THE UNIVERSITY of TENNESSEE at CHATTANOOGA

SIMCENTER

NATIONAL CENTER for COMPUTATIONAL ENGINEERING

Strategic Plan

for the

Graduate School of Computational Engineering

and

SimCenter: National Center for Computational Engineering

June 2014

Not for Distribution Outside SimCenter

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1. Executive Summary

The Computational Engineering (ENCM) department and the SimCenter are integrated academic entities that operate as a single organization with a unified strategic plan. The department operates its M.S. and Ph.D. degree programs, and the SimCenter operates the research program. During the past two years, the ENCM/SimCenter organization has been developing and implementing the integrated Strategic Plan described in this document. This executive summary gives a broad outline of the plan, which is discussed in detail here.

Mission Statement

The mission of the ENCM/SimCenter has continued with only minor modifications since its inception in 2002. It combines a unique interdisciplinary graduate degree program and integrated research program whose goal is application-focused research and education in computational engineering that will advance engineering through the use of physics-based computational modeling and simulation. Key elements for success are its integrated interdisciplinary curriculum and team-oriented research and education environment.

Background

During its first five years, the M.S. program, Ph.D. program, UTC's SACS substantive change to a PhD-granting institution, and the THEC Center of Excellence in Applied Computational Science and Engineering at UTC were all approved. The education and research programs became well established. The SimCenter rebuilt its external funding base and was fully funded by 2006 when its Lupton start-up funding was expended. Since coming to UTC, the SimCenter has secured a total of $37M in external research funding, exclusive of any recent foundation funding. US Xpress acknowledged SimCenter support in improving fuel economy when they received the 2009 EPA Environmental Excellence Award.

An ambitious SimCenter expansion effort was begun in 2009 with sponsorship by a group of Chattanooga Foundations. SimCenter Enterprises (SCE) was founded to pursue sponsored relationships with businesses and industry. The expansion goals were pursued energetically by all involved at SCE and the SimCenter. Although there have been some notable successes, the shared vision and coordination/overlap between the two entities did not materialize as originally planned. Overall, efforts by the SimCenter and SCE to secure increased external funding through research contracts and commercialization proved very difficult.

Looking back, the timing for the expansion effort seems unfortunate in that it began at the start of the 2009 U.S. financial crisis and economic downturn, which has endured much longer than expected. The SimCenter effort to grow academically and leverage itself commercially began at a time when it became very difficult to sustain even its historical funding levels. Despite recent difficulties, the ENCM//SimCenter academic and research program is very strong and remains well-positioned to address future US needs in computational engineering research and education. However, there is a critical short-term need to increase external funding to sustainable levels while maintaining quality and critical mass.

Current and Projected Future Environments

The short-term external funding environment is dominated by the two year Federal budget that included a 15% reduction in the DoD budget, which will likely lead to reduced funding of unknown levels for many research organizations that fund research in SimCenter related areas. Other federal budget reductions will potentially affect funding available from industry and certain philanthropic foundations.

Industry and government are increasingly purchasing commercial CFD software as a commodity purchased at lowest cost and often without state-of-the-art capabilities and physical fidelity. The SimCenter cannot and should not compete pricewise in this commercial market. It has a broader higher-education mission to educate students who can develop, use and extend commercial and proprietary

software, provide informed analysis of application results, and push the state-of-the-art in computational engineering. These are areas in which ENCM/SimCenter excels by virtue of interdisciplinary teamwork focused on multiple application areas of strategic importance.

The outlook is good for our ability to continue to attract well-qualified students for our interdisciplinary STEM focus, and our graduates are highly competitive and in demand.

Computing technology evolves with regard to hardware architecture and programming environments, and SimCenter faculty must be aware of and plan for any paradigm shifts that would require time-consuming and costly reprogramming of its continuously evolving software systems. The current SimCenter software architecture appears well positioned to adapt to hardware/programming trends without major disruption.

SWOT Analysis

Strengths

- The M.S. and Ph.D. programs are very strong and nationally recognized. The focus on practical problems, interdisciplinary curriculum, teamwork, and departmental organization are unique and considered by some as a model of best practice in this discipline. Graduates have been very successful in a competitive job market, and feedback from graduates and employers has been very positive.
- The collective knowledge of faculty and quality of simulation software capabilities is regarded as world class in the programs area of specialization.
- The strong faculty and student interest in using simulation to apply high-fidelity simulations to practical engineering problems of interest to industry is somewhat unusual in universities.

Weaknesses

- The marketing capabilities of current faculty are not on a par with their research and education ability.
- At present, computational engineering is a graduate-level multidiscipline, and there are no undergraduate programs in this specialty in the U.S. This makes it more difficult for the program to have curriculum impact on undergraduate programs in its component disciplines.
- Although the faculty has simulation capabilities and experience in helping small and mid-size companies solve important engineering problems, historically only large companies have been able to afford these advanced simulations. The trend of commercial software toward commodity status makes this an unattractive market except in special circumstance.

Opportunities

- A strong and synergistic partnership with ORNL is slowly being realized.
- The SimCenter is well positioned to transition its physics-based simulation capabilities into new applications areas to broaden its external funding markets.
- There is a possibility of establishing a drag-reduction center sponsored by the trucking industry to serve as a neutral evaluator of new devises in securing government approvals.
- There is a possibility of establishing an undergraduate engineering concentration related to computational engineering.

Threats

- By far the most significant threat is the need for consistent and sustainable external funding.
- The need for permanent in-place leadership at the SimCenter is an impediment to planning and sustainable external funding.

- Although the UTC program remains unique, similar academic programs are being established in many research-oriented universities, which increases competition for external funding.
- UTC does not have an executive-level research position to oversee and promote UTC research and to provide a voice at System-wide discussions pertaining to research.

Short Term Objectives, Strategies, and Tactics

- Achieve self-sufficiency by increasing external funding to $1.5M per year by the end of FY16.
- Increase the Ph.D. graduation rate to an average of 3 per year by the end of the 2015-2016 academic year.
- Strengthen national presence by establishing a strong relationship with ORNL, other national laboratories, and industry over the next two years.

Long Term Objectives, Strategies, and Tactics

- Enhance the reputation and visibility of the SimCenter and ENCM program.
- Develop closer ties with faculty in other departments within the College of Engineering and Computer Science.
- Enhance and expand relations with government agencies and businesses of all sizes.

Anticipated Benefits

The benefits of each objective are discussed in detail.

Budget Considerations

Budget needs are projected for Students and Research Faculty, the two groups most vulnerable to shortfalls in non-recurring funds. The total amount needed to sustain these two groups is approximately $1.69M, with the possibility of less if $500K promised by Dr. Milhorn is received.

Implementation Plan

The implementation plan is presented as a Gannt chart with timelines and responsible indivicuals.

2. Mission Statement

The mission of the SimCenter: National Center for Computational Engineering is to ***advance and improve engineering through the use of physics-based computational simulation.***

SimCenter: National Center for Computational Engineering (in conjunction with the Graduate School of Computational Engineering) will accomplish its mission through:

- Education of a new breed of interdisciplinary computational engineer who can solve a broad range of real-world engineering problems
- Integrated research that establishes the next-generation technologies in computational modeling, simulation and design,
- Leadership that produces a national impact in critical technology areas affecting defense, sustainable energy, environment, and health.

