Unit authorized to offer degrees:	Department Electrical Engineering
College:	College of Engineering
Degree Titles:	Bachelor of Science in Electrical Engineering (offered through the College of Engineering) Master of Science (one degree title covers our traditional full-time program, and one covers our part-time evening Professional Master's Program) Doctor of Philosophy
Year of last review:	2001
Department Chair:	Vikram Jandhyala (September 2011-)
Date Submitted:	February 1, 2012

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PART C
APPENDICES

PART A
REQUIRED BACKGROUND INFORMATION FOR REVIEW COMMITTEE

Section 1: Overview of Organization

1.1 Mission and Organizational Structure

1.1.1 Mission and Goals

Electrical Engineering is a discipline with more than a century of knowledge and tradition. At the same time, it is one of the most relevant for society's present and future needs and challenges; it has grown to encompass an impressively broad range of topics. Electrical Engineering directly and indirectly provides devices, systems, methodologies and design techniques for many of the most pressing challenges before humanity including those in global health, energy, the environment, and people-centric systems. For example, important aspects of several of the engineering challenges outlined in the National Academy of Engineering's Grand Challenges for Engineering (www.engineeringchallenges.org) are addressed by approaches within Electrical Engineering. We feel and infer that over the next decade and beyond, the importance, need, and demand for students with Electrical Engineering degrees at all levels will continue to be strong and growing in both domestic and global settings.

1.1.1.1 Context

Electrical Engineering couples skills and techniques from a wide swathe of electrical technologies, physics, applied math, design and fabrication, computation, algorithms, and measurement and test. Traditionally, Electrical Engineering has focused on electrical technologies such as power, electromagnetics, controls, and circuits and on algorithmic and system advances in communication, and signal and image processing. While these areas remain highly relevant, a sea change in the needs of our times has had a dramatic impact on the scope and role of Electrical Engineering. The interplay and interaction of Electrical Engineering with other engineering disciplines, the basic sciences, materials, medicine and biology, computation, and the social sciences has increased tremendously. This is exemplified perfectly in our department with the recent successes of an interdisciplinary multi-department Center for Sensorimotor Neural Engineering (www.csne-erc.org) where several of our faculty play critical leadership roles.

Many of the technological successes and advances in our modern society are due in a large part due to breakthroughs and innovations from the field of Electrical Engineering. Indeed, Electrical Engineering has also been the spawning ground of new disciplines. In the context of our own department, the highly respected Computer Science and Engineering, Bioengineering, and Statistics departments at the University of the Washington have all been spawned from the Electrical Engineering department.

Several technologies initiated in the field of Electrical Engineering are quite mature and have spawned new disciplines. Looking forward, we are in a challenging time of great opportunity and change. With the appropriate large-scale collaborations and crosscutting applications of high-tech technologies being developed in Electrical Engineering, we have both the responsibility and the opportunity to place our department and field squarely in addressing the challenges of our time in health, energy, the environment, and in people-centric systems.

In continuing to look forward and grow, the new administration that started in September 2011 (Chair Vikram Jandhyala, Associate Chairs Bruce Darling, Jenq-Neng Hwang, and John Sahr) and the EE faculty and staff are excited to build on the advances in the department in the previous ten years owing to the work and successes of the previous administrations of Chairs Howard Chizeck, David Allstot, Bruce Darling, and of the most recent administration (2005-2011, Chair Leung Tsang, Associate Chairs James Ritcey and Sumit Roy).

1.1.1.2 Vision

Electrical Engineering is a fast moving and rapidly changing field. As seen over the last century, the rate of this change has dramatically accelerated. For example, by 2016, the value of the combined mobile wireless voice and broadband productivity gains to the US economy – $427 billion per year – are projected to exceed today's motor vehicle manufacturing and pharmaceutical industries combined. Thus students at all degree levels, who get EE degrees which encompass significantly more than the areas of mobile wireless voice and broadband, are critical for the future of our State and Nation.

In order for our students to get the best positions and have the most influence on our future, we need to become widely known in stature as one of the world's great EE departments. We see the global economic crises not as an excuse, but instead, a chance to strategically position ourselves to carefully grow in areas, which we will describe, where top technical leadership in research, research dissemination via many channels including entrepreneurship, and research impact on education, is indeed possible. As will be seen, we are working to transform our department to lead the nation in several focus areas. These are areas where we are already well-positioned to potentially lead, yet must make the leap from merely sufficient efforts to groundbreaking and distinctive efforts. By comparing ourselves to our peer institutions using the metrics we will define, we must be able, within the next decade, to say we are amongst the best nationally, if not internationally, in these areas. Achieving top ranking is not an end in itself, but will follow from our EE research demonstrating revolutionary positive impacts on the world. This lofty goal is obtainable, but only if we harness our University's and region's unique special skills, set the bar very high for our expectations of faculty, staff, and students, and efficiently leverage the resources we have and need.

1.1.1.3 Mission

The mission of the Electrical Engineering Department at the University of Washington is

To nurture and develop tomorrow's engineering leaders in an environment of excellence in discovery with visionary researchers, by

- Providing world-class undergraduate and graduate education in Electrical Engineering

- Conducting high-impact research of technical influence and recognized excellence
- Addressing and formulating engineering solutions to aspects of the largest challenges facing humanity in health, energy, the environment, and in people-centric systems

1.1.2 Degree Offerings

The Electrical Engineering department has strong and successful degree programs at all levels, including:

- *Bachelor of Science in Electrical Engineering* described in Section 2.2.1.
- *Master of Science in Electrical Engineering* described in Section 2.2.2.
- *Master of Science (Professional Masters Program) in Electrical Engineering* described in Section 2.2.3.
- *Doctor of Philosophy in Electrical Engineering* described in Section 2.2.4.

1.1.3 Academic and Non-Academic Staffing

See Appendix A in Part C for detailed organizational charts. The Electrical Engineering Department, like most academic units, is composed of two symbiotic and intertwined organizational structures. The first is the faculty structure, in which power and authority flow upwards from the Faculty. The University of Washington Faculty Code largely defines this structure and its associated processes. The second is the administrative structure. For fiscal concerns, human resources, and other related areas, responsibility and authority flow downwards from the Dean to the Chair to the Faculty.

1.1.3.1 Department Operating Committee

The Chair, the Associate Chairs, and the lead department staff conduct day-to-day management of the department. This group meets weekly in closed session. The members of this advisory body include: Department Chair (Vikram Jandhyala), Associate Chair for Education (Bruce Darling), Associate Chair for Research (Jenq-Neng Hwang), Associate Chair for Advancement and Infrastructure (John Sahr), Department Administrator (Gloria Heaton, currently on leave; Andrei Stabrowski, interim), Lead Academic Counselor, Graduate Programs (Scott Latiolais), Lead Academic Counselor, Undergraduate Programs (Brenda Larson), Professional Programs Manager (Erin Olnon), Director of Departmental Computing (Sekar Thiagarajan), Facilities Manager (Johnny Young), and Assistant to the Chair (Sarah Espe).

The weekly meeting provides a regular opportunity for administrative leaders of the department to inform each other of challenges and problems, achievements and accomplishments, and to discuss short term and long term plans, and to provide advisory input to the decision process. The three associate chairs represent faculty interests regarding the educational, research, infrastructure, and advancement programs of the department. The task of running the meetings is assigned to the Chair, and to one of the Associate Chairs if the Chair is traveling or absent.

1.1.3.2 Governance and Oversight Committees

The Department has several other key committees that play important roles in departmental governance and management. These include

1.1.3.2.1 Faculty Executive Committee: This advisory committee (Appendix A.3) consists of the chair, associate chairs, and three faculty members nominated by the chair on a yearly basis. This committee's main purpose is to vet and refine new ideas and proposals before taking these before the Faculty in faculty meetings or in electronic correspondence with the Faculty.

11.3.2.2 Merit Review Committee: This is a representative committee empowered to advise the Chair in matters of Faculty Merit Review. It consists of three Full Professors, two Associate Professors, and two Assistant Professors who are chosen by secret ballot on a yearly basis. This is presently in a formative stage in the new administration.

1.1.3.2.3 Student Advisory Board: This consists of representatives of undergraduate and graduate students. It provides a direct communication between students and the Chair, and is advisory to the Chair. This is presently in a formative stage in the new administration.

1.1.3.2.4 Industrial Advisory Board: This is an invited board of senior industrial executives and alumni, who meet twice a year to discuss strategic ideas related to curricula, industrially relevant research, and outreach. This board is presently in a formative stage under the new administration, and will serve as a springboard to build an *Industrial Affiliates* program in the 2012-2013 year.

1.1.3.3 Management of Educational Activities

Academic advising (Appendix A.4) handles all aspects of the department's educational activities. Academic advising is led by the Associate Chair for Education (Bruce Darling) and has three distinct sections related to undergraduate, graduate, and professional programs. Each section has a faculty member serving as a program coordinator, and a lead staff member serving as a lead advisor or lead manager. Students in each area have direct access to the advisors, the coordinators, and as needed, to the associate chair for education and the chair. The undergraduate section currently handles educational activities for approximately 475 students, the graduate section handles activities for approximately for 225 students, and the professional programs section handles activities for approximately 110 students.

A Curriculum committee oversees all aspects of curricula at all levels including creating new courses and interdisciplinary education. Technical support for the educational activities of the department is handled by two groups (Appendix A5). The Computing group (Director: Sekar Thiagarajan) manages and handles all aspects of computing access to students as well as computing laboratories. The Facilities group handles all space aspects of the educational activities including instructional laboratory management.

1.1.3.4 Management of Faculty Program Activities

Faculty in the department are supported by Program Managers who report to the Department Administrator. A cluster of faculty are each supported by one Program Manager. Research project technical support for specific faculty (Appendix A7) who are leading large or specialized research groups is provided by additional staff members. As an example, Karl Bohringer leads the interdisciplinary Microfabrication Facility (www.engr.washington.edu/mff) and has five engineers and scientists as EE staff members associated with the facility.

1.1.3.5 Departmental Computing

The computing infrastructure at Electrical Engineering is one of the largest on campus. We have 12 computing labs, 13 class C subnets, uniquely hardwired subnet firewalls for perimeter security, LDAP, Kerberos for authentication and authorization, mail, DNS, DHCP services. There are over 1000 workstations and about 350 servers distributed in 4 server rooms across campus. The main infrastructure is RH Linux based with most of the frontend workstations being Windows. There are six computing staff members who take care of all of the Linux/Windows/Web based support for the entire department. The department has 12 computing labs with a total of 230 seats. Four of these are general purpose computing labs and the rest are dedicated as instructional labs. The computing labs are very unique to the students in that more than fifty EE-specific applications are available, some of which run from several thousands of dollars to millions of dollars, and hence are not available for students to install at home. A new Remote Access Virtual Computing Lab has been launched recently for students based on the Virtual Desktop Interface technology. The idea is to eliminate some of the commute time for students and to have the ability to remotely work on class assignments. Students can access these virtual lab machines from practically anywhere in the world with the ability to run EE licensed applications to complete their class assignments.

