

August 4, 2011

TO: RALPH HEXTER, PROVOST AND EXECUTIVE VICE CHANCELLOR

FR: Enrique Lavernia, Dean, College of Engineering

RE: College of Engineering Academic Plan

In response to your request, I am pleased to enclose our College of Engineering Academic Plan, prefaced by this letter with our responses to your queries specifically addressing excellence and the future of our programs.

What significant changes will the College of Engineering see by 2020?

Faculty retirements will dramatically change two of our departments – Biological and Agricultural Engineering (BAE) and Mechanical and Aerospace Engineering (MAE) – expecting turnover of a third to half by 2016, or a total of about 25 to 30 FTE. This represents both an opportunity and a challenge: an opportunity to build excellence in new and existing areas in both departments; and a challenge to develop strategies to achieve excellence that are consistent with current financial constraints. Two other departments – Biomedical Engineering (BME) and Civil and Environmental Engineering (CEE) – anticipate no retirements over the next five years. The remaining three units – Chemical Engineering and Materials Science (ChMS), Computer Science (CS) and Electrical and Computer Engineering (ECE) – expect some retirements.

Federal and industry support for research has shifted from some of our traditional strengths to new, cross-disciplinary areas. Stimulus funding provided a temporary surge for our research programs; we hope Congress will heed the advice of the National Academies to renew support for the innovation that is so critical to our economy. In addition to developing strategies to increase Federal support of our research endeavors, we continue to aggressively pursue donor opportunities with industry, alumni, and friends. In January 2011, the college hired an Executive Director of Development & External Relations, who manages a staff of five responsible for all advancement activities. One development officer leads our efforts in corporate relations, a second development officer focuses on major gifts from individuals; and the marketing and communications director works to broaden recognition of the college through consistent branding, effective social media, news placement, and strategic publications. The staff also includes an events coordinator and a gift database assistant.

Regulatory standards related to energy, health, and the environment have become more stringent, and thereby may provide a unique pathway to increase our excellence in several fields. One example of this related to energy is the California Renewables Portfolio Standard, requiring that 33% of the State's electric energy come from renewable sources by 2020. Other changes that may influence our path to excellence include new air and water quality standards (the latter responsible for two expensive projects being proposed by the City of Davis); health care requirements for prison inmates; fire regulations that increase the cost of renovations and new construction on campus; and time-consuming additions to the process for accrediting engineering majors.

In the past, the sentiment was that Americans, living in an affluent country, could afford the additional costs of energy and environmental challenges. However, it now appears that premise is being aggressively questioned. There seems to be a lack of public will or capacity to support critical public resources, such as public media, parks, transportation infrastructure, and higher education. Our aging population accounts for some of this resistance, as a higher percentage of tax revenues flows to entitlements for seniors. Health care costs in general are increasing due to aging, diet and sedentary lifestyles; the costs of new diagnostic and therapeutic technologies must be carefully managed. The College of Engineering stands poised to develop cost-effective solutions to these challenges.

A growing global population will demand more energy, food, water and other resources, especially those in countries where per-capita income is rising. Engineering remains the key to meeting these demands, all of which are related in large part to energy use and development. In most natural systems, energy enters as sunlight and cascades from one level of the food chain to another, eventually leaving the system as heat, while water and nutrients are recycled. For human systems, we need to better utilize sunlight and its derivatives (biomass, wind, etc.), and improve the effectiveness of matter recycling.

As a result of the reduction in funding for public projects and increasing demand for resources by both the public and private sectors, engineers must determine how to accomplish more with less. One example of this from the College of Engineering, Professor Tony Wexler is pursuing an offshoot of his air quality research, using sophisticated sensors and real-time analysis to reduce the cost of processing rare-earth ores.

What significant strengths will the College continue to support and build upon?

Four of our departments – BME, ChMS, CEE and CS – have strong programs and, while all face challenges and make good arguments for future growth, are on positive trajectories. BME and CEE, for example, are ranked by NSF as 6th and 7th in federal funding. ECE, while relatively small at present compared to sister programs at other top research universities, is considered a critical element of the College and has been allocated additional faculty FTE in strategic areas that will expand funding opportunities and enhance research

excellence. The two other departments – BAE and MAE – are or have been highly rated, yet will need significant reinvestment of start-ups to replace retiring faculty.

In all departments, we will rely heavily on our extremely capable younger faculty, 43 of whom have received NSF CAREER or similar awards. In fact in the year 2011 alone, six young CoE faculty were honored with high level awards from NSF, DARPA and DOE.

What specific strategies will CoE's departments employ to maintain excellence in undergraduate education and graduate education?

The CoE Executive Committee plans to address the apparent overlap that has developed in courses offered by different departments, to encourage more efficient delivery of the curricula. Some departments plan to update and enhance their majors, others to eliminate or reduce the frequency of teaching low-enrollment electives. BME will seek ideas and support from industry for senior design projects, following the successful process employed by MAE. Several departments plan to engage more undergraduates in research. To attract higher quality undergraduates, MAE changed the name of one of its undergraduate majors, to Aerospace Science and Engineering, and is now seeking accreditation of this major, as is BME for its major. MAE may drop the low-enrollment Mechanical Engineering/Materials Science major, and is considering adding a minor in robotics, in response to strong interest expressed by industry and students. To reduce time-to-degree, several departments offer required undergraduate courses during the summer.

Departmentally based graduate programs generally run more smoothly and with fewer incremental resources than do graduate groups, so BME wishes to convert the BME Graduate Group to a Program. Furthermore, MAE is working to reduce graduate time-to-degree by improving mentoring and restructuring the required core courses. At present, many top candidates for graduate school opt to attend other engineering programs. Accordingly, departments are submitting proposals for prestigious support such as IGERT and other training grants. Some departments have or are developing agreements with premier universities abroad, to bring more top international graduate students to Davis. We are providing our faculty with resources and connections as various groups are striving to win major competitive research grants, e.g. for an NSF Engineering Research Center (ERC), Materials Research Science and Engineering Center (MRSEC), and Science and Technology Centers (STCs).

ChMS has, in addition to the two majors reflecting the department name, rather unique programs in biochemical engineering and electronic materials science. These, along with the only departmentally based Honors program at UC Davis, should serve to bring in more non-resident undergraduates, in line with the new campus initiative.

The College needs more and/or better facilities for programs in all departments, especially BME, ChMS and ECE. Contracts and grants may pay for off-campus or Garamendi buildings; we are aggressively seeking partial funding from private sources for Engineering IV.

The College and departments also are seeking private gifts to endow undergraduate and graduate fellowships, industry-sponsored labs, and named professorships, by engaging alumni and emeritus faculty among others. Departments are also developing continuing education courses and professional master's programs, as revenues from these can help support core programs.

Our corporate relations director, Greg Gibbs, working through the campus Office of Corporate Relations, directs our Engineering Corporate Connections program, through which industry firms support education and other programs with annual contributions. We have a dozen companies enrolled at present.

What will CoE stop doing in order to build to its strengths?

Following a careful and exhaustive discussion of strategic opportunities for the CoE, the faculty from the Department of Applied Science (DAS) have moved to other departments, and admissions to the undergraduate and graduate programs offered through DAS have been suspended. If approved through the process defined in the PPM, these programs will be closed as soon as the current students complete their degrees. The relocated faculty have immediately boosted the capabilities of their new department homes. For example, the four faculty (3.5 FTE) moving to MAE will help offset several retirements, as will five faculty (4 FTE) moving to ChMS. In the longer term, the 13.5 FTE from DAS will partially offset the \$2.45 million reduction in faculty positions assigned to CoE allowing reinvestment in the remaining programs rather than across-the-board reductions in FTE. The DAS faculty will enhance the intellectual resources that already exist in their new departments; for example, synthetic biology in BME, modeling and simulation in ChMS, and aerospace sciences in MAE.

Some departments will reduce the number of specializations and associated elective courses for their undergraduate majors, in some cases moving to broader specializations. They plan to focus faculty replacements and research on the most important areas within the broader fields.

How have the College faculty and administration distinguished between (1) weak programs that are so fundamental that they must be strengthened, and (2) weak programs that should be phased out?

Our college must make strategic decisions that are both realistic, and that respond to the needs of the state and the nation. We continue to monitor student demand for our programs, and validate our teaching via external reviews. We seek to build demand for our program by providing students with unique opportunities to further their knowledge and develop skills that will help them excel in the workforce. In the case of DAS, the decision to close the department was based primarily on overlap with other programs and the need to have all faculty involved in a meaningful way with undergraduate education. Some disciplines are considered fundamental – civil engineering, computer science, electrical engineering, and mechanical engineering being good examples. Others, such as aerospace engineering, biological and agricultural engineering, biomedical engineering, chemical engineering and materials science, are strengths developed at UC Davis.

We have considered a number of metrics when evaluating programs: research productivity, contributions to undergraduate and graduate teaching, interest from potential students and employers in the academic programs, and the reputations of departmental faculty among their peers.

We have created the 2025 Committee, a group of faculty chaired by NAE member Subhash Mahajan, to address global grand challenges. The committee has two charges. First, what is the roadmap required for the College to have state, national and global impacts; what are our current strengths, weaknesses, and strategic opportunities? Second, how do we best prepare our students to deal with the grand challenges?

What collaboration with other schools/colleges/divisions will be necessary for the College to attain its goals?

To address sustainability issues – including supply of energy, water and other resources, infrastructure issues and environmental impacts – CoE departments must collaborate with departments in the College of Agricultural and Environmental Sciences (CA&ES), Mathematical and Physical Sciences (MPS), and Social Sciences (SS).

For health-related issues, including food, we anticipate interactions with the School of Medicine, School of Veterinary Medicine, and College of Biological Sciences, as well as CA&ES, MPS and SS. For example, BME and Chemistry are preparing a collaborative proposal to train undergraduates for research careers.