SimCenter: National Center for Computational Engineering philosophy is:

- To educate our students so that they can be effective in changing the practice of engineering through the use of physics-based computational simulation
- To accomplish our research with superior quality results at reasonable costs.

SimCenter: National Center for Computational Engineering business plan is to market our capabilities:

- In research and development of advanced physics-based simulation methodologies
- In advanced engineering services that utilize computational simulation as part of the engineering design / analysis cycle
- In the education of engineers trained to solve a broad range of engineering problems using computational simulation as a transformational tool

Our market includes local, regional, and national industry, organizations, and government agencies (AF, Navy, Army, DARPA, DoE, NASA, et al.)

3. Background

UTC Computational Engineering (CmE) and SimCenter: Original Shared Vision - The purpose at UTC was to establish an interdisciplinary M.S./Ph.D. program and SimCenter as an integrated organization that would be of transformational value to UTC and its mission as a metropolitan university. Specific objectives were to

- Create a high-quality and unique educational environment, based on past experience gained by its faculty at the NSF/Engineering Research Center (ERC) for Computational Field Simulation during its full eleven-year funding cycle ending in 2002
- Help UTC secure SACS (Southern Association for Colleges and Schools) approval for a substantive change in status to a Ph.D.-granting university
- Provide a local foundation of research, education, and highly skilled graduates required for Chattanooga to attract, expand, and nurture high-technology businesses.

The uniqueness and high-quality educational environment would derive from

- Interdisciplinary teamwork among faculty and students on computational solution of complex practical engineering analysis and design problems, using advanced software developed by the program.
- Organization of the M.S./Ph.D. program and SimCenter as a single, integrated academic unit in a dedicated research, education and computing facility

A collateral objective was service to Chattanooga's metropolitan region by engagement with business and industry to help focus research and education activities on local needs and to make computational engineering technology available to these businesses.

Start-Up and Progress in Meeting Original Objectives

(2002-2006) - The education and research programs became well established during its first five years. The M.S. program, Ph.D. program, and SACS substantive change were all approved by 2004. The program achieved national recognition and has generated strong interest from both U.S. and international students since its inception. There has been an abundance of highly qualified applicants, although a shortage of student funding. There has been strong demand for CmE graduates, good graduate outcomes, and very positive feedback on educational preparation. In some cases, companies have hired students before completing their degrees.

The SimCenter began at UTC without benefit of the software it had developed over many years, and it spent the first year or two developing advanced software (Tenasi), now declared as IP owned by the UT System. In 2005, the SimCenter helped establish the THEC Center of Excellence in Applied Computational Science and Engineering at UTC, which has been of vital importance to the SimCenter by providing seed funding for students and faculty for projects in new disciplines and that help secure external research funding. Congressional support for research also enabled growth into new disciplines, especially electromagnetics and fuel cells, and has allowed the SimCenter to help local and regional businesses benefit from SimCenter problem-solving technologies. The SimCenter was designated a TOP500 computing site, with world rankings of 90^{th} (2005) and 128^{th} (2006).

Although there was a gap in its traditional research sponsorship during the initial education and software startup period, the SimCenter had rebuilt its external funding base and was fully funded by 2006 when its Lupton start-up funding was expended. Since coming to UTC, the SimCenter has secured a total of $37M in external research funding, exclusive of any recent foundation funding.

(2006-2007) - The SimCenter engaged a number of local companies to assist them with its computational engineering expertise. Although these efforts were technically successful, they were unsponsored projects that did not generate external revenues. US Xpress acknowledged SimCenter

support when they received the 2009 EPA Environmental Excellence Award. The SimCenter began to diversify its research into new disciplines, especially electromagnetics and fuel cells.

(2008-2009) – A major SimCenter expansion effort was organized with sponsorship by a group of Chattanooga Foundations. Ambitious new goals and a new path were set for academic growth and diversification, coupled with commercialization initiative to generate sustainable income sources for the SimCenter by monetizing its technology and expertise. The University of Tennessee designated the SimCenter a National Center for Computational Engineering.

(2010) - SimCenter Enterprises (SCE) was founded to pursue sponsored relationships with businesses and industry that would utilize SimCenter technology through analytical services and software licenses. An IBM/SimCenter Alliance Agreement was signed giving the SimCenter advanced-technology computers and sponsoring collaboration with researchers at IBM-Watson Research Center.

Recent Progress and Challenges (2010-Present)

The goals of the expansion effort have been pursued energetically by all involved in the effort, both at SCE and the SimCenter. Although there have been some notable successes, the shared vision and coordination/overlap between the two entities did not materialize as originally planned. Overall, efforts by the SimCenter and SCE to secure increased external funding through research contracts and commercialization have proven very difficult.

- Looking back, the timing for the expansion effort seems unfortunate in that it began at the start of the 2009 U.S. financial crisis and economic downturn, which has endured much longer than expected. The SimCenter effort to grow academically and leverage itself commercially began at a time when it became very difficult to sustain even its historical funding levels.
- Planning for leadership transition and succession led to a national search in late 2012 for a new SimCenter director. The search was led by UT/ORNL (Oak Ridge National Laboratory) in an effort to strengthen this relationship. A well-qualified and supported candidate for SimCenter director was found, but employment negotiations ultimately were not successful.
- At present, the CmE department head is also serving as interim SimCenter director. Two of the three retirement-age faculty have retired emeritus, and this is helping to facilitate the transition to new leadership.
- An MOU between the SimCenter and the National Center for Computational Science (NICS, part of UT's Joint Institute of Computational Science – JICS) was signed in 2013 to facilitate joint use of SimCenter software and NICS computer facilities.
- Progress is being made in current efforts to establish a strategic relationship between the SimCenter and ORNL, using joint faculty and staff appointments.
- There are indications that the climate for external funding in SimCenter areas of expertise is slowly improving.

Despite recent difficulties, the CmE/SimCenter academic and research program is very strong and remains well-positioned to address future US needs in computational engineering research and education. However, the program needs to increase its external funding to maintain its quality and critical mass. SimCenter plans and efforts to secure sustainable funding levels are discussed in Section 6 of this report.

4. Current and Projected Future Environment for Academics, Computing, and Sponsored Research

Congressional and Political Considerations

The short-term external funding environment the SimCenter and the CmE program faces today is dominated by the bipartisan two year Federal budget recently passed by Congress. In that budget, Congress significantly weakened the sequestration effect on federal funding agencies, but unfortunately, also included a 15% reduction in the DoD budget. This will likely lead to funding reductions of unknown levels influenced by DoD priorities and will include all the research organizations (AFOSR, ARO, DARPA, EPA, NAVO, NIH, and NASA) that could affect the SimCenter's ability to secure research funding through these agencies. Also, budget reductions in the federal government will indirectly have a potentially negative impact on funding from industry, and certain philanthropic foundations.