1.2 Budget and Resources

1.2.1 Budget

Appendix B shows total ***direct expenditures*** in the department over the last decade. Under Electrical Engineering Total Funding, four direct expenditures are shown; state funding, external funding (grants and contracts), external funding (other sources: gifts, royalties, scholarships, fellowships etc), and internal funding (indirect cost return to department). The next graph breaks out the external funding from sources other than grants and contracts in more detail. Grants and contracts expenditures saw a peak in 2003-04, a fall in 2007-2008 with a steady increase since that time. Expenditures from other funding rose due to two revenue sources (a) A one-time Bluetooth-related settlement of $2M in 2007 and (b) Surplus revenue from the evening Professional Masters Program that commenced in Winter 2008. Challenges for the immediate future include (a) Enhancing the size of fellowships, scholarships, and donations (b) Maintaining or growing state funding given the large amount of undergraduate and graduate instruction performed by the department, and given the commencement of ABB and perhaps of differential tuition (c) Scaling research programs and funding further to be in line with our vision of being a top EE department. We would also like to point out that though total state funding has risen with the exception of a drop in the latest year, this is due to it being the sum of two parts. General Operating Funds (GOF) have seen progressive and hard cuts. Departmental Operating Funds (DOF) have risen due to growth of activities, especially of instruction in the department. Therefore reductions in GOF are currently managed through increased DOF with the caveat that these funding types are not interchangeable and have their own restrictions. However, the future in this regard is uncertain, and the department has a strong case that the societal, education and research impact of the department merits increased DOF (in an ABB / differential tuition environment as well) as well as increased or steady GOF. *An interesting note here is that according to Engineering by the Numbers (www.asee.org/papers-and-publications/publications/college-profiles/2010-profile-engineering-statistics.pdf), our department has the 4th largest number of undergraduate EE degrees awarded after the Georgia Institute of Technology, the University of Illinois at Urbana-Champaign, and Purdue University.*

1.2.2 The Electrical Engineering Building

The Department of Electrical Engineering is housed primarily in the Electrical Engineering Building (EEB). This building constructed in 1997 offers approximately 65,000 sq.ft. of office and laboratory space. Two of the basement laboratories contain special facilities: B011 is an approximately 400 sq.ft. anechoic chamber and B028/B017 is an approximately 1200 sq.ft. class 10,000 clean room. Approximately 3000 sq.ft. are devoted to teaching and computing laboratories.

The Department's administrative suite and six faculty offices are found in the adjoining Paul Allen Center, a total of approximately 6500 sq.ft. In addition, the Department controls approximately 6500 sq.ft. of Sieg Hall (very near to EEB), for teaching, teaching assistant offices, two faculty offices, and one laboratory. EE faculty occasionally use lab space and house research staff at Fluke Hall and Ben Hall, through contractual arrangements. These two facilities stand at larger distances from EEB.

The Electrical Engineering Building, while relatively new, is half of a partially failed construction project that was originally intended to house both CSE and EE. Thus EEB is in some ways unfinished, and errors in its design led to poor floor plan efficiency, and impede collegial interactions among the faculty, staff, and students. Design and installation flaws in the mechanical systems have been a continual detriment to experimental research programs. The building presents a continuing challenge in the department's desires of enhancing collegiality, collaboration, and teamwork.

Section 2: Teaching and Learning

2.1 Educational Mission and Philosophy

The mission of the Electrical Engineering Department at the University of Washington is

To nurture and develop tomorrow's engineering leaders in an environment of excellence in discovery with visionary researchers, by

- Providing world-class undergraduate and graduate education in Electrical Engineering
- Conducting high impact research of technical influence and recognized excellence
- Addressing and formulating engineering solutions to aspects of the largest challenges before humanity in health, energy, the environment, and in people-centric systems

The educational mission and philosophy is consistent with the overall mission of the department. We provide strong education relevant to the needs of industry and academia, with a B.S., two M.S. (regular daytime and evening professional), and a Ph.D. program. Our high-quality tenure-track faculty members are actively involved in all aspects of education and also integrate their research into coursework, projects, and capstones courses.

The Electrical Engineering Department is organized into seven curriculum groups:

Group	Faculty (Au'10)	Graduate students enrolled (Au'10)	MSEE graduates in last 3 years	PhD graduates in last 3 years
Communications	5	27	13	8
Devices	10	58	25	16
Electromagnetics	4	21	14	10
Energy	5	19	16	4
Signal and Image Processing (SIP)	10	57	30	21
Systems, Controls, and Robotics (SCR)	6	27	20	6
VLSI	9	57	33	11

Each of these seven curriculum groups are primarily responsible for organizing the course teaching plan, the undergraduate specialty tracks, the PhD qualifying examination, and the review of graduate applicants.

2.2 Student Learning Goals and Outcomes

The Electrical Engineering Department offers four degree programs that are summarized below. The data is from the 2010-2011 academic year and the Autumn 2011 admissions cycle. These figures have held relatively steady over the past decade, aside from the new Professional Masters Program, which began in 2008, and a recent sharp rise in MS applications.

Degree program	Total enrollment	Applications	Offers	Admits	Graduates
Bachelor of Science	469	350	130	88	163
Master of Science	32	428	32	15	37
Professional Masters	102	44	38	36	22
Doctor of Philosophy	197	592	140	46	33

2.2.1 Bachelor of Science in Electrical Engineering

Electrical engineering is both a fundamental and an expansive discipline whose purview includes an ever increasing number of topics. As electrical engineering provides the essential ingredients that so many other fields rely upon – power, computation, communication, control, and measurement – and as EE becomes more specialized in its support of new and interdisciplinary areas, these new areas grow to become sub-disciplines of EE. Over the past decade, this process has accelerated exponentially. *Addressing this vast number of topics has become problematic for many if not all EE departments*. Our approach has been to reduce our common core requirements to a comparatively small number of fundamental courses (EE-215, EE-233, and EE-235) and provide a selection of specialty tracks through which our undergraduate students can better focus and prepare themselves for specific sub-areas of the overall field. These specialty tracks are necessarily an incomplete set, but are offered based upon the existing faculty expertise, research focus, and student demand. They are dynamic by design, with new tracks developing as such focus emerges, and being discontinued as demand and interest wane. Students must satisfy the course requirements for at least one track to graduate, but it is not uncommon for some students to satisfy the requirements for several tracks by the time they graduate. Since its implementation in 2007, we have found that our small core curriculum has allowed students more credits to pursue senior level electives and capstone design courses which better support their technical focus and career aspirations.

Specialty track	Curriculum group	Capstone design course	Graduates per year (2010-2011 AY)
Analog Circuits	VLSI	EE-433	18
Biomedical Instrumentation	Devices	EE-436	38
Sensors and Devices	Devices	EE-484	not offered
Digital VLSI Circuits	VLSI	EE-477	25
Embedded Computing Systems	VLSI	EE-478	40
Electromagnetics	Electromagnetics	EE-467	21
Digital Signal and Image Processing	Signal and Image Processing	EE-443	24
Communications	Communications	EE-420	7
Wireless Communications	Communications	EE-420 or EE-467	7
Large Scale Power Systems	Energy	EE-456	43
Sustainable Electric Energy	Energy	EE-452, EE-453, or EE-456	49
Power Electronics and Electric Drives	Energy	EE-452 or EE-453	59
Controls	Systems, Controls and Robotics	EE-449	12
Student Developed	Varies	Varies	not offered

Pre-engineering majors in the College of Arts and Sciences normally apply for admission into Electrical Engineering through either the early admissions process, after completing 30 credits, or through the upper division admissions process, after completing 64 credits. Early admissions are only for Autumn quarters, whereas upper division admissions are for Autumn or Spring quarters. Some direct freshman admits are also made to exceptional applicants. Community college transfer students normally enter the program through the upper division admission process.

2.2.2 <u>Master of Science in Electrical Engineering</u>

For many specialty areas of electrical engineering, the Masters degree is the minimum requirement for entry into the industry. Examples include integrated circuit design, semiconductor processing, microsensors, photonics, and several areas of electric power systems. Our MSEE program is based around a very flexible 45 credits that can optionally involve a thesis. Each program is individually tailored to the goals of the student, in consultation with advisors and faculty. The average time to degree for our MSEE students is 5 quarters after they enter our program. Many PhD-bound students satisfy the requirements for the MSEE degree en-route to their doctorate. We offer this option to those PhD students who do not already have the MSEE degree. Over the last few years, the number of applicants to our MSEE program has increased dramatically: 224 (2010); 428 (2011); and 580 (2012).

Planning is currently underway to introduce a 5-year combined BS-MS program to better address the needs of those students who desire a fast-track to the MSEE degree directly following the completion of their BSEE, as discussed in Section 4.1.1. We anticipate being able to launch this program in the 2012-2013 academic year.

2.2.3 <u>Professional Masters in Electrical Engineering</u>

The Professional Masters Program (PMP) was launched in 2008. This program is oriented for students who have already spent several years working in industry and who are returning to school to further their careers, but with a higher level of maturity and professional accomplishment than those students who go directly into the MSEE program following their BSEE degree. These courses are offered late in the afternoon or early evening to accommodate the work schedules of these students who typically pursue this program in a part-time fashion. After an initial start-up pulse, the applications to this program have begun to level out: 71 (2009); 49 (2010); and 44 (2011). We anticipate growing this program through online versions in the next two years, as discussed in Section 4.1.4.

2.2.4 <u>Doctor of Philosophy in Electrical Engineering</u>

The PhD in electrical engineering prepares students for careers in the highest levels of the profession, including entrepreneurial, industrial, government and academic sectors. We expect our PhD graduates to first and foremost be able to identify, design, plan, and execute independent research in their chosen specialty that contributes to new knowledge, techniques, and insight. We additionally expect our PhD graduates to become leaders in their field, being able to both appreciate the global view, as well as being able to handle the smallest details, and contribute high value and lasting impact to society. Necessarily, each PhD program is customized to the student and their research, with the faculty advisor providing the critical role of guide and mentor. The average time to degree for our PhD students is 5.5 years after they enter our program. Student progress through the PhD program involves the completion of three major milestones: (1) the PhD Qualifying Evaluation, (2) the University General Examination, and (3) the Dissertation Final Defense.

<u>2.2.4.1 The PhD Qualifying Evaluation</u> is intended to be an early assessment of a student's aptitude for the degree. It nominally occurs after one year in our graduate program, after a student has completed most of the formal coursework associated with their specialty area. The evaluation consists of earning a minimum 3.5 grade in specified coursework requirements and an oral examination period. The seven curriculum groups set the required selection of courses that

must be satisfied for both breadth and depth, and they also coordinate the oral examinations that occur each Autumn and Spring quarter. The oral examinations are conducted by a panel of three faculty members that excludes the student's advisor. Students are permitted two attempts to pass the Qualifying Examination.

2.2.4.2 The General Examination is carried out by the student's supervisory committee, and is implemented as a research proposal presented by the student, followed by a closed-session question and answer period with the supervisory committee. The General Examination nominally occurs after 2-3 years into the program, after the student has developed their fundamentals skills and experience in the field, and after the student and advisor have jointly developed a topic and plan for the proposed research work.

2.2.4.3 The Dissertation Final Defense is carried out by the student's supervisory committee, and is preceded with a public announcement, and implemented as a research presentation by the student, followed by an open-session question and answer period with attendees, followed by a closed-session question and answer period with the supervisory committee. This exam typically happens in approximately 4-6 years after the student has started the Ph.D. program, in conjunction with detailed discussions and planning with the advisor.

Applications to our PhD program have remained fairly constant: 610 (2010); 592 (2011); and 595 (2012). Recruitment into our program is leveraged with multi-year RA/TA funding offers. We additionally host a visit day for prospective graduate students in the Spring along with extensive web materials and ready availability of advisors to help answer questions and solve logistical problems. Typically, about 40% of our admission offers are accepted.

2.3 Instructional Effectiveness

The department prides itself on high quality educational instruction, delivered throughout all of its programs. Instructional effectiveness is closely monitored through:

2.3.1 Student assessment of teaching

Each instructor and teaching assistant routinely solicit student feedback in each course through the Office of Educational Assessment forms and written comment sheets.

2.3.2 Peer review of teaching

Each year, peer faculty are assigned to review their colleagues' teaching by means of an in-class visit and follow up with the instructor. Priority is given to Assistant and Associate Professors who are nearing promotion.

2.3.3 ABET assessment of undergraduate courses

End-of-course evaluations are prepared at the close of each undergraduate course by the instructor. ABET outcomes are also assessed by means of instructor generated rubrics, and the class performance against selected rubrics is evaluated and reported for each undergraduate course. These outcomes are then applied toward formal course improvements as part of the ABET continuous improvement plan (CIP).

2.3.4 Professional assessment of teaching

Well over half of our faculty make use of the in-class reviews provided by consultants from the Center for Engineering Learning and Teaching (CELT). Although not required, many faculty and TAs take advantage of the resources provided by the Center for Teaching and Learning (CLT, previously CIDR).