We will also develop stronger ties to the Graduate School of Management (GSM), which already offers the Technology Management minor to our undergraduates. BME and GSM just completed the first Biomedical Engineering Entrepreneurship Academy, a week-long program for faculty, post-doctoral scholars and students selected from many institutions. We believe this is the only program of its kind in the world.

How will the College participate in emerging, multidisciplinary foci of excellence (energy/environment, water, food, society, health to name a few general areas)?

A. Sustainability

Sustainability encompasses the efficient use of energy, water and other resources; reuse and recycling of materials; and environmental impacts of human activities. Human infrastructure, such as buildings, utilities and transportation systems, also impacts sustainability. Almost all of our departments are involved with some aspect of renewable energy, such as biofuels and bioenergy (BAE, ChMS), photovoltaics (ChMS) and wind (CEE, MAE). We are developing new knowledge to help improve the energy efficiency of surface vehicles and aircraft (CEE, MAE), agriculture (BAE), buildings (CEE, MAE), electronics (CS) and lighting (ECE).

Water is a global issue, but especially important in California, due to our arid summers and geographic discrepancies between watersheds and consumers. CEE is a leader in water supply and wastewater treatment, while BAE is involved with efficient use of water for agriculture. Both departments are involved in conversion and reuse of wastes, i.e. closing the loop, and CEE is well-recognized for its research on environmental impacts. CS plans to contribute to reducing consumption and environmental impacts through information technology, networks and computing.

Much of our infrastructure is aging, as faculty members working in old laboratories on campus can attest. CEE faculty are experts in transportation networks (as are some MAE faculty) and structural engineering, and are conducting research and teaching in “Green Building.” Over three recent years, CEE added five undergraduate courses, such as ECI 125, Building Energy Performance, on aspects of sustainability and green engineering.

B. Health

BME is our leader on engineering in medicine, especially in medical imaging, tissue engineering and regenerative medicine, and cellular & molecular engineering. BME and CS are leaders in bioinformatics, and BME plans to expand its research in synthetic biology, and develop the areas of neural engineering and stem cell engineering. Other departments participate in biomechanics and ergonomics (BAE, MAE), cardiovascular modeling (BME) and biotechnology based methods for production of therapeutics (ChMS). MAE plans to develop biosensors that could be used to monitor patients via telemedicine networks, and CS plans to improve telemedicine and healthcare IT systems in general, for example, by improving the accuracy and sharing of records. MAE and CS also see possibilities for developing, maintaining and restoring (post-stroke, for example) capable and active minds, using interactive programs and brain-computer interfaces.

BME has led the development of a new campus-wide institute, Translating Engineering Advances to Medicine (TEAM), with plans to incorporate eight centers, each addressing major problems in health care.

Our faculty participate in the Foods For Health and Global HealthShare initiatives and many aspects of food supply and safety (BAE, ChMS), and we anticipate increased involvement in the future (BME).

C. Information Technology and Applications

CS has strengths in communications networks, security, graphics/visualization and several other areas. The department can evaluate and improve the social networking (Facebook, Yelp, blogs) that has recently transformed how people interact. The department

proposes a multi-course unit on “Computing for Citizens,” through which our graduates would understand “the promises and perils of the emerging cyber-world.” Every department now develops IT applications for use in its research, teaching and/or service.

D. Economic Development

Much of what we consume and utilize is now manufactured outside the U.S., although many observers feel it is imperative for us to maintain and even increase our manufacturing capabilities. MAE is a leader in this area, and mechatronics research by Professor Kazuo Yamazaki was instrumental in bringing a private R&D center to Davis, followed recently by construction of a fabrication plant that will produce machine tools, the primary elements of many manufacturing operations.

In 2010, then-Dean Bruce White established the Engineering Translational Technology Center (ETTC), to assist faculty who have developed new innovations and wish to rapidly move them into practice. ETTC offers expert guidance, connections to the resources necessary for a successful startup, and a convenient on-campus facility. ETTC has helped establish two faculty-owned companies, PutahGreen Systems, LLC, and Dysonics, Inc.

The following serve as examples of what can be accomplished by our faculty and students. Working with CEE Professor Frank Loge, a group of undergraduates developed a biological method to convert sewage sludge to biodegradable plastics, winning an EPA award of \$85,000. The students formed a company in West Sacramento, raised \$15 million of venture capital, and hope to begin commercial operation in 2012 or 2013. CS Professor Raju Pandey developed technology, commercialized through his firm, SynapSense, to wirelessly monitor servers in data centers, saving 20-35% on cooling costs.

Is there an emergent sub-discipline or interdisciplinary constellation that the College and UC Davis are not yet appropriately engaged in that you believe will become essential in the next 5-10 years?

Given the carbon flux associated with use of fossil fuels, and the several difficulties to be overcome to make renewables substantial contributors to the energy picture, nuclear-derived electric power will play a major role in the intermediate term. We consciously excluded nuclear engineering when establishing the campus Energy Initiative several years ago, focusing instead on renewables and energy efficiency, although we may wish to revisit this question.

We may have opportunities through additional courses in entrepreneurship, both at the undergraduate and graduate levels. The report of our 2025 Committee will help inform us.

What opportunities does the College’s plan offer to advance diversity at Davis and what strategies will you employ to capitalize on those opportunities?

In general, engineering throughout the U.S. lacks diversity: most engineers are white males. Relative to the available pools, however, our faculty is diverse, especially in terms of gender. Of the top 50 engineering schools, we have the fourth highest percentage of women faculty. Our student body also is relatively diverse, compared to national norms. Some of the areas we emphasize, especially biochemical engineering, biological systems engineering, biomedical engineering, environmental engineering, and materials science, historically have been of more interest to women than have other engineering disciplines.

To increase our faculty diversity, we plan to continue to employ best practices to ensure diverse recruitment pools, and use the POP bridging program when appropriate. We will highlight the supportive atmosphere at UC Davis, noting, for example, that two of our three associate deans in CoE are women.

For students, we will work at all levels, K-12 through graduate school. Within the College we have created a number of programs for members of groups that are under-represented in engineering, including the K-14 Outreach Center for Computing and STEM Education (C-STEM), our STEM Transfer Day for community college Math, Engineering and Science Achievement (MESA) students and counselors, and our NSF Research Experiences for Undergraduates program, Collaborative Research and Education in Agricultural Technologies and Engineering (CREATE-REU). We also participate in the STEM preview days organized by the Office of Graduate Studies, as well as the NSF CREATE-IGERT at the graduate level. We will involve our undergraduates in research, especially with female mentors.



Academic Plan

2011-2016

Presented to:
Provost & Executive Vice Chancellor
Ralph Hexter

August 4, 2011
Enrique J. Lavernia, Dean

2011-2016 College of Engineering Academic Plan 4 August 2011

I. Executive Summary

Since its founding in 1962, the College of Engineering has proudly focused on finding technical solutions to some of our nation's most difficult problems, while also preparing thousands of highly skilled engineers to join the United States workforce in this challenge.

Our faculty of approximately 200 FTE includes 13 distinguished professors, a high percentage of senior faculty represented among the Fellows of major professional organizations, a consistently abundant slate of annual national awards for research and teaching. Fifteen of our current and *emeritus* professors have been elected to the National Academy of Engineering; Science, and Arts and Sciences; or the Institute of Medicine. Among our current faculty, 43 have received NSF CAREER and similar awards for young researchers, including 20 over the past six years.

Our accomplished researchers and educators focus on many specific areas of concern including the following highest priorities for the College: energy, environment, health and biology, information technology and management, microwave science and engineering (a new investment area in Electrical and Computer Engineering) and physical infrastructure. We are recognized leaders in energy efficiency, biomass, wind, alternative fuels and transportation, data visualization, communications, network security and biomedical imaging.

The college is aggressively pursuing donor opportunities with industry, alumni, and friends. In January 2011, we hired an Executive Director of Development & External Relations, who manages a staff of five who are responsible for all advancement activities. One development officer leads our efforts in corporate relations and a second development officer focuses on major gifts from individuals. Our marketing and communications director is working to broaden recognition of the college through branding and strategic media placements. The staff also includes an events coordinator and a gift database assistant.

Investments in development efforts are already yielding successful results, with gifts to the college doubling from \$2.2M in 2009-10 to \$4.5 M in 2010-11. Cumulative gifts since July 2006 total \$27.3M, with 61% going to support research and instruction.

A. Goals and Associated Strategies

Research and Outreach

Goal: We intend to augment the strengths of current research and outreach as we address specific Grand Challenges for the 21st Century, as identified by the National Academy of Engineering (2008a):

- Develop environmentally friendly power
- Provide access to adequate supplies of clean water
- Advance health informatics
- Develop better medicines
- Reverse-engineer the brain
- Improve the tools of scientific discovery
- Improve adaptive methods for learning
- Enhance virtual reality
- Secure cyberspace
- And restore and improve urban infrastructure.

We build upon a firm foundation of serving society, in keeping with the University's status as a Land Grant institution. We will strive to continue this service by forging strong partnerships with industry, other educational institutions, national laboratories and government agencies to more ably transfer research results and their benefits to the marketplace and the public.

After we reach our assigned reduction in FTE through retirements and separations, we plan to reinvest any faculty replacements in our high priority areas while also ensuring coverage in the core areas of expertise necessary for our instructional programs. We are closing the Department of Applied Science as a strategic opportunity to maintain and strengthen our remaining seven departments¹. We expect to improve the rankings of several of our programs. For example, Biomedical Engineering – already a top-performing group, but under-recognized at present – will soon be ranked in the top 10. Materials Science/Engineering must move into the top 15 in the next several years.

Research support has been increasing overall and per faculty FTE. Research expenditures grew to \$451k/FTE in 2009-10. We intend to continue this trend.

Students

The College attracts and enrolls exceptional students with some of the highest entering board scores and GPAs in the University. The number of women in our graduate programs and the percentage of Ph.D.s awarded to women surpass the national average.

