ELECTRICAL ENGINEERING ACADEMIC PLAN FOR 2010

12/20/05

Maintaining and Building Excellence

Since its inception in 2001, the Electrical Engineering has endeavored to advance a research agenda in a few focused, but overlapping areas. These focus areas were identified in our 2001 strategic ten year plan to broadly include the following:

- photonics and electronics
- VLSI, MEMS, and nanotechnology
- signal processing, communications and remote sensing.

Although we are still focused in these general areas at some level, there is significant overlap between these areas and we have begun to emphasize life science applications in most of the areas.

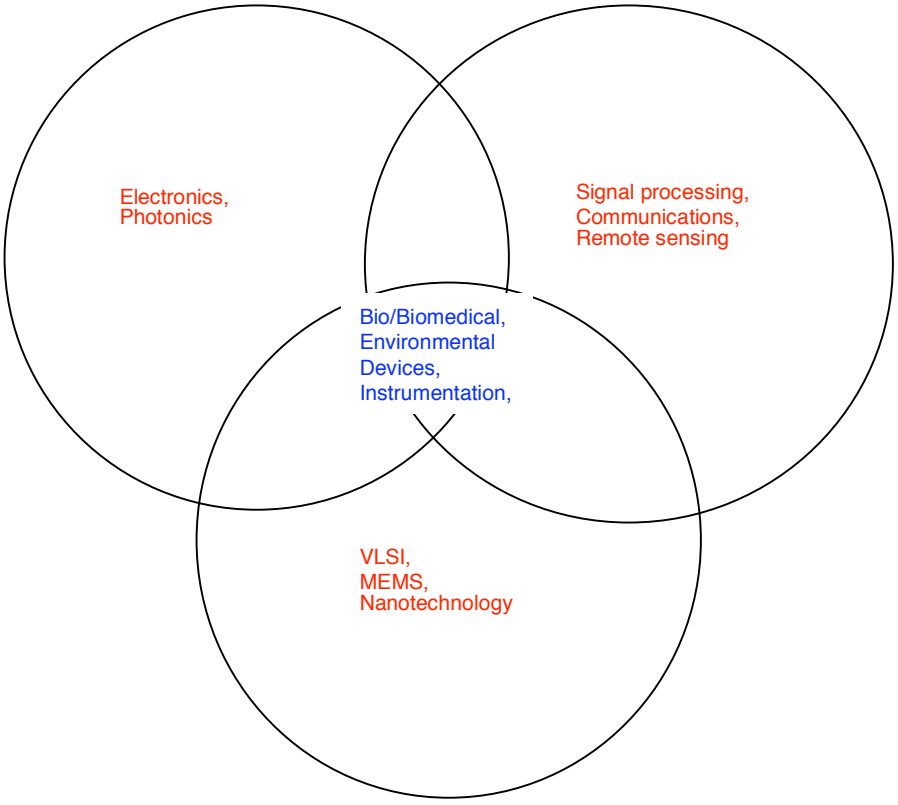
By focusing on a few strategic areas, and making targeted and synergistic hires, we hope to be able to develop the focus that will allow us to carve out our research niche and enable us to begin to develop an external profile. The research areas we have chosen are relevant not only to industry in northern California, but to the nation as a whole. Moreover, because of the interdisciplinary nature of these research areas, they allow us to easily develop collaborations across departmental and divisional boundaries. Thus we are able to function on a research scale like a larger, but still well focused, department.

A key strength of the department and a major distinguishing feature is the research focus on the underlying science necessary to solve important engineering problems. Our faculty have key collaborations across divisional boundaries with colleagues in Applied Mathematics, Astronomy, Chemistry, Physics, Molecular, Cell and Developmental Biology, Earth and Marine Sciences, Education, both on and off campus, and with various medical schools. Because much of the research within EE at UCSC tends to be somewhat interdisciplinary, EE faculty members often act as advisors or co-advisors of graduate students from computer engineering, physics, applied math, computer science, biomolecular engineering and biology. And occasionally, faculty members from other programs supervise EE students. Moreover, there are often faculty members from outside the School of Engineering on the Ph.D. committees of EE students depending upon the dissertation topic. In addition, EE faculty not only have research ties with colleagues in all of the other engineering departments at UCSC, but also, faculty from those departments teach courses that some of our students are required to take.