Nearly without exception, our faculty and teaching assistants take their teaching and their teaching reviews seriously, and spend a great deal of effort using the results of these metrics to improve their course content and delivery methods. Innovation in new methods of educational delivery, interdisciplinary projects, and state-of-the-art course topics are strongly encouraged, particularly when these innovations link research projects to undergraduate education. We also appoint a Lead TA who serves as a liaison, troubleshooter, mentor, and coordinator for our TAs. Our TAs are our most precious and critical resource for maintaining instructional quality in the undergraduate courses, and we take special effort to assign only the best, nurture their entry into this role, and insure that they get the resources they need to be successful.

Details of our ABET continuous improvement plan (CIP) can be found at:
https://www.ee.washington.edu/operations/advising/abet/cip.pdf

2.4 Teaching and Mentoring Outside of the Classroom

2.4.1 Instrumentation and computer laboratories

Electrical Engineering education relies critically upon instrumentation and computer laboratories. These laboratories provide the environment for students to put classroom concepts into practice, gaining skill and hands-on experience in electrical instrumentation and measurements, software-firmware-hardware interfaces, practical problem solving and troubleshooting, design of experiments, data and signal analysis, data communications and networking, and documenting and communicating their work through professional quality reports and presentations. These laboratory skills strongly influence the marketability of our graduates, and our department has been extremely fortunate in being able to offer state-of-the-art instrumentation and computing laboratories for our students. Continuous generous donations of electronic test equipment by John Fluke Mfg. Co., Hewlett-Packard, Tektronix, and National Instruments have kept our instrumentation labs up to date for the past two decades. Similarly, our computing support group works to keep state-of-the-art computer resources in both the general purpose and specialty laboratories. Hardware upgrades have been supported primarily through successfully funded student technology fee proposals. Computing support also involves the maintenance of a significant amount of software running on a variety of different operating systems. Beyond the ubiquitous “office” software, electrical engineering makes heavy use of special purpose computer applications for mathematical computation and modeling, circuit analysis, schematic capture, IC and PCB layout and design checking, finite-element and multi-physics modeling, and other special tools for electromechanical, electromagnetic, optical, photonic, quantum mechanical, thermal, networking, and digital systems design. In most cases, we offer our students the same or better professional level design tools that they would use in the workplace, and in some instances, tools which were developed by our own faculty.

2.4.2 Teaching Assistants

Teaching assistants are one of our department's most critical resources, and one of the key bridges between our graduate and undergraduate programs. Our TAs provide the majority of the critical individual and small group instruction in both our hardware and computer laboratories, and are absolutely essential for maintaining the quality of our undergraduate program. Each quarter we employ 32-35 TAs to support our undergraduate laboratory courses. We also employ 10-15 hourly graders each quarter to assist with the larger undergraduate courses. Most design courses have the students working in teams of 3-4 to develop solutions to the design projects posed in these courses. Collaboration and team work is strongly encouraged in these design projects with supervision provided by both the TAs and course instructors. TAs also work closely and collaboratively with faculty instructors, and in many instances, new courses evolve from research projects through these collaborations.

2.4.3 Undergraduate involvement in research and independent study

One of the most unique and valuable opportunities that our undergraduates have is the ability to participate in current research projects with our faculty. These projects can be arranged independently with faculty members, and students can obtain academic credit through either EE-400 or EE-499. There are additional opportunities offered by the UW Undergraduate Research Program and Symposium, the Engineering Undergraduate Research Program (EURP), and by the National Science Foundation Research Experience for Undergraduates (REU) program.

2.4.4 Departmental student organizations

Focused primarily for undergraduates, the department hosts active student chapters for the Institute of Electrical and Electronic Engineers (IEEE) and the electrical engineering honor society of Eta Kappa Nu (HKN). The Graduate Student Association (GSA) serves the complementary function for the graduate students. These student-led groups provide social, technical, professional, and academic activities which round out the educational environment within the department. These groups are particularly active in organizing regular social events and assisting in career fairs, information sessions, research seminars, department tours, and visitor logistics.

2.4.5 Graduate student research and thesis supervision

At the graduate level, the individual faculty teaching and mentoring provided to thesis students at both the MS and PhD levels become far more important than the curriculum found in their formal course work. Here, our goal is to impart life-long skills and professional approaches, methods, attitudes, and ethics, centered first on independent research, but extending to the development of a full career in the specialty area of each student's choice. At the PhD level, we start with bright and motivated students who later become our peers, colleagues, and friends.

The relationship between a faculty advisor and their PhD students is a unique and special one found nowhere else, and our department places a high reverence on the learning, growth, and professional development that occurs in both directions. As our PhD students start to become productive in their research output, usually near to or after their General Exam, they are expected to publish research papers and present their findings at well-respected conferences. As they near the finish of their academic degree, they typically spend more time instructing others, including their faculty mentors, and take on increasing levels of leadership and responsibility within their research group. For those students who express a desire to enter the academic profession, we strive to offer them some experience at teaching a course, beyond the role that they might have already had as a TA. In all of these roles, our thesis students work closely with their faculty advisors and become tightly integrated into the teaching, research, and service missions of our department.

Section 3: Scholarly Impact

The faculty in our department have been superbly creative and productive by all standard metrics used for judging scholarly impact including publications, awards, funding, etc. A centennial history of the department and research is available at http://www.ee.washington.edu/about/centennial/christie_history_2006.pdf .

3.1 Research Summary from the EE Kaleidoscope

While the funding and research details are too voluminous to list here, an excellent accessible resource is the Electrical Engineering Kaleidoscope (EEK) publication that provides research activity summaries and details from 2001 onwards, available at www.ee.washington.edu/about/eek.

Some early examples of scholarly awards and research highlights from EEK include:

- 2001: System-on-a-chip NSF ITR, PI David Allstot, with 10 EE faculty.

- 2002: NSF CAREER awards to Jeff Bilmes, Vikram Jandhyala, Alex Mamishev, and Radha Poovendran. Research highlight: Deirdre Meldrum co-directs the Microscale Life Sciences Center.

- 2003: NSF CAREER award to Kai Strunz. Research highlight: Karl Bohringer's work on MEMS featured as one of top scientific stories in Discover.

- 2004: MIT TR 100 recognition to Lih Lin. New IEEE Fellows: Les Atlas, Evan Goldstein, Denice Denton, and Yasuo Kuga. Research highlight: UW and EE part of National Nanotechnology Infrastructure Network.

- 2005: Research highlight: Haptic interfaces and telerobotic surgery techniques by Blake Hannaford and Jacob Rosen.

- 2006: Research highlight: Software defined radio platforms: Josie Ammer, David Allstot, Hui Liu, and Sumit Roy.

3.2 Research Summary from The Integrator

Another excellent online resource is the integrator newsletter available at www.ee.washington.edu/news/integrator/index.html that summarizes scholarly and research recognition and achievement. Some examples from the last few years are:

- 2005: Radha Poovendran receives PECASE award.

- 2006: Alumni Alhussein Abouzeid and Lisa Zurk receive NSF CAREER awards.

- 2007: Babak Parviz wins MIT TR35 award.

- 2008: Intel Fellowships to Arun Sathanur, Cherry Wakayama, and Jeffrey Walling. Microsoft Fellowships to Anna Pyayt and Amar Subramanya.

- 2009: Maya Gupta receives PECASE award.

- 2010: NSF Fellowships to Gabe Cohn, Linda Bai, and Julie Medero.

- 2011: Shwetak Patel receives Macarthur genius grant. David Allstot receives IEEE Mac Van Valkenburg award.

3.3 Faculty Awards

Several faculty have received major research and achievement awards, highlighted at www.ee.washington.edu/cgi-bin/about/faculty_awards.pl . Another indicator of scholarly success is the number of early career and career achievement awards. For our department this includes 26 IEEE Fellows, 14 NSF CAREER awardees, 11 young investigator awardees, 3 ASA Fellows, 3 PECASE awardees, 3 Sloan Fellows, 2 OSA Fellows, 2 Members of the National Academy of Engineering, and 1 MacArthur Fellow. A complete list of awards, honors, and publicity for the past ten years is available at http://www.ee.washington.edu/news/dept_news.html as well as in editions of the EEK and Integrator publications mentioned above.

In terms of scholarly achievement, reputation, and funding the faculty in the department are strong in many areas, which include as examples:

- Speech, Image, and Video Processing: multimedia data analyses, data mining and machine learning, speech and language processing
- Integrated Systems, Mixed Signal, VLSI: low power circuits, wireless sensors, mixed signal circuits
- Nanotechnology, MEMS, Photonics: nanoelectronic/photonic devices, biological and molecular systems and models
- Robotics, Controls, Mechatronics: bio-robotics, brain interfaces

- Communications and Networking: wireless networking systems, secure networks and protocols
- Electromagnetics and Remote Sensing: microwave/millimeter-wave remote sensing, antenna design/modeling, computational electromagnetics
- Power and Energy: modeling of heterogeneous energy systems, operating/planning of energy systems

3.4 Research Funding

Research funding is discussed in more detail in Section 1.2.1. Funding has remained strong across the department; the specific areas that bring in most funding have changed over time as areas have constantly evolved. In 2010-11, for example, the grants and contracts awarded equaled $12.7M. In the past 5 years, there have been 19 projects which have each brought in above $1M. Several EE faculty members have also played a pivotal role in the new NSF ERC on Sensorimotor Neural Engineering (2011).

3.5 Diversity

In the 2010-2011 academic year, the UW EE department conferred 156 BSEE degrees. Of these, 27 (17.3%) went to women. This compares favorably with the national average of 11.6% BSEE degrees going to women in 2010. At the master's degree level, UWEE granted 8 MSEE out of 60 (13.3%) to women. This is below the national average of 18.3% of MSEE degrees going to women.At the Ph.D. level, UW conferred 5 out of 32 degrees to women or a total of 15.6%. This is slightly below the national Ph.D. rate of 17.9% in EE going to women.

At the faculty level, UWEE has 8/42 (19%) women faculty, which compares very favorably with the national average of 11.2% women tenured or tenure-track faculty in EE. UWEE has a strong history of having successful women faculty. Its first woman faculty member, Emerita Professor Irene Peden, was hired in 1961 and is a member of the National Academy of Engineering.

At the BSEE level, 16/156 (10.25%) of the degrees went to underrepresented minorities (African American, Native American, and Hispanic American). At the MSEE level, 5/60 = 8.33% went to underrepresented minorities and 1/32 = 3.1% of Ph.D.s went to underrepresented minorities. The department does not currently have any underrepresented minority faculty members.

Diversity goals for the department include increasing the percentages of women students and faculty, the percentages of underrepresented students, and hiring underrepresented faculty. As far as increasing the percentages of women students, the department is leveraging its relatively high percentage of women faculty to help build community among women students.

Section 4: Future Directions

4.1 Education

The department's immediate and near-future plans in educational programs include the following:

4.1.1 An Integrated B.S. and M.S. program

We intend to create over the next two years an integrated Bachelors and Masters program. The motivation behind this program is (a) to attract our top B.S. students towards our graduate degree with a seamless transition (b) to offer students the chance to enhance their knowledge and marketability in a competitive job market and (c) to offer an opportunity for B.S. students to consider graduate research and a PhD degree while gaining a highly valuable M.S. degree.

The specific details of the additional year of curriculum are currently under discussion. Additionally under consideration is whether to include students from related B.S. majors such as other engineering disciplines, physics, and applied math for whom such an integrated program might also be advantageous.

4.1.2 A fee-based daytime M.S. program

We intend to create over the next year a fee-based daytime M.S. program. The motivation behind this program is (a) serving the needs of domestic students of high quality and a domestic market for high-tech graduates (b) serving the emerging needs of the international community and an international high-tech market, and (c) additional revenue generation for the department to be used towards fund-raising goals including funded PhD's and supporting resources. It appears based on current analysis that Activity Based Budgeting (ABB) will not benefit or provide sufficient resources to support such a program, especially without the element of differential tuition. This may change in the longer term at which time this proposed fee-based program might be transitioned to a state-funded one. We will also rapidly examine ABB-based alternatives with differential tuition if these become available; the teaching of engineering students is significantly more expensive than that for students in other units and therefore differential tuition needs to be adopted in conjunction with ABB to be relevant and useful for such a program.