Goal: We plan to increase the numbers and qualifications of our undergraduate and graduate students, while increasing the diversity of our student body and graduates. Current projections indicate substantial needs in California for engineers in several areas, notably information technology and infrastructure redevelopment. We also anticipate more demand for biomedical and other engineers, to address medical and health-related issues, and to contribute to the expanding biotechnology and life sciences industries in the state.

We anticipate that more aggressive recruiting and offers of multi-year support, and increased graduate fellowships and training programs, will increase the numbers, diversity and qualifications of our graduate students. New degree programs in energy that emphasize energy science and technology and energy policy and management also will attract top students. We expect considerable demand by undergraduates for a proposed minor in robotics.

Our current faculty numbers allow us to modestly expand our undergraduate programs, to meet our increased student-faculty ratio target of 14.1. New minors in areas including energy policy, energy efficiency, energy science and technology, computer science and materials science, and a proposed minor in robotics, will increase student enrollments in courses managed by departments in the College. To increase the numbers and diversity of our students we will highlight our existing ties with K-12 Math Engineering and Science Achievement (MESA) and other outreach programs, expand outreach and recruitment efforts with community colleges, and paint a more welcoming picture of the engineering profession to potential students. Professor Harry Cheng has created the UC Davis K-14 Outreach Center for Computing and STEM Education (C-STEM) to improve computing, science, technology, engineering, and

¹ Faculty have already transferred to other departments, and the formal closure process defined by PPM 200-20 is in progress.

mathematics (C-STEM) education in both formal and informal programs in K-14. The goal is to broaden participation of students traditionally underrepresented in computing and to develop computer-aided problem-solving skills to tackle real-world STEM problems. C-STEM has received numerous accolades from participants (teachers and students) for its initial efforts.

To retain our students, we will increase the involvement of undergraduates in research, internships and mentoring experiences on campus.

Undergraduate Curricula

Goal: We plan to revise our educational programs to better prepare our graduates for careers in a changing global economy.

The College has one of the most comprehensive engineering programs in the nation, and offers the most ABET-accredited undergraduate engineering majors in the UC system. Nevertheless, the exigencies of today's world demand undergraduate curricula that are relevant and fluid. In support of these needs Dean Lavernia has charged a committee of faculty, the 2025 Committee, to examine our intellectual framework of research and education, identify our strengths and weaknesses, and help us transform engineering education. We must educate students who can think critically and independently, and for whom innovation and entrepreneurship are second nature. The report from this committee, expected in Fall 2011, will serve as a guide for the revisions of our educational programs.

While our retention rate of students is high, we must do better. Strategies include providing more hands-on, integrative experiences during the first two years; interdisciplinary learning and projects involving multidisciplinary teams; and case studies. We will strongly encourage undergraduate research, internships and offer more such opportunities. We hope to expand the methodology we current use with students who participate in the Summer Transition Enrichment Program (STEP) to more students. Important aspects of our retention efforts include a welcoming social atmosphere during orientation and fall quarter, offering one-unit seminars to provide an introduction to engineering, assisting students who need extra help with math, providing frequent advising, and emphasizing a professional, responsible approach to life and learning.

General Understanding of Engineering

Goal: In a society that is profoundly affected by technical change and whose security and vitality require an informed citizenry, we see a clear role for Engineering in expanding general knowledge of and appreciation for technology. We propose to play a role in deepening understanding among all UC Davis graduates by expanding our general education offerings and developing a series of courses on Computing for Citizens.

Faculty Diversity

Goal: We will continue to aggressively pursue strategies to increase the diversity of our faculty.

UC Davis Engineering ranks 4th among the top 50 engineering schools in the nation for the percentage of women faculty. The College has done well relative to our specified diversity goals. We attribute our success in increasing diversity among our faculty to a strategic effort to attract diverse pools of highly qualified candidates and to mentor and support new faculty. We plan to continue these efforts for women and under-represented minorities.

B. Resource Issues

Reductions in operating budgets have changed the way our departments and the College are doing business. We have consolidated purchasing and human resource functions from the departments into college-wide shared service units, and are considering doing so for some aspects of academic personnel and information technology.

Continued increases in non-resident tuition have been challenging, causing some faculty to employ higher percentages of postdoctoral scholars and staff members to conduct research. This is worrisome, given the overall campus goal of increasing graduate enrollments.

To accommodate more undergraduate students and improve their training, we must in some cases expand the capacities and capabilities of our instructional laboratory facilities. Due to budget constraints the College eliminated the TA support provided to departments to supplement the campus allocation, forcing changes in how we offer our lab-intensive curricula.

The increased cost of competitive individual startups, even at this time of a strained economy, has to some extent diverted resources that would have supported upgrades to shared research equipment. Startups for faculty involved with experimental research are straining the College budget.

Space continues to be an important issue for the College, both in terms of quantity and, especially, quality. Many of our laboratories are old and do not well-serve the evolving needs of our faculty, primarily engineering research related to biological systems, such as bio-electronics programs in Electrical and Computer Engineering. We anticipate agreements with the School of Medicine, School of Veterinary Medicine and College of Biological Sciences to provide approximately 10,000 asf for collaborative research with Biomedical Engineering, with much of the space being on the Health Sciences campus in Sacramento. Our chemical engineers need the laboratories planned in Engineering IV, and we hope the project, now on hold, will get back on track soon.

II. Research Areas and Graduate Programs

A. Highest priorities, programmatic strengths, opportunities and targets for development

The College has research and outreach strengths in many areas, including sustainability issues such as energy supply and efficiency, water supply, physical infrastructure and environmental impacts; health, including engineering in medicine, and food; and information technology and applications. All of these represent current strengths and will continue as high priorities for the future.

UC Davis' strengths in biological and agricultural sciences and engineering create an excellent synergy for developing new supplies of energy from biomass to replace non-renewable and environmentally damaging sources. We also are focusing on the development of improved means of transportation, photovoltaics that directly convert sunlight to electric power, onshore and offshore wind energy, and improving the efficiency of energy use in buildings and elsewhere.

Faculty members, including many from the College of Engineering, are establishing the Energy Graduate Group, associated with the UC Davis Energy Institute. The new group will provide an

integrated program that will allow students to focus their studies in Energy Science and Technology, and Energy Policy and Management that will lead to a degree in Energy. The program will focus on renewable energy systems, transportation fuels and energy efficiency.

California faces many constraints related to its natural resources, especially water supply and quality and air quality, and population growth in rural areas. Several of our departments plan to increase their emphasis on environmental issues including water and air pollution, life cycle analysis and green building and manufacturing. Our faculty currently lead research efforts at multidisciplinary units such as the Lake Tahoe Research Center and the Center for Watershed Sciences. We will encourage more such centers, on a self-sustaining basis.

Many of our faculty and students are involved in research and education to minimize climate change. We are working to provide clean air and water, efficient transportation systems, reliable structures; mitigate natural and human-caused hazards; and eliminate disease-causing wastes. We are developing and evaluating innovative materials and methods for construction; advanced simulation techniques; and green engineering.

We are evaluating travel behavior and transportation systems, environmental vehicle technologies, and climate change, air quality and other environmental impacts.

Historically, most engineering disciplines were based on the application of physical, chemical and electrical principles, and many of our programs have strengths in those areas. However, the world's current problems involve the biosphere to a greater degree, so all departments within the College are applying biological and life science principles as well as traditional engineering ones. Surveys of students – both graduate and undergraduate – indicate strong interest in pursuing careers in biologically-related areas. The Department of Biomedical Engineering (BME) – the newest in the College – provides an excellent example of this shift. As part of BME's mission to solve medical and societal challenges including those associated with an aging population, the faculty aim to enhance existing strengths in the life sciences at UC Davis. Broad areas of research excellence for BME include computational bioengineering, biomedical imaging, tissue engineering and regenerative medicine, and cellular and molecular systems. BME operates the Center for Molecular and Genomic Imaging, one of the best-equipped of its type in the U.S., for researchers at UC Davis as well as other institutions and companies in northern California. The department also is collaborating with the School of Medicine and other units in a formal effort to more rapidly translate research into practice.

Many of our programs plan to expand their efforts to develop hardware and software to collect, understand and utilize the highly complex information available to us. The Internet exemplifies the increasing connectivity and shrinking size of our global community. Unfortunately, this increased networking increases our vulnerability to catastrophic failures and criminal interference. Cyber security and design of reliable applications also are being addressed more intensively by our faculty.

The College has major strengths in information technology, including graphics/visualization, networks, and security. Bioinformatics is a relatively new and important area. Our faculty are well known for their research in electronic circuits, computer engineering and information systems. Areas targeted for development include physical electronics, microwave/optoelectronic components, and the new discipline of bio-electronics. Our campus' strengths in biological sciences provide the ideal environment for leading bio-electronics and bioinformatics research centers which would provide core discipline tools to biological researchers and utilize biology to create new types of electronics and information technologies.

Mechanical and Aerospace Engineering (MAE) recently changed its departmental name from Mechanical and Aeronautical Engineering, to reflect the positions available to its graduates as well as the changing research emphases of the aero-related faculty. With the recent addition of an aerospace-related faculty member from Applied Science, MAE will resubmit an earlier request to make the same change to the name of the graduate program.

B. Opportunities for collaboration with other units/campuses

We enhance our service to society through strong partnerships with industry, other educational institutions, national laboratories and government agencies. These connections help us translate our research results into the marketplace and benefits for the public. Recent examples include advice on the security of electronic voting, California's low-carbon fuel standard, plug-in hybrid vehicles, long-lasting road surfaces, anaerobic digesters to convert organic wastes into usable energy, and drug delivery systems that can precisely target diseased cells.

Engineers throughout the world recognize that solving many of today's problems requires the efforts of highly interdisciplinary teams rather than the narrow foci of single traditional disciplines (Duderstadt 2008). Research collaboration between units at UC Davis is probably even stronger than at other institutions and is fostered by our graduate group structure as well as by our campus culture. Many of our faculty have cross-department or cross-college appointments. We have numerous collaborations with faculty in the Colleges of Agricultural and Environmental Sciences, Biological Sciences, and Letters and Sciences, as well as the Schools of Medicine (SOM), Education, Management (GSM) and Veterinary Medicine. Our faculty and students are increasingly involved in multidisciplinary research with most units on campus. We plan to expand relationships with the SOM, especially on translational engineering, health informatics and telemedicine. The Center for Biophotonics Science and Technology is slated to become a part of the TEAM Institute. We also collaborate with faculty in the Clinical and Translational Science Center, and Center for Mind and Brain, among many others.

