

Jack Baskin School of Engineering
UNIVERSITY OF CALIFORNIA, SANTA CRUZ



Baskin
Engineering  UC SANTA CRUZ

Revised Long-Range Academic Plan, 2006–2011

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EXECUTIVE SUMMARY

As the Baskin School of Engineering (BSOE) enters its tenth year, it has achieved many significant milestones. The School's reputation and visibility continues to rise regionally, nationally and internationally. This is evidenced by the increased recognition of its faculty, the increased external research funding and the increased number of visitors to the school who come here for collaborative research from this country and abroad. (See the appendix for details.)

The BSOE is on track in achieving the growth in its graduate programs and is slightly ahead of the target set in its 2001 Academic Plan. External research funding has been increasing at a 50% higher rate than the number of faculty have been increasing. Although the undergraduate enrollment has not met projections due primarily to the downturn of the high technology industries in Silicon Valley, this downturn in the economy of Silicon Valley is slowly being reversed with the upturn of "green" industries to the area. With the introduction of the new BS degree program in Computer Game Design (the first of its kind in the state) and the new BS degree program in Bioengineering, the downturn of enrollments is also now being reversed. We have actually seen a significant increase in the number of incoming freshman who intend to matriculate in the BSOE in the 07-08 academic year. Thus, the BSOE is poised for growth at all levels.

Since engineering is a dynamic and evolving discipline, interdisciplinary collaboration is the hallmark of the BSOE. Engineering faculty have taken the lead in working across departmental, divisional and university boundaries to forge outstanding programs for both teaching and research. For example, the creation of a new Bioengineering BS degree program, spearheaded by faculty in the BSOE spans four departments and two divisions. The creation of the new BS degree program in Computer Game design creates ties between the BSOE and the Arts Division and we hope, in the future to be able to create joint appointments across those two academic divisions. The proposed new curriculum in Sustainable Technology spans the BSOE and the Social Science Division and will be jointly taught by faculty from both divisions. The BSOE faculty have also been significantly involved in the developing Stem Cell Program at UCSC which was recently awarded both a training grant and a facilities grant totaling over \$4M. Finally, with the appointment of a new chair of the Biomolecular Engineering Department who comes from an industrial biotechnology background, the BSOE will play a significant role along with the Divisions of Social Science and Physical and Biological Sciences in moving forward with a program and eventually a School of Public Health. Such a program would be unique in the country in having a significant engineering component. The BSOE is committed to utilizing modern engineering techniques to solve important societal problems.

In this academic plan we have attempted to provide a guide to the intellectual areas in which we want to grow and which can build upon our existing strengths. We will present our strategic research and educational thrusts in the context of those areas. Those thrust areas where we will concentrate our energy and resources are:

- Bio-Info-Nanotechnologies
- Bioengineering
- Cyber Infrastructure
- Mathematical and Statistical Modeling
- Software and Service Engineering
- System Design

Later in the plan we will discuss the department structure within the BSOE as primarily the administrative structure for hiring faculty in the above six thrust areas.

In addition, in the section on the instructional program of the BSOE, we will show how the various programs are tied together and present a program aimed at increasing the diversity of the faculty and the student body. Several of these programs just being initiated this fall or being proposed will enhance our ability to recruit a more diverse student body. These include an Applied Math BS, a Bioengineering BS, a Computer Science: Computer Game Design BS and a Mechatronics BS. However, in spite of the fact that we produce the third highest percentage of women who receive MS degrees in engineering in the country we still have a long way to go. We will develop these programs and others with internal funds and will seek external funds to allow us to fully carry out our plan.

The BSOE is also deeply committed to developing a substantial academic and research program at the UCSC Silicon Valley Center. Since the center of high technology in this country and perhaps the world lies in the Silicon Valley/South San Francisco Bay region, we plan to develop more relationships between companies and institutions in that region and UCSC. We see the professional population in Silicon Valley as a market for further advanced degrees. And for this reason we have initiated a Technology Information Management (TIM) certificate program based in the Silicon Valley Center and we are in the process of submitting a proposal for a TIM MS/PhD program coupling the Silicon Valley Center more strongly to the main UCSC campus.

INTRODUCTION

During its first ten years, the Baskin School of Engineering (BSOE) has built education and research strength in the emerging areas of biotechnology, information technology and nanotechnology. Since engineering is a dynamic and evolving field, interdepartmental and interdisciplinary collaboration has been a tradition and hallmark of the BSOE. Our engineering faculty worked across department, division and university boundaries to forge outstanding programs for both teaching and research. We will show specific examples of such endeavors and point to expansion of these endeavors later in this plan.

In its short existence, the BSOE has launched new graduate and undergraduate programs in bioinformatics, bioengineering, computer game design, electrical engineering and statistics and stochastic modeling. The BSOE has formed new departments of Biomolecular Engineering, Electrical Engineering and Applied Math and Statistics. In only 5 years, the new Department of Electrical Engineering has already become accredited until 2009 by the American Board of Engineering Technology (ABET, the national accreditation board of all engineering programs). The world renowned bioinformatics program was born out of collaboration between the Computer Science department and the Molecular, Cell and Developmental Biology department. The Applied Math and Statistics (AMS) department faculty have worked closely with many faculty in the Division of Physical and Biological Sciences in the mathematical modeling of the environment and astrophysical phenomena. And it is expected that AMS, BME, and other BSOE departments will play a significant role in the endeavor to create a School of Public Health.

The Information Systems Management (ISM) program was initiated by the Computer Science department in collaboration with the Economics department. We have just proposed the formation of a graduate program in Technology Information Management (TIM) to complement the undergraduate degree program and later this summer we will put forth a proposal to create a department of Technology Information Management which will bring together collaboration between the BSOE and the Division of Social Sciences. In addition, the Computer Science (CS) faculty in conjunction with the Arts Division have created one of the country's first interdisciplinary BS program in Computer Game Design and we will be pursuing joint appointments between CS and Arts faculty. Finally, faculty from the BSOE along with faculty of the Division of Social Sciences are creating a new undergraduate curriculum in sustainable technology.

The BSOE faculty have assembled the first map of the human genome and created the genome web browser which is a perfect example of engineering for the public good. BSOE faculty have launched the Center for Biomolecular Science and Engineering in collaboration with faculty from the Division of Physical and Biological Sciences (PBSci); led an NSF Center for Biomimetic Microelectronic Systems in cooperation with USC and Caltech to develop the first artificial retina; led a multi-university initiative to develop a Center for Thermionic Energy Conversion (with UC Berkeley, UCSB, Purdue, Harvard, MIT and North Carolina State as

supporting institutions) to create devices that efficiently convert waste heat to electricity; led another multi-university consortium to develop Dynamic Ad-Hoc Wireless Networks and formed a partnership with Los Alamos National Laboratory to create an Institute for Scalable Scientific Data Management (co-located at Los Alamos and UCSC). In addition, the faculty in the BSOE are also major players in two of the California Institutes for Science and Innovation (CAL-ISI), the Center for Information Technology in the Interest of Society (CITRIS, with UCB, UCD and UCM) and the Center for Quantitative Biomedical Research (QB3, with UCSF, UCB).

In graduate education, the BSOE has played a major role in the campus growth of graduate education, working towards the campus goal of 15% graduate students. The BSOE has consistently maintained a 25-30% ratio of graduate to undergraduate degrees awarded from 1998-2005, about 20% of the campus total. In fact, last year the BSOE has been the only campus division to exceed its target goal for graduate enrollment based upon the 2001 academic plan. During the next five years, we plan to continue the push for graduate enrollment while at the same time increasing our undergraduate numbers through recruitment and retention efforts and expanding the BSOE academic offerings (such as computer game design and bioengineering). We will broaden our focus beyond BIN Technologies and build a more comprehensive base of engineering programs which will fit well into the university wide efforts.

The BSOE has taken a pioneering leadership role in the development of academic and research programs at the Silicon Valley Center. We realize the necessity of connecting UCSC to the wider world exemplified by the intellectual and financial dynamism of the Silicon Valley and the South San Francisco Bay region. In fall 2006, faculty of the TIM program launched a graduate level certificate program in Knowledge Services and Enterprise Management at the Silicon Valley Center aimed at the working professionals in Silicon Valley. This certificate program will eventually lead to a complete graduate degree program (the proposal has just been submitted for approval). In addition, the BSOE's focused research strengths were critical in attracting the \$330M University Affiliated Research Center at NASA-Ames to UC under UCSC management. Faculty in the BSOE play significant roles in that center and in the push to develop a Bio-Info-Nano Research and Development Institute at the Ames Research Park.

Our vision in developing an engineering school for the 21st century has been strongly influenced by the National Academy report on "The Engineer of 2020: Visions of Engineering in the New Century" (<http://www.nae.edu>). In particular, our goal is educate and graduate future leaders to serve a world defined by;

- A. Rapid technological innovation
- B. Intense global connectivity
- C. Diverse and multidiscipline based populations
- D. Social, cultural, political and economic forces determining the success of technological innovation
- E. Seamless, transparent presence of technology in our everyday life.

