas. The Center continues to seek ongoing participation from other UTC faculty and personnel to identify additional areas of strength based on their individual expertise and partnership with other Center activities.

The Center continues to solicit these activities through a campus wide request for white papers and proposals. These white papers briefly describe the proposed effort, anticipated results, support required and a potential source of continued research funding, e.g. target agency, request for proposal etc. The Center provides seed funding for initiatives in the most promising areas for project and program planning aimed at developing competitive proposals for new external funding. Such seed funding includes faculty and student support for exploratory feasibility studies, demonstration of new capability supporting proposals, contacts with sponsoring agencies, proposal development, and related travel. This solicitation procedure is a part of CEACSE annual operating cycle.

The criteria for evaluating promising research areas and initiatives includes relevance and potential for contributing to success in becoming an accomplished Center of Excellence through the Center's goals of a) sustainable growth in research funding, b) excellence in integrated research and education, c) increase in national and international stature, and d)

promoting regional economic development and economic competitiveness for the State of Tennessee.

Research Activities Funded by the Center

The following list of activities and uses of funding illustrate how the Center's plan has begun to establish Center cohesion and continuity that fosters innovation and fills gaps that would otherwise arise from multiple individual research grants that are driven by the diverse and shorter term needs of the sponsoring agencies. (Schedule 7 is attached)

Extended Research Activities Funded by the Center in Fiscal Year 2013-2014 and Continued in Fiscal Year 2014-2015

1. **A Power Efficient Multicasting Scheme Using Compressive Sensing**
   - Principal Investigator(s): Dr. Mina Sartipi, Computer Science and Engineering
   - Objective(s): To develop a distributed multihop multicast scheme that is simple, energy efficient, and reliable.
   - **S**eed Funding: $51,660
   - Results: Technology is still being developed.

2. **Quality of Service Assurance using GENI**
   - Principal Investigator(s): Dr. Farah Kandah, Computer Science and Engineering
   - Objective(s): To address the challenges that could degrade the network performance, thus degrading its quality of service, where new practical and theoretical approaches will be provided taking into consideration the delay and the throughput optimization.
   - **S**eed Funding: $65,000
   - Results: Technology is still being developed.

3. **Communication and Data processing Tools for Automated Fall Risk Assessment System**
   - Principal Investigator(s): Dr. Mina Sartipi, Computer Science & Engineering
   - Objective(s): To study the data communication and data analysis required for automated estimation of fall risk for post stroke patients.
   - Seed Funding: $35,000
   - Results: Proposal was submitted to NIH for $384,747 and awarded. Technology is still being developed.

4. **Data Acquisition and Communication in Smart Grid Networks**
   - Principal Investigator(s): Dr. Mina Sartipi, Computer Science & Engineering
   - Objective(s): Proposing a data communication for the power transmission/generation premise; Providing an uninterrupted communication link for cellphone coverage during disaster relief. This will provide and alternative solution to using the existing emergency channels allocated to emergency services.
   - Seed Funding: $85,000
   - Results: Technology is still being developed. This project was extended through FY15.

5. **Zero-based Knowledge Authentication in Aerial Networks**
    - Principal Investigator(s): Ms. Katherine Winters, Computer Science and Engineering
    - Objective(s): To build a preliminary protocol for use in zero-based knowledge aerial authentication
    - Seed Funding: $5,000
    - Results: Technology still being developed.

New Research Activities Funded by the Center in Fiscal Year 2014-2015

1. **Extension of Reduced Order Modeling Capabilities for Stability Derivative Evaluation and Computational Design**
    - Principal Investigator(s): Dr. Abdollah Arabshahi, Graduate School of Computational Engineering
    - Objective(s): Many advances have been made within the SimCenter for constructing ROMs. The primary objective of this proposal is two-fold. Firstly, continued development is required to extend this newly developed capability for constructing aeroelastic ROMs generated from Reynolds Averaged Navier-Stokes simulation data. Secondly, results from this research will be used to establish credibility via publication and presentation at peer-reviewed conferences and to directly present this capability to appropriate federal agencies.
    - Seed Funding: $22,000
    - Results: The newly developed techniques are tested and validated against benchmark cases. Furthermore, the research effort is extended these novel methodologies to high-fidelity, time-dependent physics-based modeling. The result from this research is used to establish credibility via publication and presentation at the following conferences;
        i. Hasbestan, J.J., Newman III, J.C., and Arabshahi, A., "Least Squares Spectral Element Method For Laminar Compressible Flows," to be presented at the AIAA Science and Technology Forum and Exposition (SciTech 2016) San Diego, California, January 4-8, 2016.
        ii. Hasbestan, J.J., Newman III, J.C., and Arabshahi, A., "A New Approach to Mesh Adaptation Procedure Using Linear Elasticity for Geometries Undergoing Large Displacements," FEDSM2014-22010, Proceedings of the ASME 2014 4th Joint US-European Fluids Engineering Division Summer Meeting and 11th International Conference on Nanochannels, Microchannels, and Minichannels, Chicago, Illinois, August 2014.

