UC DAVIS COLLEGE OF ENGINEERING

Faculty Hiring Plan under the 2020 Initiative
College of Engineering

5 February 2014

Submitted to

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and
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Summary

This is an exciting time for UCD, as well as for the College of Engineering (CoE), as the campus formulates and deploys plans for increasing our students by approximately 5,000 enrollment and the accompanying addition of several hundred faculty FTEs. For the past decade, our CoE has done exceptionally well in metrics related to faculty recognition, funding, graduate and undergraduate enrollments and fundraising. However, it is widely recognized that current rankings do not reflect our excellence, and that this needs to be addressed with urgency. To address this challenge, we constituted various blue-ribbon committees, involving prominent faculty as well as colleagues from industry and national laboratories, to recommend strategies for growth, communication and outreach, strategic areas for FTE investment, such as manufacturing, and diversity. Under the framework of the UCD 2020 Initiative our goals for the CoE are as follows:

1. Enhance our rankings by implementing aggressive communication and outreach strategies;
2. Identify and pursue center grants from federal, private and state agencies;
3. Increase the quality and quantity of our undergraduate and graduate students;
4. Implement interdisciplinary educational programs that address important societal problems, such as energy, environment, food, transportation and health care; and
5. Implement project-based educational programs to increase recruitment of students from disadvantaged backgrounds and enhance retention.

To accomplish the above goals, we plan to hire approximately 35 FTEs, commensurate with anticipated student growth in the College. Projecting over the coming seven-year time span of the 2020 Initiative, we anticipate that most of this growth in our faculty will occur in the form of ladder-rank positions, primarily in the following five thematic areas, in alphabetical order: 1) energy and the environment, 2) health and biology, 3) information systems and technology, especially as related to big data (and our campus initiative), 4) manufacturing and 5) resiliant infrastructure and sustainability. In addition, we anticipate hiring a small number, approximately one per department, of Lecturers with Potential for Security of Employment (LSOE). The LSOEs are part of a strategic plan in the CoE to increase the excellence of our teaching programs by hiring faculty whose primary mission is to enhance the learning experience for our engineering students via continuous improvement of instruction methods and student engagement. We propose hiring the LSOEs as a cohort so that these new faculty can collaborate on the development and implementation of new education pedagogies and work toward the common goal of preparing the next generation of engineers to address grand challenges facing the planet.

An underlying strategy is to eliminate disciplinary gaps to increase our competiveness for large center grants from federal agencies, partnering with national laboratories, as appropriate. A number of our departments conduct research with scientists and engineers at national laboratories. For example, faculty in Chemical Engineering and Materials Science collaborate with scientists at LANL, LLNL, Sandia-Livermore, LBL and PNNL. We plan to expand and strengthen our interactions with the national laboratories and further extend the value of these new positions by leveraging some FTE with partial appointments at the national labs.

We will also increase our involvement with industry, via centers sponsored by individual companies or consortia that might address research needs of a group of companies clustered around a common theme.

Many hires will come at the interface between various areas and this will present opportunities to link with other campus units including CAES, CBS, MPS, the School of Medicine and the School of Veterinary Medicine, in some cases through joint appointments.

Background

The National Academy of Engineering outlined the Grand Challenges for engineering in the 21st Century, issues that often cross national borders and cultural divides, and can best be addressed with a holistic, global approach:

- Environmentally benign power
- Access to adequate supplies of clean water
- Advances in health informatics
- Development of better medicines
- Reverse-engineering of the brain
- Improvement to the tools of scientific discovery
- Improved adaptive methods for learning
- Enhanced virtual reality
- Secure cyberspace
- Restored and improve urban infrastructure

As summarized in our College's Mission Statement, our researchers and educators focus on specific areas of concern: energy, environment, health and biology, information technology and management, and physical infrastructure. We are recognized leaders in energy efficiency, biomass, wind, alternative fuels and transportation, data visualization, optical communications, network security and biomedical imaging. Among the advancements in which our researchers provide leadership and expertise: electronic voting security, low-carbon fuel standards, plug-in hybrid vehicles, anaerobic digesters that convert organic waste into useable energy, imaging technologies that allow researchers to study biological processes at the cellular and molecular levels, regeneration and repair of cartilage and other tissues, nanomedicine and nanotherapeutics, and drug delivery systems that precisely target diseased cells.