The College has numerous joint programs with national laboratories, e.g., the Distance Education Program with Lawrence Livermore and Sandia, and the Materials Design Institute with Los Alamos.

Our departments have established relationships with leading universities abroad, to bring top students to UC Davis. In some cases, the students are supported by the home institution.

C. Research funding trends

In the past, engineering innovation in the U.S. was supported by long-term research supported by both the public and private sectors, at universities, national laboratories and industry laboratories. More recently, private companies have focused on the shorter term, and public funding for physical science and engineering research has been rather flat (Duderstadt 2008). In light of this, the recent funding success of faculty in the College is outstanding. Research expenditures increased from \$60 million (\$331k/FTE) in 2004-05, to \$87 million (\$451k/FTE) in 2009-10 (Figure 1). Over the last three years, BME and ChMS have stood out, averaging over \$600k per FTE, respectively, versus the College average of about \$440k over that period.

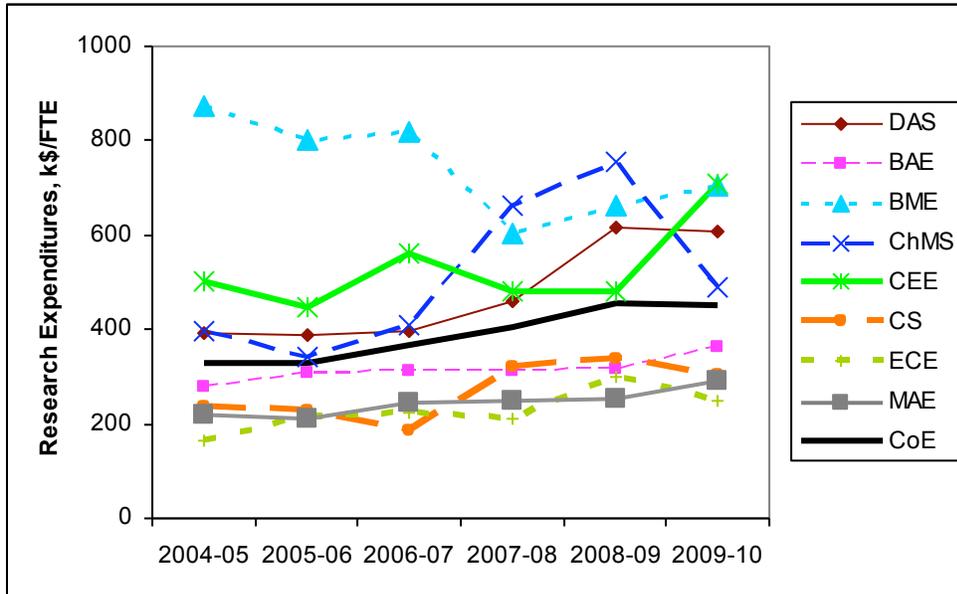


Figure 1. Research expenditures per FTE within the College of Engineering and its departments.

Approximately half the College’s research funding is federal, with the remaining split about equally between state and private sources. ASEE data (2011) showed that UC Davis was 27th of all U.S. engineering colleges in total research expenditures in 2010, and fourth within UC, after UCB (\$183 million), UCSD (\$143 million) and UCLA (\$93 million). For 2007-08, NSF ranked UC Davis Engineering (16th of 662 total) and the following engineering programs: BME (ranked 6), Chemical Engineering (13), CEE (7), CS (46), ECE (48), and Mechanical Engineering (32).

D. Constraints for graduate programs

We place a high priority on enhanced support for graduate students. Within engineering, faculty generate most of this support through research grants and contracts. However, the current campus policy on nonresident tuition (NRT) creates a burden for faculty who obtain grants from state agencies that will, through unwritten guidelines, not generally allow grants to cover NRT. This effectively excludes nonresident students from participating in state-funded research, creating problems for departments with strong research ties to State agencies, such as CEE.

A number of departments consider NRT to be a serious impediment to expanding or even maintaining graduate enrollments, as half or more of their students are non-residents, and many are international. Other constraints include lack of office and laboratory space, and of funding for TAs and staff.

Maintaining quality while increasing enrollments is a challenge. Numbers of domestic applicants have been limited, and it is expensive to support non-residents. Aggressive recruiting efforts, such as recruitment weekends, have been found to be helpful by many of our programs. Some programs guarantee four years of support to all doctoral students. This is an excellent approach for attracting top prospects. But other programs admit many students without guaranteed support and have found that good candidates will enroll because of a program’s strong reputation.

E. Graduate student goals and strategies

Faculty bringing in larger grants need and can support more students. We can enhance the quality and diversity of students by ramping up financial support, increasing publicity about our graduate programs, leveraging interdisciplinary strengths and increasing outreach to the best graduates from predominantly undergraduate institutions. We will actively participate in recruitment efforts coordinated by Graduate Studies, and increase outreach efforts by departments and individual faculty.

To attract top students we must increase graduate fellowships (e.g., GAANN, NSF, NIH) and graduate traineeship programs (NSF IGERT, NIH T32). Responses to our Graduate Admissions Survey tell us that prospective students are most concerned about opportunities to conduct outstanding research, so the more we can do to provide unique, interdisciplinary research, the better.

The STEM preview days organized by the Office of Graduate Studies are excellent recruiting tools for underrepresented graduate students. In addition NSF Research Experiences for Undergraduates (REU) Programs help to acquaint students to our campus. The Collaborative Research and Education in Agricultural Technologies and Engineering (CREATE-REU) Site aims to recruit students traditionally underrepresented in engineering to undergraduate and graduate programs at UC Davis. In summer 2010 our REU program had eight students participate; five of the students were women, three were underrepresented minorities and two were first generation community college students who began their studies at UC Davis in Fall 2010. This year we have nine students in the program. Four of these students are underrepresented minorities, two are first generation community college students, and five are women. Expanding similar research opportunities for UC Davis students is a goal for the College.

F. Student numbers, diversity and quality

Graduate enrollments have increased 6% over the six-year period from Fall 2005 through Fall 2010 (Figure 2). BME and CEE experienced large increases – 28% and 43%, respectively – partially offset by declines in some other programs (Figure 3).

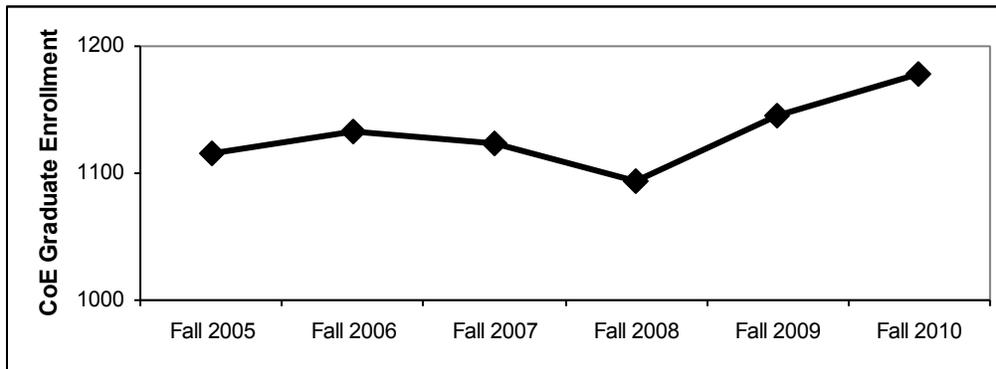


Figure 2. Graduate enrollment trend for the College of Engineering.

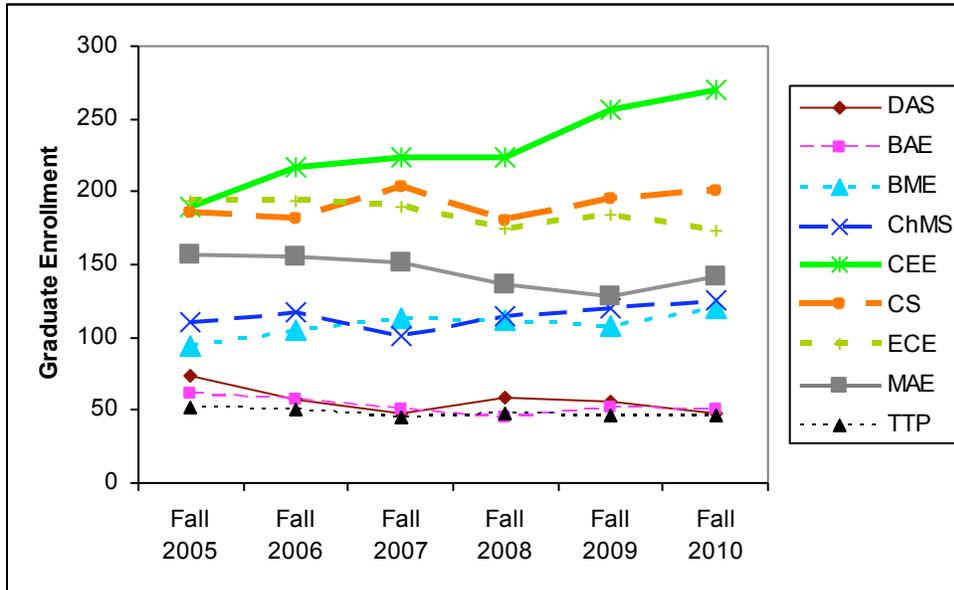


Figure 3. Graduate enrollment trends for programs within the College of Engineering.

Table I. Graduate Students per Faculty FTE, 2009-10.