2. **Numerical Simulations of Airflow and Particle Transport in a CT-Based Human Airway Model**
    - Principal Investigator(s): Dr. Abdollah Arabshahi, Graduate School of Computational Engineering
    - Objective(s): To assess the effects of inhalation transience on fluid physics during numerical simulation of airflow through the human pulmonary airways. The purpose of this study was to examine a critical assumption in the vast majority of previous studies. A computational geometry of the airways was generated from a set of CT images. Physiologically appropriate, lobar-specific boundary conditions were developed to best replicate the complex, physical flow conditions in the airways during respiration.
    - Seed Funding: $55,000
    - Results: In idealized geometries with smooth surfaces, airways of uniform diameter, and constant radii of curvature, the effects of inhalation transience on secondary flow phenomena may not be noticeable. In complex, realistic airways, however, the effects of inhalation transience are not negligible; rather, they appear to be relatively significant. The significance of these effects is something that should be examined in future work. Particularly, the significance of these observed effects on aerosol transport should be examined in depth.

3. **Rupture Predictions for Aneurysms**
    - Principal Investigator(s): Dr. Abdollah Arabshahi, Graduate School of Computational Engineering
    - Objective(s): Apply numerical method to investigate cerebral hemodynamics. Challenge: to predict the rupture status of an intracranial aneurysm.
    - Seed Funding: $33,000
    - Results: Because reliable information is not available up to now, the rupture-prediction challenge might be expanded to more complex cases to test the accuracy and consistency of the CFD simulation.

4. **Utilization of Computational Design Optimization Technology for Sub-Model Parameter Optimization**
    - Principal Investigator(s): Dr. Abdollah Arabshahi, Graduate School of Computational Engineering
    - Objective(s): To optimize sub-model parameters and to attempt to determine functional relationships between these values and varying physical scenarios.
    - Seed Funding: $30,000
    - Results: Complete.

5. **Electromagnetic Simulation and Optimization of Metamaterials**
    - Principal Investigator(s): Dr. W. Kyle Anderson, Graduate School of Computational Engineering (switched to Li Wang)

- Objective(s): To continue the development of electromagnetic simulation and design capability within the SimCenter by building on previous progress so that a two-dimensional metamaterial can be successfully simulated and coupled with time-dependent adjoint optimization methods to achieve improved performance.
- Seed Funding: $55,000
- Results: Along with the development of the present EM finite element solver for simulation of electromagnetic metamaterial, considerable work has also been performed for obtaining the adjoint-based sensitivity derivatives in the context of the high-order streamline/upwind Petrov-Galerkin method.

6. An Application for on Demand Plume Tracking for Evacuation Planning

- Principal Investigator(s): Mr. Ethan Hereth, Graduate School of Computational Engineering
- Objective(s): To create a fast, parallel solver capable of solving the time accurate unsteady compressible or incompressible Euler equations with added pseudo-viscous terms for the inclusion of diffusive effects. The solver uses a Cartesian aligned octree grid generated automatically from cityscape geometry. This solver will be designed to generate plume propagation data used to assist first responders in their evacuation plan. The software developed for this project has been named PAROS: PARallel Octree Solver.
- **S**eed Funding: $40,000
- Results: Technology still being developed; the application framework is complete and validation efforts continue.

7. Research into Tetrahedral Grids Produced From Physics-Based Point Placement

- Principal Investigator(s): Mr. C. Bruce Hilbert, Graduate School of Computational Engineering
- Objective(s): To investigate difficulties in creating tetrahedral grids produced using a given per-triangulated geometry and points placed inside that geometry via physics-based methods. CEACSE had previously funded research for the development of a tetrahedral mesh generator based upon point insertion and Lawson-style edge flipping.
- Seed Funding: $40,000
- Results: Need improvement of the particle-dynamics-based point placement simulation and further integration of the two algorithms.

8. Travel for Presentations and Networking at the Pointwise User Group Meeting

- Principal Investigator(s): Mr. C. Bruce Hilbert, Graduate School for Computational Engineering
- Objective(s): Travel for Presentations and Networking at the Pointwise User Group Meeting

- Seed Funding: $5,500
- Results: Complete.

9. A Robust Network Design in Cognitive Radio

- Principal Investigator(s): Dr. Farah Kandah, Computer Science and Engineering
- Objective(s): To create an accessible and easy to use smartphone application that will allow users at emergency incidents to use their smart device to capture and stream images/videos to high processing servers for reporting purposes. This will generate high traffic demand that needs special setup to be carried over the network without any delays and therefore, we will be taking advantage of the Global Environment for Network Innovations (GENI) testbed to support that.
- Seed Funding: $45,000
- Results: Technology still being developed.

10. Exascale Computing Leadership Class Machines Using FUNSAFE Framework

- Principal Investigator(s): Dr. Sagar Kapadia, Graduate School of Computational Engineering
- Objective(s): To develop new capabilities and perform required modifications in FUNSAFE framework to make it capable of running efficiently on leadership class machines.
- Seed Funding: $25,000
- Results: Proposal submitted to NSF not funded. Proposal submitted to Collaborative Research Initiative for Sponsored Programs (CRISP) was funded.

11. Harnessing the Power of Big Data in Arial Network Authentication and Medical Analysis and Predictions

- Principal Investigator(s): Dr. Joseph Kizza, Computer Science and Engineering
- Objective(s): In our study, we will revisit two old problems and try to apply known big data solutions and also try to develop new big data algorithms, where possible in Airborne Networks Authentication and Medical Analysis and predictions. Our solutions, especially those in airborne networks, will significantly minimize the challenging USAF aerial vehicle security problems and the skyrocketing medical problems
- Seed Funding: $50,000
- Results: Enhance our capability to effectively secure communication among airborne network entities and ground control. Provide a solution to test, evaluate cost and performance of, and prolong life based on better medical data analysis and predictions. Promote better and cheaper health preferences. Promote security in airborne networks. Submitted 5 NSF proposals, 3 were declined, 2 are pending.