Primary Areas for Growth

1. Energy and the Environment

Availability of clean, cost effective energy is of critical concern to California, the nation, and the world. The California Renewables Portfolio Standard legislation requires 33% of the state's electric energy to come from renewable energy sources in 2020, spurring strong interest in the development of renewable energy, energy efficiency, and energy storage technologies as well as numerical tools to analyze and optimize the integration of systems involving a wide range of power generation, power consumption, and energy storage devices. In transportation, hybrid-electric and fuel-cell based vehicles are being viewed as the systems of choice.

Within this general area we anticipate hiring in the Departments of Biological and Agricultural Engineering, Chemical Engineering and Materials Science, Civil and Environmental Engineering, and Mechanical and Aerospace Engineering. These will expand on our strengths in dealing with energy supply and efficiency, such as the work of the Institute of Transportation Studies and various departments on alternative fuels, hydrogen generation and storage, photovoltaic and wind energy, hybrid and fuel cell vehicles. We anticipate expanding research on hard materials and nanotechnology, including catalysis and applications in photovoltaics and batteries.

Research in energy will be coupled with that in manufacturing, addressing the Energy Efficient Manufacturing Processes and Materials initiatives of the Department of Energy.

2. Health and Biology

Medical, biological and chemical systems research has taken a leap akin to the profound advances introduced by the development of novel imaging modalities. Today's imaging and sensing technology allows researchers to probe the most fundamental components of living things, research fundamental to fighting complex, serious diseases like cancer and to ensure the safety of our food supply. There is increasing demand for engineers trained in biotechnology, skilled in exploration and innovation at the molecular, cellular, tissue, systems and organism levels.

Biomedical Engineering has a tremendous opportunity to shape the future direction and build the knowledge infrastructure of the biomedical field. The Department recently conducted a study of trends and emerging disciplines within the field of biomedical engineering to help guide future hiring directions. Key opportunities for growth are:

- Immunoengineering, focusing on research into targeting or modulating immune cell function in vivo, for example using nanoparticles, or addressing important immunological questions using novel in vitro assays and technologies, or computational techniques.
- Protein engineering and systems biology: This emergent area has great potential, especially at UC Davis. Specific areas that are of interest include protein chemistry and therapeutic proteins, synthetic biology, and cell signaling.
- The interface of neuroscience and engineering: A bridge between the strong neuroscience community at UC Davis (Center for Neuroscience, MIND Institute, Alzheimer's Disease Center and Center for Mind and Brain) and BME would generate a whole host of opportunities, especially with the upcoming NIH BRAIN initiative.
- Cardiovascular devices: The recent funding by NIH of the UC Center for Accelerated Innovation (led by UCLA, and including UC Davis), focused on technologies to improve diagnosis, treatment, management and prevention of heart, lung and blood disorders opens a significant opportunity, especially given the strengths at UCD in cardiovascular research.
- Bioinformatics and the underlying explosion in the storage, analysis and implementation of big data as related to healthcare

For the Davis campus, which is so dominant in biology and medicine, it is important to grow in areas of Computer Science such as computational biology, bioinformatics, and digital medicine.

Within Chemical Engineering and Materials Science, current research in soft materials and biomolecular engineering addresses fundamental challenges ranging from biomolecular transport and self-assembled systems to biocatalysis, being important in the food, health, and energy sectors. New hires would have interests in applying engineering principles to investigate new molecules and materials that interact with biological molecules and tissues. It is envisioned that new faculty would provide synergy by using techniques that expand on the current arsenal, including, for example, organic synthesis, self-assembly, peptide and nucleic acid-based engineering, directed evolution, nanofabrication, in vivo and in vitro protein expression systems, and synthetic biology broadly. At the intersection of soft and hard materials, potential faculty hires would focus on a number of critical questions, e.g., evaluating the structural performance of bio-based or bio-derived materials, or materials for biology/health/food related applications, making new materials either for biology related applications or from bio-derived materials.

3. Information Systems and Technology

Today's world is connected by largely hidden but highly complex information networks. The speed at which this massively webbed data environment evolves is both exhilarating and daunting. Such technology has the power to unite us, can address some of our most difficult problems, and allows previously unimaginable human achievements. However, the complexity of our highly connected global community also makes us vulnerable. There is an urgent need in California and the nation for engineers trained in information technology. The Bureau of Labor Statistics estimates that computer-related occupations will comprise most of the new engineering and scientific jobs in the current decade.

Although growth our Computer Science and Engineering (CSE) major is at present restricted by a cap on freshman admissions, the number of L&S Computer Science majors and transfers into CSE have increased the number of students in our CS majors by 45% since 2008.