4.1.3 Enhancing quality and funding of students in the PhD program

As discussed in Section 3, an enduring and growing strength of the electrical engineering department is the quality and impact of the research program. A strong element of this program is the admission, mentoring, and accomplishment of high-quality graduate students. The department has a long and successful track record in attracting and retaining high-quality graduate students, including funding and participation in research projects. The following areas will be the focus of continued enhancement over the next several years (a) A goal of fully funded PhD students (b) The increased ability to offer multi-year guaranteed funding to high-quality entrants and (c) Recruitment of high quality students from B.S. and M.S. programs.

4.1.4 An Expanded Professional Masters Program

The electrical engineering department's professional masters program has been in existence for four years and has successfully provided a means to (a) provide career-enhancing education to the local workforce in the Pacific Northwest and (b) provide an additional revenue path to the department in times of massive state funding compression. The need, demand, and benefit of the PMP warrants an expansion while managing quality. Towards this goal, the department is working on exploring and then implementing the following options in the next two years (a) Online delivery of content and enrolment of students in online-only PMP offerings using technology made available at the University of Washington (b) Remote two-way classes with local TA support at locations in high-demand locations and employers in the Pacific Northwest, nationally, and internationally (c) Integration of the electrical engineering PMP with other PMP offerings in engineering and the sciences in order to create further differentiation, flexibility and interest for applicants. An important feature of our PMP has been the high-quality and industrially relevant teaching by involving regular research-active tenure track faculty, and it will be a challenge to continue to maintain the quality while scaling the PMP. There will be a need for training additional high quality instructors and involving high-quality TAs in many aspects of the program.

4.2 Integrating Education and Research

The need for integrating research with education is stronger than ever before, and is critical to our mission. We will continue to build on our strengths in this area by involving our industry advisory board and industrial affiliates, using industry collaboration and support for capstone classes, developing new mini-curricula in conjunction with center and large-scale research proposals, and providing support for faculty developing integrative research and education proposals including IGERT, IGAANN, EURP, NSF REU and others. The department has a strong and established record in this area and we will continue to grow in this dimension. The educational programs discussed in Section 4.1 and the research directions in Section 4.3 will result in a significant amount of collaborative and integrative coursework, projects, and curricula.

4.3 Strategic Research Areas

As part of the strategic plan for the department currently under development and initiated in early 2012, a strategic committee was formed to develop and discuss with the faculty strategic research areas. Based on a detailed analysis of six impact factors (faculty, education, funding, collaboration, tech transfer, and development & resources), the following three strategic areas have emerged as the most important for the department's research future in terms of building stature, funding and resources, overall impact, and consistency with the department's mission.

4.3.1 <u>Big Physical Data and Complex System Design</u>

In the vertical integration and design of engineered systems, there is the acceptance that a *design gap* is evident and growing. The reason for this gap is the inability of design and manufacturing methods to optimize over every hierarchy and level in order to synthesize systems that function near physically realizable limits. This is particularly true for electronic systems and those where some level of electrical actuation, sensing, computation, and communication, are central. Design gaps are evident in manufacturing methods and scaling, costs, power consumption, interoperability and coexistence of systems, security and trust, health and environmental impact, and deployability and reuse of systems.

We aim to push forward towards the envelope of physical reliability by integrating vertical strengths in the department, college of engineering, and the University of Washington in order to reduce design gaps and offer scalability of the form made famous by Moore's Law in the most complex engineered systems arising in energy, health, the environment and related large-scale problems. We intend that the long-term outcome of this area will be new mechanisms for discovery, synthesis, and design of complex engineered systems.

Big physical data and complex system design is our department's strategic thrust and research area that conjoins two complementary and parallel methodologies:

- The devices, systems, and signals associated with complex engineered systems that interact with physical sources
- The design and synthesis techniques for the devices, systems, and signals associated with complex engineered systems

Big physical data refers to the large volume physical datasets of dimension, scale, size, and rate so large that existing techniques for the storage, capture, visualization, and sharing of such datesets is not possible with existing techniques. Big physical data is the physical manifestation of the Big Data area that falls within the purview of computer science, statistics, and applied math. The term physical implies the availability of underlying dynamics, sparsity, causality, entropy, conservation laws, energy etc. in the data that brings detailed structure and richness. Electrical engineering systems that sense, measure, communicate, compute, and evolve are all generators of big physical data. Complex system design refers to the challenges associated with vertical hierarchical design across multiple levels of abstraction, from the smallest molecular devices through system susbtrates to the algorithms, architectures, and applications that both exploit and drive these system designs.

The excitement around this thrust area is furthered by the belief that the critical mass for growing this area rapidly already exists in the department with expertise in circuits, electromagnetics, communications, nanoscale and molecular simulation, synthetic biology, control systems, energy systems, wireless systems, and a range of computational and optimization algorithms. This area is necessarily inclusive and interdisciplinary in nature, requiring experimentalists, designers, theorists, and computational experts to build the vision of big physical data and complex system design as a team.

A specific example of this area is the challenge of coexistence of multiple wireless systems in interference-rich environments while managing power, security, resource efficiency, and health and privacy issues. A second example, showing synergy with the Medical and Molecular Systems and Devices strategic research area, relates to engineering design automation for synthetic biology, wherein interactions between biological species are highly networked and nonlinear. A third example is the design of devices, systems, and data management for highly networked point-of-care diagnostics and distributed health monitoring systems.

This thrust, while necessitating breakthrough long-term basic research, also has strong industry drivers including the need for the design of integrated systems under uncertainty and cost constraints, inverse problems or synthesis of systems, design gap reduction, and product scalability. We envisage workshops leading to a center proposal in the area of *Synthesis of Physical Systems*. Such a center will require strong collaborations with many areas at UW and elsewhere including computer science, engineering, medical and molecular sciences, basic sciences, applied and pure math, statistics, and also involving the business school (Foster) and the center for commercialization (C4C).

4.3.2 Medical and Molecular Systems and Devices

The University of Washington has a world-leading enterprise in biomedical research, and this proximity is a key strategic advantage for our department compared to other EE departments. Substantial interactions already exist to exploit this resource, but as biological ideas grow to have greater technological impact, and as society has greater needs for higher quality of healthcare, we need to increase such interactions.

There are at least two general ways in which Electrical Engineers can play a key role in this field: creating physical interfaces to biology and creating quantitative models of biological systems. Our current EE faculty has already a strong base in these areas, which should be expanded systematically:

- New interfaces between biological and electronic systems, spanning size scales of many orders of magnitude: from quantum dots and molecular probes that can provide signals from the inside of a living cell, to implantable MEMS/NEMS devices that establish permanent interfaces between electronics and biology, to robotic surgery and robotic prostheses.

- The way we think of biological systems is being increasingly influenced by engineering approaches. With larger computing power and better algorithms, more and more complex systems can be effectively modeled and (re-)designed. This area has a natural overlap with the first thrust area in Section 4.3.1.

Some examples of high-impact ongoing research in this interaction cluster in the department are:
- Synthetic Biology
- Surgical Robotics and surgical skill assessment
- Brain machine interfaces
- Robotic rehabilitation devices
- Nano scanning endoscopes

The construction of molecular systems involving a significant number of interacting components (and not just single types of molecules) is at the forefront of engineering today. The main example is synthetic gene networks in genetically engineered organisms. Synthetic biological networks will be used in the near future in a variety of entirely new, transformative industries. These industries include: using cells to diagnose disease states; directed gene therapy; tissue and organ engineering; neural interface engineering; plant and foodstock engineering;

bioremediation; bio-defense against emerging infectious diseases. However, a number of key challenges stand in the way. Primarily, we do not yet know how to design, construct, model, test, or predict large-scale synthetic gene networks that sense, compute, and respond to their environments. To make progress requires us to understand more than how proteins fold, how DNA stores information, or how the cell performs chemical synthesis. What is required is that we understand how living systems compute.

One key observation of the 21st century will be*: Life is computation and that it is entirely engineerable*. Synthetic gene networks use molecular sensors, such as membrane bound receptors, that can sense molecular concentrations, chemical gradients, electrical charge, light, and so on. They involve signal processing, in which the activity of sensor molecules must be thresholded, filtered, integrated, and routed. They involve engineered effectors such as molecular synthesis, cell movement, bioluminescence, differentiation and many other effects. Synthetic gene networks require careful modeling in the face of vast uncertainties and large, noisy datasets -- as well as clever engineering. Gene networks are designed very similarly to early analog circuits. For example, vacuum tubes are traditionally difficult to model. However, large tables of their properties in certain contexts allowed engineers to build reliable and robust systems with them -- especially using feedback. Indeed, many of the ideas explored by Bode, Nyquist, Black, and others are being revisited in the synthetic biology community. Synthetic biologists have implemented Boolean logic, built adders, amplifiers, communication networks, and more. The paradigm of electrical and computer engineering is proving to be incredibly useful for synthetic biology.

Others at UW (in biochemistry microbiology, genome sciences, bioengineering, chemistry, biology, etc) are building the parts. UW is a world leader in genetic engineering -- for example the legacy of Ben Hall is based on genetic engineering and the expertise to put any gene into any organism and figure out what it does is here; UW's students are the best trained to feed into a synthetic biology program, as evidenced by our world championship winning iGEM team (synbio.washington.edu/education/igem/) ; UW and Seattle have arguably the best presence in the world in global health research and funding, much of which is based on molecular and genetic engineering of diagnostics and therapeutics for infectious diseases, etc.; Seattle is a hub for biotech and biotech-related venture capital. Furthermore, there is tremendous interest in synthetic biology, as shown by attendees at a recent UW workshop on synthetic biology which brought more than 80 researchers together for a day of talks at Microsoft Research in January 2012.

The fact that this thrust involves both medical devices and molecular systems is not accidental. *Convergence*, especially as discussed by the National Institutes of Health, involves merging and interplay between devices, biologics, and drug design. In a larger sense, convergence between the life sciences, physical sciences, and engineering is also inevitable and we feel this thrust area can both benefit from and lead these paradigm changes.

4.3.3 Sustainable Energy

The drive to put energy consumption on a sustainable footing is driven not only by environmental concerns but also by economic and political considerations (e.g., industrial competitiveness and energy security). This issue is therefore not going to go away any time soon and its solution will require more than installing a few wind farms. Here are some examples of areas where our department already contributes to a sustainable energy future

- The development of enhanced devices for photovoltaic energy conversion.
- The development of techniques for the efficient operation and planning of power systems with a significant amount of stochastic and intermittent energy sources
- The development of techniques for incorporating large scale storage and demand response in the daily operation of the grid
- The design of communication and control systems that make possible the implementation of the "smart grid" concept
- The design of sensors and sensor systems that make possible a more efficient use of energy
- The design of ultra low power devices and of devices that can harvest energy from their environment.

Our strategy with respect to research in sustainable energy is not to approach it as a problem in traditional power engineering but rather as a complex issue that will require contributions from specialists in areas such as communication, control, sensors, optimization, devices and materials. There are also many opportunities for collaboration with other engineering and non-engineering departments, for example:

- With mechanical engineering and civil engineering on the integration of specific renewable energy sources into the grid
- With computer science and engineering on smart grid architecture issues
- With industrial engineering on optimization techniques as applied to the large, non-linear and non-convex power systems problems
- With material sciences and engineering on the development and deployment of energy storage devices
- With the College of the Environment on the environmental impact of renewable energy sources
- With the departments of economics, public policy, and business on the economic, business viability and acceptability aspects of energy issues.

On all these issues, the EE faculty members who specialize in electrical energy can provide the domain-specific expertise and will actively pursue the development of joint research proposals. The appointment of the endowed Close Professor and of a research assistant professor, as well as the planned 2012 hires of a tenure track assistant professor and of a WOT (without tenure) professor in collaboration with PNNL will bring the size of this core group of individuals working in the sustainable energy area to six, which represents a critical mass of expertise.