12. High-Order Adaptive-Overset Dynamic Grid Development

- Principal Investigator(s): Dr. James Newman, Graduate School of Computational Engineering
- Objective(s): Two-dimensional prototype software has been developed to perform adaptive mesh refinement and dynamic overset grid simulations independently. This seed grant is focused on integrating and extending this technology into the three-dimensional, multidisciplinary and multiphysics, FUNSAFE framework.
- Seed Funding: $55,000
- Results: The baseline three-dimensional FUNSAFE framework was completed and validated. As a result of this developed technology, three proposals have been submitted and 4 peer-reviewed conference and 3 archival journal publications produced. The proposals include: one to the Naval Surface Warfare Center Carderock Division (NSWCCD) for $120K for one year; one to NASA Langley Research Center with a three year budget of $244K; and a pre-proposal white paper to the U.S. Air Force Seek Eagle office with a three year budget of $300K.

13. A Prototype Disaster Management System for Hazardous Material Releases

- Principal Investigator(s): Dr. Ramesh Pankajakshan, Graduate School of Computational Engineering
- Objective(s): To develop a disaster management system (DMS) that can predict the path of a hazardous gas release and suggest strategies such as staged building evacuations and road closings in order to minimize harm.
- Seed Funding: $55,000
- Results: The ability of FastParticle to deliver result in real-time was demonstrated. FastParticle needs to be validated using experimental data from large scale real world experiments and verified by comparing results with CFD simulations for the same cases.

14. Algorithms for Index Case Identification and Exposure Prediction in Infectious Disease Epidemics

- Principal Investigator(s): Dr. Ramesh Pankajakshan, Graduate School of Computational Engineering
- Objective(s): To develop algorithms for solving an inverse problem to locate the index case from an agent-based epidemic simulation.
- Seed Funding: $22,000
- Results: The approach was demonstrated with simplifying assumptions using synthetic datasets. Future work will focus on two key issues for making the code useful for real world applications. The first is to address the high-memory requirements that prevented the billion-point case from completing. The 2nd problem arises from the characteristics and lacunae of real world data and can only be solved if actual samples can be obtained for use in generating more realistic synthetic datasets.

15. Standards for Numerical Simulations of Drag Reduction Devices for Class 8 Trucks

- Principal Investigator(s): Dr. Kidambi Sreenivas, Graduate School of Computational Engineering
- Objective(s): The main objective of this project is to carry out preliminary work that would result in a proposal, in collaboration with ORNL, to the EPA. The aim of the proposal would be to create standards for CFD simulations that can be used in certification of drag reduction devices.
- Seed Funding: $30,000
- Results: A geometry model was obtained from an online source which represented a modern tractor. This model required significant cleanup as the requirements for mesh generation necessitate a water tight geometry. This has been accomplished and the model is ready for use. A trailer geometry was also generated and is available for use. An engine block needs to be added to the tractor geometry in order to provide a realistic blockage so that the flow will have the correct behavior. Additionally, contact has been made with EPA with regard to developing standards for CFD certification of drag reduction devices. This project received external funding from Smartruck Systems in order to carry out simulations of their proprietary drag reduction devices. These simulations, however, did not use the geometry from this project; the geometry was provided by Smarttruck Systems.

16. Improvement in the Thermodynamic Performance of Steam Turbines

- Principal Investigator(s): Dr. Kidambi Sreenivas, Graduate School of Computational Engineering
- Objective(s): To evaluate the concept of employing a nozzle downstream of a steam turbine. If successful, it can reduce operating costs significantly while improving performance.
- Seed Funding: $14,000
- Results: Several concepts were evaluated to see if they could improve the efficiency of steam turbines. These varied from nozzles downstream of the turbine to admittance chambers where the steam could be condensed. While some of these concepts proved to be able to condense the steam efficiently, all of them resulted in the water at very low pressure. This made all of these concepts thermodynamically inferior to the current steam turbines. Consequently, there was no effort made to turn this into white papers or proposals for external funding.

17. Mitigating Wind Effect on Air Cooled Condensers

- Principal Investigator(s): Dr. Kidambi Sreenivas, Graduate School of Computational Engineering
- Objective(s): To lay the ground work for a white paper that will be submitted to the Department of Energy. The focus of this proposal is to develop a strategy that will mitigate the effects of wind on the performance of Air Cooled Condensers (ACCs).

- Seed Funding: $14,000
- Results: Results showed an improvement in the performance of the ACCs with the use of screens around the bottom of the ACCs. These screens could be raised on lowered depending on ambient conditions, thereby creating a plenum that can be "charged" with ambient wind. Unfortunately, a similar concept has been patented by a company which is selling it as a commercial product. Therefore, no effort was made to seek external funding for this research.

18. Combined Spectral Element/Pseudo-Spectral Method for Complex Three-Dimensional Geometries

- Principal Investigator(s): Dr. Lafayette Taylor, Graduate School of Computational Engineering
- Objective(s): To develop a three-dimensional capability, which combines spectral elements and pseudo-spectral methods, for the spectral simulation of complex geometries. A key component of this effort is to maximize the efficiency of this combined approach to yield a methodology that is feasible in three dimensions. Validation cases will be performed for either a three-dimensional fluid flow or an acoustic or electromagnetic scattering problem to demonstrate the developed technology.
- Seed Funding: $30,000
- Results: The validation cases will demonstrate the ability to perform spectral method simulations for three-dimensional complex geometries. However faculty member left the university so only a portion of the research was completed.