Department/Group	Grad Enrollment, Fall 09	Budgeted FTE, 2009-10	Grad Students per Budgeted FTE
DAS	56	14.5	3.9
BAE	52	7.3*	7.2
BME	108	19.3	5.6
ChMS	120	24.9	4.8
CEE	256	31.7	8.1
CS	195	31.5	6.2
ECE	184	28.0	6.6
MAE	128	30.0	4.3
TTP	47		
CoE as a whole	1146	183.6	6.2

* Includes I&R FTE in CoE and CA&ES

Graduate degrees awarded per year have held relatively constant over the last six years, averaging approximately 270 (range: 256 to 287). ASEE (2011) listed UC Davis at 28th in doctoral degrees awarded, fourth in the UC system, behind UCB, UCLA and UCSD.

Graduate applicants and new enrollments both remained steady from 2005-06 through 2009-10, then increased to 2,800 (up 17%) and 340 (up 20%), respectively, in 2010-11.

Of UC Davis engineering graduate students over the recent six-year period, 26-28% are women, exceeding the national average of 22% in 2009 (ASEE 2010). UC Davis programs with high percentages of women include BAE (27%-36%), BME (41%-46%), CEE (30%-38%), ChMS (35%-50%) and TTP (now up to 34%). This parallels national trends as described later in the section on undergraduate programs.

When excluding international students, numbers of under-represented minorities have been increasing slightly, now accounting for 9% of our enrolled graduates, close to the 10% national average reported by ASEE (2010). At UC Davis, ChMS (averaging about 12%) has been substantially above the College average.

Quantitative measures of student quality were relatively consistent across programs and time for the six-year period. Means for undergraduate GPAs and quantitative GRE scores were about 3.4 and 82%, respectively.

G. Employment of recent graduates

All our graduate programs report strong demand for their students and placement in appropriate areas, including many faculty positions at prestigious universities. ECE's graduates are essentially all employed by industry, primarily due to the large in-state job market in electrical and computer engineering.

H. Graduate program competitiveness

Based on 2005-06 data, the National Research Council (2010) ranked several of our engineering graduate programs highly: Chemical Engineering (13 to 41 of 106 total), CEE (6 to 37 of 130), CS (15 to 51 of 126) and Materials Science (7 to 31 of 83).

US News & World Report (America's Best Graduate Schools 2011) ranked UC Davis Engineering at number 32, and 20th among public institutions. Program rankings reflect the views of engineering deans rather than rigorous metric-based evaluations. In the 2011 ranking, Aerospace Engineering was 24, BAE 5, BME 23, Chemical Engineering 30, Civil Engineering 16, CS 37 (40), ECE 38, Environmental Engineering 14, Materials Science 26, and Mechanical Engineering 33. TTP is subjectively self-ranked among the top five graduate transportation programs in the U.S.

There is lag time between a rapid change in a department's actual performance and its stature in the US News ratings. For example, despite BME being one of the best-funded programs (6th) of its type in the U.S., and being formally recognized in 2011 by the Hartwell Foundation as one of Hartwell's Top Ten Centers of Biomedical Research, it is not yet well-known and therefore is ranked in the twenties by US News & World Report. We are aggressively developing a marketing and communication plan to ensure our programs receive the recognition they merit.

III. Undergraduate Program

A. Present majors

BAE: Biological Systems Engineering

BME: Biomedical Engineering

ChMS: Biochemical Engineering, Chemical Engineering, Materials Science and Engineering, Electronic Materials Engineering, Chemical Engineering / Materials Science

CEE: Civil Engineering

CS: Computer Science (in the College of Letters & Sciences), Computer Science & Engineering

ECE: Electrical Engineering, Computer Engineering

MAE: Mechanical Engineering, Aerospace Science and Engineering, Mechanical

Engineering/Material Science Engineering

Computational Applied Science (closed to new applicants)
Optical Science and Engineering (closed to new applicants)

B. Present minors

BAE: Geographic Information Systems, Precision Agriculture (both in the College of Agricultural & Environmental Sciences), Energy Science and Technology, Energy Policy, Energy Efficiency
CEE: Construction Engineering Management, Sustainability in the Built Environment
CS: Computer Science, Computational Biology and Bioinformatics (PENDING)
Optical Science and Engineering
BME: Biomedical Engineering (PENDING)
ChMS: Materials Science (PENDING)

C. Employment of Recent Graduates; Future Outlook

Surveys indicate most students are satisfied with their educations, career choices and current positions. Our departments report that substantial numbers of students continue on to graduate school while most others obtain employment in their fields of choice. Many graduates accept positions in industry; more than half of CEE's join agencies in the public sector such as Caltrans and environmental quality boards.

Recent reports from the National Academies (2007, *Rising Above the Gathering Storm: ...*; 2010, *Rising Above the Gathering Storm, Revisited: ...*) call for a substantial increase in the science and technology workforce. A group of business and technology associations believes the U.S. needs to double the number of graduates in STEM fields by 2015 (*Tapping America's Potential 2008*).

Average salaries for engineers and computer specialists are strong relative to those in many other fields (BLS 2010, Carnevale et al. 2011).

The manufacturing sector and associated engineering employment are expected to decline in the U.S., however losses there will be more than offset by substantial growth in information technology and other areas. Projections for employment for 2008-2018 in selected fields relevant to the College are shown in Table II. (The Bureau of Labor Statistics classifies most computer-related occupations including software engineers separately from engineers.) Information technology is expected to be the leading growth sector within STEM specialties. Overall engineering employment in the U.S. is expected to grow by about 11 percent over the decade. Biomedical, civil and environmental engineering are all expected to have high percentage growth rates, while aerospace, computer/electrical and mechanical engineering will also see significant growth in absolute terms although not in percentages.

Table II. Projected engineering and computer-science-related employment trends in the U.S.

	United States		
	Projected employment, 2018	Change, 2008-2018	
		(thousands)	(thousands)
Total Employment	166,206	15,274	10%
Computer Specialists including Administrators & Software Engineers	4,187	763	22%
Engineers	1,750	178	11%
Aerospace	79	7.4	10%
Agricultural	3	0.3	11%
Biomedical	27.6	11.6	73%
Chemical	31	-0.6	-2%
Civil	346	68	24%
Computer (hardware), Electrical & Electronics	382	5.9	2%
Environmental	70.9	16.6	31%
Materials	26.6	2.3	9%
Mechanical	253	14.4	6%

Sources: BLS (2010)

The occupational categories listed by the government agencies are based on past employment. We believe there also will be significant demand for engineers with biology backgrounds, in addition to those in the biomedical area. Emerging biological and biotechnology industries are of growing importance to California and the U.S. For example, graduates from our Biochemical Engineering and Biological Systems Engineering programs have had excellent success with job placement, even though these occupations aren't included as distinct categories in the employment statistics. This bodes well for new programs such as bio-electronics and bioinformatics.

D. Current challenges

Engineering faces three major challenges: preparing graduates for careers in a constantly changing global economy; recruitment of students, especially from under-represented groups; and retention of students (NAE 2005).

Changing Education

The National Science Board (2007) stated, "In addition to analytic skills, which are well provided by the current education system, companies want engineers with passion, some systems

thinking, an ability to innovate, an ability to work in multicultural environments, an ability to understand the business context of engineering, interdisciplinary skills, communication skills, leadership skills, an ability to adapt to changing conditions, and an eagerness for lifelong learning. This is a different kind of engineer from the norm that is being produced now.” These thoughts parallel those of many other observers (e.g., Duderstadt 2008, NAE 2004).

How should we address these issues? A number of proposals have been put forward. The NAE (2005) suggested considering the B.S. as a pre-engineering degree and designating the M.S. as the professional degree. Duderstadt (2008) went further, recommending that engineers first obtain a liberal arts undergraduate degree, then receive focused education in a professional

program similar to those for medicine or law. While these approaches would more broadly prepare engineers, they do not seem practical from the standpoint of efficient use of the limited resources available for public education.

A substantially different approach, implemented by the Olin College of Engineering, provides holistic, project-based education “emphasizing entrepreneurship, liberal arts, and rigorous science and engineering fundamentals” throughout a four-year undergraduate program (Olin College 2008). We are proud to note that the president of Olin College, Dr. Richard Miller, is a UC Davis alumnus (BS Aeronautical Engineering 1971).

Our accreditation organization – ABET – is concerned with the changing needs for engineers and in fact addresses many of these in the student outcomes required to obtain accreditation. We have already made incremental and sometimes substantial changes to our programs to meet these requirements, but more can be done. We anticipate following some or all of the recommendations put forth recently (e.g., NAE 2005, NSB 2007):

- Introduce students to the “essence” of engineering early, by providing hands-on and integrative experiences in the first years
- Include out-of-classroom experiences, interdisciplinary learning, and emphasize social relevance, volunteerism and collaboration. Consider projects involving multidisciplinary teams.
- Promote undergraduate research, internships, study-abroad programs and participation in professional organizations.
- Use case studies of engineering successes and failures.

Our programs already employ many of these aspects. For example, MAE and the College sponsor several teams that participate in design/build competitions such as Formula SAE. In 2002, students in CEE initiated a campus chapter of Engineers without Borders. UC Davis has been excellent at involving undergraduates in research. For example, most BME faculty regularly engage undergraduates in their laboratories, and approximately a quarter of CEE students obtain research experience with faculty before graduation.

We hope to expand access for all eligible California students through enrollment growth. Our current faculty numbers can accommodate more students. However, our teaching laboratory facilities are taxed, and in some fields we do not attract enough qualified applicants.

One hears stories of laboratory facilities in some countries being used 24 hour per day. We are certainly nowhere near that point. Nonetheless, we have difficulties accommodating our current students in laboratory courses due to the limited numbers of individual student stations. It is not clear if we can add more sections without creating conflicts with other required courses. This is

partly a digital problem; with a critical mass of enrollment, multiple sections of all courses can be offered efficiently at different times, eliminating the time conflict issue. We are not yet at that stage in many of our programs.