Very few electrical engineering departments in the country have succeeded in maintaining an active research program in energy/power engineering. Besides UW, the notable exceptions are Arizona State University, Iowa State University, the University of Illinois, Texas A&M, the University of Wisconsin-Madison, Washington State University, and Georgia Tech. With the renewed interest in energy issues, other universities are trying to ramp up their activities in this area but often find that they lack the core knowledge needed to make their research proposals credible. Our department is currently developing strategic collaborations with significant regional partners such as Pacific Northwest National Laboratory, Bonneville Power Administration, Alstom Grid and Washington State University to position itself to bid for a DOE-funded Energy Regional Innovation Center (E-RIC).

4.4 Advancement and Entrepreneurship

The department has a large number of successful alumni generated over a long time period. Previous strong efforts in advancement have led to a modest number, of fellowships, scholarships, and professorships. Appendix B shows that there is a significant need to enhance the number of scholarships and fellowships.

In order to support our large PhD program, RA support needs to be supplemented with some state funding (TAs) but also importantly with fellowships for guaranteed multiyear support from the onset. This is a critical part of raising the stature of our department through attracting top student talent. We have made this our primary advancement goal going forward, with a second critical goal of professorships and endowed professorships for attracting and retaining high-quality faculty of the level that our department is fortunate to have.

We will aim to continue the near decade of investment in EE400, the EE Leadership Seminar Series, in which we bring UW EE alums to talk to our students about their careers, and engage in stewarding them towards donations. We have also discussed the idea of merging this into the undergraduate curriculum more broadly, possibly with the Introduction to Professional Issues course (EE398).

For the first time in the history of the department, the new administration (September 2011) includes an Associate Chair for Advancement (and Infrastructure) who will work with College Advancement and share the tasks of fundraising with the Chair.

Building strong relationships with industry is critical for aspects of the department's mission. Towards this goal, we will revitalize and focus our Industrial Advisory Board with invited top management from high-tech companies who would be interested in advising the department on strategy. We also aim to build a new Industrial Affiliates Program, for which we have received strong early interest from a range of high-tech companies. Membership in this program will enable companies to interact with faculty and students, and influence aspects of research and course projects. We intend to start this program in 2012-2013.

We also believe that entrepreneurship can provide additional flexibility and avenues for leadership, discovery, and overall enrichment of both the student and faculty experiences. Recent successes in the department of companies such as Zensi and Nimbic, and the recent emergence of a strong and successful Center for Commercialization (C4C) at UW strengthens the opportunities in this area. The department will work with C4C, the Foster Business School, and entrepreneurs and the local investment community (which has been very strong in supporting UW startups) in building these strengths in a significant manner towards additional impact, stature, and revenue.

PART B
UNIT-DEFINED QUESTIONS

5 Unique Strengths to Build Upon

5.1 What synergies in the university and region can our department leverage ?

The department of electrical engineering, in the college of engineering, at the University of Washington has the benefit of several local and historical strengths that it can call upon. These include

- The research strengths and research traditions in the department
- The strengths of other departments and units on campus including the highly ranked and renowned medical school, and the highly ranked computer science and engineering and bioengineering departments
- The abundance of collaborative opportunities with natural allies in sciences and engineering including other engineering departments, physics, math and applied math, chemistry, biology
- The possibility of meaningful collaboration in new crosscutting areas in conjunction with the College of the Environment, the Foster Business School, and the UW Center for Commercialization.
- An establishment of large high-technology companies in the Seattle area and surroundings including but not limited to Boeing, Intel, Microsoft, Amazon, Google, etc.
- A large and thriving startup and entrepreneurial culture in the greater Seattle area, especially in the areas of biomedical systems and enterprise software including the presence of angel investors, venture funds, foundations, and a market for strong technical talent.
- The relatively strong geographical location w.r.t to the strong high-technology sector of established companies, startups, and funding sources in the Silicon Valley of California.
- The relatively strong geographical locations w.r.t. positioning of alternative energy initiatives in the state of Washington
- The relative strong geographical location w.r.t to the emerging high-technology needs and demands of the Asia-Pacific rim

5.1.1 What strategic research areas should our department pursue ?

As discussed in Section 4.3, we are developing a new strategic plan based on our strengths and opportunities. Based on a detailed analysis of six impact factors (faculty, education, funding, collaboration, technology transfer, and resources), the following three strategic areas have emerged as the most important for the department's research future in terms of leadership and excellence in discovery, building stature, funding and resources, overall impact, and consistency with the department's mission.

- Big Physical Data and Complex Systems Design (Section 4.3.1)
- Medical and Molecular Systems and Devices (Section 4.3.2)
- Sustainable Energy (Section 4.3.3)

5.1.2 How do we enhance collaborative research and impactful large-scale innovation?

We have a strong feeling and evidence in the department that meaningful collaborative research can benefit us in many ways including (a) bringing faculty and students together to create a more cohesive and collaborative community and (b) enabling us to build on core strengths and at the same time lead in emerging areas. All the three strategic areas that the department intends to pursue are by nature highly interdisciplinary and will require the involvement of a large proportion of our faculty and collaboration across the college of engineering and other units in the university.

In a foreseeable future of diminishing state funding, budget challenges, and the continuing impacts of a shaky global economy, alternative and parallel modes of supporting such research are critical. A modest yet effective method that provides leverage and has generated success is to provide seed funding for release time, exploratory projects, and workshops. The present administration will build on this idea by providing support for workshops and multi-PI proposals. A successful example of this was a January 2012 workshop in the emerging area of Synthetic Biology (and part of our Medical and Molecular Systems and Devices) that brought together a large community of researchers across UW. A similar model eventually led to the successful NSF ERC on Sensorimotor Neural Engineering, consistent with the thrust area in Section 4.3.2, and where several EE faculty are playing key leadership and innovation development roles. Our aim is to expand our scope such that we may have within the next decade *at least one recognized nationwide center in each thrust area*. There is recognition that with the expansion of synthetic biology that the thrust area in Section 4.3.2 may have more than one associated center.

Hiring in focused strategic areas is one of the best approaches to growing and developing super-critical mass and topical excellence and leadership. In 2012, we are in the process of hiring faculty in the strategic area of Sustainable Energy. We feel that, based on the development of critical strategic areas, that hiring in each of these areas is important in order to build excellence and become leaders in the field. Avenues for strategic hiring will extend beyond regular departmental hiring to work with multiple departments, multiple colleges, university initiatives, and advancement opportunities. This has worked well in the past in the department through interdisciplinary and multi-department hires in Molecular Engineering, and with CSE through the EXCEL program.

5.1.3. <u>What is the core competence of Electrical Engineering, what is our Electrical Engineering identity? How do we maintain this core and identity while also responding sensibly to the imperatives for interdisciplinarity? What is our role and our place in the college and the university ?</u>

This question represents an ongoing enquiry and healthy debate into the evolution of our field. We continue to be respectful of all sub-disciplines in EE; it is observed that the relative maturity of different sub-disciplines is different and changes over time. We aim to focus on the core strengths and principles of EE, while also understanding that new breakthroughs often come at the interface of existing areas. Our strategic areas discussed in Section 4.3 are therefore chosen to use the core strengths in the department to attack interdisciplinary areas with the rigor and techniques associated with EE. We believe that EE should be central in whichever areas we want to focus on, but that the nature of EE will itself evolve over time. In a similar manner, our role and our place in the college and at UW will be consistent with our mission of addressing the biggest challenges of our time. Therefore it is imperative that our strategic plan and our faculty are involved in building excellence and leadership across the college and university, while maintaining EE centrality and using our core strengths for high impact programs in health, energy, the environment, and people-centric systems.

6 Strategies for Degree Programs

Following on our discussion Section 4.1, enhancing our degree programs further is important, in a manner that maintains the excellent standards that these programs have had for a long time. A daytime masters program (Section 4.1.2.), fee-based or ABB/differential tuition based is being currently discussed. Our relatively new and successful Professional Masters Program is a contact-only program and we are exploring ways to take this program online (Section 4.1.4) as well as combine with other similar programs across campus to provide students with strong flexibility through a hub-spoke model of courses. In our elite PhD program, our emphasis is to find means to attract the best students (Section 4.1.3) through endowed fellowships in addition to research based assistantships and state-funded teaching assistantships. Finally, we intend to develop an integrated BS-MS program (Section 4.1.1) with the possibility of involving other departments in engineering and the sciences.

7 Alternate Pathways for Revenue Generation

At a time when state funding is at precipitiously low levels with possible further cuts, there is an immediate need to develop additional revenue sources in order to maintain and grow the quality and strength of our program. Professional degree programs including the PMP, fee-based graduate programs, revenue generation through intellectual property, startups (Section 4.4), and royalties, and additional incentives for high quality service teaching paralleling the A/B plan for incentivizing research will all be pursued aggressively.

We will also streamline processes and automation in our department to enhance efficiency. These include electronic databases and web access, and student information. For instance, recent changes in graduate admissions databases has allowed a more streamlined graduate admissions process at a new all day faculty retreat (most recently held in January 2012) to discuss and complete admissions and funding offers nearly a month earlier than before.

8 Moving Forward and Upward: Consolidation and De-emphasis

Are there areas where we should place a significant part of our resources, and are there areas to de-emphasize ? Our department has always valued, and will continue to value strong intellectual and scholarly work, both individual and in collaborative teams, in all areas in EE. At the same time, we recognize that we intend to stay true to our long term vision

To nurture and develop tomorrow's engineering leaders in an environment of excellence in discovery with visionary researchers, by

- Providing world-class undergraduate and graduate education in Electrical Engineering
- Conducting high-impact research of technical influence and recognized excellence
- Addressing and formulating engineering solutions to aspects of the largest challenges facing humanity in health, energy, the environment, and in people-centric systems

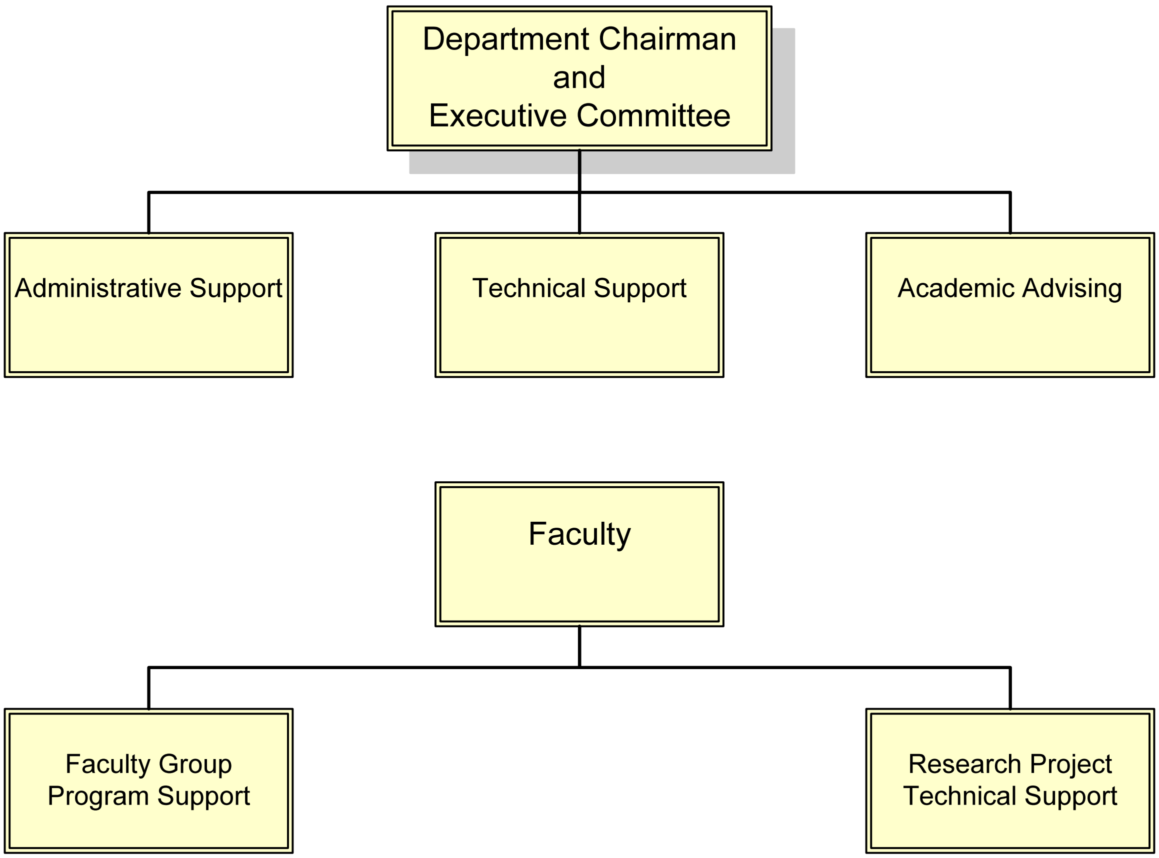
Therefore we intend that strategic research areas will form the basis of resource allocation in the form of strategic collaborations, large-scale center efforts, faculty hires, seed funding, and curriculum development for integrating research and education. This will be done without in any way trading off quality, since we feel that new discoveries are generated by using the rigor at the core of traditional areas in new ways. The department will also work towards helping faculty in research adaptation through collaborations, focussed sabbaticals, seeded projects, and mentoring.