19. Towards Accurate and Efficient Hybrid RANS/LES Modeling for Acoustic Noise Prediction Using High-Order Multi-scale Finite Elements

- Principal Investigator(s): Dr. Li Wang, Graduate School of Computational Engineering
- Objective(s): To develop discontinuous-Galerkin (DG) and Petrov-Galerkin (PG) finite-element schemes to advance a hybrid Reynolds-averaged Navier-Stokes (RANS) and large-eddy-simulation (LES) method for acoustic noise prediction.
- Seed Funding: $50,000
- Results: 3 papers have been published in peer-reviewed journals and national and international conferences, and one proposals submitted to NASA for 222K for one year (pending).

20. Large Scale Simulation of Low-Pressure Compression System of the Energy Efficient Engine

- Principal Investigator(s): Dr. Robert Webster, Graduate School of Computational Engineering
- Objective(s): To approximate a quarter-wheel of a low-pressure compression system of the energy efficient engine at 100% of the design speed.

- Seed Funding: $14,000
- Results: Large-scale simulations of the E3 fan and boost compressor stages was completed, one of the largest turbomachinery-related simulations ever accomplished by the SimCenter team. It is planned to re-examine the quarter-wheel case by extending the core duct to match that of the experimental setup. A conference paper was presented on this work at the 53rd AIAA Aerospace Sciences Meeting in January, 2015. Also, early results from this were part of a presentation to an experimental team at Purdue University; the purpose of this presentation was to foster interest in forming a collaborative team with the personnel at Purdue.

21. Extending Stall Margin of Axial-Flow Turbomachines Through the Use of Passive Flow Control Devices

- Principal Investigator(s): Dr. Robert Webster, Graduate School of Computational Engineering
- Objective(s): To focus on the area of stability of turbocompressors.
- Seed Funding: $40,000
- Results: In the two cases that were run, the turbo fan could not be declared to have stalled at any point. This is an important step because, once stall is achieved, the results of the simulations at conditions nearing that which stalled the turbofan can be analyzed to understand the flow mechanisms generating the instabilities that lead into stall. It has also given root to other ideas that are planned for a proposal to the Air Force Office of Scientific Research for the use of passive flow control devices.

22. Fully Conservative Semi-Lagrangian Methods for Viscous the Energy Efficient Engine Flow Simulations

- Principal Investigator(s): Dr. Robert Wilson, Graduate School of Computational Engineering
- Objective(s): To develop a next generation, fully conservative semi-Lagrangian method for the solution of viscous · Navier-Stokes equations with multiple phases. Such an approach has the potential to eliminate truncation errors due to discretization of the convective term, alleviate time step restrictions, increase robustness, reduce sensitivity due to element type, and guarantee conservation of mass, momentum, and energy, particularly for multiphase flows.
- Seed Funding: $14,000
- Results: Faculty member left the university so only a portion of the research was completed.

23. Development of Free Surface Interface Models for Higher-Order Finite Element Methods

- Principal Investigator(s): Dr. Robert Wilson, Graduate School of Computational Engineering
- Objective(s): To develop and implement multiphase interface models into the existing higher-order finite element FUNSAFE framework. An

interface capturing approach will be used, which is capable of simulating unsteady interfaces with complex topological changes such as breaking waves, bubble merging, and drop formation. Such a capability would allow high-fidelity simulations of free surface flows around ships and structures, environmental flows in rivers and oceans, bubbly flows, and medical applications.

- Seed Funding: $30,000
- Results: Faculty member left the university so only a portion of the research was completed.

24. Development of a Fully-Coupled Fluid-Structure Interaction Approach for Hydrodynamic Application

- Principal Investigator(s): Dr. Robert Wilson, Graduate School of Computational Engineering
- Objective(s): to leverage past research on hydrodynamic applications and recent progress in the development of an in-house fluid structure interaction (FSI) capability for the Tenasi flow solver. The proposed research is part of a multi-year effort for the development of a general purpose, fully-coupled FSI capability. In the first year of the this project, simulation of a FSI interaction for an offshore application was performed. Demonstration of a general purpose multidisciplinary approach for hydrodynamic fluid-structure interactions will greatly enhance future efforts to secure funding from various research agencies. In addition, efforts to market and distribute the Tenasi flow solver through the SimCenter Enterprises division will be vastly improved with this technology.
- Seed Funding: $30,000
- Results: Faculty member left the university so only a portion of the research was completed.

25. Securing Internet of Things by Capability-Based Access Control

- Principal Investigator(s): Dr. Li Yang, Computer Science and Engineering
- Objective(s): IoT will increase the amount of available data through smart sensor devices.
- Seed Funding: $50,000
- Results: Further research is needed.

26. Big Data Solution for Improved Mental Health Management

- Principal Investigator(s): Dr. Ashish Gupta, College of Business
- Objective(s): Team worked with a portion of data provided by Siskin that included functional independence measure (FEM) scores of patients with stroke, traumatic brain injury (TBI) and non-traumatic brain injury (nTBI).
- Seed Funding: $55,000
- Results: Among other accomplishments, submitted a proposal to the NSF sponsored US-Ignite program addressing development of a smart, cost-effective and cross-disciplinary analytics platform that can be utilized for

stroke rehabilitation as well as risk assessment and prediction of athletic injuries. An NIH proposal is under preparation for submission in Oct 2015 that utilizes the system that was developed.

