Vision 2015
Department of Electrical and Computer Engineering

Contents

1. Introduction

This planning document was conceived as a grass roots effort from faculty, staff and students. Positions independently developed by individuals or groups were simply collated by an 'editorial team' and discussed by the faculty at a retreat. It is a credit to the ECE people that through dialogue we reached a consensus in the matter of research thrusts for the Department of Electrical and Computer Engineering, making the work of the editorial team a simpler task.

The exercise has already proven to be of value for the Department. In addition to identifying areas of research that we should develop, the planning effort has made us evaluate our instructional effectiveness and identify actions that we can take to better serve our students.

This document reports only our internal analysis. We expect that as result of this college-wide planning effort, there will be a productive exchange across units. We expect to identify other areas of possible interest to the College as a whole and where we can contribute our fair share. One such area that we wish to highlight is bioengineering and health sciences. We have considerable expertise in some aspects of that area dealing with imaging and sensors which, integrated with expertise from other units, can lead to significant interdisciplinary activity.

The Department also views itself as a good citizen for the College and the University. We actively seek interdisciplinary collaboration. For example, faculty in ECE are interested in developing collaborative work in areas of renewable energy and energy storage. Our expertise in areas such as wireless communication, sensors and networks can contribute to research in infrastructure, intelligent sustainable buildings and coastal protection.

2. Research

The Department will seek collaborative research activity with other units in the College, the University and the Nation. We will assume leadership in developing research programs that successfully compete for funding at the national level in four research thrust areas: computational science and engineering, digital media, electric power and energy, and physical electronics.

2.1. Computational Science and Engineering

The Current Situation

Computational modeling and simulation using high-performance computers has become integral part of scientific investigation, becoming the "third pillar of science" along with theory and experimentation. With the widespread emergence of multi-core processors as the computing engine in all commodity platforms, coupled with increasing complexity in numerical algorithms, these areas have become extremely important and will remain so easily over the next decade.

Several ECE faculty members work in key areas of computer systems in computational science and engineering, including architecture, compilers, and parallel algorithms. ECE faculty play a key role in recent initiatives in areas such as computational materials, CFD, and quantum chemistry. The Department has significant course offerings in the area. Federal agencies are investing heavily in computational science, e.g., the SciDAC program from DOE and several recent programs from NSF; current funding in ECE for this area of research is close to $1.3M.

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- Establish a national and international reputation for computer systems research in computational science and engineering.
- Establish strong and lasting collaborations with national labs (such as Oak Ridge National Labs), international research organizations (such as INRIA in France) and computer systems industry (such as Intel, NVIDIA) for research and development and for workforce development (student internships, placement).

The Strategy

- Actively collaborate with domain scientists within LSU and from national laboratories on large nationally-visible projects and establish a national/international presence in the area.
- Work with other departments in the College and elsewhere on campus to offer courses in computer systems that complement course offerings in computational science and engineering.
- Actively pursue funding from federal and industry sources for large projects in computer systems research.
- Increase the number of faculty in the area by recruiting promising junior faculty and established senior faculty.
- Increase the number and quality of undergraduate students focusing on computer systems, and significantly increase the number and quality of graduate students.
- Pursue funding from private sources for scholarships, in addition to pursuing funding for increasing the number of graduate student positions for research.

2.2. Digital Media

The Current Situation

Digital media (DM) extends beyond pictures and music to include visualization, animation, gaming and speech/image understanding. This thrust is one area that is interdisciplinary and fosters collaboration inside and outside the Department. LSU, the City, and the State are heavily invested in digital media. EA Games and PreSonus (created by an ECE graduate) already have a local presence. The Arts, Visualization, Advanced Technologies and Research (AVATAR) initiative at LSU is a university-wide focus on research and instruction related to digital media, including computer graphics and digital music and where ECE is an active participant: an undergraduate minor in digital media has been developed as part of AVATAR and ECE houses the capstone project for the technical component; ECE courses constitute a significant part of the technical component of the minor; ECE faculty have developed, and continue to develop and teach, courses in many key DM areas: graphics modeling, graphics hardware, high-performance computing, parallel computation, speech/audio/image/video signal processing, wireless communication, security in wireless communication, cognitive radios, and sensor networks. Faculty have presence and active funded research in most of these DM areas. The Department has up-to-date equipment for graphics, computer, communications, and signal processing research and instruction.