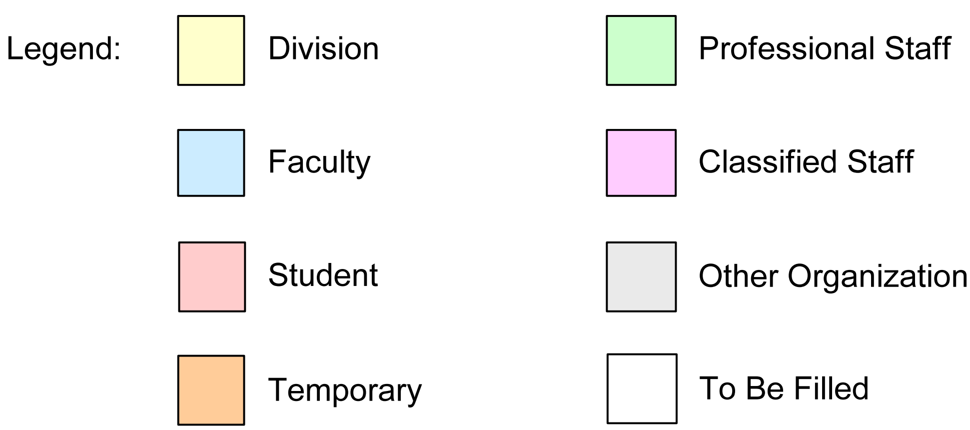
Electrical Engineering is at an exciting and opportune juncture where it can rightfully form a strong leading basis in many of the new discoveries yet to be made in addressing the largest challenges facing humanity, and as a department and a unit of the University of Washington we intend to be at the forefront of this adventure over the next decade. Our singular goal is aggressive, to be counted as an EE department of the highest stature.