As described previously, our 2025 Committee will examine our intellectual framework of research and education, with the goal of transforming our programs so we produce students who can think critically and independently, and for whom innovation and entrepreneurship are second nature. The report from this committee, expected in Fall 2011, will serve as a guide for the revisions of our educational programs.

Recruitment

California's high school graduating class of 2015 is projected to include 47% Hispanics, 29% White non-Hispanics, 16% Asian/Pacific Islanders, 7% Black non-Hispanics and 1% American Indians/Alaska Natives (WICHE 2008). We are committed to increasing diversity in our student body since we believe that inclusive, diverse professions are more capable of creating long-term, relevant answers to societal problems. We also believe that diversity is a strength that promotes excellence. The engineering profession needs to dramatically change our message to accomplish this important goal. According to the NSB (2007), the public associates engineers with "things"; we do not draw in people who are interested in collaborating on teams to improve the quality of life or the environment, therefore many individuals, especially women and minorities, do not visualize themselves as engineers. A recent NAE report (2008b) found it preferable to encourage young people to make a positive impact through an engineering career, rather than focusing on the challenge of math and science. It noted, "The medical profession does not market itself to young people by pointing out that they will have to study organic chemistry or by emphasizing the long, hard road to becoming a physician. The image of the physician is of a person who cures diseases and relieves human suffering." Engineers can and should adopt a similar approach.

In 2010-11, community-college transfers represented approximately 21 percent of our newly enrolled students, up from 13 percent in 2005-06. These cohorts are more ethnically diverse than our "native" freshmen, and transfer students who attend UC Davis are as successful as students admitted as from high school. The CoE Undergraduate Studies office co-sponsors a STEM Transfer Day to familiarize community college Math, Engineering and Science Achievement (MESA) students and counselors with our programs, enrichment opportunities, and student-support services available on campus. We had 70 students and 10 counselors participate in 2009. Our survey results of this event indicated that participants greatly appreciated the opportunity to visit the campus and learn of transfer opportunities and resources available to them. Results also showed that students were more likely to apply to UC Davis because of their experience at STEM Transfer Day.

Faculty members are incorporating into their NSF and other proposals, initiatives to recruit and retain more diverse populations of undergraduates as well as graduate students. These include courses in nanotechnology to be offered during the summer to community college transfer students, 1-unit seminars for transfer students and design activities for MESA design competitions.

Retention

Nationally, more students depart engineering to pursue other majors than enter from non-engineering programs (NSB 2007). This may result from the relatively prescribed/rigorous

nature of coursework; engineers have few electives. In addition, engineering students are subjected to background mathematics and science in the first two years, therefore they develop little connection with engineering practice. A number of our programs now offer practice-oriented courses early on, and ECE plans to offer an undergraduate seminar that will bring in engineers from industry to present the problems they are solving and products they are creating.

The College has developed retention efforts that build on existing student support structures and program elements at UC Davis. These structures include the Undergraduate Scholarships Office as well as the Student Academic Success, Undergraduate Research, and Internship and Career Centers at UC Davis and the undergraduate advising resources in the College of Engineering. Support structures include a summer transition program, an introductory engineering course, academic advising, tutoring, internship and research opportunities and student clubs. These are described in more detail below.

Special Transitional Enrichment Program (STEP). STEP is a four-week summer residential program designed to help some incoming freshmen prepare for success at UC Davis. These incoming freshmen receive extensive preparation for the start of fall quarter, ranging from advice on courses and study skills to comprehensive academic refresher classes. The College of Engineering provides supplemental funds to the STEP program to increase participation by engineering students.

Introductory Engineering Course (ENG 11). ENG 11 is a 1-unit, graded, introductory course, developed to allow students to learn engineering concepts through participation in a basic engineering design project. Students develop team-building, communication and leadership skills and have the opportunity to build social and academic networks to promote continued academic growth and success. ENG 11 serves to continue the cohort established in STEP. The course was piloted in Fall 2009 and enrolled 9 students and was offered in Fall 2010 with 21 students. In 2009 the class was assigned the task of redesigning an evacuation chair used for individuals with limited-mobility during a building evacuation. In 2010 the design project involved the development of a system to alert a blind pedestrian of bike traffic. Students received hands-on instruction in the engineering design process, as well as project management, budgeting, and meeting customer needs.

Advising holds. The College of Engineering has a well-established advising structure to ensure students complete degrees in a timely manner and meet requirements for accreditation. Students receive advising from advisers in their home departments and in the Dean's Office. In addition to the annual advising appointment required of all students in the College of Engineering, students who participated in STEP also meet quarterly with Dean's Office advisers to monitor academic progress.

Tutoring. Tutoring in math, physics and chemistry is already available through the Student Academic Success Center (SASC) at UC Davis. Proposals are being prepared to the NSF that will support additional tutors for lower division engineering courses to ensure students have the resources they need to be successful.

Student Clubs and Organizations. Engineering students are strongly encouraged to participate in engineering professional societies, campus chapters of their national engineering diversity organizations, and the variety of engineering design competitions to further build community networks, leadership, hands-on design and collaboration skills, and professional development.

Gearing Up for Graduate School. The College of Engineering holds the “Gearing Up” seminar every year to introduce students to graduate school. The seminar is structured as a series of weekly workshops delivered by advising specialists, graduate students, industry recruiters, and faculty panelists. Gearing Up for Graduate School (offered in Winter Quarter) encourages students to explore their potential for graduate education and outlines the steps for application readiness.

Initial data have indicated that the support structures and programs described above are successful in increasing both the retention and academic success of the participating students, so the College hopes to eventually offer these opportunities to many more of our students. Additional advising support from the Provost will be used to expand these programs for more students.

Outreach

We need better-prepared students at the freshman level. The NAE (2005) believes professors at the university level should actively participate in efforts to improve K-12 education, as well as to improve the technical literacy of the public. Duderstadt (2008) stated, “Perhaps the most urgent need of our society is a deeper understanding and appreciation for technology on the part of all college graduates rather than only those seeking engineering degrees.” We at UC Davis can assist by expanding our offerings of freshman seminars and general education courses. One such course is “Nuts and Bolts” a 1-unit, pass/no pass seminar that introduces students to both the different “branches” of engineering study and the abilities needed to become a successful engineer. Through brief assignments and participation in discussions, participants deepen their understanding of the personal commitment required to study engineering as they explore the range of engineering majors and careers available upon graduation. Key goals of the seminar are to demystify all fields of engineering and to highlight the similarities and differences among them. The course was offered in Fall 2010 and Winter 2011, respectively enrolling 125 and 22 students. Those in the course were treated to a “guided” walk through a particular engineering discipline from a faculty member from that department. They also learned about opportunities for involvement in student clubs, internships, research and study abroad. We expect to continue to offer this course for incoming freshmen.

UC Davis and CSU Sacramento have partnered to deliver the largest MESA program in California, serving approximately 3,000 middle- and high school students. In 2008 UC Davis, UCLA and UC Berkeley were in the top five colleges for enrolling graduating seniors from MESA. In recognition of the importance of MESA for undergraduate engineering training, the College prepared a proposal to the National Science Foundation Graduate STEM Fellows in K-12 program, entitled Renewable Energy Systems Opportunity for Unified Research Collaboration and Education (RESOURCE). The \$2.8M funded RESOURCE program leverages our campus commitment to energy research and partnerships with MESA elementary and middle schools to develop and demonstrate a reproducible model for Graduate/K-12 research and teaching partnerships. RESOURCE currently impacts over 200 students in educationally disadvantaged schools in the Sacramento region.

Our Outreach Center for Computing and STEM Education (C-STEM) aims to improve computing and science, technology, engineering, and mathematics (STEM) education in both formal and informal K-14 programs. The goal of C-STEM is to broaden participation of students in computing and to develop students' computer-aided problem-solving skills to tackle real-world STEM problems. C-STEM also studies how to streamline the curriculum on computing

education in the context of STEM subjects in elementary schools, middle schools, high schools, and the first two years in college to increase student interest in pursuing computing and STEM related careers, and post-secondary study. The College will continue to provide administrative support to these important outreach and recruitment programs.

To help bring in high-achieving high school students, ChMS implemented the only departmentally based honors programs at UC Davis. They have attracted a substantial number of Regents' Scholars. Faculty teach one-unit honors sections associated with each regular course. The honors programs requires more faculty and staff FTE per student than the regular programs.

Resources

TA support is an issue for many programs across the College. For the College of Engineering, the supported student/TA ratio is 31.2. Note that this takes into account the greater need for TA support in engineering courses due to the high percentage of laboratory sections, as the campus average student/TA ratio is 40.1. Despite the lower ratio compared to the rest of campus, many departments indicate that the TA support they receive is still too low to adequately support their courses, particularly laboratory courses.

A number of programs face challenges due to the limited capacities of and aging equipment in their teaching laboratories.

E. Anticipated changes to curricula

Early in the life of the College, students in most majors took a common set of core courses. Over the past several decades, many departments have developed their own specialized courses in place of one or more of the core "ENG" offerings. In light of the current and anticipated future budget situation, the CoE Executive Committee plans to ask departments to review their classes and consider consolidating similar ones. Some departments have already initiated these efforts.

Some programs are considering modifying their capstone design courses so that larger numbers of students may be accommodated without substantial increases in resources. For example, a department may offer a single project rather than allowing each team of students to pursue a different project. Some departments already use this model.

Sustainability is a critical issue. CEE has added several new courses relating to environmental issues, e.g., Green Engineering (for majors) and Urban Sustainability (GE for the campus), and other departments have or are planning to modify their courses and/or curricula to more fully address this topic.

As recommended by ABET reviewers in 2006, MAE has changed its Aeronautical Science and Engineering program to Aerospace Science and Engineering. The Department is in the process of developing new courses to reflect the change in emphasis.

In the first few years after the Optical Science and Engineering major was established in 2000 by DAS, it drew a large influx of students, peaking at over a hundred. Enrollments then dropped substantially and did not rebound. Since DAS is closing, admissions to the OSE major have

been suspended, and we will soon propose to close the major, unless a new home department can be identified.