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- Achieve leadership in at least one DM area, such as graphical modeling and animation, GPGPU algorithms, GPU design, multimedia signal processing, mobile communications, and wireless sensor networks.
- Establish broad contacts with DM industry, including sponsored research and cooperation on industry-wide standards and tools.
- Develop the capability and the infrastructure to build mobile media devices and systems.
- Lead efforts to obtain large-scale complete-system research grants.

The Strategy

- Aggressively use AVATAR to develop funded research, attract faculty and recruit students.
- Select medium-term collaborative goals, such as developing a physics engine or mobile media devices, and use them to tune near-term research funding solicitation and ensure concerted medium-term research decisions.
- Hire faculty in graphics/ hardware and RF circuit design to complement existing strengths.
- Develop DM concentrations, including one in dynamic simulation and one in media processing.
- Lead multidisciplinary dialogue and integration of existing LSU resources.
- Exploit synergies among digital music, biomedicine, computer algorithms, networks to develop funded research activity.
- Actively promote DM instruction, with multiple concentrations culminating in capstone.

2.3. Energy

The Current Situation

ECE can contribute to the College "signature area" of Energy in several significant ways and can lead in selected areas of research and instruction, in particular those related to electric power.

There is significant worldwide activity in implementing smart grid concepts for power transmission and distribution, in the development of renewable and alternative energy sources, and in the storage of large amounts of energy. The electric power industry is a major factor in the State's economy and is in dire need of graduates to replace a graying workforce. This industry has significant issues of industrial R&D problems which are multidisciplinary in nature. ECE has two faculty in the power area and several others with expertise in related disciplines. The Department is searching for a new faculty member in the power area and has two-year support for a post-doctoral research associate.

Power programs at a majority of U.S. universities have been closed or drastically reduced in the past two decades. This situation, combined with industry needs, creates a unique opportunity for LSU to establish a major educational and research center for the power industry.

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- ECE and the College must contribute to fundamental research in emerging challenges in the area of energy, such as efficient operation and protection of power grids, efficient drive systems to conserve energy, smart grids, and renewable energy sources.
- Lead in selected research issues where, essentially, all the expertise in the Department can contribute, for example, measurement and instrumentation, communication, control and optimization, modeling and heavy duty computing, and visualization.
- Develop a long term R&D relationship with industries in the energy sector from generation to end users.
- Lead in preparing the next generation of engineers for the energy sector, emphasizing such goals as a clean-energy smart grid, operation and protection of a power grid with distributed and highly time-varying generation and efficient end-use; the College must become an active agent for workforce development in the energy sector.

The Strategy

- Create a technical relationship to address industry R&D problems and generate revenue for ECE to support post docs, graduate students and contribute to education of undergraduates.
- Form collaborative activity with industry and consultants to support undergraduate education in the power area, e.g., laboratories, teaching assistants, adjuncts.
- Use the expertise of the graying workforce in the power and energy sector to support ECE in the education of undergraduates.
- Focus strengths toward key energy directions and develop collaborations with the Center for Energy Studies and other academic units on energy subjects of common interest.
- Hire at least one more faculty that can develop federally-funded research in the power area.

2.4. Physical Electronics

The Current Situation

ECE strengths in physical electronics lie in design and fabrication of RF-, optical- and bio-MEMS including fabrication of high-aspect ratio structures, electronic material growth and characterization, device fabrication, nano-lithography and metrology, plasmonic structures, and VLSI circuit design and modeling for novel nano-structure devices. These areas are interdisciplinary in nature, and the faculty members have been extensively engaged in interdisciplinary research. Industrial recruiters prize electronics graduates for their hands-on lab experience. The available computing resources are excellent. However, the material and device laboratory infrastructure is nearing its useful operational life and will soon need to be replaced. Though many devices and MEMS can be fabricated in-house, some MEMS and all integrated circuit fabrication are done externally through foundry services.