EE faculty have been recipients of numerous national and international awards, such as the IEEE Third Millennium Medal, the Rank Prize in Optoelectronics, the Burton Medal of the Microscopy Society of America, The Mac Van Valkenburg Award of the IEEE Circuits and Systems Society. In addition, our faculty have been elected as IEEE Fellows, AAAS Fellows, Packard Fellows and four of our faculty have won NSF CAREER awards. EE faculty have played major roles (PI or co-PI) in large scale multi-

investigator, multi-institution research centers. The NSF Engineering Research Center in Biomimetic, Microelectronic Systems (USC, lead; UCSC, CalTech) and the ONR Center for Thermionic Energy Conversion (UCSC, lead; UCB, UCSB, Purdue, Harvard, North Carolina State) are just two examples.

We see the intersection of the life sciences with engineering (and particularly electrical engineering) as one of the intellectually exciting areas of the future. This is true not only for the instrumentation arena, but also in the biomedical, environmental and materials areas as well. The department is beginning to build up major foci in these application areas. At present, there are three faculty who have a major effort in the biodevice/instrumentation area, a fourth who is beginning to have part of his program going in that direction, and a fifth looking at novel approaches to biomedical imaging. Building on existing strengths, we are beginning to develop nano/microtechnology for a variety of bio/biomedical applications.



Electrical Engineering Focus Areas

For example, single molecule diagnostics on as chip is being developed using ARROW waveguides and optics on a chip technology, technology for micro and nanoscale prosthetic devices, imaging devices for the characterization of functional units in biological systems, thermal micro-imaging devices and novel forms of image processing and devices that have applicability to biological imaging. . With the addition of a new junior faculty member (a search to be initiated in the 2005-06 academic year) in the bioelectronic device area, we will have a significant nucleus of faculty to begin a biodevice concentration program at both the undergraduate and graduate levels within EE. We will also be developing a bio-instrumentation minor within EE and are deeply involved in an effort to create an interdisciplinary bioengineering undergraduate B.S. program to be jointly administered by the departments of Biomolecular Engineering and Computer Engineering. As we get more students interested in this intersection of engineering and life sciences, we will work with the departments of Biomolecular Engineering and Molecular, Cellular and Developmental Biology to develop more course offerings in this area. In addition, various faculty in EE are in discussions with faculty at UCSF regarding the possibilities of joint course offerings between campuses.

We also see the intersection of the environmental sciences and electrical engineering as another emerging area in which our faculty are getting involved. They are not only working on both developing novel forms of remote sensors for earth and ocean environments, but they are also investigating many aspects of the "physical layer" of wireless communications needed to tie networks of sensors (radar, sonar and optical) together in order to sense multidimensionally on a large scale. This work complements that going on in the Department of Computer Engineering on the networking layer of wireless communications. A significant effort is ongoing in the department with respect to the transformation from traditional communications to cooperative based communications. This effort is supported by several DOD agencies and is part of a long term plan to combine the particular strengths of different departments (in this case EE and CE) in order to secure large scale, long term funding. In fact, many of the wireless technology protocols being developed by EE faculty can be thought of as being "dual use" technologies, which have applicability not only for commercial wireless systems but also for the increasing need to be able to monitor the environment.

With a significant program in opto-thermo-electric conversion devices, some faculty members in the EE department are also looking at alternative methods of energy conversion. Energy generation and its environmental impact is another of the key issues in society and it will certainly become more important in the future as fossil sources are depleted. As mentioned before, the EE department is already leading a multiuniversity consortium on thermionic energy conversion. The goal of this center is to build thermal to electric energy conversion systems with greater than one watt per square cm at 20% efficiency. A new thrust is looking at generating electricity inside the body to power prosthetic devices and investigate methods of using the efficiency of biological systems to generate electric power. These thrusts are consistent with developing materials expertise within EE that focuses on the materials science needed to solve particular device problems.

The other exciting area in which we plan to expand (and which overlaps with the other areas) is that of low power/analog/mixed signal circuit design. The need for such circuitry not only in biomedical diagnostics, but also in many other remote sensing and communication scenarios is enormous, and there is a pressing need for students skilled in that art in the industries of northern California and elsewhere. At present we have only three faculty members working in some aspect of this area and this limits the type and breadth of curriculum we can pursue. We plan to hire an additional faculty member in this area in the next several years in order to develop a major thrust in this growing and exciting area.