As a school of the 21st century, our goal is to train students to use technological innovation to solve the critical problems of society. In this regard, we feel that the evolution of our program is entirely consistent with the six overarching themes of the new academic plan of UCSC:

- A. Technology and Its Impact on Society
- B. Public Documentation and Communication
- C. Science and Policy of Evolving Environments
- D. Human Health
- E. Cross-Cultural Initiatives
- F. Transnationalism and Globalization

In order to address the societal needs of the future for renewable energy, clean environment, improved health care, innovation services and security, based upon its existing strengths, the BSOE is poised to build excellence in the following six intellectual areas:

- 1. Bio-Info-Nano Technologies
- 2. Bioengineering
- 3. Cyber Infrastructure
- 4. Mathematical and Statistical Modeling
- 5. Software and Service Engineering
- 6. System Design

The alignment between these six focus areas and the six campus priority areas is shown in Table 1:

TABLE 1
Alignment Between BSOE Focus Areas and Campus Priorities

	BIN Tech	Bioeng	Cyber Infra	Math Stat Modeling	System Design	Software & Servcs
Technol & Impact on Society	X	X	X	X	X	X
Human Health	X	X	X	X	X	X
Public Doc & Communication			X		X	X
Cross-Cultural Initiatives		X				
Science and Policy of Evolving Environments	X	X	X	X	X	
Transnationalism & Globalization	X		X	X		X

At present, the faculty FTE we have in particular intellectual focus areas are shown below in Table 2, where the number in parentheses is the current number of faculty in that area including the 06-07 recruitments. At the time of this writing, the BSOE had 71 faculty FTE members with 7 more to be hired in 2006-07 searches.

TABLE 2
Current Faculty FTE in BSOE Intellectual Thrust Areas

1. Bio-Info-Nano Technologies (11.5)
2. Bioengineering (10.75)
3. Cyber Infrastructure (14.5)
4. Mathematical and Statistical Modeling (13.5)
5. Software and Service Engineering (15.75)
6. System Design (12)

Our hiring plan is accomplished through the academic departments who coordinate the intellectual areas with one another. The alignment of the departments with the focus areas is shown below in Table 3 where the numbers in parentheses are the faculty FTE in the department and the numbers in the brackets indicate the intellectual areas associated with the faculty in that department. This alignment of intellectual areas with departments shows that with the exception of the new TIM program, all departments at present range from about 10-20 FTE's with about a dozen faculty in each focus area. We will discuss the departmental structure later in the plan.

TABLE 3
Alignment of Departmental Faculty FTE with BSOE Thrust Areas

<i>Department</i>	<i># FTE</i>	<i>Thrust Area (table 2)</i>
A. Applied Math and Statistics	(12)	[2,4]
B. Biomolecular Engineering	(8.2)	[1,2]
C. Computer Engineering	(16.8)	[2,3,5,6]
D. Computer Science	(21)	[3,4,5]
E. Electrical Engineering*	(16)	[1,2,3,5]
F. Technology Information Management	(4)	[3,5]

* Includes the Acting Dean of BSOE and G. Kalonji in this number.

It should be noted that although we have almost doubled in faculty size over the last five years, the external funding brought in by those faculty has almost quadrupled. This means that the indirect costs brought in by faculty are increasing at a faster rate than the number of faculty and this allows for more “opportunity funds” to ramp up our programs. We expect this trend to continue in the future as we build up the nucleus of programs in which we will be concentrating.

Because we are a new school of engineering, it is often difficult to make comparisons to more traditional and older schools, since the programs may not be identical and we are still quite small. For example, UCSD has the same number of departments that we do at UCSC, but their department size is more than twice as large as ours and they have a much different distribution of expertise areas (at UCSD, 175 faculty in five departments of Computer Science and Engineering (49 FTE), Electrical and Computer Engineering (52 FTE), Mechanical and Aerospace Engineering (40 FTE), Bioengineering (16 FTE) and Structural Engineering (18 FTE)).

It is known that the size of the reputation of public engineering schools is correlated with faculty

size and the age of the school, (the age, of course, relates to the recognition factor). In the original Terman report analyzing the need for more schools of engineering in the state of California, Terman came to the conclusion that to create a viable world class school of engineering one would need a faculty size of about 120-130 FTE's and that could be done without addressing every engineering discipline. Thus, our long term goal is to reach a faculty size of 120-130 in the next decade. The reductions in our allocated FTE's in the next five years from 114 to 105 will result in a redistribution over the next few years, but our ultimate goal is approximately 125 faculty. Our philosophy in choosing the strategic areas is related to those areas which we feel will be the most intellectually exciting, in demand in this new century, will resonate well with the industrial demand in Northern California, particularly Silicon Valley, and which will have the most impact in solving societal needs.

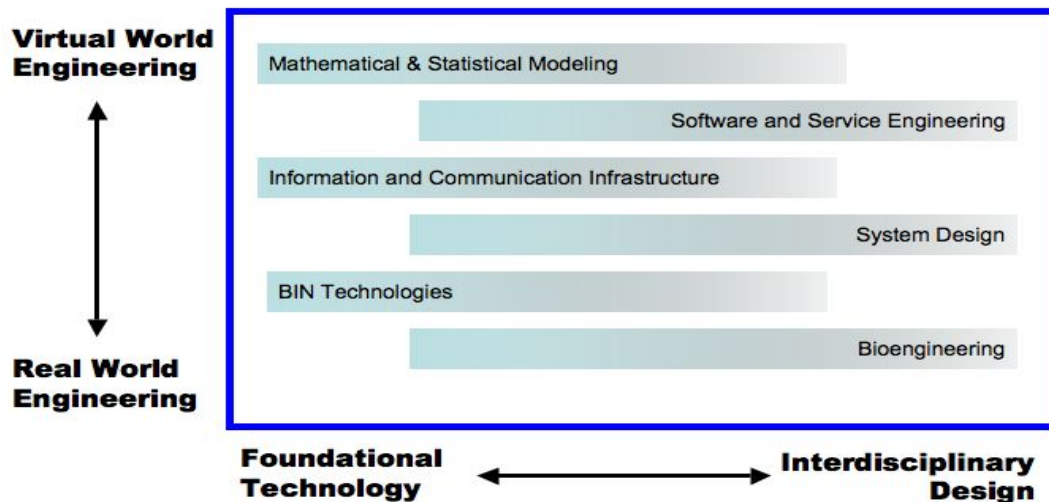
Initially, the BSOE has put its efforts in areas in which it had strengths (i.e., information technology). Over the last several years and in the next decade we will be growing the scope of our programs to cover some critical areas that we feel are key for the BSOE to become a comprehensive engineering school. For example, we have expanded into the bio-biomedical engineering arena, creating a new department and concentration areas across existing departments. At present we only offer a BS Bioengineering and Bioinformatics degree, but envision in the future offering advanced degrees in these areas in conjunction with the Biomedical Sciences Initiative and the School of Public Health Initiative. The BSOE is heavily involving in the areas of engineering relevant to public health and we expect to play a key role there.

We plan to develop and offer a mechatronics engineering program combining areas of modern mechanical engineering and electrical engineering. And we are working with faculty in PSci to develop a program in Materials Science and Engineering which will again cross divisional boundaries. Finally, we will be expanding our Technology Information Management Program with the emphasis on program development at the Silicon Valley Center. It should be emphasized that in many of the areas in which we are expanding, interdepartmental and interdivisional cooperation is critical. And the ability to offer joint appointments across departmental and divisional boundaries becomes crucial.

In the next section we will summarize the strategic research areas of the BSOE, where we are and where we want to go in the next five years. We will then discuss in detail our instructional and diversity plans and explain our organizational plan for growth given the opportunities and constraints of the UCSC campus.

STRATEGIC RESEARCH AREAS OF THE BASKIN SCHOOL OF ENGINEERING

The Jack Baskin School of Engineering (SOE) concentrates on six intellectual areas: bioengineering (the interface of engineering with the life sciences), bio-info-nano technology (the foundational technologies that underpin modern science and engineering), cyber infrastructure (the infrastructure of the knowledge age), mathematical and statistical modeling (the fundamental tools of data and system analysis), software and service engineering (the use of information technologies to solve problems in industry and society), and system design (the design and design techniques of physical systems). These six areas are schematically represented in the figure below.



The intellectual areas in which we choose to focus are synergistic in nature with one another, cross disciplinary boundaries and are the foundations for solving critical societal problems, leveraging campus expertise. Engineering programs in the Baskin School reflect the change in engineering over the last century and promote an integrated vision of science and engineering that serves the needs of the greater Silicon Valley region, California and the nation. The goal of the Baskin School is to produce graduates who are contributing citizens and leaders in a high technology society.

Bio–Info–Nano (BIN) Technologies

We look at the intersection of engineering with the life sciences as one of the exciting intellectual areas of the future, as well as one which can have great societal impact. We have separated this intersection amongst several intellectual focus areas, noting that there is significant overlap among the various areas. BIN Technology as we define it here relates to the development of novel devices and tools for life science, information science and energy needs which incorporate micro and nanotechnological concepts. In this arena, the focus is to develop device concepts that have the utility to solve critical needs. We look at nanotechnology as the enabling technology that will allow us to develop these novel devices.