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ECE will continue to exploit its strengths to enhance its status and be competitive at the regional/national level in the following niche areas:

- MEMS/NEMS including high-aspect ratio structures for biomedical, RF, and optical applications, and integrated microsystems that combine MEMS/NEMS with circuitry.
- VLSI circuit design
- Novel device structures in semiconductor materials including organic and nano-materials, and material characterization pertaining to device operation, and modeling of novel nano-structure devices.
- Photonics and plasmonics structures – design, analysis, fabrication.
- Lithography and metrology for nanometer linewidth structures.
- Apply MEMS to monitor infrastructure, e.g., smart structures, highways, levees, and coastlines.

The Strategy

- Partake in interdisciplinary research in the signature areas of importance to the College, University, and the State involving Energy and Infrastructure; the research will involve smart grid development utilizing renewable energy resources and infrastructure monitoring of coastline, levees, highways, and weather through sensor arrays and networks.
- Add two new faculty members in nano-materials, devices, and nano-fabrication areas to supplement the existing strengths will enhance our capability to take advantage of national funding trends and technological needs.
- Continue to exploit strengths in electronic materials growth and characterization, device fabrication, MEMS and NEMS design and fabrication, VLSI circuit design, plasmonics, optics, and metrology.
- Utilization of CAMD and foundry services for MEMS fabrication.
- Develop collaborations with industry and other universities.

3. Instruction

We must prepare students to thrive as engineers and become leaders in the global workplace, with strong communication skills and social awareness. Our curricula must be nimble to allow a diversity of interests and adaptation to a world with continually changing technology.

3.1. Undergraduate Instruction

The Current Situation

ECE offers two ABET-accredited undergraduate programs, in electrical engineering and computer engineering; the computer engineering program is the only ABET-accredited program in the State of Louisiana. The graduates can pursue a productive career and/or pursue advanced studies. We are addressing local and state needs by enhancing teaching in the power area to meet perceived industry changes in renewable energy sources and smart grid technology.

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- Prepare students, with strong communication skills and effective team abilities, to assume leadership in the workplace.
- Address local and state needs for electrical and computer engineers.
- Develop flexible curricula allowing both student specialization, and breadth in the field.
- Expand the laboratory experience to provide more hands-on instruction favored by industry.
- Contribute to establish multidisciplinary curricula; e.g., bioengineering and health sciences.

The Strategy

- Maintain electrical and computer engineering instruction current with the evolution of technology
- Regularly replace and upgrade lab equipment.
- Have a cadre of dedicated laboratory instructors and extensive laboratory instruction
- Establish a fully-equipped capstone lab, with a full-time instructor.
- Establish engineering course for all freshmen in the College of Engineering.
- Link capstone courses across the College of Engineering.
- Link digital media minor with other academic units.

3.2. Graduate Instruction

The Current Situation

Typically, we have about 55 Ph.D. students and about 65 M.S. students, and the GPA of incoming students in Fall 2009 was 3.35. An accelerated Master's program is currently under review by the University. This program will enable students to obtain a B.S.E.E. and an M.S.E.E. in five years. Faculty regularly offer special topics courses on cutting-edge topics.

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- Have high-quality doctoral students contributing to the research mission of the Department.
- Expose students to the modern topics, tools and techniques needed for success.
- Graduate students with strong understanding of fundamentals.

- Become the resource of choice for Louisiana's graduate education in electrical and computer *engineering.*

The Strategy

- Increase the number, retention, and quality of graduate students.
- Improve support for graduate students.
- Foster interdisciplinary work.
- Develop concentrations in areas matching the research thrusts.
- Use Accelerated MS to increase quality and number of graduate students.
- Improve support for grad students, for example, with "TOPS-like" financial incentive.
- Enhance communication among students; e.g., through seminar series to expose students to more cross-cutting ideas and issues.

4. Outreach and Development

The Current Situation

ECE does little formal outreach. In the past year, the Department has supported high school projects at the State Engineering and Science Fair. In Development, ECE has a half-time Associate Director with office in the ECE building.

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Development goals include

- Minimize dependence of teaching laboratories operation and maintenance from state budget through naming sponsors.
- Develop named scholarships for undergraduate teaching laboratory assistants.
- Develop good support for graduate education through named scholarships and fellowships

Outreach goals include

- Improve name recognition and communication with local middle school and high school teachers and counselors.
- Increase diversity in our student population.
- Make ECE is the destination of choice for graduate education in electrical and computer engineering for other state schools.