27. **Spectral and Energy-Efficient Distributed Multicast for Wireless Networks**
    - Principal Investigator(s): Dr. Mina Sartipi, Computer Science and Engineering
    - Objective(s): Focus on investigating the multicast algorithm that uses CS for both at the source and intermediate hops on the paths from source to the destitutions.
    - Seed Funding: $50,000
    - Results: Technology still being developed

28. **Trust Propagation and Distrust (Rumor/Second Hand Trust) in Web of Trust (WOT) and Airborne Networks Authentication**
    - Principal Investigator(s): Dr. Joseph Kizza, Computer Science and Engineering
    - Objective(s): To focus on trust relationships in both a web of trust {WOT) and trust in airborne networks. In particular, we are interested in finding new models and new algorithms that will give us a better understanding and ultimately better authentication of entities in these networks.
    - Seed Funding: $50,000
    - Results: Technology still being developed. Submitted 3 NSF proposals, 1 was declined, 2 are pending.

Summary of CEACSE funding allocation (Figure 2) illustrates the major categories into which the CEACSE budget was allocated for Center activities during the past fiscal year of operation. It should be noted that grant awards from proposals and funding requests sought from this fiscal year funded projects normally will lag 6 to 12 months.

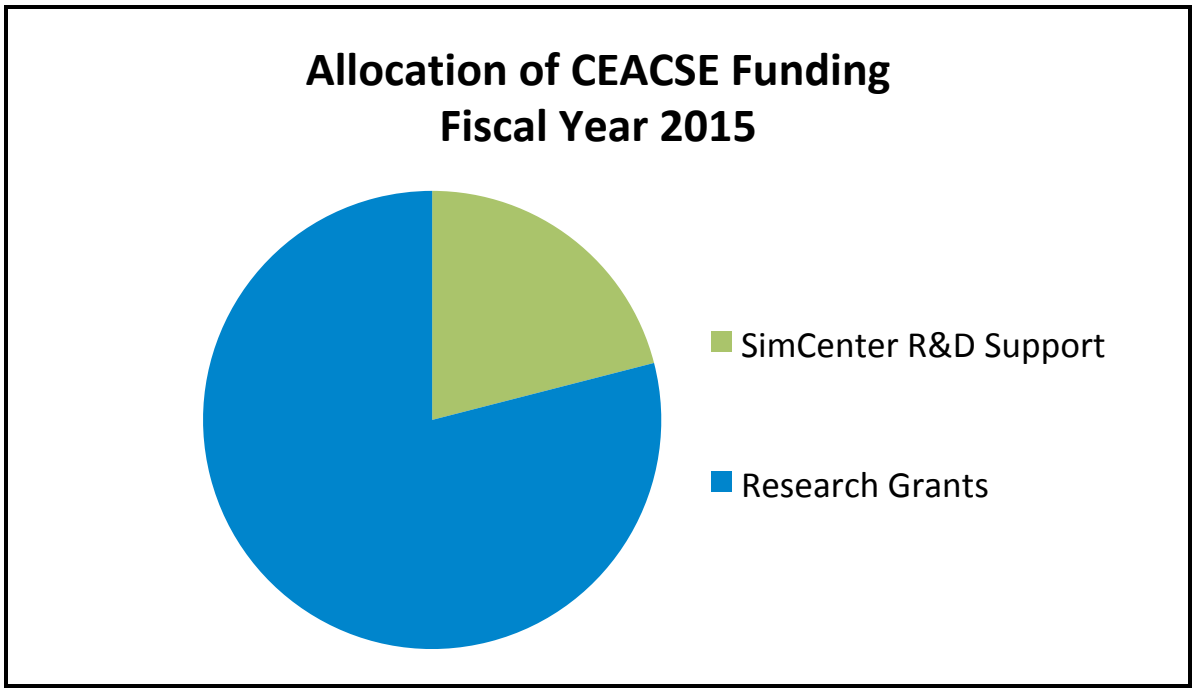

Figure 2

External Funding Awarded as the Result of the Center's `Research Investment*

External Funding Awarded in Fiscal Year 2005-2006:	$ 2,195,529
External Funding Awarded in Fiscal Year 2006-2007:	$ 3,291,102
External Funding Awarded in Fiscal Year 2007-2008:	$ 1,855,276
External Funding Awarded in Fiscal Year 2008-2009:	$ 4,765,948
External Funding Awarded in Fiscal Year 2009-2010:	$ 6,427,956
External Funding Awarded in Fiscal Year 2010-2011:	$ 1,111,097
External Funding Awarded in Fiscal Year 2011-2012:	$ 1,161,648
External Funding Awarded in Fiscal Year 2012-2013	$ 1,853,443
External Funding Awarded in Fiscal Year 2013-2014	$ 1,078,942
External Funding Awarded in Fiscal Year 2014-2015	$ 1,309,527
Total External Funding Awarded:	**$25,050,468**

* These funds represent funds committed by external funding agencies. Some of the awards included are multi-year awards with each year's funding dependent upon availability of funds.

A multi-year view of the outcomes achieved by CEACSE is portrayed in Figure 3.