Commercial Software

The SimCenter will also need to confront the widespread adoption of commercial computational fluid dynamics (CFD) software by industry and government organizations who in many instances consider CFD software a commodity which can be purchased on the basis of lowest cost with less than adequate appreciation for quality. Commercial software providers are also beginning to package their software with computing hardware by migrating to the cloud, thus allowing on-demand access to computing power to execute the software. The SimCenter cannot compete pricewise with commercial operations whose mission is to sell their software as a service. The SimCenter and the CmE program has a broader higher-education mission to educate students who are not only familiar with commercial software but who can also extend the usefulness of this software, provide informed analysis of the results produced, become developers of commercial and proprietary software, and push the state-of- the-art (SOA) in CmE. To do this, the SimCenter is at the leading edge both in educating such students and in some critical application areas and, fortunately, possesses faculty and staff who themselves have leading-edge physics-based simulation development skills. To meet its mission, CmE/SimCenter faculty and staff need to stay aware of the SOA and be engaged in all application areas deemed to be of strategic importance. Obviously this requires keeping abreast of journal literature, conference proceedings and to stay in contact with program mangers in all the agencies mentioned above and to be aware of the their program priorities.

Both the items discussed above (reduction in the Federal budget and competition from low cost CFD software) are concerns to the SimCenter/CmE and its mission because of the potential negative impact on the SimCenter's ability to win grants and contracts because of the shrinking pool of available funding.

Student Recruiting

Fortunately, prospects for recruiting well qualified students into the computational engineering graduate program appear relatively bright. Since the CmE program was first established at Mississippi State University in 1990, and after moving to Chattanooga in 2002, recruiting a sufficient number of well qualified students interested in pursuing advanced degrees in physics-based computational simulation has never posed a significant problem, despite there being non-trivial fluctuations in overall interest by high school seniors in STEM fields (science, technology, engineering, and mathematics). This could be the result of CmE being a "niche" discipline that seems to attract students with interests in all STEM fields, but especially in engineering and scientific computing. It is well known that the number of students who begin their college career in a STEM field drops significantly as they progress through a particular STEM-related program. However, observations suggest that students who have been exposed to scientific computing during their undergraduate studies tend to also have been exposed to some form of simulation. A good portion of these students recognize the potential power and value that simulation can have in a design environment, especially in the engineering disciplines, and are motivated to seek graduate programs that fit their desired career path. Since 2004 many government and state agencies

have placed significant emphasis on attracting students into STEM-related fields, which seems to be slowly increasing the number and diversity of students pursuing one of these areas as a career discipline. Thus, it is fully expected that the success in attracting well qualified students into the CmE program that has occurred over the past 10+ years will continue and even improve going forward.

Computing Technology

Perhaps one of the most influential technology innovations in computer architecture to occur in the past several years is the use of so-called GPU's (graphics processing units) in "main-stream" high performance computing (e.g., ORNL's Titan supercomputer). GPU's (manufactured by NVIDIA and AMD) or accelerators (manufactured by Intel, referred to as Xeon Phi) in general are used for speeding up a code's execution. However, the future direction of this technology seems to be in the integration of the GPU with the CPU (central processing unit) onto the same die. This will eliminate the need to move data between memory of the GPU and CPU, which accomplishing inefficiently can effectively negate any speed-up advantages gained by using the accelerator.

For the SimCenter to use accelerators right now, faculty and staff writing code would need to use a combination of open source software used to enable parallel execution (e.g., OpenMP or OpenACC) with so-called "message passing interface" (MPI), or use a parallel computing programming language like OpenCL. The OpenMP/OpenACC option is preferable as it can be used on clusters that have GPU's as well as those that don't (i.e., no accelerators) and no fundamental changes in programming language would be required (except perhaps for minor syntax changes). The disadvantage of using OpenCL is that it is actually more of a programming framework and would necesitate many changes to legacy codes as it uses a low level "language." In addition, large-scale adoption of OpenCL would probably necessitate incorporating OpenCL-related instruction into the existing parallel computing courses. Although taking this path could turn out to be necessary, faculty would need to acquire the knowledge and background to teach the material, which could be a nontrivial cost to the program.

Looking to the future, if the hardware manufacturers keep pace with current trends and place both processing units on the same die, the resulting programming environment would be essentially the same that exists today. The combination of OpenMP/OpenACC with MPI should serve the SimCenter/CmE programming environment well into the future.

5. SWOT Analysis

The graduate program in computational engineering at UTC is fundamentally anchored in its academics; that is, in the Graduate School of Computational Engineering (CmE). As such, the fundamental business of the CmE program is to educate and graduate students within this discipline. There are two related but distinct aspects of graduate education, i.e., coursework and research. However, it is the in-house interdisciplinary integration of these activities that greatly boosts the effectiveness of the CmE program's outcomes. It is noted that the academic portion of the CmE Program is housed in the Graduate School of Computational Engineering, whereas the research is focused in the SimCenter.

This section presents an objective assessment of the CmE Program's business of integrated research and education by examining its perceived strengths, weaknesses, opportunities, and threats (SWOT).

Strengths

- The graduate program for M.S. and Ph.D. students seeking degrees in Computational Engineering is considered by some as a model of how such programs should function. The mix and quality of tenured and research faculty (and research staff) who direct students' research and mentor their progress provides a comprehensive, team education in the discipline. The number of students in this niche but vital program and the rate of graduation are limited only by the available resources. The demand for graduates and feedback from industry and government as to students' ability to have an immediate positive impact speaks to the quality of the program.
- The quality of the simulation computer programs developed and being developed at the SimCenter are without parallel. The assembled knowledge of the faculty and staff in algorithm development, flow solvers, fluid mechanics, electro-magnet fields, structures and solid mechanics, grid generation, and engineering applications has resulted in a world class capability for utilizing these computer programs to perform high fidelity physics based simulations.
- The ability and desire of the professors, researchers, and students participating in the CmE graduate program to apply high fidelity simulation to real-world industrial problems is outstanding. While larger corporations have leveraged the use of physics-based simulation to improve their products for quite some time, it is unusual for university faculty to have interest in performing applications-driven research in support of smaller enterprises; yet the number of these entities whose bottom lines have been positively affected by CmE faculty and staff is significant. For many mid-size and smaller companies the use of simulation is new. The SimCenter has been able to engage with people at these smaller companies, understand their problems and needs, demonstrate how simulation can be useful, and often provide a viable solution.

Weaknesses

- The marketing and sale of SimCenter capabilities by SimCenter personnel is not on par with their research and education ability. The traditional sources of research funding by federal government have been greatly reduced due to current economic conditions. Although substantial efforts have been made to develop new networks and industrial sources of funding, they have been slow in developing.
- The SimCenter has heard that there is a perception that SimCenter simulation capabilities are limited to fluid flow (i.e., computational fluid dynamics, CFD), and this perception, in-turn, limits the areas in which it is considered as a viable contributor. The long-term success of the SimCenter and the CmE program in solving fluid flow problems has probably contributed to this perception. A large sector of industry considers CFD a maturing technology that can be

purchased commercially on the basis of lowest cost and unfortunately without adequate appreciation for quality and simulation fidelity. The SimCenter actually has excellent simulation and simulation-related capabilities in other areas such as electro-magnetic fields, grid generation, and structures but these are more recent and less well known.

- There has been a reluctance of CmE faculty (and its leadership) to stray from the original vision and mission of the CmE Program, which focuses exclusively on graduate education. Although the SimCenter has continuously utilized undergraduate students in its research, this occurs more-or-less on an opportunistic basis and there has never been a concerted effort to expand the vision and mission to formally include undergraduate education. Although there are nontrivial academic/curriculum reasons for this, this reluctance to change has been viewed negatively by some outside constituents and therefore can be considered to be a weakness of the Program.