F. Opportunities to strengthen programs via collaboration with other units/campuses

At present, the College has three robust majors related to biology – Biochemical Engineering (in ChMS), Biological Systems Engineering (in BAE) and Biomedical Engineering – as well as a specialization in Biomedical and Engineering Fluid Mechanics (in MAE). With ECE's interest in establishing a bio-electronics program, we have an excellent opportunity to collaborate on advertising as well as delivering these programs.

The UC-wide Bioengineering MRU hosts annual symposia. In the past, the focus has been primarily on graduate students, but it may include more undergraduate emphasis in the future.

We plan to highlight our joint UC Davis/CSU Sacramento-sponsored MESA program to encourage more participants from that program to attend UC Davis.

Skill in computing is now a fourth basic "R", and CS faculty help meet the related educational needs by providing GE courses to the entire undergraduate population. CS can also play a lead role in introducing new technologies for instruction throughout the campus.

G. Student numbers, diversity and quality

Our numbers of freshman applicants have increased to 8,300 for Fall 2010, from 5,300 for Fall 2005. While enrollments in CS have decreased, this decrease has been more than offset by increases in BME, CEE, Chemical Engineering and Biochemical Engineering. Freshman enrollments were at 773 in 2005, and increased to 815 in 2010; BME and CEE absorbed most of the increases. Our total enrollments increased to 3,250 in 2010, reversing a declining trend that began in the early 2000s, caused in part by a residual effect of an unanticipated freshman enrollment blip in 2001. Within the UC system, UC Davis is fourth in enrollments and BS degrees, behind UCSD, UCB and UCSB. Departmentally, enrollments in DAS, BAE and ECE declined while those in BME, CEE and ChMS increased substantially (Figure 4). MAE experienced a dip, but numbers increased 20% over the last two years, and in Fall 2010 was essentially tied with CEE for the largest undergraduate enrollment in the College. CEE's student numbers rose by 24% over the five years; CEE supports the largest major in the College at present, with 21% of our undergraduates. Our enrollment changes between 2005 and 2010 have generally followed national trends, although percentage growth in our BME program has been more than double the national average (ASEE 2011).

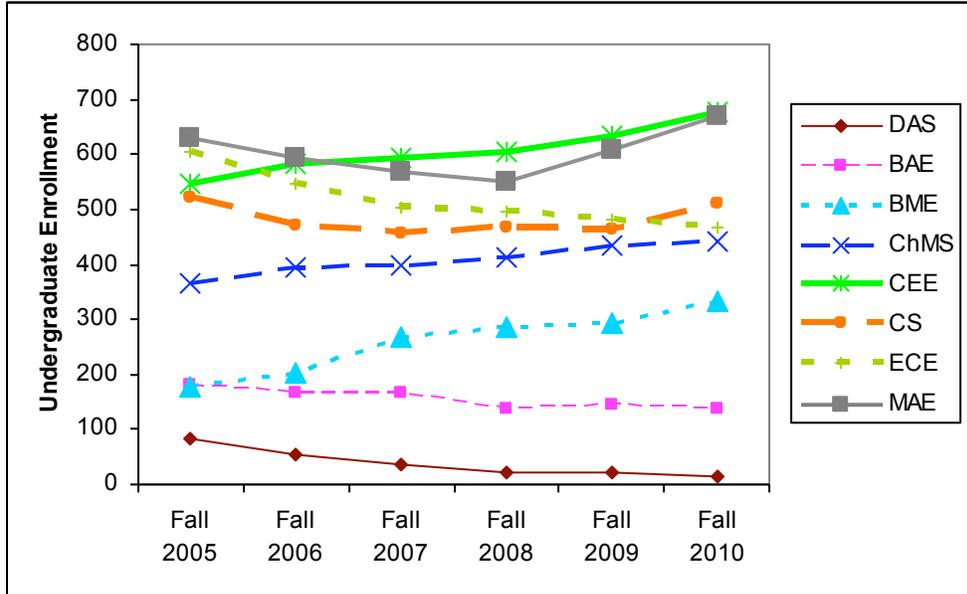


Figure 4. Undergraduate enrollment trends for departments within the College of Engineering.

On a percentage basis, we have more women engineering students (19-23% from Fall 2005 through Fall 2010) than the national average (18% in 2009; ASEE 2010). National figures show high percentages of women (33%-44%) in BAE, BME, Chemical Engineering and Environmental Engineering, and our enrollments parallel these patterns closely, with 24%-53% women in BAE, BME, CEE and ChMS. For the first time, the number of women exceeded the number of men in one of our engineering majors (Biological Systems Engineering, 53% women in 2009).

Our percentages of under-represented minority students have consistently increased, from 10% in Fall 2005 to 17% in Fall 2010 and in line with national averages (14% in 2009; ASEE 2010). CEE has attracted higher relative numbers (14% to 22%), exceeding the national average.

On average, the quality of our entering freshmen has remained consistently high based on quantitative measures. Over the past five years, the average high school GPA has increased from 3.8 to 3.9, with combined SAT increasing from 1730 to 1820.

H. Competitiveness

Of our 14 continuing undergraduate majors (we are moving forward with the closure of CAS and OSE), 10 are accredited by ABET. Of the unaccredited programs, Chemical Engineering/Materials Science and Engineering, and Mechanical Engineering/Materials Science and Engineering are long-standing combined majors. (ABET's regulations make it extremely difficult for combined programs to fulfill accreditation requirements within a reasonable number of units.) These programs have very small enrollments. Biomedical Engineering is relatively new – the first class graduated in 2006 – but is now preparing for accreditation at the next full review of the College's programs, in 2012. ABET did not allow the accreditation associated with the former "Aeronautical" major to transfer to the "Aerospace" Science and Engineering, so MAE is pursuing accreditation of the new major.

US News & World Report's 2011 "America's Best Colleges" ranks the College of Engineering 32nd overall and 18th among public schools, both new highs. Among the engineering specialties, BAE ranked 6th; it also produced 4% of all the B.S. degrees from BAE programs within the U.S. in 2008-09 (ASEE 2010).

IV. Instructional workload

Our student FTE/ladder faculty FTE ratio (SFR) fluctuated between 10.8 and 11.7 over the five years, 2005-06 through 2009-10. (For comparison, our target ratio was 13.1 and has been increased to 14.1) In 2010-11, our ladder SFR increased 21% from the previous year, to 14.1. Two departments, DAS and BME, have had ratios below 10, although BME's has now increased to 11. BME is still in an expansion phase, for both student and faculty FTE, and the department is developing short term (for example, having BME faculty teach in other departments) and long term strategies to comply with our college goal of 14.1. DAS is being closed.

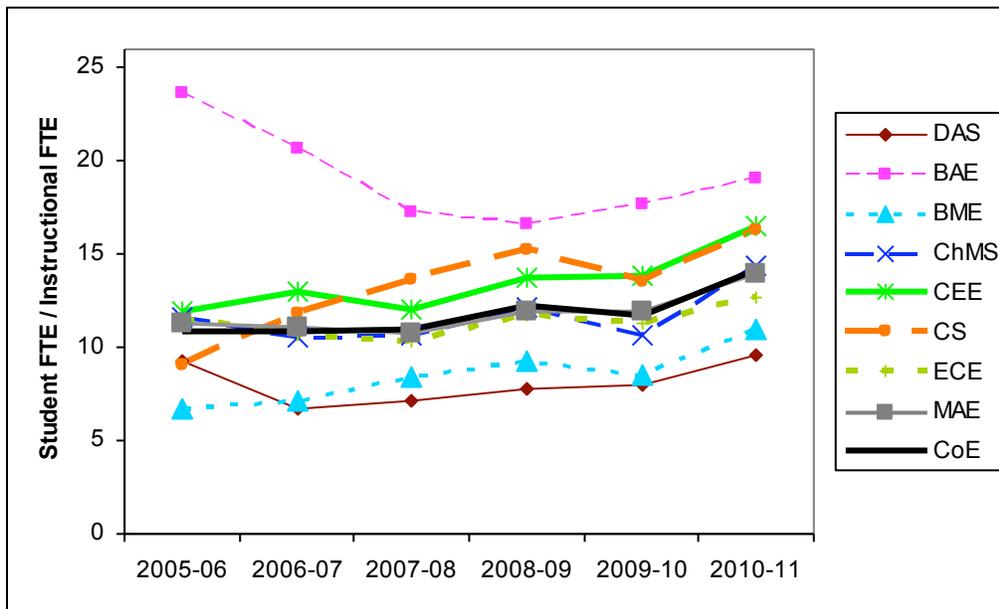


Figure 5. Instructional workload within the College of Engineering and its departments.

National employment projections and especially California's infrastructure needs and technology industries argue for producing more engineers. With current faculty numbers, we should be able to accommodate additional students, to help bring us to our target SFR. A number of departments also are exploring collaborative opportunities to assist with teaching outside CoE.

V. Faculty

A. Current size and future size

At the end of 2010-11, we had approximately 204 budgeted (and 184 filled) ladder-rank FTE. CoE has been directed to reduce budgeted FTE to 189-192 by July 2013. The needs of the State and country argue for expansions of engineering education and research: the U.S. ranks

27th among developed nations in the proportion of college students receiving undergraduate degrees in science or engineering (NAS 2010). Several other factors make UC Davis an excellent venue for more than average growth. These include the strengths of the campus in the biological and environmental sciences, the initiatives of our engineering faculty in those areas and success at obtaining research support, and the physical possibility of expansion. At our current size, the incremental benefits of larger scale – such as the ability to offer multiple sections of courses – outweigh the disadvantages such as the need for students to travel longer distances between classes.