Because of the multidisciplinary research of the EE faculty, the faculty is involved with several campus research centers (the Santa Cruz Institute for Particle Physics{SCIPP}, the Center for Adaptive Optics{CfAO}, the Center for Biomolecular Science and Engineering{CBSE}, the Center for Integrated Marine Technology{CIMT}, the Institute for Geophysics and Planetary Physics{IGPP} and the Center for Remote Sensing{CRS}, two of the California Institutes for Science and Innovation (the Center for Information Technology in the Service of Society{CITRIS}, a consortium of UCB, UCD, UCSC and UCM and the Center for Quantitative Biology{QB3}, a consortium of UCB, UCSF and UCSC) and the new California Institute for Regenerative Medicine{CIRM}.

In the last two years, the department has made two senior hires in the broad area of biomedical devices/VLSI/nanotechnology. And as mentioned before, in the 05-06 academic year, we plan to hire a junior faculty member in the biomedical device area. Moreover, we realize that as we push forth our programs in photonics and electronics, even though there may be some life science bent, the EE faculty must necessarily engage in a significant amount of materials research in developing their devices. We will expand these efforts and build up a “materials for devices” core. We note here that the last hire made in EE was for a faculty member who is working on MEMS actuators for deformable mirrors in conjunction with the Center for Adaptive Optics. Such an expansion in “materials for devices” is consistent with the university effort to build up a materials research core between physics, chemistry and EE; the ultimate goal being to propose to develop a NSF funded Materials Science and Engineering Center (MRSEC) at UCSC. Towards this end, we will begin a search in 2005-06 for a faculty member (at the associate or full professor level) who has interests not only in developing novel materials for devices but also in taking an active role in building up this materials research core at UCSC. If we are serious in carving a niche for nanotechnology at UCSC, we need to concentrate at bringing in external dollars for large scale research centers where we can take advantage of the economy of scale and leveraging which such centers allow. Finally, EE faculty are deeply involved in building collaborations with the University Affiliated Research Center at NASA-Ames, not only in developing joint programs, but also in the planning of the Bio-Info Nano Research and Development Institute (BIN-RDI) to be developed at the Ames Research Park. Such development will aid in our goal of creating large scale research centers led by EE faculty.

In addition to research excellence, the faculty in EE are also playing leading roles in developing programs aimed at increase the diversity base of electrical engineering. EE faculty supervise undergraduate students in the UC LEADS program as well as partcipate in supervising students in the NSF-REU "SURF-IT" program run by the Department of Computer Engineering. EE faculty play lead roles (PI and co-PI) in the NSF funded DEEP program, a $2M program aimed at creating a seamless transition between community colleges and UCSC in engineering and increasing the number of underrepresented graduate in engineering at UCSC. EE faculty are also involved in outreach programs to the schools aimed at increasing the number of students going through a STEM curriculum in the schools. In particular, we are involved with the Pajaro Valley School District in developing STEM experimental modules in optics and microscopy in conjunction with the Educational Partnership Center and the CaMP statewide program.

In addition to having EE play a major role in developing a materials research effort here at UCSC, we also are looking towards having an NSF funded ERC (or equivalent) led by EE faculty within the next half decade. We are exploring the idea of initiating a Center for Nanotechnology and Renewable Energies. An EE faculty member is looking at the possibility of proposing an ERC in Adaptive Optics as the successor to the NSF-funded STC Center for Adaptive Optics among several possibilities. Finally, we are bringing together faculty from diverse disciplines from UCSC and NASA-Ames to look at the possibility of putting together a proposal for a Center for the Exploration of the Limits of Life (CELL) in the next round of NSF science and technology centers (2007). We see the cost-effectiveness of large scale centers not only from a research point of view, but also from the point of view of being able to allow students to participate in solving large scale, important societal problems, and in being able fund the resources to deliver more professional development opportunities to students (such programs are integral components of such centers). Furthermore, such centers are able to offer more outreach opportunities to students traditionally underrepresented in engineering disciplines.