Opportunities

- **ORNL –** A strong and synergistic partnership with Oak Ridge National Laboratory (ORNL) is slowly being realized. A permanent association with ORNL should put the SimCenter in a better position to compete for and win government grants, as many of these grants require a teaming of university, government, and industry. Working with ORNL will also allow the SimCenter to gain capability and credibility is areas of energy generation, storage, and distribution.
- **Trucking** – Establishment of a drag reduction center for the trucking industry is not being actively pursued at this time, but is a possibility. The SimCenter has had a long association with the trucking industry and has become known as a place that can provide simulations to determine if various add-on devices or configurations can reduce fleet fuel consumption by reducing overall drag. Thus far these simulations have been done on a company-by-company basis. It has been suggested that the trucking industry fund the SimCenter to be the final arbitrators as to the effectiveness of any proposed devises and tractor / trailer configuration.
- **New Application Areas** – Expansion of SimCenter physics-based simulation capabilities into new areas has been successful in the past; e.g., development of capabilities in incompressible fluid flow led to a very successful, long-term relationship with the Office of Naval Research (ONR) for providing simulations of many types of warship-related marine vehicles. However, because many of the skills needed to develop and execute physics-based simulation software can also be applied to other, non-traditional areas of research and applications, CmE faculty should explore these areas at least to the point that a reasonable assertion can be made as to a particular area's applicability to the CmE research and education program, and to its potential to attract external funding.
- **Undergraduate Education** – Exploration of ways in which the education and experience of CmE faculty can be efficiently exploited to enhance and expand teaching the undergraduate engineering course curriculum in areas that are in need and match available skills. One possibility that has been suggested is to establish a computationally oriented undergraduate concentration in aerospace / aeronautical engineering under the existing umbrella of the Bachelor of Science in Engineering degree. However, even though several CmE faculty have aerospace / aeronautical academic backgrounds, there are several obstacles that would have to be overcome to make this a viable approach; e.g., adequate laboratory space and equipment.

Threats

- By far the most significant threat to the SimCenter's existence is lack of consistent (i.e., sustainable) funding to maintain and/or grow the current research and education program. Reliance on grants and contracts, the UT System, various philanthropic foundations, and donations from individual has sustained the operation of the center's research and education program from its inception. While attempts have been made to further develop funding sources from commercialization of SimCenter research and industry contracts, these have met with limited success and have not sufficiently reduced the reliance on traditional funding sources. If sufficient funding is not found the number of faculty and staff will necessarily be reduced. The loss of key personnel will have a detrimental effect on the graduate program, the research it conducts, the breadth and depth of its simulation capabilities, and the ability to obtain outside funding.
- The lack of permanent, in place, leadership continues to stress the SimCenter. Interim leadership has taken charge and forged ahead, but the uncertainty as to the long-term future of the SimCenter and what changes new leadership will bring has resulted in wariness of the staff and students. Uncertainty also affects the ability to obtain funding as the future of principle researchers is unknown.
- Over the past several years a number of similar academic programs have been established at other institutions, both in this country and around the world. Although a recent analysis showed that UTC's CmE program is unique in several ways (e.g., CmE faculty are housed and tenured in a single department), the emergence of competing programs, some at highly-ranked universities, represents a threat in terms of student recruitment and in faculty competing for external funding in areas common to physics-based computational simulation.
- Most research-oriented universities have an executive-level position that functions as the overseer and promoter of university-wide research, usually referred to as a "vice president," or "vice chancellor" of research. In the current environment, the University of Tennessee System has a Vice President for Research who oversees research on all campuses. In addition, with the exception of UTC and UTM, both UTK and UTHSC have their own Vice Chancellor for Research (VCR) who report directly to that campus' Chancellor. UTC not having this type of position since the SimCenter was established in 2002 has likely hindered progress, at least to some degree, because it has not had a voice in System-wide discussions pertaining to the "business" of research. For UTC to continue without a VCR is likely detrimental to UTC's desire to move more toward a research-oriented university.

6. Objectives, Strategies, and Tactics – Short Term (1-2 years)

Because the current state of the SimCenter's and the CmE department's financial status, we believe it is important to consider both short term and long term objectives (1-2 years, and 3-5 years, respectively). Even though the present document is intended to address longer term, strategic issues, if some shorter-term issues are not addressed relatively soon, the longer term issues will become less important.

6.1. Short Term Objective #1: ***Achieve self-sufficiency by increasing grants and contracts expenditures to $1.5M per year by the end of FY16 (June 30, 2016).***

6.1.1. Strategies and Tactics to Achieve This Objective

- Strategy #1: *Use personal contacts to sell SimCenter research and analysis services.* Historically, much of CmE/SimCenter sponsored research has been funded by U.S. government agencies. As mentioned in a pervious section, these agencies have experienced severe cuts in their overall budgets over the past three to four years, which has caused a substantial decrease in funding outside these agencies, including fundamental research in universities. For various reasons, some ongoing relationships forged over many years of working closely with agency program managers have faded somewhat (e.g., retirements, promotions, changing interests, etc.). Despite the reduced budgets of these program managers, we believe it is important to explore reestablishing at least a few of these relationships to discover how recently developed SimCenter technology can serve their needs, in search of new / renewed funding opportunities.
  - Various CmE faculty and staff will visit the following Program Managers with the intent to establish (or re-establish) communication and to learn more about the Program Managers' needs and how SimCenter knowledge and expertise might be applied:
    - Ki-Han Kim, Office of Naval Research
    - Jack Benek, Air Force Research Laboratory
    - Peter Majumdar, US Marine Corps
    - Ron Joslyn, Office of Naval Research
    - Frederick Ferguson, Army Research Office
    - Dennis Huff / Mike Hathaway, NASA Glenn Research Center
    - Name TBD, NASA Langley Research Center
    - Name TBD, NASA Marshall Space Flight Center
- Strategy #2: *Demonstrate electromagnetic (EM) simulation capabilities to potential customers and learn about their problems*
  - CmE Faculty will visit the following individual who has expressed a desire to learn more about SimCenter EM simulation capabilities.
    - Richard Bott, Aurora Flight Sciences
- Strategy #3: *Propose to establish a center for evaluating drag reduction devices for large (Class 8) trucks.* As discussed in the above SWOT section, it has been suggested that government agencies such as the Department of Transportation or the Environmental Protection Agency (EPA), in conjunction with the trucking industry establish at the SimCenter an organization focused on being the "white hat" arbitrators of the effectiveness of any proposed drag reduction devises and tractor / trailer configurations
  - Use contacts in trucking industry to explore their receptiveness of establishing such a "center"[1]

[1] SimCenter personnel have recently held discussions with Yves Provencher of Performacne Innovation Transport (PIT), a non-profit company based in Quebec (Canada). This company is effectively performing testing and analysis on behalf of a consortium made up of over 50 trucking fleets across Canada (and two from the U.S.). The discussions are very preliminary but are focused on determining how the SimCenter's expertise in computational

- Identify contact in DoT and/or EPA to which proposal would be made
- Explore with colleagues at ORNL their interest in teaming to establish this center, perhaps as part of their desire for establishing a "virtual automobile" capability at ORNL.