The Strategy

- Develop, and coordinate with the College, summer camps targeted to middle school.
- Involve student organizations to establish a system of Ambassadors to schools in the area
- Identify and collaborate with organizations involved in education outreach.
- Partner with local industry in outreach activities such as job shadowing, mentoring.
- Task Development with establishing continued industry support for outreach.
- Seek STEM funding for outreach efforts from appropriate federal agencies.
- Seek funding to support the accelerated MS program "TOPS –like" initiative.
- Increase involvement of alumni and industrial affiliates.

5. SWOT Analysis

5.1 Strengths and Weaknesses

Strengths	Weakness
A. Instruction 1. *The ECE Department has an extensive course repertoire spanning fundamental, practical, cutting-edge and multi-disciplinary course offerings, many with strong lab and project support.* The Department also has an ongoing seminar series that exposes students to multidisciplinary topics. 2. *The ECE undergraduate and graduate programs are competitive and highly-valued by our students.* The Computer Engineering program is the only one in the State that is ABET-accredited. Our program is highly valued by students; many students choose to self-fund their studies in ECE and several students from other departments across campus take our courses. 3. *ECE Advisory Board actively participates in Program evaluation, often feeding back industrial perspectives.* **B. Research** 1. *ECE Department has a strong faculty, representing many areas of ECE, including the four thrust areas identified in the vision statement.* 2. *ECE faculty members have a strong history of collaboration within LSU (including CCT/AVATAR, the Computer Science Dept. and the Pennington Biomedical Research Center), in-state (including Louisiana Tech., UNO, ULL and Southern Univ.) and out of state (including MIT, Univ. of Arizona, Texas Southern and the Tuskegee Institute).*	A. **Instruction** 1. *Graduate Assistant support*. Our graduate assistant stipends are not competitive. The Department has recognized this weakness and addressed it directly, increasing nine-month doctoral student stipends by $1500 and supplementing many of them with additional awards and scholarships. The Department has managed to use Development to preserve GA budget in these difficult times. A College-wide effort is necessary to reduce dependence on State budget. 2. *The Department has a shortage of teaching assistants for key courses.* This issue is difficult to address without increased institutional support 3. *The quality of incoming graduate students has declined over the years.* While this is part of a larger trend across many engineering disciplines, the ECE graduate program is aggressively using Development to recruit superior doctoral students. Last year, the Department introduced the Guidry Doctoral Fellowship. **B. Research** 1. *Additional faculty members are needed in key areas of the Department, including energy/power, graphics, computational science and nano-materials.* The current faculty strengths (see Research Strengths 1 and 4) will tide us over this weakness in the short term. More importantly, addressing these faculty needs could significantly add to the Department repertoire and help make it a significant player in emerging research areas.

3. *Identification of Department's research thrust areas.* The Department has identified four thrust areas, each involving large sections of the Department, often working in cross-cutting research. We also expect that this effort will foster more intra-departmental collaboration and give faculty more opportunities to work on large-scale projects than is currently available. Minors and concentrations are also expected in these thrust areas. In fact, a digital media minor has been established. 4. *The Department is currently well-positioned in a number of fronts.* The power engineering area, though small, has a strong history of funding. The computational science area has significant federal support and is nationally visible. Physical electronics research in the Department is nationally competitive in niche areas and faculty members in digital media are currently in wide-ranging collaborations at LSU. The Department also has access to up-to-date equipment in graphics processing and computational resources (including those of CCT).	2. *Departmental research could be more collaborative.* This weakness will be addressed through the identification of the Departments thrust areas (Research Strength 3). 3. *Faculty research is limited by infrastructural weaknesses in some areas.* Areas such as device electronics, materials research and computing require expensive equipment. These are also areas with applications that cut across the College and, to some extent, the University. While ECE faculty have managed to be productive despite some of these infrastructural limitations, in the longer term this weakness can only be addressed by institutional support. It is worthwhile to share such cross-disciplinary resources through college-wide support. 4. *Institutional research support is not steady.* Budget stability is essential for supporting doctoral students through a 5-year cycle. LSU should further streamline its procedures for intellectual property agreements with interested companies.
C. Outreach and Development 1. *ECE has a development officer who keeps an excellent level of communication with alumni and industry supporters. The College of Engineering also has people dedicated to outreach and development* 2. *The Department has a loyal alumni base spread across the US in various companies and represented in several universities.*	**C. Outreach and Development** 1. *There are few ECE related companies in Louisiana.* While this limits development and research opportunities, in general, recent collaboration with Entergy have opened up new possibilities in the power and energy areas. The City and State support for digital media and related industries is also promising (Research Opportunities 1 and 2).