We should note that any eventual growth FTE could easily be absorbed by a few departments or even a single department. For example, ECE is currently small in relation to similar departments, and would like to grow from approximately 30 FTE at present to 40 over the next several years, to reach critical mass in the core areas, and enhance new areas, such as microwave science and technology, while building a new bio-electronics cluster. This size also would help make ECE more competitive at the national level. CEE sees an urgent need to grow by 10% to help meet the infrastructure needs of the State and believes ample research funding opportunities exist for this level of expansion. ChMS wishes to grow to address teaching overload issues for the chemical engineering (versus materials science) faculty. CS believes it should strive to expand approximately 20% to a target of 40 faculty. BME sees strategic opportunities to grow from the current size (approximately 20 FTE) to an ultimate number of 25-30.

Departments with large percentages of senior faculty likely to retire include BAE, ChMS and MAE.

B. New faculty priorities

There is a consensus across several departments that core needs for teaching must be addressed with some of the new hires, but new research areas also must be pursued. Each department has identified priorities in their individual academic plans. The following areas are high priorities for the College of Engineering:

- Sustainability, encompassing the supply of energy, water and other resources, more efficient use of energy and other resources, reuse and recycling of materials, and environmental impacts of human activities. Human infrastructure, such as buildings, utilities and transportation systems, must also be sustainable.
- Health and biology, including engineering in medicine (e.g., medical imaging, tissue engineering and regenerative medicine, bioinformatics, synthetic biology, biomechanics, telemedicine and healthcare IT systems) and enhanced food supply, quality and safety.
- Information technology and applications, such as communications networks, security, graphics/visualization, social networking, and IT applications for research, teaching and/or public use.
- Economic development, especially through improved manufacturing (one of the best funded areas at NSF and DOE), and through developing new innovations and rapidly translating them into practice.

Positions will eventually be released to strengthen these areas and address existing departmental programmatic needs and those arising when current faculty depart.

C. Assumptions for start-up packages

Startup costs may range from a quarter million dollars for an individual focusing primarily on theory or computational areas, to close to a million dollars for an experimentalist working in an area that is new for the campus. In addition to this, costs for laboratory renovations can vary from nothing to nearly a half million dollars. High-cost startup packages have to some degree become self-fulfilling prophecies. Departments logically encourage substantial packages since startups have essentially replaced other internal sources of funding for new equipment. The situation might be remedied somewhat by annually allocating formula-based funds to departments for a range of uses including laboratory renovations and equipment, whether associated with startups or not. Departments might then shift more resources toward shared facilities and equipment.

Departments also might be allowed to “bank” salary dollars for open positions, to be used for startups. The department could choose to fill a position early, with a smaller dowry, or delay until a larger sum was available.

Nonetheless, equipment and, in some departments, laboratory renovations for many of our hires will continue to be expensive, in part due to the transition from physical to biologically-based research. Large laboratories must be reconfigured into smaller ones, and dry laboratories into wet laboratories.

D. Availability of suitable space for new faculty

Using CPEC space guidelines as a measure, we are short in the amount of space that should be provided by the campus to the College. In addition, the CPEC guidelines fail to capture the increased complexity in the types of research space required by recent hires. In some cases, for example, a faculty member may require multiple fume hoods, which are not only expensive from the purchase and installation standpoints, but also may be limited by overall building capacity. It might be argued that we can be more efficient with existing space (see below), but in any case we are deficient in wet laboratories needed by new faculty who will work in biological fields.

E. Faculty diversity, goals, opportunities, and plans to meet goals

UC Davis is fourth among the top 50 engineering schools in percentage of faculty who are women – 18% at UC Davis versus a 13% national average in 2009. Within the UC system, UC Davis has the highest absolute number and percentage of women engineering faculty (ASEE 2010). Our percentage of women faculty has increased from 14% to 18% between 2005-06 and 2010-11. BAE, BME and ChMS all have nearly 30% women.

We are making progress with under-represented minorities, although we still have goals (Table III). Minorities have ranged between 4% and 5% from 2003 through 2010. While absolute numbers in our workforce have increased, from 7 to 9, and goals have decreased, from 8 to 4. The latter change is primarily due to an unfortunate reduction in the availability percentages.

Table III. Current workforce and goals for Academic Senate faculty, absolute numbers

	Current Workforce	Goals
African-Americans	3	3
Asian-Americans	53	0
Native Americans	1	0
Chicano/Latino/Hispanics	5	1
Women	32	0

F. Awards, recognitions and professional service

Over the College’s history, 20 of its faculty members have been members of the National Academies², including eight (Diran Apelian, William Chancellor, Bruce Gates, Linda Katehi, Subhash Mahajan, Michael Savageau, Paul Singh and George Tchobanoglous) elected during the past decade. These represent the tip on a pyramid of accomplishments, national and international awards, and service by UC Davis faculty, including designation as fellows in professional societies and designation as editors of many of the most important journals in their fields, and extensive service to public agencies, other clientele groups and professional organizations. Current members of the College faculty have received 43 NSF CAREER and similar awards for young researchers, including 20 over the past six years.

VI. Resource Challenges and Opportunities

A. Operating Budgets

Budget reductions have strained departments’ abilities to support instruction and research, in terms of salaries for office staff, expenses to help prepare, administer and service research grants, and in some cases for technical staff. Research programs have expanded dramatically, and projects must be rigorously administered to ensure compliance with State and federal regulations.

Following the CA&ES model, we have moved to a zero-based, formula-driven budget model, making transparent the elements considered important. Most of the weight is placed on what we accomplish (teaching, research) rather than faculty size. We have moved to shared services for purchasing, human resources and some aspects of academic personnel, and are considering such a strategy for information technology. Our departments look forward to an increase in return of indirect costs to help sustain their operations.

We are establishing a formula to allocate TA support to departments, factoring in the types of courses offered (lecture, laboratory, discussion) as well as student credit hours. This is a zero-sum game, although the formula makes the allocation process transparent.

B. Support for Graduate Students

Funding for graduate students is a concern for some of our programs. A number have obtained or are pursuing NSF IGERT funding and other grants to supplement current resources. CEE cites the “perfect storm” of explicit campus regulations on NRT and implicit policies of State

² Five are now deceased.

agencies to not fund NRT as a major impediment to research. Ideally, negotiations with the State would allow NRT to be included in grant proposals.

C. External Support

Our proximity to Sacramento will continue to promote close associations between our faculty and state agencies, providing opportunities for major funding for many of our programs and students.

Nationally, research funding provided by NSF, DoD and DOE has not expanded substantially in absolute terms, while funding through NIH has grown dramatically until recently. BME has been very successful in obtaining funding from NIH, and this source represents a major opportunity for programs such as the new bio-electronics emphasis in ECE, especially if more of the funding is directed at translational efforts.

We have further potential to increase funding in response to ERC and STC initiatives and large interdisciplinary research opportunities. For example, CEE obtained many new grants to address regional problems associated with non-point-source pollution.

Through our departmental advisory boards and College-level programs, we hope to increase funding from leaders in industry and successful alumni. In January 2011, the college hired an Executive Director of Development & External Relations, who manages a staff of five who are responsible for all advancement activities. One development officer leads our efforts in corporate relations, a second development officer focuses on major gifts from individuals; and the marketing and communications director works to broaden recognition of the college through consistent branding, effective social media, news placement, and strategic publications. The staff also includes an events coordinator and a gift database assistant.

Investments in development efforts are already yielding successful results, with gifts to the college doubling from \$2.2M in 2009-10 to \$4.5 M in 2010-11. Cumulative gifts since July 2006 total \$27.3M, with 61% going to support research and instruction.

D. Facilities

Most of our departments cite lack of suitable and high quality space as a major issue. The College recently received additional space in Academic Surge Building and at an off-campus building on Chiles Road, however the majority of this substituted for the loss of laboratories and offices in Walker Hall. We will see a gain of approximately 25,000 square feet when Engineering IV comes on line, but design and construction have unfortunately been put on hold due to budget constraints.

We need additional space for expanding departments such as BME and ECE. Collaborations between BME and SOM would be well-served with facilities located at the Health Sciences campus in Sacramento, for translational programs.

In many cases, the changing character of new required facilities is as important as the amount of space. For example, wet laboratories for biologically-based research are needed by several of our departments.

According to PPM 360-21, space allocations should be evaluated based on workload factors, program requirements, adequacy of existing area, technological improvements, environmental

and geographic considerations, and state-approved guidelines. This is a challenging task, to say the least. Understandably, faculty members do not wish to give up space because they realize how difficult it would be to recover it, should their circumstances change. Deans and department chairs exercise considerable caution when redistributing space. As a result, some space is underutilized and some is essentially used for storage, although the latter is discouraged by official policy.

It is hard to precisely assess how much space is underutilized, and our office continuously works with individual faculty and departments as we re-assign existing space to meet the needs of our current and new faculty; we place particular urgency on meeting the needs of junior faculty in a timely fashion. This requires the right question to be posed, and that involves the full cost to society of constructing, operating and maintaining the space. If faculty members were “charged” the full cost of the space assigned to them (other than their own offices), how much space would be relinquished? Unfortunately, there is no practical or legal means of testing or implementing such an approach, but surrogates might be effective. For example, rather than constructing a new building, offer current faculty an annual amount per square foot to give up current space. The amount would be some fraction of the annualized total cost (capital plus operating and maintenance) for a new structure. Or, space could be allocated to departments and individual faculty through a formula, e.g., on the basis of a rolling average of research effort and productivity for on-campus projects. Coefficients could be applied to various types of activities to reflect the space requirements of each.

E. Graduate Group Teaching

Graduate groups in some cases find it difficult to find faculty to teach group-specific courses, in contrast to departmentally-based courses. We appreciate Graduate Council’s proactive approach to avoiding these problems when new groups are established or curricula for existing ones are modified.

VII. Methodology for Assessing Success of the Plan

Easily obtained quantitative measures of the quality and growth of the programs within the College include grant funding and research expenditures, numbers of undergraduate and graduate students, student-faculty ratio, grade point and test statistics for students, amount and types of student support, number of endowed chairs and national rankings.

Other measures will include the quality, quantity and impact of research, success of our graduates in finding employment and their ultimate contributions to the field, satisfaction of our faculty, staff and students; awards and other recognitions; and alliances with industry and other clientele.

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