Sustainability within Available Resources

The number of Electrical Engineering ladder rank faculty have been increasing at a rate of about 8.25% per year since the department inception in 2001 (although there was no search during the 2004-2005 period). It should be noted, that because of the leadership roles which EE faculty play in the university, the number of ladder rank FTE's available for teaching is significantly less than the number of FTE's. During this same time frame, the number of undergraduates has increased about 18.5% per year and that of graduate students at a rate of about 37.5% per year. Over this same time period the amount of external research funding has almost quadrupled to over $4M per year. At present, this amounts to about $330K per ladder rank FTE. However, this amount is not uniformly distributed among all the faculty and we hope to be able to change this distribution in the future. We feel that as we grow to our revised number of 18 FTE's by 2011 (15% less than proposed in our 2001 Strategic Plan), we can almost double the total external funding and reach a $500K -$600K per faculty value, a number consistent with the top

ten EE departments in the country. This will, of course increase the number of graduate students that can be supported. Furthermore, as the fraction of domestic graduate students increases (as it has been doing since the inception of the EE PhD program), we will be able to support more students on the same amount of money. In addition, by distributing our research portfolio across multiple agencies (NSF, NIH, DOD and private foundations), we will be less prone to the year to year fluctuations of federal funding.

Furthermore, we would like to increase the number of adjunct/research faculty whose primary concentration is on research. However, the UCSC policy of having adjunct appointments (at 0% time go through the identical hiring process as for ladder rank faculty results in excessively long delays (one to two years) in hiring and prevents the department from taking advantage of unique targets of opportunity. The current UCSC policy makes it extremely difficult to bring on board esteemed researchers from industry and government laboratories. If such hiring could be done within the purview of the School of Engineering, we could significantly increase our research effort and thus have a percentage of adjunct research faculty more akin to the top-ten EE departments in the country.

There are several key issues that the department faces in the near-term and long term. The most critical one is that of appropriate infrastructure. The School of Engineering was initially set up with the idea that the departments would be those that did not require significant physical infrastructure. Thus, computer science and computer engineering became the first departments in the new School of Engineering (they were already in existence for more than a decade before the founding of the School of Engineering). Electrical engineering came into existence as the first new department. Initial hires were in the signal processing. communications areas, those areas that were computationally oriented and required little specialized laboratory space. As the EE department started to grow in the device and nanotechnology area, more materials processing needs and specialty spaces became essential. Moreover, some of the areas of proposed expansion will also be heavily in such areas because those are the exciting interface areas of the future and there will be an increasing demand for students trained in those areas in Silicon Valley industries. Thus, there is a critical need in EE for wet chemistry, materials processing and characterization space (much of this needs to be in vibration and EM interference free environments).

The new engineering building (E2) is a “dry” building; that is, offices and dry labs. It is suitable only for the computational and circuit design aspects of EE. The School of Engineering understands this dilemma and is beginning to undergo renovation of the Baskin Engineering Building to accommodate these needs. One lab has been recently renovated in the basement of Baskin which will house microscopy, cell culture and microcharacterization facilities.

In the next alteration phase of the Baskin Engineering Building, which hopefully will start by March of 2006 when the new Physical and Biological Sciences building is completed), we will get more renovated basement space for the MEMS, nanotechnology efforts and two semifinished labs on the second floor. In addition, there will be a small,

900 square foot, class 1000 clean room for photolithographic processing, with the possibility of another 1000 square feet for expansion when we get the funds to do so. This will alleviate some of the problems we have now in device fabrication, which is all done external to UCSC, either at Cornell, UCSB, Stanford or Brigham Young University. However, that space is not expected to be finished until 2007. This space is critical to our program since we cannot hope to develop a world class program in nanotechnology if all the device fabrication and processing is performed off-site.

For this reason we would like to expand into the basement space of the Baskin Engineering Building (which has the extremely low vibration and EM interference characteristics necessary for nanotechnology work), but that cannot happen soon until the university printing shop, the paint room and chemical storage facility moves out. The characteristics of such space are essential if we are to mount any type of serious effort in nanotechnology. In the long term, we are looking at expansion space for both applied optics, microfabrication and processing in the old Texas Instruments building which UCSC has recently acquired. Although the building is two miles from campus, it does potentially allow for further process space expansion since part of that building was used as a semiconductor microfabrication research facility. This is just in the planning stage at present, and it could be many years before this space is actually available for use and we can acquire the funding to renovate that space. Furthermore, there is also the long term possibility of utilizing research space in the Bio-Info-Nano Research and Development Institute being planned at NASA-Ames Research Park. However, that too, is still in the planning stage.