3. *Alumni, in general, have fond memories of their student days and take great pride in the "LSU brand" of hands-on experience and leadership qualities* 4. *The Department has a fledgling, but aggressive, outreach campaign.* Last year the Department sponsored awards for High-School projects at the State Science Fair. This, along with departmental visits by these students and their families, is expected to be a regular event. The Department is participating in graduate school sponsored recruitment visits and is exploring avenues to develop agreements with feeder institutions, both local and international.	2. *The Department needs more aggressive outreach and recruitment of students for our graduate program from the State and the Nation.* As noted in Outreach Strength 4, the Department recognizes this and has already taken steps to correct this weakness. 3. *The College of Engineering's outreach focus is currently too narrow. It should be used to aggressively increase enrollment and to attract better students.*

5.2 Opportunities and Threats

Opportunities	Threats
A. Instruction 1. *Tight job markets make engineering and professional degrees more attractive.* We plan to develop an MS program tailored to doctoral students of other STEM disciplines. A professional MS program (possibly spanning several College of Engineering departments) could be developed to target employees of local companies. 2. *The current financial situation may present an opportunity to share resources within the College. This is also an opportunity for research* ECE faculty could teach courses (such as in computing related topics) for the College of Engineering. This effort could be part of an interdisciplinary course development. The College could support essential infrastructural items such as a clean room that can be utilized for multidisciplinary research. 3. *The Department can provide leadership in distance-learning courses.* **B. Research** 1. *LSU, Baton Rouge and Louisiana support of digital media.* LSU supports the AVATAR initiative. The city supports the digital media industry. The Baton Rouge Area Digital Industries Consortium (BRADIC) (see www.bradic.org) is promoting entrepreneurship in animations, video games and visual effects, and considers the city to offer one of the highest digital media incentives. EA Games, one of leaders in the gaming software industry, has a testing center in Baton Rouge.	A. **Instruction** 1. *Lower enrollments (due to lower projected high-school graduating classes, and a national trend among ECE departments)* This threat is somewhat mitigated by the high value students place on our program (see Instruction Strength 2). We need more proactive recruiting, however, both in-state and out-of-state through various programs, including REHAMS. 2. *Reduced budgets and budgetary uncertainties impact everything from recruiting, infrastructure, long-term planning and the academic experience, in general.* One way to blunt this threat is though resource sharing (Instruction Opportunity 3) and generation of revenue streams to make the College less dependent on State funding **B. Research** 1. *Faculty attrition (and a hiring freeze) in the current fiscal situation.* A proactive stance from the Department, College and LSU in developing key research thrusts could place us in a better position than other peer institutions that are also under similar financial stress. 2. *Loss of MHI positions in digital media and computational science due to the current fiscal situation.* A timely development of industrial ties (Research Opportunities 2) with continued support from LSU, the city and the State (Research Opportunities 1) could renew the initiatives.

2. *The Department has an opportunity to develop a strong partnership with local industry.* The Department has a working relationship with Entergy We now have an opportunity to develop a partnership with EA Games and other digital media companies. 3. *There are increased federal funding opportunities in Energy, computational science, smart infrastructure, Bio-MEMS and materials research.* **C. Outreach and development** 1. *Utilize the sesquicentennial celebration in 2010 as a focal point to establish renewed ties with the alumni base.* 2. *National concern about low enrollment in STEM disciplines may present opportunities for federal funding.*	**C. Outreach and Development** 1. *Lack of ECE related industry in Louisiana and its effect on fund raising.* Our relationship with Entergy, other process industries and the opportunity to develop partnerships with the digital media industry (Research Opportunity 1 and 2) are important here. 2. *Difficulty in reaching anticipated alumni support because of economy.* Development should insure that our well-placed and loyal alumni (Outreach Strength 2) will continue supporting the Department.