Although the field of nanotechnology has evolved as a result of miniaturization of electronic components, it has exploded in the last decade as the combination of miniaturization and new chemical approaches to synthesis have brought about the discovery of new physical phenomena which could be used to construct and design new tools which allow for molecularly sensitive biosensors, more powerful computational tools, and new materials with specific properties. Thus, this thrust area incorporates not only the development of Microelectromechanical systems (MEMS) and the nanoelectronic equivalent (NEMS) for applications ranging from adaptive optics to single molecule sensing, but it also includes materials synthesis for developing new materials and structures.

This convergent technology (BIN) has the potential to transform many disciplines. The federal government has invested about a billion dollars in its National Nanotechnology Initiative and the areas of growth are in every sector, from the development of advanced materials with thermal protective properties, more efficient fuel cells for energy needs to molecular probes for biomedical diagnostics. This thrust area is closely associated with the Center for Biomolecular Science and Engineering, the California Institute for Quantitative Biology (QB3) and the California Institute for Information Technology Research in the Interest of Society (CITRIS).

Research Goals

At UCSC, we are concentrating on several areas:

- 1) MEMS, NEMS systems for applications in adaptive optics in astronomical science and deep tissue biological microscopy (i.e., outer space and inner space),
- 2) By combining nanoparticle fabrication methods with molecular beam epitaxy we are developing the foundational science and technology to construct highly efficient thermal to electric energy conversion devices. If successful, such devices could have a huge impact on our ability to convert waste heat to useful energy (50% of the energy used in transportation for example is lost as heat.),
- 3) Coupling nanooptics and electronics on a chip to allow for molecular diagnostic devices which could result in fast, inexpensive DNA sequencing on a chip, leading the way towards pharmacological agents targeted to an individuals' genetic makeup.
- 4) Using nanotechnology, researchers at UCSC are developing implantable chips (in

conjunction with USC and Caltech) which act as an artificial retina, enabling blind people to see.

- 5) Developing advanced classes of bio-inspired materials.
- 6) Development of advanced materials processing technologies for nanowire fabrication for next generation computational and diagnostic devices.

As a relatively small school, we must be innovative in finding the niche areas in which we can excel and invest. A good example of the intertwining of technology and understanding are the areas of bioengineering and materials science. In both, the technology drives the knowledge and the knowledge drives the technology. This intertwining also leads the way for collaboration across traditional disciplines. As we try to grow our research endeavors and graduate programs at UCSC, one area with great potential is that of materials science and engineering. The exploitation of new materials and phenomenon are at the heart of new advances in technology over the last century and into the next. The BSOE in collaboration with PBSci is working to develop a strategic plan for developing a program for materials science and engineering at UCSC. Although a preliminary white paper was produced a little over a year ago, it was too diffuse and tried to be all inclusive. We have since continued to explore the possibilities and will be putting together a 2nd revised version of a coherent materials initiative plan for UCSC.

Instructional Goals

What the BSOE lacks at present is a suite of instructional laboratories to go along with the nanotechnology courses we are developing. As we begin to build up our nanotechnology program, the faculty will begin to develop instructional modules and laboratory development proposals to the NSF so that we can acquire the equipment needed to set up these instructional laboratories. It is also important to note that our space plan relies on the development of nanotechnology instructional labs in the space vacated by the Mathematics department when they move to McHenry in 08-09.

We plan also to submit proposals for training grants (NIBIB, IGERT, GAANN, etc.) which would allow us to provide better first year experiences for incoming graduate students so that they could rotate through several labs before selecting their research area. Finally, we will develop a course in microscopy and imaging in order for students in BSOE and PBSci to get a more formal grounding in the imaging tools needed for work in nanoscience and technology.

Relationships

The technologies developed in this research thrust are ideally suited for developing research connections across disciplinary boundaries since the field by itself is interdisciplinary in nature. Thus, faculty from BSOE and the Division of Physical and Biological Sciences are working together on developing a “materials initiative” white paper to form the intellectual basis for creating an informal group whose aim is to craft a proposal to establish an NSF funded Materials Science and Engineering Center (MRSEC) at UCSC. (The preliminary proposal is due September 5, 2007.) This proposal will tie together the departments of Electrical Engineering, Physics, Chemistry and others.

In addition, research in BIN technologies also crosses the boundaries between the departments of Electrical Engineering, Biomolecular Engineering and Molecular, Cell and Developmental Biology with respect to bio-diagnostic capabilities. Thus, we envision that jointly taught courses may be developed in the future. Engineering graduate students in this area often have members of their committee from the Division of Physical and Biological Sciences. In addition, since the research area is so interdisciplinary, in this year's search for EE faculty in the area of biomaterials and bioelectronics, the search committees consisted of half faculty from BSOE and half from PBSci. We also see faculty associated with this thrust area playing a role in the proposed School of Public Health.

BSOE faculty play an active role in the Center for Adaptive Optics in utilizing MEMS technology to develop the deformable mirror arrays for the adaptive optics sensors. This has led to proposals (along with faculty in MCDB) to look at the feasibility of adaptive optics techniques for deep tissue imaging in confocal microscopy. In addition, faculty in the BIN Technology thrust area also closely cooperate with the UARC in the area of nanotechnology processing and diagnostics. We are exploring the possibilities of setting up laboratories in the Advanced Studies Laboratory at NASA-Ames, a joint lab between NASA and UCSC.

Bioengineering

Bioengineering is another example of the convergence of technologies. In this case, it is the intersection of engineering principles utilized to solve life science problems. There are several components of bioengineering being practiced in the BSOE. In a broad sense, these are:

- 1) Biotechnology deals with the development of pharmacological agents and diagnostic tools.
- 2) Bioinformatics combines math, science and engineering to explore and understand biological data from high throughput experiments such as those obtained on gene sequencing or gene expression chips.
- 3) Prosthetic technologies involve developing devices that can mimic a particular function that the body can no longer perform, due to illness, injury or age. These can range from prosthetic devices such as the artificial retina, to the development of macro-assistive technologies utilizing computer systems and sensors to improve the quality of life for people with disabilities.

The Bioengineering thrust area is closely associated with the Center for Biomolecular Science and Engineering, the California Institute for Regenerative Medicine and the California Institute for Quantitative Biology. The academic departments associated with the bioengineering thrust are AMS, BME, CE, and EE in BSOE and MCDB and Chem in the PBSci Division.

Future Vision and Goals

Biotechnology is a rapidly growing component of the California and national economy. It is estimated that the Biotechnology industry currently employs approximately 60,000 people in California and generates approximately \$13.5 billion in revenues. The center of the California Biotechnology industry is in the San Francisco bay area and there is an urgent need for trained workers. An important goal of this thrust area is to develop and supply talent for employment in

companies relying on existing technology and to develop graduates to play a leadership role in the development of new technologies which emerge at the interface of bio-, info-, and nano-technologies. The academic focus on Bioinformatics, Protein Structure Prediction, Nanotechnology, Assistive Technology, Biotechnology and Bioethics is viewed as the best way to accomplish this mission.

Research and Instructional Goals

While the BSOE is well known as a leader in bioinformatics, it is gaining world wide recognition as a leader in protein structure prediction, biology oriented nanotechnology and micro prosthetic neural devices. As the reputation of UCSC grows in these areas, it is anticipated that student enrollments and course offering will grow proportionally. Recently the Department of Biomolecular Engineering has recruited a new Chair who has broad experience in the Biotechnology Industry. Based on this expertise, the BME department intends to build a curriculum and training program in various technical aspects of Biotechnology such as infectious diseases, protein expression, cell engineering and fermentation engineering. The bioengineering area will expand by developing joint programs between the BSOE, the Division of Physical and Biological Sciences and the Division of Social Sciences to create courses such as clinical research and epidemiology that provide preparation for careers in Public Health and Biotechnology. In fact, later on we will discuss the BSOE role in creating a unique School of Public Health.

The recently approved UCSC BS degree program in bioengineering, through its participating faculty and departments, will provide students with inspiration and quality education in the theory and practice of bioengineering. The program will provide students with fundamental knowledge of mathematics, science, and technology. Students will also gain advanced training in engineering principles and practice at the molecular, cellular, and organismal levels. Graduates will be prepared to work as engineers solving problems in the biomedical and biomolecular domains and to pursue advanced degrees in engineering, medicine, or science. The program is a collaboration between the departments of biomolecular engineering, computer engineering, and electrical engineering, with additional program faculty in the departments of molecular, cell, and developmental biology and chemistry and biochemistry. The program has extensive course requirements in mathematics, science, and engineering. Every major must have a bioengineering faculty adviser, assigned by the BSOE Undergraduate Advising Office, and with that adviser must formulate a program of proposed course work that meets the major or minor requirements.