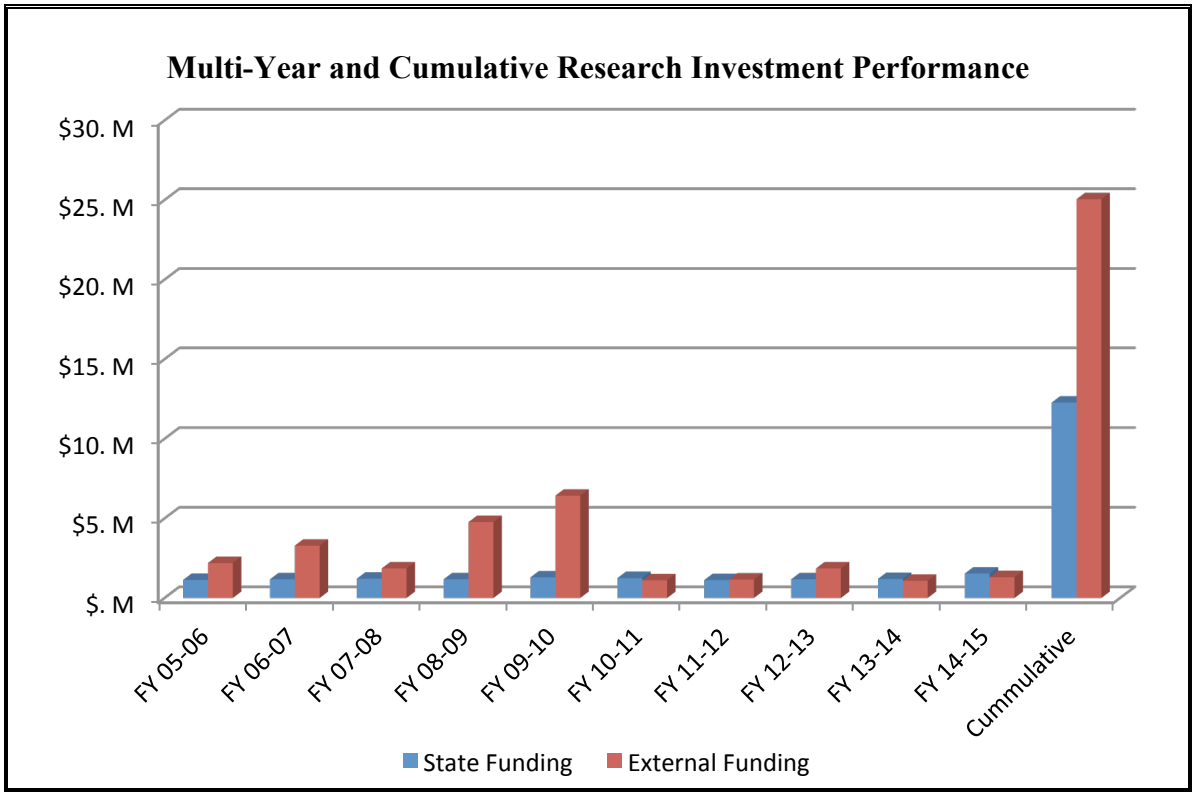

Figure 3

FY 2015 Publications and Presentations of the Center's Research Activities

National and International Conference Proceedings:

1. Hassan, W.E., Sreenivas, K., Mittal, A., Taylor, L.K., and Hereth, L. "Blade Resolved Simulation for a Wind Farm," AIAA Paper 2015-2269, 33rd AIAA Applied Aerodynamics Conference, Dallas, TX, June 2015.
2. Mittal, A., Sreenivas, K., Briley, W.R., and Taylor, L.K., "A Parabolic Method for Accurate and Efficient Wind Farm Simulation," AIAA Paper 2015-2268, 33rd AIAA Applied Aerodynamics Conference, Dallas, TX, June 2015.
3. Mittal, A., Taylor, L.K., Sreenivas, K., Briley, W.R., and Nichols, D.S., "Extension of a Parabolic Method without Pressure Approximations for Wind Turbines in ABL Flows," AIAA Paper 2015-3391, 33rd AIAA Applied Aerodynamics Conference, Dallas, TX, June 2015.
4. Kamali, S., Ahrabi, B.R., Webster, R.S., and Sreenivas, K., "Numerical Simulation of Compressible Flow in a Diffusing S-duct with and without Vortex Generators," AIAA Paper 2015-2715, 33rd AIAA Applied Aerodynamics Conference, Dallas, TX, June 2015Karman, S. L., "AdaptiveOptimization-Based Smoothing for Tetrahedral Meshes," AIAA-2015-2038, SciTech 2015, Kissimmee, FL, January 2015.
5. Webster, R. S., Sreenivas, K., and Hilbert, C. B., "Computational Simulation of the Fan and Low-pressure Compressor Stages of the Energy Efficient Engine," *AIAA-2015-1344*, 53rd AIAA Aerospace Sciences Meeting, AIAA SciTech Forum 2015, 5-9 January, 2015, Kissimmee, Florida.
6. Sreenivas, K., Mittal, A., Hereth, L., and Taylor, L.K., "Computational Simulation of the Interaction Between Tandem Wind Turbines with Offset," *AIAA Paper 2015-0224*, 33rd Wind Energy Symposium, AIAA SciTech 2015.
7. Mittal, A., Briley, W.R., Taylor, L.K., and Sreenivas, K., "A Parabolic Method without Pressure Approximations for Wind Turbines," *AIAA Paper 2015-0728*, 33rd Wind Energy Symposium, AIAA SciTech 2015.
8. Mittal, A., Sreenivas, K., Taylor, L.K., and Hereth, L., "Improvements to the Actuator Line Modeling for Wind Turbines,"*AIAA Paper 2015-0216*, 33rd Wind Energy Symposium, AIAA SciTech 2015.
9. L. Wang, W.K. Anderson, L. Taylor and S. Kapadia, Multiscale Large Eddy Simulation of Turbulence Using High-Order Finite Element Methods, AIAA 2014-3211, 7th AIAA Theoretical Fluid Mechanics Conference, Atlanta, GA, 2014.
10. Liu, C., Newman III, J.C., and Anderson, W.K., "Three-Dimensional Dynamic Overset Method for Stabilized Finite Elements," *Proceedings of the 22nd Computational Fluid Dynamics Conference*, AIAA Paper 2015-3423, Dallas, TX, June 2015.
11. Ahrabi, B.R., Anderson, W.K., and Newman III, J.C., " An Adjoint-Based *hp*-Adaptive Petrov-Galerkin Method with Hierarchical Basis for Turbulent Flows," *Proceedings of the 22nd Computational Fluid Dynamics Conference*, AIAA Paper 2015-2603, Dallas, TX, June 2015.
12. Newman III, J.C., and Anderson, W.K., "Investigation of Unstructured Higher-Order Methods for Unsteady Flow and Moving Domains (Invited)," *Proceedings*