Computer Science research as well as teaching is important for the campus. Computation is now fundamental to research in most disciplines. It is at the heart of the campus Big Data initiative, and, for example, CS faculty are involved in eight out of the twenty RISE and IFHA awards. The 2014 NSF budget request has the prefix "Cyber-" in three out of its six main priorities.

Core Computer Science: Over the last several years we have, for a variety of reasons, concentrated much of our faculty hiring in Applied Computer Science. But we need now to build up our core Computer Science faculty.

- Our lack of faculty in databases is clearly an issue for a campus that intends to excel in data-driven science. All leading Computer Science departments have a faculty cluster in machine learning and artificial intelligence, another area of strategic importance to data-driven science.
- The Web and social media are hugely influential examples of Computer Science advances in human-computer interaction. While Davis has interesting related research in the humanities, we have never had any faculty in this area.

- The Systems area includes hardware, operating systems and performance; it is central to the field. We have very few systems faculty. The major current issue in this area is the resurgence of parallel processing as we approach the limits of how densely circuitry can be packed onto a chip. We need faculty whose research touches on this crucial issue.
- Even in the areas in which we have excellent research groups, we anticipate hiring needs. In recent years UC Davis has become an important force in programming languages and software engineering, and strengthening this small group would put us into the first tier.

Applications in Computer Science: Many of these new hires may well do work that addresses important application areas, and we are also open to hiring new faculty in applied computer science through campus interdisciplinary initiatives.

Biological and Agricultural Engineering has identified a Sensor Development and Automation Engineer for Agriculture as a priority hire. This individual would lead automation efforts for vineyards, orchards and fresh market crops; precision crop management and harvest; and sensor development.

Multiscale computational modeling is at the center of the growth strategy for Chemical Engineering and Materials Science. The Department presently has efforts in both applications and development for molecular, course-grained, and continuum scales, and in both equilibrium and disequilibrium settings. One of the missing pieces is the electronic structure scale, which is a crucial component of materials understanding. Filling this void would bolster our integrated theory and modeling portfolio and also connect computation directly to many experimental efforts. And a more complete representation of the broad spectrum of condensed matter modeling would help the Department in its pursuit of multi-investigator proposals, e.g., for centers like a CEMRI.

4. Manufacturing

The importance of manufacturing in employment and economic growth of the country has recently been well publicized. President Obama launched the Advanced Manufacturing Partnership (AMP) in 2011 to develop partnerships between industry, the federal government, and universities for addressing emerging technologies to create high quality manufacturing jobs and enhance the global competiveness of the United States. The key elements of the AMP program include manufacturing in security industries, efficient development and deployment of advanced materials, advanced robotics, and energy efficient manufacturing processes and materials. The president proposes to invest $1 billion over ten years to create a National Network for Manufacturing Innovation, consisting of up to 45 Institutes for Manufacturing Innovation. The National Laboratories, including Livermore and Los Alamos, have embarked on a major initiative in manufacturing sciences. Locally, Congressman John Garamendi has established a Manufacturing Advisory Committee (MAC), on which our College is represented.

The current excellence of the College of Engineering in this area is most evident through the Intelligent Manufacturing Systems (IMS) laboratories of Professor Kazuo Yamazaki of the Department of Mechanical and Aerospace Engineering. Our other major current facility is the College's Northern California Nanotechnology Center (NC2), which has much potential for growth. Several faculty members across four of our departments – Mechanical and Aerospace Engineering, Chemical Engineering and Materials Science, Electrical and Computer Engineering, and Biomedical Engineering – conduct research and professional activities in areas relevant to manufacturing, such as plasma sintering, spray atomization and deposition, nano-scale electronic/photonic design and fabrication, self-assembly of nano-meter scale electronics, micro-fabricated sensors, micro-mechanical (MEMS) devices, robotics, and modeling for virtual manufacturing systems. The work of Professors Richard Dorf and Andrew Hargadon of the Graduate School of Management, on entrepreneurship and technology ventures, is very relevant to manufacturing.

The campus can clearly benefit from an interdisciplinary center in manufacturing that involves faculty members who are directly involved in research and professional activities in the area of manufacturing. Much of the emerging manufacturing technology is interdisciplinary. The College plans to allocate additional positions to this area, across the Departments of Mechanical and Aerospace Engineering, Chemical Engineering and Materials Science, Electrical and Computer Engineering, Biological and Agricultural Engineering, and Computer Science. We envision strong ties between this group and the Graduate School of Management. As recommended in the 19 March 2012 Report of the College's ad hoc Committee on Manufacturing for the 21st Century, we plan to create a Manufacturing Research Group to pursue funding opportunities and to help establish a graduate group in manufacturing. With the support of several regional manufacturers, we have also proposed an Integrated Manufacturing Education Innovation Center (IMEIC), located on campus, to provide education and training programs for advanced emerging manufacturing technologies.