Future Opportunities for Investment in New Endeavors

As we look at the mix of MS and PhD students in our graduate program, we are exploring the possibility of offering another type of graduate degree, a project oriented masters of engineering degree (MEng). The basis for this is that there are a significant number of students enrolled in graduate courses in EE at UCSC who work in Silicon Valley. UCSC has established the Silicon Valley Center headquartered at the NASA-Ames Research Park in Mountain View, just 25 miles away and the School of Engineering is committed to developing academic programs in that center. The first program planned is that of the Systems and Technology Management (STM). At present, many EE faculty have research ties with NASA-Ames and several faculty have offices in the UCSC Silicon Valley Center.

The rationale for a project oriented MEng degree is that it could be completed within a 12 month time frame full time or within two years on a part-time basis and would consist of courses and a project (not a thesis). Many part-time students in our graduate programs work in Silicon Valley and the ability to take courses at both the Silicon Valley Center and the UCSC main campus would be attractive to many students. Moreover, a video link to be set-up between the Ames site and the Santa Cruz campus would allow students to take courses at both locales. A project based degree would offer more connection between students and faculty than a pure course oriented degree and would encourage

more industry/university interaction as well, since projects could be sponsored by industry. Such a program would not only be attractive to students working in the valley, but could be used as a recruiting tool for undergraduates. Students could get more advanced technical training in their 5th year and at the end of five years would have two degrees, a BS and an MEng. There is at present, no equivalent type of project-based professional degree offered at Silicon Valley edcational institutions.

Of course, given that we do not have enough faculty to teach our existing courses, it is not immediately obvious how we might accomplish this extra load. However, the courses we would need to teach for an MEng program would be the same that we want to teach for our MS/PhD program. Thus, we would have to bootstrap our way to develop such a program. However, the existence of such a program would fit in well with the STM program and the possibility of a UCSC School of Management centered at the Silicon Valley Center. Since we anticipate that such an MEng program would attract a significant number of students, we would then be in a position to get the additional resources to the department which would allow these courses to be taught.

Educationally, an MEng program appears to make sense, since often there are students who would like more technical expertise before embarking on their career, there are workers with BS degrees who would like an advanced degree in their specialty, there are workers who might want to retool their expertise and there are a smaller subset of students who are not sure if the PhD research route is for them and would like the idea of an intermediate terminal degree to test the waters before making a decision. Finally, an MEng program would strengthen the ties between the EE program and industry in the Silicon Valley, thus enhancing our program in the same way that the Honors Co-op program has worked for many years at Stanford.

Plan for Additional Ladder-rank Faculty

As mentioned previously, it is planned to expand the department by five faculty in the next five years. Although this is less than the number proposed in the 2001 Ten year plan, and less than we think we need in order to get into the top 20 rankings of EE departments, we feel that by concentrating on a few niche areas we can establish a world class presence in those areas. It should be noted that although we have targeted specific research areas in specific years as per campus policy, our plan is to constantly be on the lookout for the best people in the focus areas in which we are concentrating our efforts. Therefore, this hiring plan should be viewed as a guide rather than a blueprint.

In the 2005-06 period we will be recruiting a junior faculty in the area of biomedical devices/bioelectronics. This will give us almost a half dozen faculty working in biomedical related areas. In the same time frame we will be recruiting for a faculty member in the device materials area, in particular, a tenured faculty who can catalyze the materials effort at UCSC. If possible, this person would have ties to the Center for Adaptive Optics. At present, there is no coherent materials science and engineering

presence at UCSC, even though many faculty are working in the areas of materials research. We are coordinating this hire with the search in physics so that we may develop a coherent materials effort at UCSC with the ultimate aim of being successful at bring an NSF funded MRSEC to UCSC. Along with the materials efforts going on at NASA-Ames and the development of a Bio-Info-Nano Research and Development Institute there and the potential of the TI building for further collaborations, we feel we are moving in the right track to have a successful end.

