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 6$^{th}$ and 7$^{th}$ 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.