PART C
APPENDICES

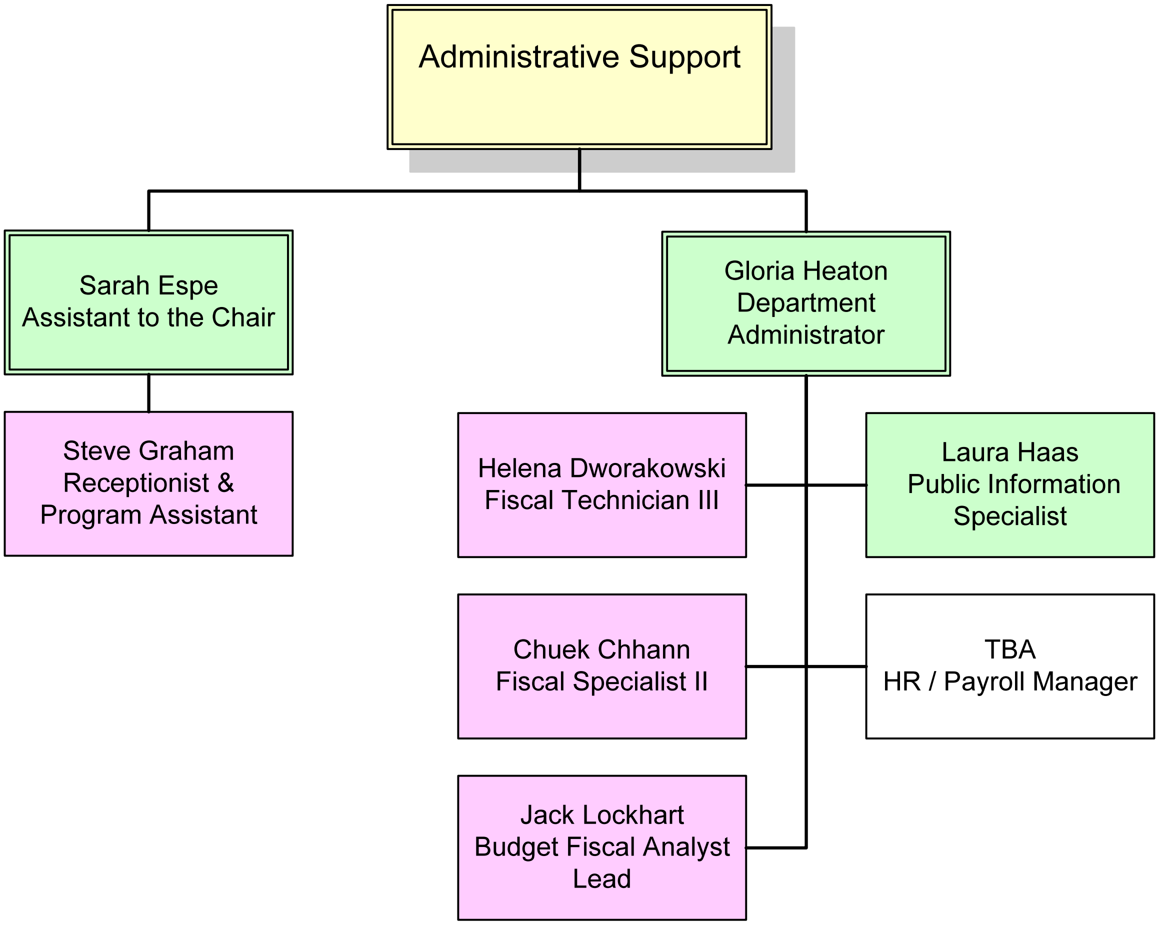
Appendix A: Organization Charts

A.1 Division Chart and Legend

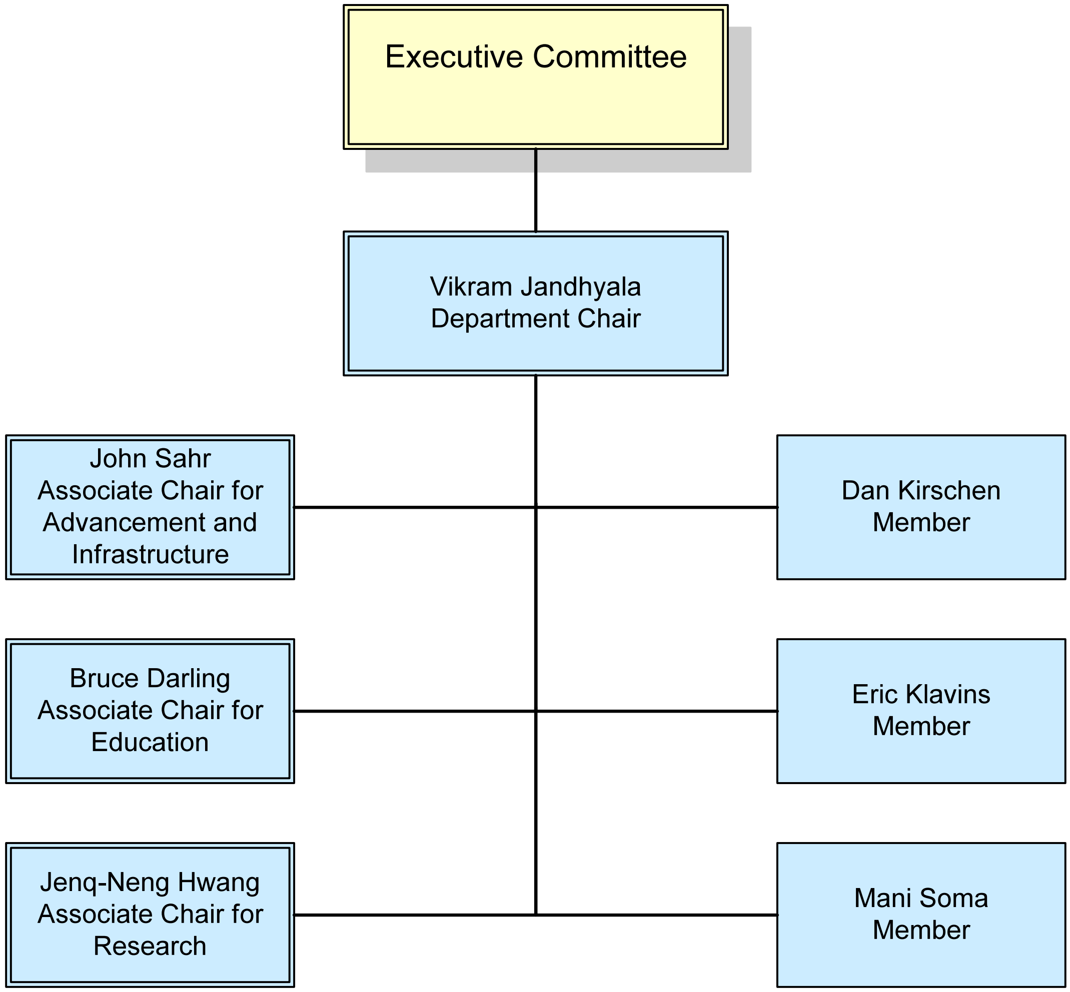




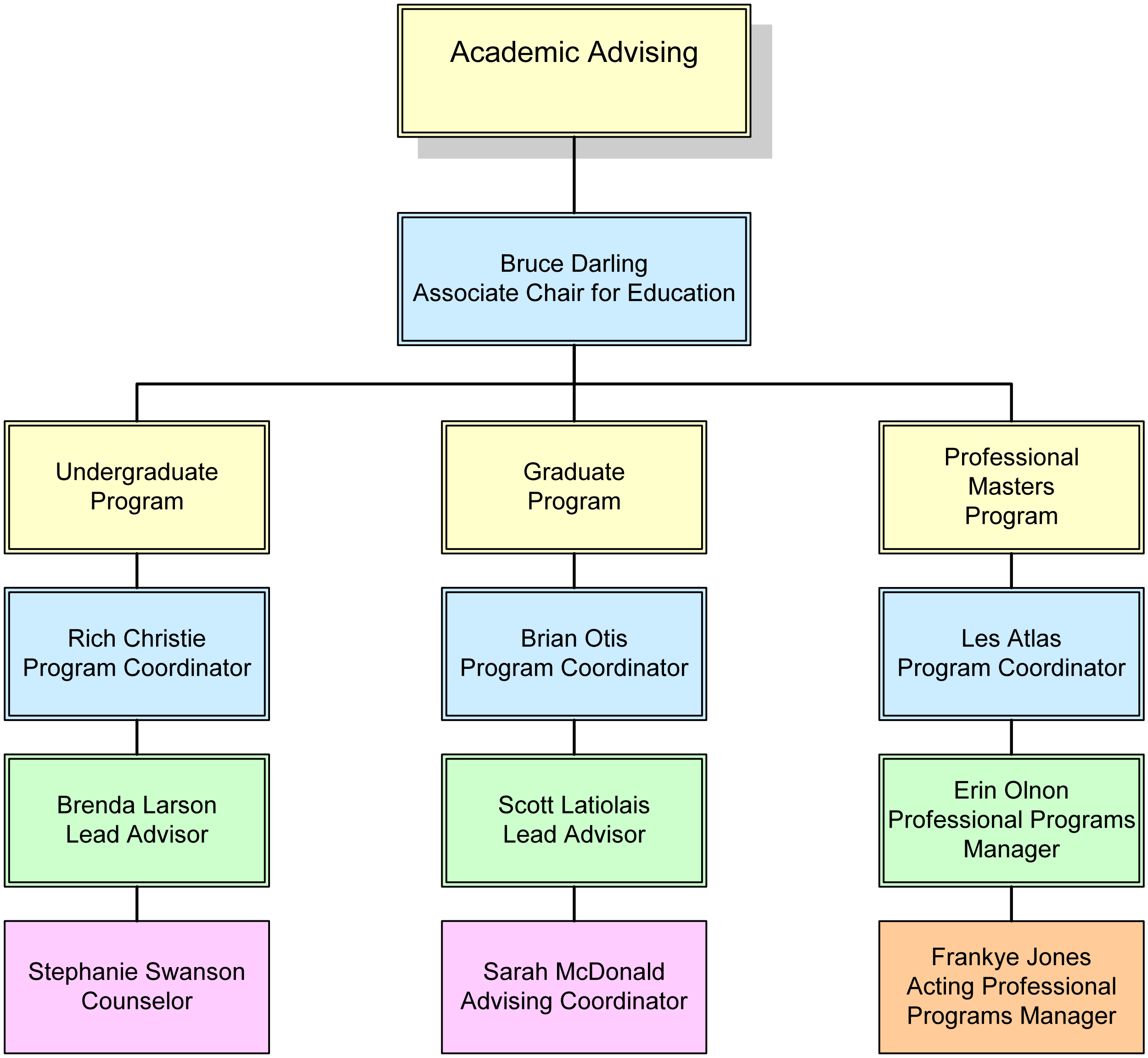
A.2 Administrative Support



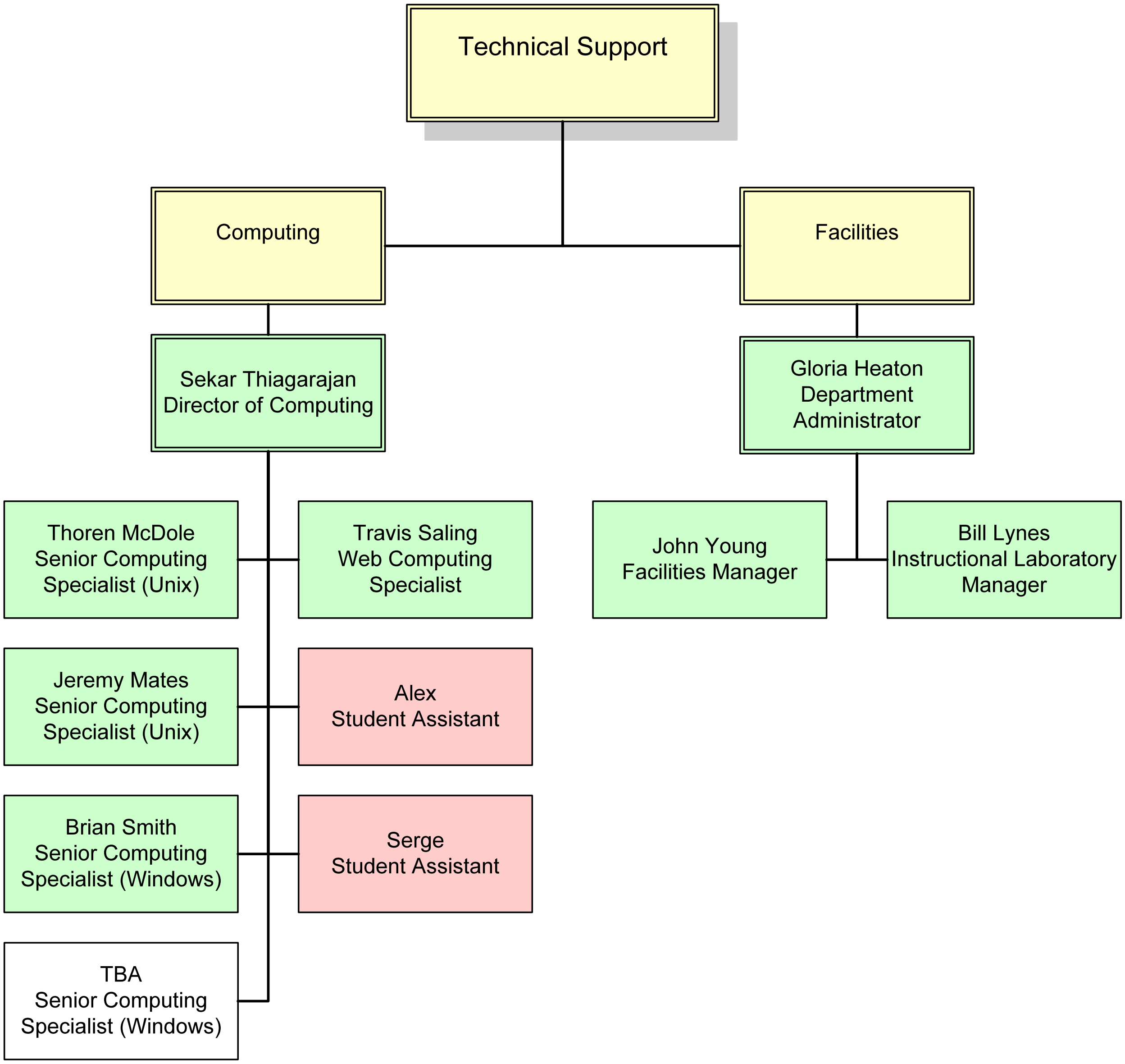
A.3 Executive Committee



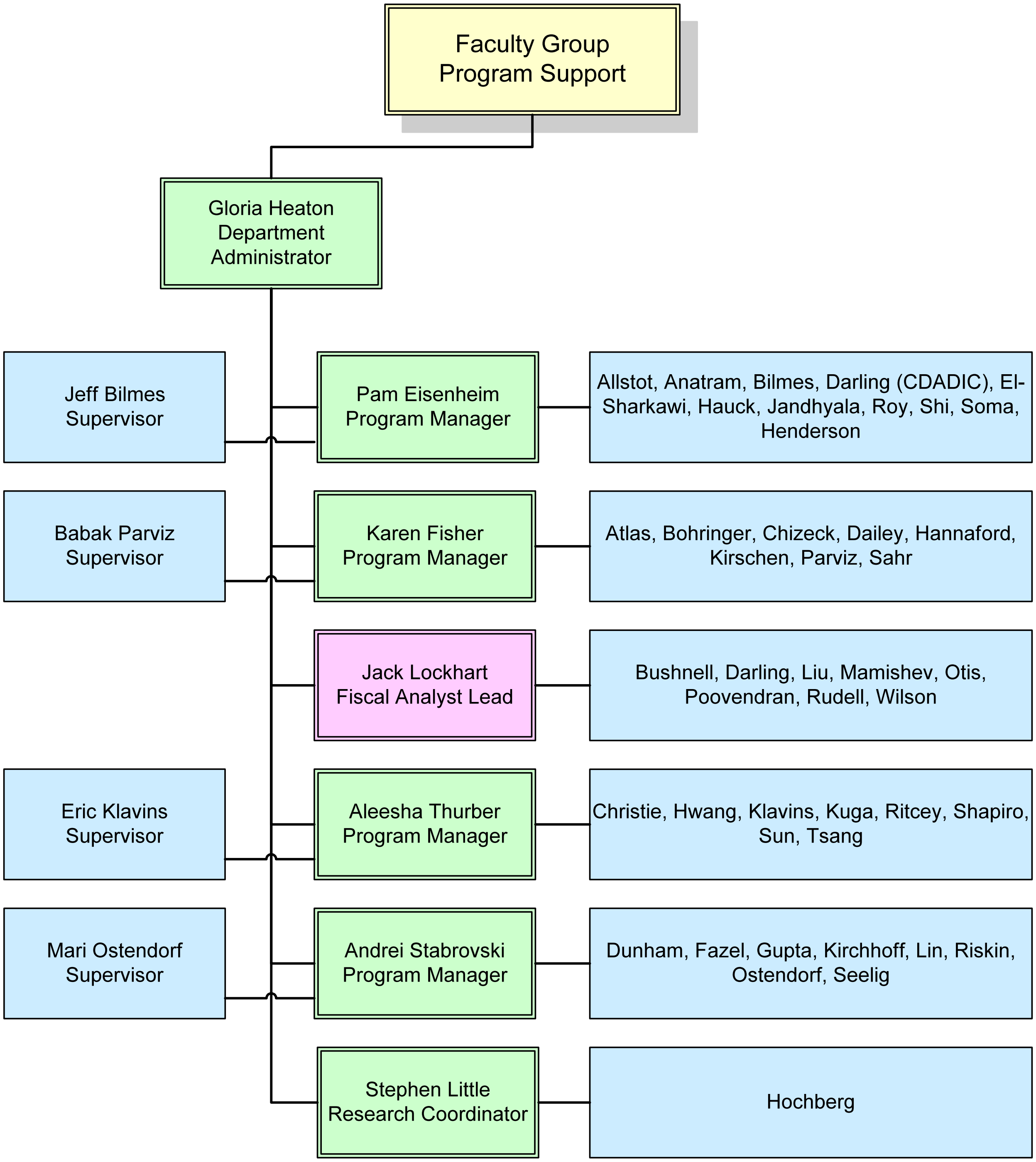
A.4 Academic Advising



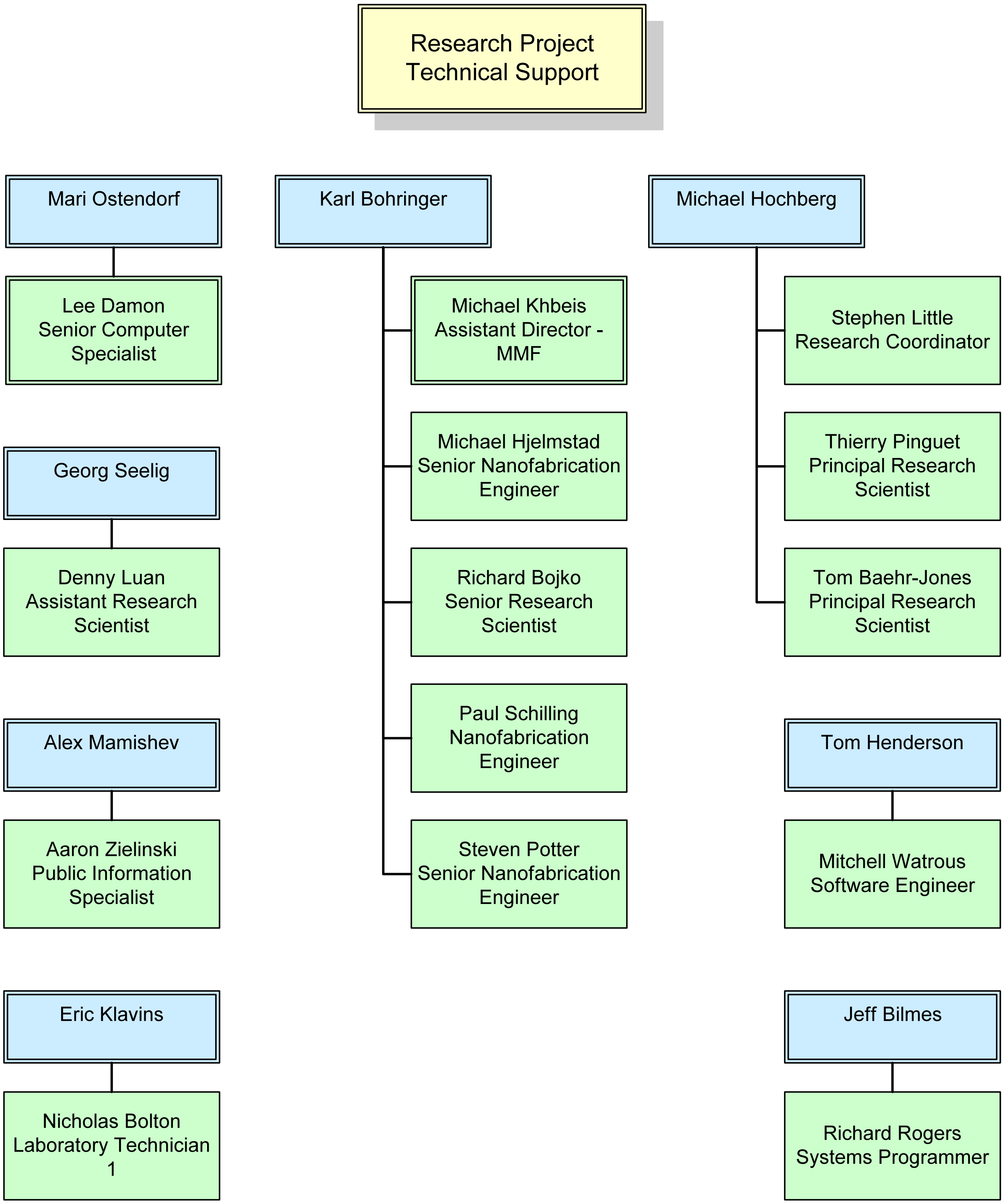
A5. Technical Support



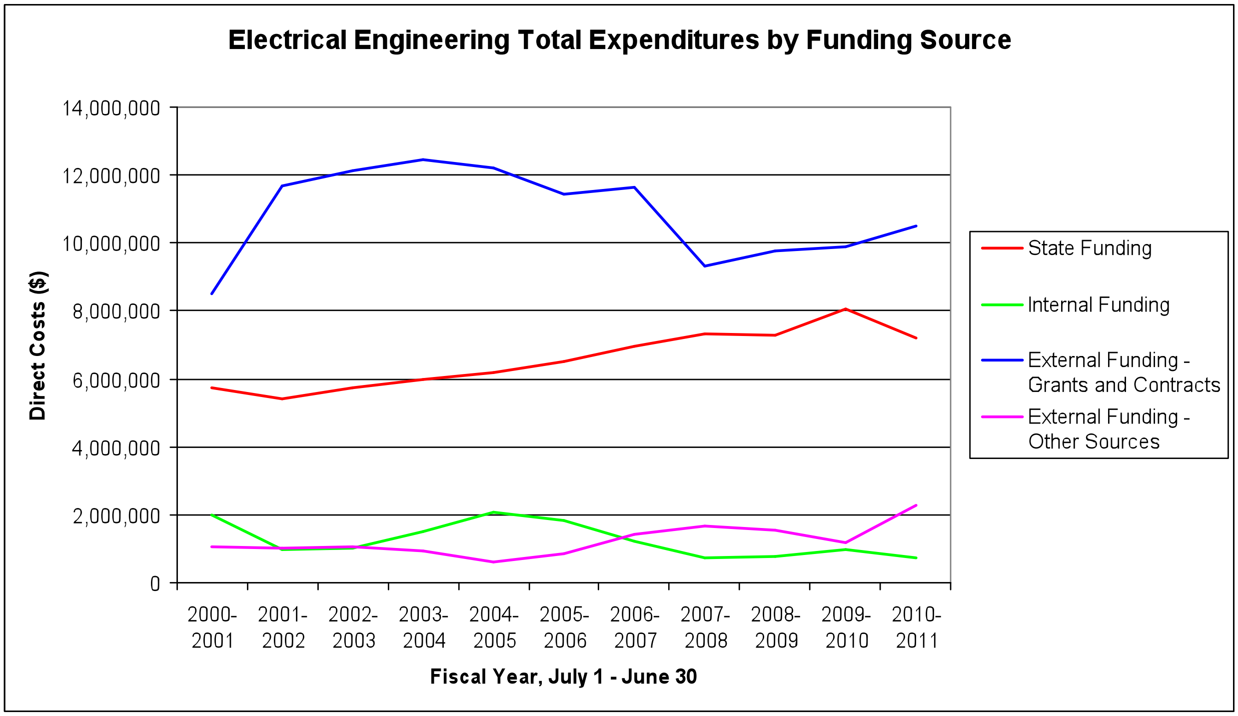
A6. Faculty Group Program Support



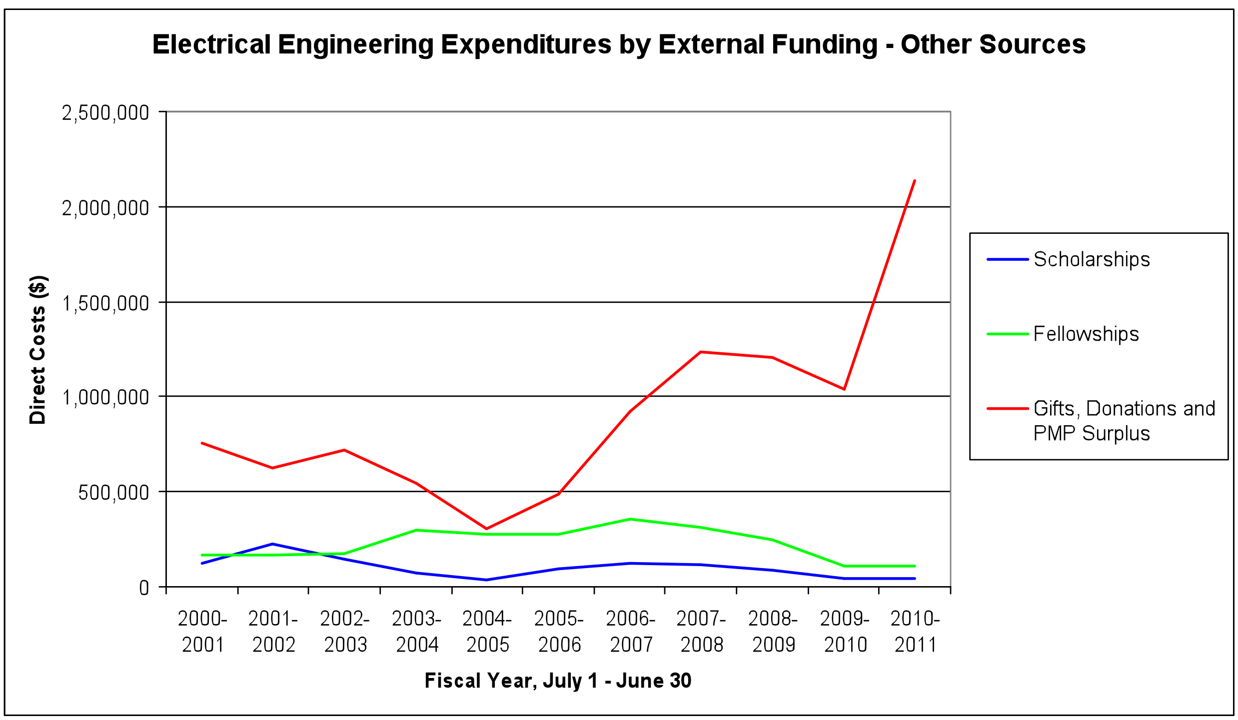
A7. Research Project Technical Support



Appendix B: Budget Summary



State funding includes the general operating funds plus tuition operating fees.
Internal funding includes indirect cost recovery plus investment income.



Appendix C: Information About the Faculty

Tenure Track Faculty	Title	Appointment Type	Joint and Adjunct Appointments
Afromowitz, Martin	Professor	9 Month	N/A
Allstot, David	Professor	9 Month	N/A
Anantram, M.P.	Professor	9 Month	N/A
Atlas, Les	Professor	9 Month	CSE
Bilmes, Jeffrey	Associate Professor	9 Month	CSE, Linguistics
Bohringer, Karl	Professor	9 Month	CSE, ME
Chizeck, Howard	Professor	9 Month	BioE
Christie, Richard	Associate Professor	9 Month	N/A
Darling, Bruce	Professor	9 Month	N/A
Dunham, Scott	Professor	9 Month	MSE, Physics
El-Sharkawi, Mohamed	Professor	9 Month	N/A
Fazel, Maryam	Assistant Professor	9 Month	CSE, Math
Fu, Kai-Mei	Assistant Professor	9 Month	BioE, joint w/ Physics
Gupta, Maya	Associate Professor	9 Month	Applied Math
Hannaford, Blake	Professor	9 Month	BioE, Surgery
Hauck, Scott	Professor	9 Month	CSE
Hochberg, Michael	Assistant Professor	9 Month	N/A
Hwang, Jenq-Neng	Professor	9 Month	N/A
Jandhyala, Vikram	Professor	9 Month	N/A
Klavins, Eric	Associate Professor	9 Month	CSE
Kuga, Yasuo	Professor	9 Month	N/A
Lin, Lih	Professor	9 Month	Physics
Liu, Hui	Professor	9 Month	N/A
Mamishev, Alex	Associate Professor	9 Month	ME
Ostendorf, Mari	Professor	9 Month	CSE, Linguistics
Otis, Brian	Assistant Professor	9 Month	N/A
Parviz, Babak	Associate Professor	9 Month	N/A
Patel, Shwetak	Assistant Professor	9 Month	joint with CSE
Poovendran, Radha	Professor	9 Month	N/A
Riskin, Eve	Professor	9 Month	CSE
Ritcey, James	Professor	9 Month	N/A
Roy, Sumit	Professor	9 Month	N/A
Rudell, Jacques Chris	Assistant Professor	9 Month	N/A
Sahr, John	Professor	9 Month	Earth & Space Sci
Seelig, Georg	Assistant Professor	9 Month	BioE, joint with CSE
Shapiro, Linda	Professor	9 Month	joint CSE
Shi, Richard	Professor	9 Month	N/A