- Strategy #4: *Set as a goal that <u>all</u> CmE faculty be either a principal investigator (PI) on at least one grant/contract proposal, or a co-PI (or co-investigator) on at least two grant/contract proposals in FY2015 and FY2016.*.
  - For many years the burden of "chasing money" was largely borne by a single individual in SC/CmE. This model is not sustainable, especially in the current leadership transition, and therefore more faculty need to be involved in the fund-raising process. SC/CmE faculty have long been recognized for their teamwork and for a team to be successful each individual has something unique to contribute for the benefit of the team. It is unrealistic to expect all faculty members who are outstanding technically to also be successful proposal writers and also be willing and passionate about engaging with sponsors, travel, etc. Therefore, this Strategy is meant to, over the next two fiscal years, engage as many SC/CmE faculty as practical in this process. Senior faculty will mentor junior faculty in proposal writing.
- Strategy #5: *Explore how the emerging discipline of Data Analytics ("big data") can fit into the SimCenter's research portfolio.*
  - Although the discipline of data analytics is usually not thought of as being within the realm of CmE and SimCenter faculty's core competencies in physics-based field simulation, there are technological areas within the two disciplines where skills and knowledge overlap, especially in computational mathematics and parallel computing, thus making the pursuit of funding from sponsors in need of data analytics services within the purview of CmE faculty. There are currently two SimCenter faculty working with an external consulting company to identify areas in which we can contribute, and also to identify potential funding opportunities with local businesses that need data analytics services.

6.2. <u>Short Term Objective #2</u>: ***Impact the Computational Engineering program by producing an average of 3 Ph.D. graduates per year by the end of the third THEC evaluation period which ends in the 2015-2016 academic year (in conjunction with the Graduate School of Computational Engineering)***

6.2.1. Strategies and Tactics to Achieve This Objective

- Strategy #1: *Ensure CmE faculty are aware of THEC requirement of 3 Ph.D. graduates per year (average per year over a five year period) and continually monitor student progress.*
  - Historically, the program has been more focused on the number of students enrolled and the quality of its graduates than it has on the number of graduates. This proposed action is intended to simply increase the faculty's awareness and place greater emphasis on the importance of graduation-rate requirements. The CmE graduate coordinator will also discuss students' progress with their major advisor on a regular basis (at least once per semester for each student) as a means to ensure faculty and students know about graduation requirements

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simulation can add value to PIT's use of physical testing for determining various products designed to make large Class 8 trucks more efficient, including aerodynamic drag reduction devices.

- Strategy #2: *Ensure student evaluation committee is screening student applicants to identify academically well qualified candidates who are also most likely to complete degree requirements*
    - Screening of applicants is perhaps the most important step in the admissions process. The CmE program coordinator and CmE department head will participate in the screening process alongside the evaluation committee to help focus on the importance of choosing the best academically-qualified students who are also the most likely to graduate[2]
- Strategy #3: *Set semi-hard requirement that Ph.D. students finish program requirements in four years (assuming they begin with a M.S. degree).*
    - We believe having this knowledge will incentivize and motivate students to complete degree requirements in the allotted four year time frame. The CmE program coordinator and students' major advisors will ensure students are well aware of this requirement, and that exceptions are granted on a case-by-case basis and as resources permit.
- Strategy #4: *Establish a timeline over which students must achieve specific milestones in order to remain in the doctoral program.*
    - Defining incremental objectives for students to achieve will (a) provide faculty a more quantitative measure of student progress, and (b) provide students short-term goals that taken collectively emphasize graduation as the completion of a sequence of well-defined steps. The CmE department head will work with faculty to define milestones and timeline, and a process to monitor students' progress will be established (e.g., finish course work in 6 semesters, pass preliminary exams at the beginning of the 8^{th} semester, complete, present, and have approved a dissertation proposal at beginning of 9^{th} semester, defend dissertation and graduate by end of 12^{th} semester).
- Strategy #5: *Explore positives and negatives, in terms of increased graduation rates, of restricting admission to the M.S. concentration in CmE (i.e., admit mostly Ph.D. students)*
    - This consideration is driven by the observation that the number of our M.S. graduates is largely decoupled from the assessment of the CmE doctoral program by the number of Ph.D. graduates.
    - Pro: Restricting the program to only Ph.D. students would tend to increase the number of graduates.
    - Pro: Funding required for M.S. students would be eliminated.

[2] Since the program's inception, a total of 67 doctoral students have been enrolled for at least 1 semester. To-date (April 2014), 17 have graduated, 28 are currently enrolled, and 22 have withdrawn from the program. Of these withdrawals, 18 were either job-related or academic in nature, and 4 lost interest in the program. The dominant reason for job-related withdrawals was that students were offered and accepted employment before they could finish their degree (two were part-time students who simply could not balance employment and academic requirements). The primary reason for the shortfall in meeting graduation benchmarks is the high rate of withdrawal for these job-related and academic reasons. In part, this reflects the fact that our students and graduates develop computational engineering skills that are in high demand, and the program has a unique but difficult interdisciplinary curriculum synthesizing engineering, computational mathematics, scientific computing, and team-oriented research. Nationally, undergraduate majors in engineering and science do not provide an ideal background for students entering our program, and our curriculum is being improved continuously to address this issue. Therefore, choosing academically well qualified students, and choosing students who are motivated to complete degree requirements are critical considerations for increasing graduation rates.

        - Con: Would decrease the student headcount in CmE and overall College M.S. program.
        - Con: There is anecdotal evidence that the M.S. degree is the degree industry is most likely to pay their employees to get, and M.S. graduates are more likely to be hired. Therefore, restricting admission to the M.S. concentration could have a negative impact on industries which hire CmE graduates.
    - Strategy #6: *Explore benefits, in terms of increased graduation rates, of retention of M.S. concentration in CmE by: (a) restricting degree requirements to non-thesis only, and (b) using "hybrid" in-class / online delivery of instructional material.*
        - Determine requirements to "convert" traditional course delivery (in-class) to be online.
        - Determine sample timeline online students would follow to complete degree requirements.
    - Strategy #7: *Explore possible benefits, in terms of increased graduation rate, of revising CmE course sequences to include the summer semester.*
        - Determine example timeline(s) of course sequences that satisfy degree requirements in less time than currently needed.

6.3. Short Term Objective #3: ***Strengthen the Program's national presence by establishing a strong working relationship with national laboratories and industry over the next two years (earlier if possible), beginning with Oak Ridge National Laboratory (ORNL).***

6.3.1. Strategies and Tactics to Achieve This Objective

- Strategy #1: *Aggressively engage ORNL (UT-Battelle) and UT System leadership*
    - Make the case for why a strong working relationship is advantageous, and how establishing such a relationship will be synergistic for ORNL and the University of Tennessee in general, and UTC in particular.
- Strategy #2: *Aggressively seek to identify technical areas in which there is considerable overlap of knowledge and expertise between ORNL and SimCenter personnel*
    - Use existing personal relationships with ORNL and those of former students now working within UT's Joint Institute of Computational Science (JICS) to establish initial paths of communication that can enable discussions between technical personnel at both ORNL and UTC/SC.
    - Conduct a "workshop" involving ORNL researchers and CmE faculty to identify potential areas for collaborative projects.
- Strategy #3: *Establish Joint Faculty Appointments (JFA) for interested ORNL personnel, and Joint Staff Appointments (JSA) for interested CmE faculty, such that joint faculty can mentor students, teach classes, etc., and that joint staff can easily gain entry(via a photo-ID) to the ORNL campus for collaborative work with ORNL personnel.*
    - Duplicate as much as possible the JFA / JSA process already established between ORNL and UTK to produce the same outcome at UTC.
- Strategy #4: *Explore establishing SimCenter/CmE industrial affiliates organization*
    - Contact Tim Spires, current President / CEO of the Chattanooga Regional Manufacturers Association to discuss potential interest of local manufacturers. Objective is to form a traditional affiliates program whereby member companies would pay an annual fee in order to gain access to SC expertise and simulation technology

7. Objectives, Strategies, and Tactics – Long Term (3-5 years)

The discussion given in the previous section describes specific actions that, if successful, will provide stability over the next 2-3 years. This will allow ample time for the Computational Engineering program and the SimCenter to pursue longer-term objectives that have been chosen to promote stability and sustainability.