Public Health Program

The Baskin School of Engineering has a unique capability to contribute to Public Health programs at UCSC. While Public Health has been largely focused on environmental factors that affect public health (pathogens, diet, exposure to chemicals, social and behavioral harms), a new area of research relates to genetic factors that are associated human diseases. The focus of this effort is “computational biology” which has been applied towards the assembly of the human genome and is being used to define the genetic basis and pathogenesis of inherited diseases, as well as the genetic basis of susceptibility to acquired diseases (such as cancer, neurodegenerative disease, metabolic diseases, and autoimmune diseases). With the completion of the human genome project in 2000, computational biology has taken center stage in discovery research and

human biology. All indications are that this area of research will play an ever increasing and important role in biology, medicine, and drug development over the next 1-2 decades and will pave the path for the new fields of Molecular Epidemiology and Individualized Medicine.

Perhaps the greatest accomplishment of computational biology was the assembly of the human genome which was carried out in the UCSC School of Engineering. The assembly of the human genome and the development of the UCSC Human Genome Web Browser provides a key tool in biomedical research that is used by thousands of researchers world wide every day. Going forward, the technology used to assemble and analyze the human genome has been applied to two other projects at UCSC: 1) Comparative genomics which involves comparison of the human genome with the genomes of other species. This technology represents a major tool that allows researchers to assemble and compare information about the structure, function and activity of genes across species and provides a means for assigning a possible role to human genes whose function has not been established. 2) Genetic association studies where polymorphisms in the human genome are associated with various disease processes. In this regard UCSC expects to play a leadership role in creating the computational architecture required to link genetic sequence data with clinical data both prospectively and retrospectively. This kind of retrospective analysis has been called “data mining” and can be used to extract significant information regarding the diagnosis and treatment of human diseases from clinical data associated with medical records and clinical trials of pharmaceutical products. Both areas of research involve academic training in areas of expertise of the Baskin School of Engineering. These areas include: Bioinformatics, Applied Math and Statistics, and Bioengineering. Indeed it is now recognized by the Food and Drug Administration that Bayesian statistics (a particular area of expertise of the Baskin School of Engineering), represents an important tool in the testing of new drugs. In the post genomic world, Molecular Epidemiology and Individual Medicine promise to change the way medicine is practiced. These new technologies, depend in large part on analyzing genetic data obtained from a new generation of diagnostic testing that includes “haplotype” mapping and diagnostic sequencing of an individual’s genome. The development of diagnostic tests using both technologies are a high priority for both commercial and not-for-profit organizations, and are expected to create important economic opportunities for the California economy. The education and training provided by the BSOE provide UCSC with a unique expertise that will be in high demand in the field of Public Health for years to come.

Faculty in the Bioengineering thrust area in SOE along with faculty in the Division of Social Sciences and the Division of Physical and Biological Sciences have recently discussed the possibility of establishing a School of Public Health at UCSC. The school would provide undergraduate (BS) and graduate (MPH) degree programs. Discussions within the BSOE have noted that the interests of many of the existing faculty are consistent with the future needs of Public Health programs. The completion of the sequence of the human genome combined with new technologies (e.g. low cost genome sequencing and analysis of polymorphisms) promises to usher a new era in Public Health opportunities. These include areas such as individualized medicine, genetic risk assessment, molecular epidemiology, genetic detection and response to emerging infections and invasive species. These opportunities fall into the area of expertise and interest for several BSOE departments (e.g. Biomolecular Engineering, Electrical Engineering, Applied Math and Statistics, and Computer Engineering). There is considerable interest in

information technologies that can reduce the cost and improve the efficiency of healthcare delivery systems. In this regard technologies for digitizing and accessing medical records, mining epidemiologic data from healthcare databases, and web crawling to provide an early warning system for new and emerging infectious diseases are all areas receiving considerable attention and funding from both government and non-government public health organizations.

Although other Schools of Public Health exist in California, none could claim to provide the expertise in bioinformatics and information technologies that could be provided by UCSC. As envisioned, a Public Health program would have significant synergies with other departments on campus such as Molecular, Cellular, and Developmental Biology, Environmental Health and Toxicology, Social Sciences, Anthropology, and Psychology. Although many schools of Public Health are associated with medical institutions, close proximity is not a requirement and there are many institutions within the Bay Area and California that would provide convenient access to the data required for training and faculty research. Such an expansion into the area of Public Health is also consistent with the BSOE participation in the California Institute for Quantitative Biology (QB3) and the Center for Information Technology Research in the Interest of Society (CITRIS).

Expansion of Existing Collaborations

Another area for expansion relates to further interaction between the bioengineering focus group and the BIN Technology focus group. For example, current activities focus on the development of nanodevices for microsequencing and detection of pathogens, future activities will include areas such as power and data management of microelectronic systems that have the potential to provide a means to create a new generation of drug delivery devices. Other activities will be engineering centered on development of new confocal microscopy and photonics systems which promise to provide new tools for developmental biology, cell engineering, and diagnostic applications. In addition, development of an integrated academic approach by the Department of Biomolecular Engineering can be seen in the success in the areas of Comparative Genomics, Systems Biology, and Stem Cell Biology which have both attracted attention and funding from a variety of sources.

Connections with the Campus

Members of the Bioengineering thrust area actively collaborate with the Physical & Biological Sciences departments of MCD Biology, Chemistry & Biochemistry, Environmental Toxicology, Ecology & Evolutionary Biology, and Ocean Sciences. The Biomolecular Engineering department has developed ties with the Philosophy Department which has joined with BME to create courses in Ethics of Technology and Stem Cell Research. Particularly noteworthy is BSOE faculty leadership in creating the Center for Biomolecular Science and Engineering (CBSE) and the campus Stem Cell Research Initiative.

Connections With the World

The BSOE recently hosted the Annual California Bioengineering Symposium at UCSC (organized by Prof. Wentai Liu from the EE Department). This symposium brings together once a year bioengineering researchers from all UC campuses.

The BSOE is host to the UCSC Genome Web Browser. This website and database (updated daily) includes a compilation of all of the sequence information publicly available on the human genome. It is an essential tool for biomolecular research worldwide, and sometimes logs more than a million hits a week. Besides the human genome the UCSC Genome Browser contains genomic information from a variety of species and is an essential tool in the emerging science of Comparative Genomics which provides insight into the structure and function of genes associated with a variety of biological processes (growth and development, disease pathogenesis). The Protein Structure Predication group led by Kevin Karplus participates in an annual competition to predict protein structure (CASP) and hosts a website used by investigators to make predictions. Another genetic sequence database of the primitive Archea family of organisms is maintained by Todd Lowe (Archeal Genome Browser) for use by investigators world wide. Finally Jim Kent and Phillip Berman are creating database architecture which, for the first time, will link sequence data with clinical trial results. This database will be launched using data from AIDS Vaccine trials, but will be expandable to include data from a variety of clinical trials. A database of this type will afford investigators the opportunity to make more efficient use of information collected in clinical trials and will be useful in associating genetic polymorphisms with biological responses (e.g. disease progression, sensitivity and resistance to pharmaceutical interventions, and side effects). It is anticipated that researchers from around the world interested in AIDS Vaccine Development will be users of this database. In addition, the BSOE (led by Wentai Liu of the EE department is one of the partners of the Center for Biomimetic Microelectronic Devices (a partnership of USC, UCSC, and Caltech), which is leading an effort to create an artificial retina.

Funding from Non-Government Research Organizations

It is well established that federal funding for basic research from government organizations such as the National Institutes of Health and the National Science Foundation is remaining static or decreasing. This has caused many academic labs to downsize and made it more difficult for investigators (particularly new investigators) to grow their programs as fast as they could otherwise. However, a major new source of funding for Biomedical Research has been provided by large philanthropic Non-Government Research Organizations (NGOs). Organizations such as the Bill and Melinda Gates Foundation and Google.org are interested in funding research of the type carried out at UCSC. The BSOE is well positioned to receive funding from these organizations to support research and educational activities consistent with the Mission and Values of the University of California. We will attempt to put together several large scale proposals to various such organizations within the next few years.

Cyberinfrastructure

Cyberinfrastructure is the convergence of technologies—the Internet, low-cost low-power microchips, storage systems, and databases—leading to a fundamental change in the way that computing and communications are used in our lives. Information processing has become ubiquitous and enables a host of applications ranging from fuzzy logic rice cookers to hybrid cars to Google. At the SOE, cyberinfrastructure focuses on three areas promoting the ubiquitous availability of information: Storage Systems, Database Systems, and Networked Systems.

Research Goals

Research in cyberinfrastructure addresses fundamental issues that limit the further availability of information, creating more efficient ways of collecting, retrieving, and distributing information. As these technologies are developed further, ever greater uses of information are possible, ranging from distributed networks of low-power environmental sensors used to track ground-water, pollution, or endangered animal movement, to mass storage systems capable of storing the Library of Congress and making its information searchable by every citizen in the country.