In the AY2007-2008 period we will be recruiting a faculty member in the area of analog/mixed signal circuit design. There is a crying need in this country for engineers in this area which affects sensors, diagnostics and wireless communication systems. Moreover, with the addition of an additional faculty member in that area, we would be able to teach a reasonable number of circuit design courses consistent with what is necessary for a top tier EE department. The following year (AY2008-2009), we plan to recruit in the signal processing area with an emphasis on biomedical imaging. Here we hope to tie more closely the nanotechnology and applied optics groups with the signal processing groups to address critical problems of the imaging of biological systems from the molecular to the organismal level. Finally, (in AY2010-2011) we would make an additional hire in the wireless communications area, bringing the number of faculty in that area to four.

Table I

EE Hiring Plan

Year	Specialty	Position
2005-2006	Biomedical devices / bioelectronics	Assistant professor
2005-2006	Device materials / adaptive optics	Associate / full professor
2007-2008	Analog / mixed signal / current design	Assistant professor
2008-2009	Biomedical imaging / signal processing	Assistant professor
2010-2011	Wireless communications	Assistant professor

Plan for Enrollment FTE

Even though, in our new hiring plan we will only hire five new faculty through 2011, we feel that we can become more efficient in our academic offerings, so that we may be able to offer a wider selection of courses with fewer faculty than anticipated in the 2001 Strategic Plan. In terms of increasing the undergraduate enrollments, we have been offering one 80 level introduction course (modern electronic technology and how it works). We offer this course once a year in the winter quarter to about 100 students. We will be offering a second course in this series this spring on renewable energy resources.

And we plan next year to develop a third course in this suite relating to nanotechnology or biomedical instrumentation. We feel, that such courses will attract students as EE majors as well as provide the type of course needed to develop technical literacy to a wider population of undergraduates. Moreover, these introduction course will have the benefit of attracting more students to STEM disciplines, not only EE. Such a strategy should benefit the entire campus population, and it will bring more resources (ie, TA's) to enable faculty in EE to provide a better quality of instruction. Along with this, we will be consolidating some of our mezzanine/first year graduate courses. This will allow us to teach to a larger set of students (graduate and undergraduate) as well as allow more faculty for teaching upper level specialty courses which are essential for a substantial graduate program and the existence of which will draw a higher caliber of student to EE at UCSC.

Under discussion is also the development of more hands-on courses to potential EE students in their first two years. We will be submitting proposals for exsternal funding to develop experimental modules for the "introduction to modern electronic technology" course, and are looking at the possibilities of introductory hands-on optics laboratories that will give students the impetus to learn their physics and mathematics and to see early-on the connection between the math, physics and engineering. Often, the major problems with retention occur in the first two years where students take few, if any, engineering courses.

One significant method of increasing the undergraduate retention rate in EE, thus increasing enrollment, is to revise the advising and mentoring system to allow for more faculty-student contact. In the past, once entering the EE major, students are assigned a faculty advisor. However, they do not have to see their faculty advisor, ever! The School of Engineering has a central advising office, consisting of professional staff who advise students on their curriculum path. Many students are more comfortable with the staff advisors. The problem with this method is that faculty-student interaction is minimized. Although, the advising staff is quite professional and has deep experience, they must follow the prescribed curriculum chart and they often cannot answer questions related to career choices or which courses serve certain career objectives. As a result, one often hears in exit interviews that students wished they had taken a different sequence or courses, or that they had engaged in independent study, or they had taken more math, or that they had taken their physics sequence earlier, or they had gotten more involved with the faculty. Thus, regardless of whether students go directly to industry or to graduate school upon graduating, they often regret not having taken advantage of faculty "advice".

To improve this situation, beginning with the fall 2005 quarter, the EE faculty have unanimously voted to **require** that all students meet with their faculty advisors on a regular basis. We ultimately plan to enforce this requirement by not allowing preregistration for the following quarter unless they have met this requirement. And we will require faculty approval for their curriculum plan. This is not to say that we do not want the students to meet with the staff advisors, but we merely want faculty oversight of their plan, and we want the students to have more faculty interaction. The goal is to develop a one unit seminar type course that would be required by all EE students in

which they would regularly meet their faculty advisor to discuss professional development, academic progress and career paths.