7.1. Long-Term Objective #1: ***Enhance Reputation and Visibility of the SimCenter and CmE Program.***

7.1.1. Strategies and Tactics to Achieve This Objective

- Strategy #1: *CmE faculty become more involved in professional society activities*
  - SC director and CmE Department head will strongly encourage faculty and staff to publish research results at technical society meetings, and to submit technical papers to be considered for journal publication
  - Faculty currently serving on society technical committees will promote continuity of SC/CmE representation on the committee by encouraging other CmE faculty to serve when the existing member rotates off the committee.
  - Faculty will be encouraged to serve in other professional society activities such as Journal reviewer, session chair, etc.
- Strategy #2: *Encourage faculty and staff to propose research that will result in seminal publication(s)*
  - Approach the leading CmE faculty researchers who are most likely to "make a break through" and provide incentives that will encourage this outcome.
- Strategy #3: *Become affiliated with ORNL and other national laboratories*
  - See tactics under Short Term Objective #3.

7.2. Long-Term Objective #2**:** ***Develop closer ties with faculty in other departments within the College of Engineering and Computer Science***

7.2.1. Strategies and Tactics to Achieve This Objective

- Strategy #1: *Explore modifying the SC/CmE "culture" from concentrating solely on graduate education and research to include more undergraduate (UG) teaching*
  - Conduct a "skills inventory" of CmE faculty to search for alignment and / or overlap with existing UG coursework needs
  - Explore setting as a goal for each CmE faculty member to teach 2-3 courses per year[4] (undergraduate and/or graduate).
  - Explore establishing a new (to UTC) undergraduate engineering concentration within the existing, ABET accredited, B.S. in Engineering[5] that could involve a good number of CmE faculty. For example, preliminary discussions have taken place about a establishing a concentration in aerospace / aeronautical engineering as well as an UG concentration in computational engineering[6]..

[4] Three courses per year is the prescribed teaching load in the colleges of engineering at Virginia Tech and Texas A&M, which are well known research-oriented universities. Currently, nine CmE faculty teach eighteen courses that are taught at least once per year; that is, on an annual basis, six CmE faculty teach two graduate courses each, one teaches five graduate courses, and two faculty share the teaching of one graduate course. The goal of three courses per year is arbitrary but representative of engineering faculty in other, highly regarded research universities. Of course, this number must be balanced with the need and required skills/background.

[5] Several SC/CmE faculty have aerospace / aeronautical engineering backgrounds (both academic and work experience) as well as undergraduate teaching experience.

[6] Many CmE faculty have academic and experiential backgrounds in aerospace and/or aeronautical engineering-related fields.

- Strategy #2: *Explore modifying the CoECS "culture" from concentrating on undergraduate teaching to include more sponsored research, especially research that aligns with CmE faculty interests*
  - Conduct "exploratory workshops" involving CmE and other CoECS faculty to identify overlapping and/or mutual research interests.
  - Jointly pursue collaborative proposals and projects

7.3. Long Term Objective #3: ***Enhance and expand relations with government agencies and businesses of all sizes***

7.3.1. Strategies and Tactics to Achieve This Objective

- Strategy #1: *On an as-needed basis, assist local (small) businesses with simulation needs*
  - Continue to respond to requests for simulation services as has been accomplished in the past
  - Continue to be compensated for these services where the objective is to "break even"
- Strategy #2: *Initiate formation of a marketing plan*
  - Solicit marketing expertise from C.T. Cozart (member of SimCenter Advisory Board)
  - Work with Mr. Cozart to create a comprehensive marketing plan for selling SimCenter and CmE products and services. It is noted that this should include "marketing" in terms of education and advanced degrees
- Strategy #3: *Attract students from large companies and government agencies into the CmE graduate program.*

  Exploit contacts in various companies and government agencies to explore willingness of management to sponsor employees' doctoral program.

8. Anticipated Benefits

Benefits of achieving each Objective will be discussed in this section. It is noted that the overall benefit of successfully achieving these objectives is sustaining a viable and robust doctoral program in computational engineering.

Short Term Objective #1: ***Achieve self-sufficiency by increasing grants and contracts expenditures to $1.5M per year over the next two years.***

The costs of sustaining any doctoral program originate from several sources, but one of the largest and most uncertain sources of funds needed to sustain UTC's CmE program is "soft" money to pay for students and research faculty. Unlike funds provided by the State of Tennessee for its tenured faculty (to execute and administer its academic program), this "soft" money must come from grants, contracts, and/or gifts. Therefore, for programs like this to exist a delicate balance must be maintained between (a) the ability of the unit (CmE/SimCenter) to raise these funds, and (b) the number of research faculty, staff, and students needed to perform the required research. At the program's projected strength on August 1, 2014 of 14 faculty (5 tenured, 9 research), 6 staff, and 38 students, annual revenues of approximately $1.5M is needed from grants and contracts to balance the SC budget for FY2016 and beyond. Note this is based on the further assumption that the other sources of funding remain viable (see discussion in the following section).

Short Term Objective #2: ***Impact the Computational Engineering program by producing an average of 3 Ph.D. graduates per year by the end of the THEC evaluation period which ends in the 2014-2015 academic year (in conjunction with the Graduate School of Computational Engineering)***

The Tennessee Higher Education Commission (THEC) requires all doctoral programs approved within the State of Tennessee higher education system to produce at least 3 graduates per year, averaged over a 5 year period. During the period defined by academic years (AY) 2005-2006 through 2009-2010, the CmE program had 9 doctoral graduates, or an average of 1.8 graduates per year over that 5-year period. This number of graduates prompted THEC in November 2011 to question the Program's effectiveness and asked for a recommendation about whether the Program should be continued. Based on a then-current analysis of past graduates and number of students in the Program, it was recommended that the Program be retained; this recommendation was accepted by THEC.

Therefore, the benefit of achieving this objective is to meet (preferably exceed) the required number of graduates as defined by THEC and thus avoid jeopardizing the Program's existence by continuing to have a lower-than-required number of graduates. Unfortunately, during the first 3 years of the 5-year period between 2010-2011 and 2014-2015, only 4 doctoral students have graduated thus far. The current projected number of graduates during the 2013-2014 and 2014-2015 academic years is 3 and 5, respectively, bringing the total number during this 5-year period to 11, which is still less than the 15 needed to meet the metric. Therefore, it may not be possible to achieve this Objective relative to the THEC period of performance defined above. However, the 5-year period over which the THEC metric is computed is somewhat arbitrary and so using another period of performance will likely produce a different number. For example, the 3-year period spanning AY's 2013-2014 and 2015-2016, the total number of graduates is projected to be 14 which averages to 4.7 graduates per year. Even though graduation projections have some degree of uncertainty (because of the research component of the degree requirements), the amount that this projection exceeds the metric gives some degree of confidence that the 3 graduates per year metric can be achieved during the next 5-year THEC examination period (assuming that the number of doctoral students in the program remains approximately the same over that period).