Storage Systems include research on new storage technologies, techniques for higher-performance and lower-power data storage, and mass storage systems capable of storing petabytes to exabytes of data for periods ranging from minutes to decades. At the device level, new technologies are being explored in conjunction with the Bio-Info-Nanotechnology groups to develop the next generation of storage devices. Research on new storage technologies focuses on the use of new non-volatile storage such as FLASH or MRAM in increasing the performance or reliability or reducing the power consumption of existing storage systems. Storage system techniques include adaptive data management (in collaboration with our Machine Learning colleagues) aimed at predicting and adapting to changing workloads in the data processing stream. Our mass storage system research develops new techniques and architectures for handling the ever-increasing volumes of data being generated and processed in a host of different applications ranging from the Internet to medical diagnostics to home entertainment.

Database Systems include developing new tools and technologies for tracking data provenance to managing and making sense of the ever-increasing volumes of data. As we digitize and store more and more information electronically, it is increasingly important to know the provenance of that information, including copyrighted materials such as music and books, important documents such as wills and legal agreements, and critical intelligence such as information about potential terrorist attacks. In addition, as the volume of information increases current information-management techniques are becoming overwhelmed and inefficient, crushed by the volume of data they must handle. New techniques and architectures are being developed to make that information searchable and retrievable to a growing population of information-savvy users.

Networked Systems include creating efficient, high-performance techniques for disseminating information, including wireless networking, analysis and design of algorithms and protocols for computer communication, and network hardware. Our wireless networking research aims to find efficient low-power techniques for wireless networking useful in a host of sensor network applications including environmental monitoring and tracking, mobile computing, and networked traffic monitoring. Our research in analysis and design of algorithms and protocols includes new techniques for *ad hoc* networking and multimedia networking supporting both the rapidly expanding audio and video industries and other real-time multimedia applications such as real-time data visualization. Our network hardware research has developed ultra-high-speed network switches, able to speed wired and optical network performance by orders of magnitude.

Instructional Goals

The National Science Foundation's Blue Ribbon Advisory Committee says that,

[E]nvironments and organizations, enabled by cyberinfrastructure, are increasingly required to address national and global priorities, such as understanding global climate change, protecting our natural environment, applying genomics-proteomics to human health, maintaining national security, mastering the world of nanotechnology, and predicting and protecting against natural and human disasters, as well as to address some of our most fundamental intellectual questions such as the formation of the universe and the fundamental character of matter.¹

The BSOE's instructional program in cyberinfrastructure aims to develop the student's understanding of and ability to provide the underlying infrastructure needed to address these priorities.

Cyberinfrastructure is a key part of the undergraduate degree programs in Computer Science and Computer Engineering and students in these programs take a number of required and elective courses supporting these goals. These include undergraduate and graduate courses in computer systems, operating systems, databases, and networking. The cyberinfrastructure educational programs have made particularly high contributions to the advanced training of industry professionals.

Our networks group created UCSC's first Silicon Valley graduate program, the MS in Computer Engineering with an Emphasis in Network Engineering. Our storage systems group has led the creation of a distance learning graduate program with the UC-managed national laboratories through the Institute of Scalable Scientific Data Management (ISSDM), a joint program between UCSC and Los Alamos National laboratory (LANL). This program is expanding and will serve as a model for the programs that the BSOE envisages in the Silicon Valley Center.

The Cyberinfrastructure faculty have nationally recognized graduate programs in Storage Systems and Networked Systems, and a growing presence in Database Systems.

Storage Systems

Storage systems are one of the driving technologies behind the internet economy (eBay, Google, Yahoo, Amazon, etc.) and a driving force behind a significant sector of the US economy. Our Storage Systems graduate program is recognized as one of the premier storage systems programs in the world, with only Carnegie Mellon University as a serious competitor. It provides training

¹ National Science Foundation Blue Ribbon Advisory Panel on Cyberinfrastructure. (2003). *Revolutionizing Science and Engineering Through Cyberinfrastructure*.
http://www.communitytechnology.org/nsf_ci_report/

in all aspects of storage systems research and development and their applications to embedded systems, mobile systems, personal systems, enterprise systems, and large-scale scientific computing systems.

Focusing on systems aspects of storage (as opposed to devices), we pursue research and education addressing the current and future storage needs of world through direct interaction with the computer and storage industries located in nearby Silicon Valley and through our extensive contacts in the high-performance computing community, whose storage needs generally lead those of the rest of the computing community by about 10 years. Providing the foundation for the information collection and storage aspects of cyberinfrastructure, our plans are to continue focusing on the critical needs of the industry and national laboratories including performance, power management, scaling to petabytes and beyond, new storage technologies and architectures, long-term storage management, and storage security.

Our research spans the BSOE and includes network research in CE spurred by the need for new network architectures to support large-scale and high-performance storage systems, new storage device research in EE, information retrieval research in TIM, and the unique high-performance storage needs of BME. Future research will include the large-scale high-performance storage needs of researchers in the other Sciences, applications of new storage technologies to distributed sensor networks in a wide variety of applications, and a continued focus on the ever-increasing uses of storage in a variety of new and existing applications.

Database Systems

Database systems are ubiquitous in modern computer systems as they provide crucial support for storing, organizing, and querying information. In particular, the advent of the Web and its related suite of applications (such as, e-commerce sites, on-line auctions, social networking) has pushed database systems beyond the realm of business transaction processing and has made them an integral part of the standard system architecture for web-applications.

The database group at UCSC performs research on four primary areas, namely, information integration, data provenance, data reduction and approximation techniques, and self-organizing systems. These areas span a wide range of theoretical and systems-related problems, including the development of foundations for managing and understanding the semantic relationships between data sources, exchanging data, sharing and archival of scientific data, and the design of novel architectures for the implementation of database systems. Research projects are supported primarily by grants from the National Science Foundation and involve collaborations with researchers in other institutions, namely, IBM Almaden Research Center, Intel Research, University of Toronto, University of Tel Aviv, and I.N.R.I.A. in France. Moreover, the database group fosters a close relationship with key industrial partners in the database industry, such as IBM, Microsoft, and Oracle, and several projects are partly funded by awards from these partners.

The database group spans several departments within the BSOE working on the development of search facilities over massively distributed file systems. Future plans include the collaboration

with groups in other divisions, and particularly in physical and biological sciences on the topic of managing large scale scientific data sets.

Networked Systems

The Internet and wireless networks are enabling always-on connectivity to content and services. Access to network-based services forms an integral part of the way people interact with one another at work and at home. However, many of the protocols and techniques used in today's networks date back to the days when in-network storage and processing were too expensive to even consider. Today, storage and processing are so affordable that, together with bandwidth, they should be considered as part of the shared network resources.

The faculty involved with research in networked systems are developing new theories, algorithms, protocols, architectures, and prototypes for the future internet, which will be pervasive, invisible to end users, and link people, devices, information and the environment. During the most recent 3 academic years (2003—2006), the Networked systems Group has graduated 27 MS students and 10 PhD students, many of whom have taken tenure-track positions at leading academic institutions.

The work by our faculty is carried with funding from the U.S. government and industry, and in many cases is carried out in collaboration with other institutions. For example, the DAWN project (Dynamic Ad hoc Wireless Networks) is a Multidisciplinary University Research Initiative (MURI) led by UCSC that involves MIT, Maryland, Stanford, UC Berkeley, UCLA, and UIUC. DAWN constitutes what is arguably one of the most ambitious research teams of experts ever assembled to mount a truly cross-disciplinary approach to develop a general theory of complex and dynamic wireless communication networks. The networking group is a participating campus on three other MURIs, a recognition of our excellence in networked systems.

Relationships

- ❖ Cyberinfrastructure faculty and students have engaged in annual, on-campus UCSC-hosted research seminars for SOE faculty, students, and industry and government research sponsors. In addition, the BSOE is home to the Storage System Research Center, a consortium of university, industry and national lab partners.
- ❖ High-performance storage research aimed at the critical infrastructure needs of the National Laboratories leading to the development of Ceph, widely considered to be the most advanced distributed storage system in the world.
- ❖ UCSC and Los Alamos National Laboratories have created (with DOE funding) a joint Institute for Scalable Scientific Data Management with facilities at LANL and UCSC.
- ❖ Collaboration with a wide variety of industry sponsors including Microsoft, Intel, Cisco, Network Appliance, IBM, PARC, HP, Seagate, Hitachi, LSI Logic, and others.

Structures

- ❖ Grow the core of our Storage Systems and Networked systems groups, building upon our

now successful education and research programs already in place; and

- ❖ Enhance the interfaces between the cyberinfrastructure groups and others on campus, leveraging our success in these areas to enhance success in areas making use of this infrastructure.
- ❖ Increase our investment in Database Systems to reach critical mass and achieve the level of national recognition now enjoyed in Storage Systems and Networked Systems.

Mathematical & Statistical Modeling

Mathematical and statistical modeling involve the creation of quantitative models of observable processes and the collection and analysis of data generated by those processes, for the purpose of assessing and decreasing uncertainty about quantities relevant to the solution of important practical problems. Mathematical modelers tend to focus on modeling the process, often through systems of ordinary and/or partial differential equations that describe how the process unfolds in space or time or space-time; statistical modelers tend to focus on modeling the data, by regarding the data as realizations of stochastic (random/probabilistic) processes and using this representation to quantify uncertainty about unknown or partially-known quantities and to help researchers and policy-makers make decisions that hedge against the uncertainty in an optimal way. The importance of mathematical and statistical modeling to California and the United States has been ably summarized in the Strategic Plan² of the National Science Foundation (NSF): two of NSF's three goals are to "enable the United States to uphold a position of world leadership in all aspects of science, mathematics, and engineering" and to "achieve excellence in U.S. science, mathematics, engineering, and technology education at all levels."