Biological and Agricultural Engineering intends to hire a Mechanical Design Engineer for Agriculture, to work on mechanization, robotics and automation for specialty crops; modeling, design, analysis and testing of agricultural machinery; fluid power; and the machine/human interface.

5. Resilient Infrastructure and Sustainability

The physical infrastructure of the United States is aging and, according to a 2009 report by the American Society of Civil Engineers, needs an immense investment of resources to remain viable. There will be an ongoing demand for highly skilled engineers who can apply innovative engineering solutions to sustaining and improving an aging infrastructure in a climate of increasing demand.

Given the inter-dependence of the different components of the infrastructure and the increasing complexity of the issues that need to be resolved, Civil and Environmental Engineering believes that future areas of growth need to address the problem from a "systems" perspective. Expertise in the following areas will be critical:

- Science-based modeling of complexity and uncertainty
- Assessment and mitigation of infrastructure vulnerability
- Models and methods for sustainable infrastructure design
- Physics-based computational simulation to enable infrastructure system design

Our strengths in hard materials will also be exploited in the areas of functional materials, and novel materials synthesis and characterization. We need to hire materials scientists to take advantage of opportunities in micro-mechanical behavior and devices based on fabricating and characterizing optical, electronic, and magnetic materials. Materials consumption on an unprecedented scale will provide opportunities for research on recovery and recycling materials issues that involve energy storage systems, stress, chemically induced corrosion, and thermoelectrics.

Computer Science faculty are needed to support sustainability research. The introduction of sensors into the environment and built infrastructure provides interesting networking and data challenges, and the potential to manage resources at much higher resolutions than are currently possible. We hope to address the design of such cyber-physical management systems, including automatically optimized actuation and control. The organization and management of spatial data and GIS is important to the sustainability effort as well.

There is also a need to focus on Manufacturing for Sustainable Development. This includes energy, mobility/transportation, housing, food and water, and materials recovery and recycling.

6. Lecturers with Potential for Security of Employment

There is a need to transform our undergraduate engineering education to prepare our students to tackle pressing global grand challenges, and to achieve traits critical for long-term success: (1) critical thinking based on conceptual understanding of core knowledge, (2) ability to write and speak well, (3) ability to design in a multi-dimensional space, (4) recognition and understanding importance of economic realities, (5) understanding elements of entrepreneurship and innovation, (6) political astuteness, and (7) an appreciation of global challenges. In particular, our engineering curriculum should build in experiences for students to develop skill sets that are traditionally not taught in our classrooms, including better communication (both presentation and technical writing) skills and entrepreneurship, and exposure to the design and innovation process that takes into account real-life constraints from economic, social, and political perspectives.

We view Lecturers with Security of Employment (LSOE) as strong candidates to assist with this transformation. In particular, to create more rewarding educational experiences for students, we want to expand our laboratory and simulation capabilities to give more practical and hands-on experience, so that students can learn by "doing" rather than "listening." However, this requires significant human resources to implement. Our LSOE would focus their scholarly effort on curricular innovation, which is important for addressing the demands that graduating engineers will encounter. Recent curricular innovations including mobile apps and media computing have been successful but stretched our limited teaching resources.

Our goal is to have one to two LSOE faculty in each department. These Senate faculty will be responsible for completing a holistic review of current engineering curricula, and collaborating with existing faculty to transform programs to better achieve the educational goals for each major and instill in our graduates the skills we believe are necessary for success.

Conclusion

The College of Engineering at UC Davis faces an unprecedented opportunity to grow in excellence in the context of UCD 2020 and dramatically increase external recognition in rankings. The strategic growth in the excellence of our faculty (senior and junior), as evidenced by the remarkable number of NSF Career Awards, for example, provides the foundation for a quantum jump in reputation during the next five years. The areas selected for FTE growth outlined in this proposal were strategically identified to leverage existing and future UCD strengths and thereby leverage campus-wide opportunities for interdisciplinary centers of excellence.

In just 50 years since it was founded, the College of Engineering at UC Davis has achieved remarkable success and recognition by all measures of academic excellence. In the next five years, the CoE will implement the FTE plan described in this document and will attain the external recognition that it deserves.