Short Term Objective #3: ***Strengthen the Program's national presence by establishing a strong working relationship with national laboratories and industry over the next two years (earlier if possible), beginning with Oak Ridge National Laboratory (ORNL).***

There are two major benefits to the SC/CmE program should this objective be achieved: (1) CmE faculty, by working collaboratively with national laboratory personnel (such as ORNL), will gain access to funding sources not currently accessible. For example, ORNL personnel can propose research efforts to various program elements within the Department of Energy (DoE) that are restricted to personnel (contractors) supporting a federally funded research and development center (FFRDC). FFRDC personnel can serve as the principal investigator on these proposals with SC/CmE faculty (as joint staff appointments to ORNL) serving as co-PIs or co-investigators and in so-doing pay for part of the faculty member's salary. (2) UTC's and the SimCenter's affiliation with ORNL will bring with it a degree of credibility and prestige that is unprecedented at UTC. This by itself will significantly enhance SC's (and UTC's as well) ability to attract funding.

Long-Term Objective #1: ***Enhance reputation and visibility of the SimCenter and CmE Program.***
Elite universities such as MIT, Stanford, Cal Tech, etc. are regarded as "elite" because of their stellar reputation of delivering excellence in teaching and research. Their graduates are also highly regarded, often simply because of where they received their education. Clearly, enhancing the reputation of the SimCenter and UTC is beneficial and of considerable value but must be earned over a long period of time.

Long-Term Objective #2**: *Develop closer ties with faculty in College of Engineering and Computer Science.***
When the SimCenter moved to Chattanooga in 2002, it was envisioned that a synergistic relationship would develop between SimCenter faculty and those in other departments in the College, and that this would occur naturally over time. Unfortunately, the level of collaboration that was projected has not materialized for multiple reasons, but mostly because of the differences in the cultures of an organization focused on graduate teaching and research, and one focused on undergraduate teaching. Although these two cultures do not clash, they are different enough to have hindered each other from establishing a strong working relationship. Minimizing these differences is the desired outcome of achieving this objective where the benefit is providing opportunity for both groups to move toward the other's way of thinking. Specifically, SimCenter faculty could be called upon to teach more undergraduate courses, and faculty in other departments could be involved in pursing more research. It is noted that finding adequate resources is critical to realizing this benefit because at least some portion of SimCenter faculty who would be teaching undergraduate courses would be research faculty whose salaries come from non-education-targeted accounts.

Long Term Objective #3: ***Enhance and expand relations with government agencies and businesses of all sizes.***
The benefits of achieving this objective are related to the above objective of enhancing the reputation and visibility of the SimCenter, but are different depending on the size and location of the enterprise being served by the SimCenter. For large companies and government agencies (such as Lockheed-Martin, Boeing, etc.) the benefits of having established long-term relations with these companies come from the fact that sustained, collaborative projects between the organizations' personnel have been successful enough to warrant keeping the collaboration and funding stream active. For smaller, local and regional companies, the benefits are tied to assisting these companies to be more productive and/or efficient. While this is also true for the larger companies, it is our observation that smaller companies typically are interested in using SimCenter services to better realize short-term gains in productivity and/or efficiencies, and therefore are able to realize the benefits of the collaboration much more quickly.

9. Budget Considerations

As mentioned elsewhere in this document, the two groups most vulnerable to shortfalls in non-recurring funds (which must originate from non-state allocated resources) are students and research faculty. As such, the following projections will be focused on addressing budgetary issues and needs of these two groups, specifically. for FY15 (1 July 2014 through 30 June 2015) and FY16 (1 July 2015 through 30 June 2016). Of course, any projections provided here will be based on certain assumptions and the accuracy of the projection will depend (at least somewhat) on the accuracy of the assumptions. An attempt will be made to highlight those places where assumptions have been made that could affect the overall projection.

(a) Students

At present (June 2014) we have 38 total students which can be broken down into various categories:

Male	30
Female	8
Full-Time	34
Part-Time	4
US Citizen	17
International	21
Ph.D.	29
M.S.	9
GRAs	35
Non-GRAs	3

We are projecting that 4 will graduate in August (2 MS, 2 PhD), thus reducing the total number of students to 31 (no new students will be added this summer). These 4 all have GRAs, so by the end of the summer 2014 semester, we will have 32 GRAs because one will be returning to the Ph.D. program. University leadership seems to be of the opinion that the number of new students the CmE program should admit for the fall 2014 semester should be small, maybe even zero. We agree that the number should be small, but are of the opinion that the right answer is probably greather than zero because no new students will cause a dip in graduations some years out. However, we are also of the opinion that if a small number of students are admitted this fall, they should be limited to Ph.D. students only. So, the assumption is being made that we will admit 3 new PhD students this fall, bringing our GRA total back up to 35. We will assume this number is constant throughout FY2015; that is, there will be no new admissions for the spring 2015 and summer 2015 semesters.

The projected cost of these 35 GRA's over FY2015 is approximately $1.17M. These costs will be paid from foundation funds and grant funds, which will end FY2015 with a cumulative balance of approximately $140,000 (surplus). Assuming the costs of students will increase only because of inflation (that is, assume 35 GRAs for FY2016[7]), these costs are projected to be $1.23M in FY2016. Therefore, the net amount needed to sustain 35 GRAs throughout FY2016 is projected to be $1.09M.

(b) Research Faculty

At present the SimCenter employs 11 research faculty. However, 2 of these are retiring effective June 30, leaving a total of 9. If the uncertainty in funding becomes more acute over the next 3-6 months this number will likely get smaller due to attrition. These 9 individuals bring very unique and diverse skills into the huddle, which, historically, has been a critical enabler to the SimCenter continually possessing a

[7] Note this means we've assumed 3 will graduate in FY2015 and that we'll add 3 new students in fall 2015.

"critical mass" of skills that can be brought to bear on solving a particular problem. Whereas the risk is relatively small that losing a single individual from these 9 will cause the department's critical mass to go "uncritical," as the team shrinks so will the capability to address the diversity of problems that can currently be addressed with relative ease.

The conclusion here is that the present research staff, which includes both tenured and non-tenured faculty, is able to "do the work." There is no doubt that a smaller number could do almost the "same amount" of work. However, the more important number is that associated with what is required to maintain a "critical mass of skills," and that number is unknown.

So to provide a projection that is arguably more conservative (i.e., higher) than might be needed, the present budgetary requirements will be developed using 9 research faculty. These 9 individuals' salaries and benefits are presently paid from THEC funds, grants, contracts, and gifts (a small number teach one course per year which is paid from the department's educational account). Collectively, these sources of funds are projected to have a (positive) balance of approximately $1.35M at the beginning of FY2015 (July 1, 2014). For FY2015, we project ending the year essentially with a zero balance[8]. This projection is based on assuming (1) $155,000 of grants and contracts[9], (2) $700,000 of THEC funding, (3) $495,000 of funding from our reserve account[10], and (4) $0 from gifts[11] (Foundations). Therefore, we will begin FY2016 (July 1, 2015) with (1) no carry over of grants and contracts from the previous year (assume $0), (2) new THEC grants (assume $750,000[12]), (3) no reserve funds, and (4) no gift funds. As such, assuming a 3% inflation rate on salaries and benefits, the net amount needed to sustain 9 research faculty throughout FY2016 is projected to be $600,000.