Research Goals

The primary research goals of mathematical and statistical modelers in the BSOE involve the creation of interdisciplinary collaborations with investigators at UCSC and elsewhere to use mathematical and statistical models to solve important real-world problems in science and engineering. Secondary research goals that flow from these primary objectives include (a) development of new mathematical and statistical methods and theories that may prove useful, not only in solving the original real-world problems but also in solving other similar problems, (b) publication of the research findings in leading journals in applied mathematics, statistics and machine learning as well as in the substantive fields in which the primary research problems are posed, and (c) submission of high-quality grant proposals to leading funding agencies to obtain research support for faculty and graduate students, with the subsequent funding of as many of these proposals as possible. Current research foci for mathematical modelers in the BSOE include (a) astrophysical and geophysical fluid dynamics (with applications in astronomy, astrophysics and earth and planetary sciences), (b) control theory (with applications in autonomous systems/robotics and remote sensing), and (c) mathematical biology (with applications in biochemistry, biology, and ocean sciences). Current research foci for statistical modelers in the BSOE include (a) Bayesian statistical methods of inference, prediction and decision-making (with applications in biomolecular engineering, community studies, computer

² The plan is available at www.nsf.gov/nsf/nsfpubs/straplan/goals.htm

science, earth and planetary sciences, economics, environmetrics, health sciences, and ocean sciences), (b) bioinformatics (with applications in biology and the health sciences (c) machine learning (with applications in economics, information management, medical diagnostics, etc.).

Instructional Goals

The instructional goals of mathematical and statistical modelers in the BSOE involve the creation of lower-division, upper-division and graduate programs of study in the theory, methods and applications of mathematical and statistical modeling that meet the instructional needs of undergraduate and graduate students from all relevant Departments at UCSC. Secondary instructional goals that flow from these primary objectives include (a) high-quality lower-division service teaching in applied mathematics and statistics, (b) support for the existing undergraduate minor in statistics, (c) the eventual establishment of an undergraduate major and minor in applied mathematics and an undergraduate major in statistics, (d) support for the existing graduate program in Statistics and Stochastic Modeling (SSM) and the existing specialization in machine learning within the graduate program in Computer Science, (e) the eventual name change of the SSM graduate program to Statistical and Applied Mathematical Modeling, with parallel tracks for students concentrating on (i) applied mathematics and (ii) statistics, and (f) the admission and eventual graduation of high-quality cohorts of undergraduate and graduate students in applied mathematics, statistics and machine learning. At present 23 graduate students are pursuing M.S. and/or Ph.D. degrees in the SSM graduate program in collaboration with 10 BSOE faculty, a graduate-student-to-faculty ratio of 2.3; a goal of this graduate program is to increase this ratio to 2.5-3.0 as the faculty with research concentrations in mathematical and statistical modeling grows (so that, for example, at a faculty size of 16 the SSM graduate program would have 40-48 enrolled graduate students (perhaps 27-32 Ph.D. students and 13-16 M.S. students) at any given time).

Research Relationships

In pursuit of the above research goals, mathematical and statistical modelers in the BSOE have established a large number of collaborative relationships with researchers in a wide variety of fields, both at UCSC and elsewhere. In addition, mathematical and statistical modelers will play a significant role in the proposed program in public health which is being discussed between the BSOE, and the Divisions of Social Sciences and Physical and Biological Sciences. Here, the expertise is in the statistical and mathematical analyses needed for epidemiological studies, as well as for the statistical analysis of clinical diagnoses for improving patient care. An example of the latter is the recent NIH grant to AMS to analyze the medical diagnosis records of all files from Kaiser Permanente of Northern California in order to improve the efficiency of medical diagnosis.

In addition, the area of control theory is one in which the department is building up significant expertise. This is an extremely important area that has significant applications in robotics, remote sensing, biomolecular technology and air traffic management and AMS faculty are working in all three areas. As an example, control theorists in AMS are working with researchers in the Center for Biomolecular Science and Engineering to develop optimal ways of fast DNA sequencing on a chip with the aim of fast inexpensive genomic analysis.

Instructional Relationships

In pursuit of the above teaching goals, mathematical and statistical modelers in the BSOE have established a large number of collaborative relationships with faculty in a wide variety of fields at UCSC. Examples of recent and/or on-going instructional collaborations include the following:

- (a) Shared teaching of pre-calculus and calculus between the BSOE and the Department of Mathematics in the Division of Physical and Biological Sciences;
- (b) the development of a graduate course (AMS 205) on *Mathematical Statistics*, in collaboration with faculty from Economics, which is a required course for Economics graduate students;
- (c) the comprehensive redesign of a lower-division course (AMS 7/7L) on *Statistical Methods for the Biological, Environmental and Health Sciences*, in collaboration with faculty from (1) Environmental Studies (ES); (2) Ecology and Evolutionary Biology (EEB); (3) the Health Sciences (HS) Program; and (4) Molecular, Cell and Developmental Biology (MCDB), which is a required course for ES and EEB majors and a strongly-recommended laboratory course for MCDB and HS majors;
- (d) the re-design of a lower-division course (AMS 5) on *Statistics*, in collaboration with faculty from Economics, which is a required course for Economics majors.

Software & Service Engineering

Software and services includes the creation, design and implementation of the computer software that enables computers to perform desired tasks. In the BSOE, our research encompasses software in the broad spectrum from that managing the hardware and computer resources through database management and networking support, to creation of functions, applications and services that are made possible by software. The breadth of this is suggested by the scientific applications as in data visualization, animation and computer graphics employed by the arts, and computer games which include contexts that may represent social structures and inter-personal interactions studied by social scientists. Services include such topics as information retrieval, data mining, and decision-support systems. As many large corporations whose previous business was in the manufacture of computational and electronic devices are turning more towards service applications, this aspect of service science and engineering research is very attractive. Moreover, as we move towards a knowledge and service economy, such skills are being highly sought after in all sectors.

The creation of software is a complex engineering processes, and addressing both the programming and the management of the software development process is part of this strategic area. Providing access to computer applications via computer networks, and management of the information technology infrastructure of an organization are included in services. Thus this research area includes aspects of computer science, information science, technology and systems management, and economics and business management, with applications in the sciences, arts, humanities and business.

Goals

The primary research goals of researchers in software and services in the BSOE are to; 1) invent, design and create better software for a range of applications and services in areas ranging from computer gaming, data visualization and data mining, information retrieval, knowledge management, and tools for support of management decision making; 2) creation of better platforms or "middleware" to improve implementation and performance of software supporting user applications and services; and 3) creating processes and methodologies that improve the effective and efficient production of software. At present, it takes the same amount of person-hours to create one line of software code as it did 20 years ago. Algorithms and models as developed in various disciplines in the BSOE are inputs to the creation of new software, software systems and services.

Instructional Goals

Due to the proximity of UC Santa Cruz to Silicon Valley, there are substantial opportunities to provide graduate instruction on the construction of large software systems, the management of software systems and technology, and the development of interactive computer games. Graduate programs in these areas are expected to attract workers from Silicon Valley firms, and hence the knowledge they receive from these programs would be directly applicable to their ongoing activities. There is the potential to create a highly effective technology transfer pipeline via this graduate instruction, where leading edge techniques taken directly from recent research advances are quickly integrated into instruction, and then diffuse out into Silicon Valley firms via the worker/students in our degree programs. Over time, UC Santa Cruz can have notable impact on the culture and productivity of Silicon Valley firms by injecting new technologies and management approaches more quickly into these firms. This will be accelerated as we expand our program offerings at the Silicon Valley Center. Moreover, the expansion of this center will bring a new breed of students to UCSC.

Over the next five years we will focus on the development of three new graduate degree programs that embody this vision of engaging workers in Silicon Valley firms with advanced science, technology and management knowledge. These are the MS/PhD in Software Engineering, the MS/PhD in Technology and Information Management, and the MS in Computer Game Design. These are described briefly below.

MS/PhD in Software Engineering

Silicon Valley firms create software. A lot of software. Yet, despite having sophisticated development and quality assurance practices, they still deliver software that regularly has large numbers of bugs, and schedule slippage is also common. Within the past 10 years, the Software Engineering research community has made substantial progress on automated techniques for finding bugs, predicting where these bugs will occur, restructuring software to make bugs less likely, automated construction of software by computer that will be bug-free by construction, and estimating the cost of software projects. Silicon Valley firms by and large do not engage the software engineering research community, and hence are largely unaware of these advanced techniques. UC Santa Cruz faculty members are leading researchers in many of these fields, especially the static analysis of software, use of model checkers, software security, programming

languages, and evolutionary analysis of software. The proposed MS degree program will be oriented towards working professionals in Silicon Valley, and will emphasize the range of techniques now available for improving the quality of software. This will both differentiate our program from other local software engineering graduate programs, as well as act as a technology transfer conduit for these advanced techniques into local firms. The PhD in Software Engineering will increase the scope and visibility of our software engineering research efforts. Furthermore, potential spin-offs of such technology could result in a burgeoning software industry within the Santa Cruz area itself, thus working to cement relationships between the town and UCSC.