of the 22nd Computational Fluid Dynamics Conference, AIAA Paper 2015-2917, Dallas, TX, June 2015.

13. Liu, C., Newman III, J.C., and Anderson, W.K., "Three-Dimensional Overset Method for Stabilized Finite Elements with Dynamic Hole Cutting," Accepted for publication, *Proceedings of the 54th AIAA Aerospace Sciences Meeting*, San Diego, CA, January 2016.

Archival Journal Publications:

- Liu, C., Newman III, J.C., and Anderson, W.K., "Petrov-Galerkin Overset Grid Scheme for the Navier-Stokes Equations with Moving Domains,"*AIAA Journal*, accepted for publication (doi: http://arc.aiaa.org/doi/abs/10.2514/1.J053925).
- Anderson, W.K., Ahrabi, B.R., and Newman III, J.C., "Finite-Element Solutions for Turbulent Flow over the NACA 0012 Airfoil," *AIAA Journal,* accepted for publication.
- Ahrabi, B.R., Anderson, W.K., and Newman III, J.C., "High-Order Finite-Element Method and Dynamic Adaptation in Laminar and Turbulent Flows," under review *Journal of Computational Physics*.
- Li Wang, W.K. Anderson and T. Erwin, High-order Discontinuous Galerkin Method for Computation of Turbulent Flows, AIAA Journal, Vol. 53, No. 5, pp. 1159-1171, 2015.
- Li Wang, W.K. Anderson, T. Erwin and S. Kapadia, Discontinuous Galerkin and Petrov Galerkin Methods for Compressible Viscous Flows, Computers and Fluids, Vol. 100, pg. 13-29, 2014.

Presentations at Conferences and Workshops:

- Liu, C., Newman III, J.C., and Anderson, W.K., "Three-Dimensional Dynamic Overset Method for Stabilized Finite Elements," *Proceedings of the 22nd Computational Fluid Dynamics Conference*, Dallas, TX, June 2015.
- Ahrabi, B.R., Anderson, W.K., and Newman III, J.C., " An Adjoint-Based *hp*-Adaptive Petrov-Galerkin Method with Hierarchical Basis for Turbulent Flows," *Proceedings of the 22nd Computational Fluid Dynamics Conference*, Dallas, TX, June 2015.
- L. Wang, Multiscale Large Eddy Simulation of Turbulence Using High-Order Finite Element Methods, 7th AIAA Theoretical Fluid Mechanics Conference, Atlanta, GA, 2014.
- L. Wang, Towards Accurate and Efficient Simulation and Design Using High-Order CFD Methods, Invited talks, Modern Techniques for Aerodynamic Analysis and Design, Tsinghua University, Beijing, China, 2014.

Conclusion

Throughout its first decade of service, CEACSE has contributed greatly to the enhancement and expansion of significant and innovative research in computational simulation and applied computational science and engineering. By being responsive to changes in these fields of study, the needs and interests of partner agencies and societal realities, the Center has accomplished much in the past year despite changes in faculty and personnel.

Computational simulation is critically important for the analysis and design of future high technology products and systems in a competitive global marketplace. The future security and economic well being of our country will depend in part on an adequate supply of scientists and engineers who are highly skilled in the use of computers to solve important engineering problems using modeling and simulation.

This evolution has already transformed the use of high technology by introducing computational simulation and design software that supplements experiments and testing to produce competitive advantages in critical areas such as price, time-to-market, life-cycle costs, and overhead. CEACSE is honored to continue to play a role in that transformation.

In view of the extensive use of computational methodologies in design by industry, there is a significant role for innovative programs such as CEACSE which feature integrated research and graduate education (i.e., graduate research in an applications environment) that is distinct from traditional university research activity.

Science education in the U.S. has not responded adequately to the challenge of providing graduates who are adequately prepared to meet the demands of a changing future in response to market demands and advances in technology. The use of computers to solve complex, large-scale, practical problems is a trend that will only accelerate in years to

come. Through its work with the recruitment and of outstanding graduate students, the Center is working to address the increased need for computational scientists.

Through THEC's support, CEACSE's work effectively recognizes that these prospects offer a dramatic window of opportunity to provide the leadership in computational applications driven research and education needed for future competitiveness in the high-technology sector of the global economy.

Research funding through the Center for a number of diverse projects has engaged additional faculty and students across the campus during the report year. The committed seed funding enabled various faculty to pursue their research and develop opportunities to obtain follow-on support externally. There is increased level of external funding being sought from the activities of the Center. This focus will continue and expand.

With current external economic conditions and funding levels for research, there is increased competitiveness for the available funding. The SimCenter will refocus efforts to remain competitive and a highly viable competitor in securing available and sustainable funding.