Smith, Joshua	Associate Professor	9 Month	joint with CSE

Soma, Mani	Professor	9 Month	N/A
Sun, Ming-Ting	Professor	9 Month	N/A
Tsang, Leung	Professor	9 Month	N/A
Wilson, Denise	Associate Professor	9 Month	N/A
Research Faculty	**Title**	**Appointment Type**	**Adjunct Appointments**
Bushnell, Linda	Research Assistant Professor	12 month	N/A
Crum, Lawrence	Research Professor	12 month	N/A
Dailey, Daniel	Research Professor	12 month	N/A
Kirchhoff, Katrin	Research Associate Professor	12 month	CSE, Linguistics
Nelson, Brian	Research Associate Professor	12 month	N/A
Without Tenure	**Title**	**Appointment Type**	**Adjunct Appointments**
Arabshahi, Payman	Associate Professor, WoT	3 Month	APL (primary)
Lecturers	**Title**	**Appointment Type**	**Adjunct Appointments**
Peckol, Jim	Senior Lecturer	9 month	N/A
Emeritus/Departed	**Title**	**Appointment Type**	
Kim, Yongmin	Professor	9 Month	Professor of Bioengineering and EE; President of POSTECH-Pohang University of Science and Technology

Faculty CVs are available at http://www.ee.washington.edu/operations/administration/dept_review_2012/faculty.html

Appendix D: HEC Board Summary

EXISTING PROGRAM REVIEW: HEC BOARD SUMMARY

Unit authorized to offer degrees:	Department Electrical Engineering
College:	College of Engineering
Degree Titles:	Bachelor of Science in Electrical Engineering (offered through the College of Engineering) Master of Science (one degree title covers our traditional full-time program, and one covers our part-time evening Professional Master's Program) Doctor of Philosophy
Year of last review:	2001
Date Submitted:	February 1, 2012

Number of instructional faculty, students enrolled, and degrees granted over the last three years
(Autumn-Summer)

	2008-09	2009-10	2010-11
FTE instructional faculty:			
Tenure-track faculty	38	41	41
Research-track faculty	7	6	6
Lecturers and WOT	1	4	2
Total	46	51	49
FTE graduate teaching assistants **	129	130	134
Degree Program: Bachelor of Science			
Headcount of enrolled students	486	473	469
Number of degrees granted	173	156	163
Degree Program: Professional Master's Program			
Headcount of enrolled students	64	111	102
Number of degrees granted	0	33	22
Degree Program: Daytime Master's Program			
Headcount of enrolled students	55	30	32
Number of degrees granted	43	50	37
Degree Program: Doctor of Philosophy			
Headcount of enrolled students	199	199	197
Number of degrees granted	27	28	33

** Graduate teaching assistants are appointed 50% time. The table shows the number of TA appointments made over the academic year (4 quarters).