MS/PhD in Technology and Information Management

If Silicon Valley firms are making a lot of software, then they are also managing the development of this software. Silicon Valley firms also produce a wide range of hardware, and combine the hardware and software into novel assemblages that deliver new services. Consider Silicon Valley firm TiVo, which creates digital video recorders for television. This device requires both traditional forms of technology management, overseeing the creation of a combined hardware/software platform. It also requires services engineering, which involves conceptualizing the device as the center of a network of services, including program and movie downloads to customers, as well as use statistics collection. Teaching this holistic view of combined technology management and services engineering is the goal of the MS in Technology and Information Management. Like the MS in Software Engineering, by teaching this knowledge to Silicon Valley workers, we quickly transfer best practices and leading edge techniques to the managers actively engaged in product development. The PhD in Technology and Information Management complements the MS degree by creating a structure for attracting and training researchers in this area. The ready access to Silicon Valley firms makes UC Santa Cruz a nearly ideal location for this kind of research, as site access to firms to perform research is plentiful.

MS in Computer Game Design

California has one of the highest concentrations of firms creating computer games, and the computer games industry overall is growing 5-10% yearly. The recent transition to so-called next generation consoles (Xbox 360, PS3, Wii) has made it clear that advances in graphical processing power is no longer sufficient, by itself, to drive innovation. Advanced artificial intelligence techniques that create realistic, believable, interactive characters of the sort found in UCSC Computer Science Assistant Professor Mateas' game Facade will increasingly be needed to create more engaging game worlds, and deeper narratives. These AI techniques are not those that can easily be just "picked up" from a technical session at a conference, and hence there is a need for graduate instruction that can train game designers and developers on these techniques. Furthermore, there are many software engineers in Silicon Valley who would like to do computer game development, but require additional training to be qualified for these jobs. We see the MS in Computer Game Design as the evolution of our new BS degree in Computer Game Design acting as a channel for the transfer of advanced artificial intelligence techniques to California computer game makers, and for training the professionals who will work in this growing area.

Relationships within the Baskin School of Engineering

The academic offerings in the BSOE in the area of Software & Service Engineering are primarily in Computer Science, and in the undergraduate Information Systems Management program and the (developing) graduate program in Technology and Information Management (TIM). In addition, courses offered in areas of architecture and systems by Computer Engineering and in areas related to modeling and optimization by Applied Math and Statistics are important to the programs of study by students in Software & Service Engineering.

The management of technology courses offered by faculty are being taken by a variety of SOE students, and fills a need expressed by some of our graduate students from industry for such courses in their program. The TIM graduate courses on data mining, modeling and optimization also attract students from across the BSOE.

Software engineering students in the area of computer gaming find the courses in computer graphics, animation, and visualization very relevant to their interests, as well as courses in artificial intelligence and others in software design and architecture.

Relationships with Other UCSC Divisions

Instructional collaborations in the areas of Software & Service Engineering are many. They range from those of the computer games focus with colleagues in Digital Arts and New Media, and Psychology, to collaborations with Economics and with Linguistics by those in information systems and technology management. Economics plays a central role in design and pricing of service offerings and in the broad area of knowledge management and overall technology management. Linguistics has a very strong connection to work in text mining and related topics.

The proposed UCSC School of Management would provide additional relationships, especially related to areas of management of software development and to the applications of information technology for decision support in management. In the emerging area of services, there are many business questions relating to pricing, marketing and management of these complex offerings, and expertise from a SOM would complement the expertise of the BSOE faculty addressing services engineering.

Research Relationships

Close ties with computers, networking and software companies is essential in research in these areas, to provide meaningful examples, contexts and test environments, and to be working in the context of the latest technologies. Within the BSOE there are close ties between those in this area and colleagues in Mathematical & Statistical Modeling, Information & Communications Infrastructure, and System Design. The technology areas of Bioengineering and BIN provide applications contexts for both software and services. Colleagues also have ties to the Humanities, especially with Linguistics in text retrieval and data mining, and to the Social Sciences, with faculty in Economics who are concerned with the economic value of services and software and

psychology with social context/organization game scenarios.

System Design

System Design is the combination of underlying technologies and tools to create complete systems solving important problems from other disciplines and society. At the BSOE, System Design focuses on systems designed and built from several technologies: electrical, mechanical, biological and software components.

Research Goals

Research in system design includes tackling the difficult problems of the design process itself ("the science of design"), creating new technologies for building systems, and designing systems using existing technologies in innovative ways. In all three of these categories, the goal is to design systems and technologies that solve previously unsolvable problems from engineering, science, and society.

Within the System Design group, we seek excellence in research across a spectrum of three interrelated areas: computer design, computer system design, autonomous system design and microelectromechanical system (MEMS) design.

Computer design includes developing new tools and technologies for creating the hardware infrastructure of the information age. This includes existing research groups in computer-aided design (CAD) systems for integrated (VLSI) and reconfigurable (FPGA) systems. As computer chips continue to shrink into "deep sub-micron" and "nanoscale" technologies, in which billions of transistors may be placed on a single computational chip, the problems of how to manage this staggering complexity abound. In this area, our goal is to develop the CAD and testing technologies necessary to successfully build these immense systems. We also strive to develop new architectures that can make effective use of the billions of transistors that are available.

Computer system design uses the underlying computational chips and other hardware and software to develop full systems. In some cases, these systems are largely for computational domains (such as bioinformatics, or high-energy physics), while in other cases they must interact with the environment in some manner, most frequently with video. The goal is to solve interdisciplinary problems, producing both a solution to a specific problem and advancing the underlying technologies of engineering. We have a particular focus on creating new systems for societal problems, such as assistive technologies for people with disabilities, monitoring systems for the environment, and multimedia systems for remote interaction. Work in this area has evolved into our goals of creating new initiatives in assistive technology (also part of the bioengineering program, and a 2006-7 successful faculty search) and environmental sensing.

In autonomous system design, we combine the technologies of computer system design with mechanical engineering and other practices to make autonomous systems for land, sea, and air.

Control theory, the fundamental mathematics of this area, is also used with economic systems. The research goals in this area include developing the autonomous sensors and systems needed to monitor wildlife and the environment; designing autonomous vehicles to increase safety on the roads and ocean, developing systems for air traffic management and developing assistive technology systems to aid the elderly and disabled.

In microelectromechanical system (MEMS) design, we develop micromechanical electrically actuated systems that can have applications from microsurgical tools, high frequency electronic devices to arrays of thousands of movable mirrors for adaptive optics corrections of large scale telescopes for astronomical observations.

Instructional Goals

The BSOE's instructional program in system design seeks to develop the student's "ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability" [footnote: Criteria for Accrediting Engineering Programs, ABET Engineering Accreditation Commission, October 2006. www.abet.org].

Interdisciplinary system design is integral to the undergraduate major programs in Computer Engineering and Electrical Engineering. It is also a requirement of national accreditation. Students in these programs complete a team-based six-month research, design, and development project, culminating in a Senior Design Project competition that is held twice each year and judged by distinguished alumni and our industrial partners. Bioengineering majors will soon join the Senior Design Project course, and Computer Science: Computer Game Design students will undertake a nine-month project as part of the Game Design Studio.

System Design faculty have the goal and responsibility for maintaining currency in rapidly evolving technologies and tools, and integrating these into the undergraduate and graduate curricula. Our goals include:

- ❖ Re-creating a complete curriculum in field-programmable gate array (FPGA) and very large-scale integrated circuit (VLSI) system design across the undergraduate and graduate levels, providing a continuous path from introductory to advanced design.
- ❖ Integrating design issues in first- and second-year courses and throughout the undergraduate curriculum.

The System Design faculty members are working to create a graduate emphasis in Autonomous Systems and Control, new degree program in Mechatronic Engineering, in 2008-9, and a minor in Environmental Technology in 2009-10.

Autonomous Systems and Control

The graduate Autonomous Systems (AS) program will provide training in dynamical systems theory and control, coupled with intensive study of their applications in science and engineering. A new set of engineering courses and their associated labs (e.g. “Modern and Robust Control, I and II”, “Applied Feedback Control”, “Introduction to Mechatronics”, and “Adaptive and Optimal Control”) will be provided, in addition to the needed background courses in dynamical systems theory. The program represents a broad, interdisciplinary research and education paradigm designed to meet the challenges of designing and implementing an increasing number of automated and intelligent systems technologies in the 21st century (e.g., robotic assisted living and planetary rover technologies). The current faculty has expertise in state-of-the-art control theory and computational tools, embedded multi-sensor technologies, and applications ranging from mobile sensor networks to large-scale telescopes. All of these contribute to the large potential for future interdisciplinary, systems theory-based collaborations within the UCSC Baskin School of Engineering, in particular AMS, CE, EE, and TIM, as well as with the relevant departments in the Division of Physical and Biological Sciences, and the Division of Social Sciences.