Through the seed funding for research activities, undergraduate and graduate students are being engaged in a diverse range of topics. Additional efforts in this area assist in increasing the interaction and involvement of students with research faculty. Strengthened efforts will need to be defined, focused, and initiated to enhance/increase outreach to pre-college students and their teachers. This area will receive renewed and continued attention.

In conclusion, the role of engineering and science in Tennessee and the United States is paramount to the economic and social betterment of our State and the nation. The need to maintain and improve advancement through applied research is increasingly apparent. CEACSE is emphasizing and supporting the leveraging of its funding to enhance

Tennessee's stature in engineering, science, and education in the arena of computational science and engineering. The Center's efforts and initiatives in turn contribute to the ongoing economic and societal development of the Chattanooga region and all of Tennessee.

The University of Tennessee at Chattanooga and its students, faculty, and staff who are a part of the work of CEACSE believe that the future work of the Center will continue to positively impact, enhance, and accelerate the growth and advancement of Tennessee's scientific and engineering capabilities and resources.

Schedule 7

CENTERS OF EXCELLENCE ACTUAL, PROPOSED, AND REQUESTED BUDGET

Institution:	UTC	Center:	Center of Excellence in Applied Computational Science & Engineering

	FY 2014-15 Actual			FY 2015-16 Proposed			FY 2016-17 Requested		
	Matching	Appropr.	Total	Matching	Appropr.	Total	Matching	Appropr.	Total
Expenditures									
Salaries									
Faculty	$216,080	$419,448	**$635,528**	$280,000	$520,000	**$800,000**	$204,000	$396,000	**$600,000**
Other Professional	$48,925	$94,973	**$143,898**	$35,000	$65,000	**$100,000**	$34,000	$66,000	**$100,000**
Clerical/ Supporting	$1,671	$3,243	**$4,914**		$0	**$0**	$0	$0	**$0**
Assistantships	$31,710	$61,555	**$93,266**	$70,000	$130,000	**$200,000**	$34,000	$66,000	**$100,000**
Total Salaries	**$298,386**	**$579,220**	**$877,606**	**$385,000**	**$715,000**	**$1,100,000**	**$272,000**	**$528,000**	**$800,000**
Longevity (Exclude from Salaries and include in Benefits)	$1,504	$2,919	**$4,423**	$2,100	$3,900	**$6,000**	$2,100	$3,900	**$6,000**
Fringe Benefits	$79,932	$155,161	**$235,093**	$98,000	$182,000	**$280,000**	$98,000	$182,000	**$280,000**
Total Personnel	**$379,822**	**$737,300**	**$1,117,121**	**$485,100**	**$900,900**	**$1,386,000**	**$372,100**	**$713,900**	**$1,086,000**
Non-Personnel									
Travel	$6,627	$12,865	**$19,492**	$7,000	$13,000	**$20,000**	$6,800	$13,200	**$20,000**
Software	$239	$464	**$703**	$5,250	$9,750	**$15,000**	$5,100	$9,900	**$15,000**
Books & Journals	$0	$0	**$0**	$0	$0	**$0**	$0	$0	**$0**
Other Supplies	$4,527	$8,788	**$13,315**	$7,000	$13,000	**$20,000**	$6,800	$13,200	**$20,000**
Equipment	$3,737	$7,254	**$10,991**	$3,500	$8,173	**$11,673**	$3,400	$8,357	**$11,757**
Maintenance	$0	$0	**$0**	$17,500	$32,500	**$50,000**	$13,260	$25,740	**$39,000**
Scholarships	$14,976	$29,070	**$44,046**	$0	$0	**$0**	$0	$0	**$0**
Consultants	$0	$0	**$0**	$0	$0	**$0**	$0	$0	**$0**
Renovation	$0	$0	**$0**	$0	$0	**$0**	$0	$0	**$0**
Other (Specify):	$0	$0	**$0**	$0	$0	**$0**	$0	$0	**$0**
Communications	$46	$89	**$134**	$1,750	$3,250	**$5,000**	$1,700	$3,300	**$5,000**
Print	$298	$578	**$875**	$350	$650	**$1,000**	$340	$660	**$1,000**
Freight	$52	$101	**$153**	$373	$694	**$1,067**	$325	$631	**$956**
Other Personal Services	$306	$594	**$900**	$700	$1,300	**$2,000**	$680	$1,320	**$2,000**
Cost Share Deficit	-$9,384	-$18,215	**-$27,599**	$0	$0	**$0**	$0	$0	**$0**
			$0			**$0**			**$0**
Total Non-Personnel	**$21,423**	**$41,586**	**$63,010**	**$43,423**	**$82,317**	**$125,740**	**$38,405**	**$76,308**	**$114,713**
GRAND TOTAL	**$401,245**	**$778,886**	**$1,180,131**	**$528,523**	**$983,217**	**$1,511,740**	**$410,505**	**$790,208**	**$1,200,713**
Revenue									
New State Appropriation		$773,015	**$773,015**		$757,250	**$757,250**		$795,113	**$795,113**
Carryover State Appropriation		$218,806	**$218,806**		$212,935	**$212,935**			**$0**
New Matching Funds	$405,600		**$405,600**	$405,600		**$405,600**	$405,600		**$405,600**
Carryover from Previous Matching Funds	$131,600		**$131,600**	$135,955		**$135,955**			**$0**
Total Revenue	**$537,200**	**$991,821**	**$1,529,021**	**$541,555**	**$970,185**	**$1,511,740**	**$405,600**	**$795,113**	**$1,200,713**
NET	**$135,955**	**$212,935**							