(c) Summary

Therefore, the total amount needed to sustain the two groups at their present strength (35 GRAs and 9 non-tenured research faculty) for FY2016 (i.e., from July 1, 2015 through June 30, 2016) is approximately $1.69M. Note that Dr. Milhorn's promised $500K could reduce the need by this amount if these funds are received.

[8] Dr. David Milhorn of the UT System has recently pledged $500K of support but it is not clear when this disbursement will occur; this amount is not counted here.
[9] This assumes no new grants and contracts in FY2015.
[10] This will deplete the reserve account.
[11] Foundation resources are used to fund students.
[12] This is a historical average since 2008.

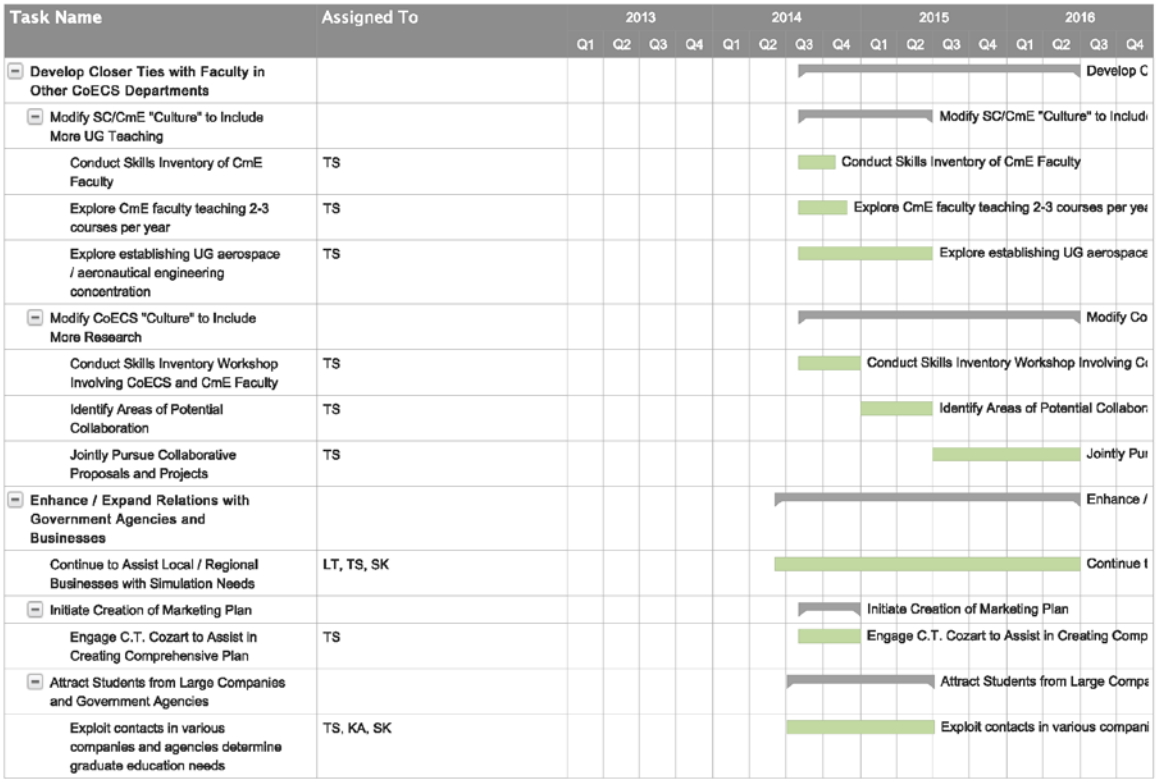
10. Implementation Plan

The effectiveness of the Strategic Plan will be lessened without a "plan to execute the plan." The table below presents a Gaant-type chart where time-lines for completing both short- and long-term objectives discussed in sections 6 and 7 are shown. Also identified are individuals either responsible for or helping to execute the various actions called for in the overall plan[13].

SC/CmE Strategic Plan

	Task Name	Assigned To	2013				2014				2015				2016			
			Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	**Achieve Self Sufficiency**																	
2	Visit Past Sponsors	TS, LT, KA, SK																
3	Demonstrate EM Capability	KA, LW																
4	Propose "Center Level" Funding	LT, RP, KA, TS																
5	Promote Faculty Participation in Proposal Writing	TS																
6	Explore Data Analytics	CB, SK2																
7	**Increase PhD Graduation Rates (minimum 3 per year)**																	
8	Promote Faculty Awareness	TS																
9	Promote Careful Screening	TS																
10	Set Time-Limits on Getting Degrees	TS																
11	Establish Timelines and Milestones	TS																
12	Explore Restricting MS Admissions	TS																
13	Explore non-Thesis MS and Hybrid Classes	TS																
14	Explore Year-Round Course Offerings	TS																
15	**Establish Relationships with ORNL and Local/Regional Industries**																	
16	Engage ORNL and UT System Leadership	TS, LT, KA, SK, JN																
17	Identify Areas of Potential Collaboration	TS, LT, KA, SK, JN																
18	Establish Joint Faculty Appointments	TS, LT, KA, SK, JN, KS, RP																
19	Establish Industrial Affiliates Program	TS																
20	**Enhance Reputation of SC/CmE**																	
21	Become More Involved with Professional Societies	TS, LT, KA, SK, JN																
22	Encourage Faculty to Propose Seminal Work	TS																
23	Become Affiliated with Other National Labs	KA, SK, JN																

[13] TS=Tim Swafford, LT=Lafe Taylor, KA=Kyle Anderson, SK=Steve Karman, JN=Jim Newman, KS=Kidambi Sreenivas, RP=Ramesh Pankajakshan, CB=Chad Burdyshaw, SK2=Sagar Kapadia



	Task Name	Assigned To	2013				2014				2015				2016			
			Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
24	**Develop Closer Ties with Faculty in Other CoECS Departments**																	
25	Modify SC/CmE "Culture" to Include More UG Teaching																	
26	Conduct Skills Inventory of CmE Faculty	TS																
27	Explore CmE faculty teaching 2-3 courses per year	TS																
28	Explore establishing UG aerospace / aeronautical engineering concentration	TS																
29	Modify CoECS "Culture" to Include More Research																	
30	Conduct Skills Inventory Workshop Involving CoECS and CmE Faculty	TS																
31	Identify Areas of Potential Collaboration	TS																
32	Jointly Pursue Collaborative Proposals and Projects	TS																
33	**Enhance / Expand Relations with Government Agencies and Businesses**																	
34	Continue to Assist Local / Regional Businesses with Simulation Needs	LT, TS, SK																
35	Initiate Creation of Marketing Plan																	
36	Engage C.T. Cozart to Assist in Creating Comprehensive Plan	TS																
37	Attract Students from Large Companies and Government Agencies																	
38	Exploit contacts in various companies and agencies determine graduate education needs	TS, KA, SK																