One particular point to note in this years exit interviews is that many students wished they had taken (or learned) more math. We had begun to offer in winter quarter 2005, an on-line math diagnostic exam before students enter EE 135 (electromagnetics) to pinpoint math deficiencies and provide quick review to help them increase their mastery of the subject. However, it became apparent that this diagnostic needs to occur even earlier in the curriculum. We find this lack of mathematical facility to be the biggest impediment to students being successful in our program. As a point of note, it appears that students that have learned the math "in context" rather than just symbol manipulation appear to have a better grasp of the mathematical fundamentals. We are exploring ways to alleviate this problem. By instituting a diagnostic exam early on, and requiring tutorials/reviews to those that need it, we hope to solve this problem.

We are putting together various proposals to get the resources to do this. What we would like to do is offer two tracks into EE: in one track the students who can place into calculus in their first semester would be encouraged to begin physics (5A) their first quarter. This set can begin to take the EE core courses in their sophomore year. With faculty advising them, they then can pursue an adequate path to meet their career goals, including the advice on what they need to do to get into graduate school if they so desire. In the second track, are those students who must take pre-calculus. They are thus forced to wait a full year to take the physics 5 series. This delays their EE core courses until their junior year. As a result, they do not have the flexibility in their course offerings if they want to get their degree in 4 years. We will begin encouraging incoming freshman to take the math placement exam in the spring. If they do not place into calculus, we will encourage them to take pre-calulus over the summer before they enter UCSC so that they can be on the math/physics track when they arrive at UCSC.

In addition, over the longer term, we will develop a formal internship program to allow for our students to work in industry during the summers. For their internship experience to have some meaning, we need to carefully screen the students and look for the type of individual who would have such characteristics.

Plan for Extramural Research Support

As mentioned previously, the present external funding per faculty FTE in EE is about $320K per year (about $4.1 M total last year excluding gifts).The total external funding has almost quadrupled since 2001, while the number of faculty have only increased by 44% during that time period. Thus, as our program is ramping up, the amount of external funding per faculty FTE is increasing significantly. However, this funding is not uniformly distributed among all faculty. While we understand that different disciplines within EE have different funding profiles, we hope to develop a strategy which will help those underfunded faculty build up there funding levels. This will consist of regular

meetings with the Chair to develop funding strategies as well as mentoring by the more successful senior faculty (although it should be noted that some of our junior faculty have more external funding than some of the more senior faculty). Our goal is to increase the external funding level to be more like $500K -$600K per faculty by 2010, consistent with the top ten EE departments to the country.

We plan to do this by concentrating on several approaches:

1. Developing interdisciplinary training program proposals to the NSF, NIBIB and DofED, to name a few. These proposals will allow for multiyear promised financial support than we can do at present. Moreover, such programs will allow for student rotation in different labs the first year and will provide leverage for further research grants.
2. Concentration of efforts in developing large scale externally funded center grants, such as ERC's, STC's and NCRR resources.
3. Increase the diversity of funding sources to include a wider range of federal agencies as well as private foundations.
4. Develop closer ties to the national labs and NASA-Ames (through the UARC and the BIN-RDI).
5. By actively recruiting U.S. citizens and permanent residents to our graduate program. This will allow us to increase the number of students per research dollar, thus facilitating more ambitious programs to be undertaken.

As the department matures, we hope to be able to operate in the black and get the cash flow necessary to develop the administrative infrastructure to allow the faculty to more easily put together large scale research proposals. At present, we have faculty actively involved in investigating the possibilities of proposals for externally funded centers on the following topics:

1. an ERC for Nanotechnology and Renewable Energy Resources,
2. an ERC for Adaptive Optics,
3. an STC for a Center for the Exploration of the Limits of Life
4. a training program in Imaging Across Scales
5. an Institute for Air Traffic Management (with the UARC)
6. a Materials Science and Engineering Research Center
7. a Center for Innovative Materials, Sensors and Systems

It needs to be mentioned again, that a crucial aid in allowing to pursue these various pathways is the ability to be able attract esteemed research/adjunct faculty. UCSC needs to be able to streamline the process in which we get adjunct appointments. This is not only a problem for electrical engineering, and engineering as a whole, but will also be a program for the proposed School of Management.