Mechatronic Engineering

This is an area that is growing in importance and increasing in popularity as a field of study around the world. While most departments in mechatronics are currently in universities in other nations (e.g., Canada, Australia, Turkey), several U.S. universities offer mechatronics as a specialization of either mechanical or electrical engineering, and one offers an ABET-accredited major.

Students are naturally drawn to mechatronics, as it combines many of the disciplines normally taught in electrical, computer, and mechanical engineering, as well as computer science. Robotics, applied control, analog and digital circuit design, statics and dynamics, and embedded software and hardware all fall within the mechatronics umbrella.

At BSOE, we already have many of the faculty necessary for launching a mechatronics curriculum within the Baskin School of Engineering, and the new hires in Autonomous Systems will enable the launch of this program. At present, undergraduate engineering enrollments tend to suffer from the limited curricular ranges of the Baskin School of Engineering. The mechatronic engineering program, focused on one of the most exciting areas of mechanical engineering, will draw not just mechatronic engineering students, but also students unsure of which specific engineering discipline they wish to follow at the time of enrollment. Graduates of this program will be prepared for careers in several industries, including aerospace, computer hardware, biotechnology and robotics broadly applied, as well as for further advancement in academia.

In three years, we estimate that undergraduate enrollments in this program will range between 20 and 40 students per year.

Environmental Technology

The BSOE has for a long time considered launching a program in Environmental Engineering, which is projected to be one of the two fastest-growing areas of engineering through year 2014, growing “much faster than average”. (Biomedical engineering is the other area.) (Footnote: Occupational Outlook Handbook, 2006-07 Edition, U.S. Department of Labor, Bureau of Labor Statistics, Bulletin 2600, <http://www.bls.gov/oco/oco2003.htm>).

Student and faculty interest in environmental technology is high, as is evident from numerous senior design projects and faculty research projects involved in aspects of environmental monitoring and technology. The SOE will be launching a new course in environmental sensing as a result of collaborations with Environmental Studies and Ecology and Evolutionary Biology. In the short run, with existing faculty resources, the goal is to consider development of a minor in Environmental Technology or Environmental Engineering in 2009-10 appropriate for major programs in SOE, ENVS, EEB, and other fields.

Relationships

On campus, System Design faculty and students have engaged in projects such as

- ❖ Hardware accelerators for scientific computation with SCIPP.
- ❖ Coral reef monitoring, terrestrial mammal monitoring, and marine mammal monitoring with EEB and LML.
- ❖ Geyser monitoring at Yellowstone National Park with USGS.
- ❖ Numerous industrial collaborations in computer-aided design, VLSI and FPGA design, and autonomous systems design.
- ❖ Exploration of enhancements to system design education with new laboratory partially funded by industry contributions.

Structures

Grow the kernel of our autonomous systems program to create a robust research group; and enhance the interfaces between the bioengineering research group and the system design research group; and build an autonomous systems research facility to enable researcher interaction and tours.

INSTRUCTIONAL PROGRAM OF THE BASKIN SCHOOL OF ENGINEERING

Goals

1. Respond to Student Needs and Interests

The instructional program of the Baskin School of Engineering addresses the academic needs and interests of several target groups.

1. Undergraduate students majoring in fields other than Engineering are offered courses that provide a general introduction to (a) computation, technology, and design, and their impacts on the way we live, and (b) their role as contributing citizens in a high-technology society;
2. Students earning a bachelor's degree from the Baskin School are prepared to enter the high-tech workforce or continue on to more advanced training or academic careers;
3. Students earning a master's degree from the Baskin School receive advanced preparation for careers in technology fields and the academic foundation for Ph.D. studies at the BSOE or another institutions with complementary programs;
4. Students earning a doctoral degree from the Baskin School receive excellent preparation for teaching and research in academia or industry.

The faculty updates the program's curricular content in a continuing process that seeks to anticipate the fast pace of technological change and to prepare students of today for society's needs and priorities of tomorrow^{3,4}.

2. Contribute to the Growth of UCSC's Graduate Program

In 2002, UCSC committed itself to growth in graduate and professional programs with a goal of achieving a student population of at least 15% graduate students.

The BSOE has, over the past eight years, maintained an undergraduate to graduate student ratio between 25% and 35%, well above the campus target of 15%. While the current 33% graduate degrees can be attributed in part to passing the nationwide nadir in undergraduate engineering enrollments, the graduate impact of the Baskin School on the campus is clear.

In 2005-6, with 12.5% of campus faculty, the Baskin School accounted for 22% of campus graduate applications, 19% of campus graduate enrollments and 17% of campus graduate degrees. It is our goal, through the introduction of new programs and expansion of existing

³ National Academy of Engineering. (2004). *The Engineer of 2020: Visions of Engineering in the New Century*. <http://www.nap.edu/catalog/10999.html>

⁴ National Academy of Engineering. (2005). *Educating the Engineer of 2020: Adapting Engineering Education to the New Century*. <http://www.nap.edu/catalog/11338.html>

programs to, even as we increase the School's relative size, extend further its contribution to the campus. Thus, when on reaching the planned 105 faculty in 2012 (13.5% of campus faculty), the School should contribute 25% of campus graduate enrollments in steady state. In 2005-6, the Baskin School accounted for 688 of campus applications for graduate study, with an overall acceptance rate of 35% and yield of 42%, and a Fall 2006 entering class of 102 new graduate students. These ratios show the fast achievements of our new programs, as well as continuing improvements of existing ones.

3. Respond to National and State Needs

The needs of California and the nation for tomorrow's engineers can only be described as extensions of today's complex and rapidly evolving priorities. Current research priorities, which define future needs for engineers, are suggested by public statements of society's leaders. For example, Governor Arnold Schwarzenegger's FY 2007-08 budget proposal features his Strategic Research and Innovation Initiative⁵, focused on science and technology research in several areas:

- ❖ Super-efficient solar energy technology and alternative fuels;
- ❖ Information technology, biomedical research and nanotechnology;
- ❖ Development of the next generation of supercomputers

At the national level, National Science Foundation Director Arden L. Bement, Jr., has presented the NSF's FY 2008 budget proposal for Discovery Research for Innovation⁶, and stated,

"In nearly every field of science and engineering, we are moving toward new knowledge that will help us resolve some of society's most stubborn problem...in energy, security, health and the environment. And we are on the threshold of technological innovations that will power the economy well into the future."

According to Director Bement, the NSF's budget priorities for the coming year begin with the following initiatives, all of which are strongly oriented to engineering and well represented in the Baskin School of Engineering's Strategic Research Areas:

- ❖ "Cyber-enabled Discovery and Innovation, "to explore a new generation of computationally based discovery concepts and tools at the intersection of the computational world and the physical and biological worlds;"
- ❖ Ocean Research Priorities Plan, "to link ocean research to societal issues ranging from the stewardship of ocean resources to the ocean's role in climate;"
- ❖ National Nanotechnology Initiative, "to support fundamental nanoscale research and the

⁵ Schwarzenegger, A. (2007). *State of the State*.
http://www.gov.ca.gov/sots/research_innovation.html

⁶ Bement, A. (2007). *FY 2008 Budget Presentation*.
http://www.nsf.gov/news/speeches/bement/07/alb070205_budget.jsp

development of nanomaterials” with “ramifications for manufacturing, medicine, and next generation computing;”

- ❖ International Science and Engineering, “to expand international partnership opportunities for U.S. scientists, engineers and students;”
- ❖ Preparing the Workforce for the 21st Century, “to maintain the Nation’s competitive edge” and “broaden participation of underrepresented groups;”
- ❖ Math and Science Partnership Program, “to improve K–12 science and math education and teaching;
- ❖ Graduate Research Fellowships, which, with other NSF programs, “brings the total number of graduate students supported to about 5,375;”
- ❖ Transformational Facilities and Infrastructure, “to invest in tools that promise significant advances in a field and to make them widely available to a broad cross-section of investigators.”

The priority for research and development in these rapidly evolving areas of science and engineering points to long-term, continuing and growing needs for graduates that are prepared for productive careers in industrial and academic settings. The NSF underlined these workforce needs, as projected by the Bureau of Labor Statistics (BLS), in the following statements⁷:

The most recent occupational projections from BLS, for 2002–12, forecast that employment in S&E occupations will increase about 70% faster than the overall growth rate for all occupations. It is worth noting that these projections involve only the demand for strictly defined S&E occupations, and do not include the wider range of jobs in which S&E degree holders often use their training.

4. Respond to Student Interests

In addition to responding to campus, state and national priorities, the Baskin School’s curriculum must appeal to student interests. Respecting these interests can increase both enrollment totals and enrollment diversity. The percentage of women in engineering is much lower than their general share of the college population, which stands at 56 percent. Although this has focused the attention of engineering colleges, ASEE data (M. Gibbons, 2006) shows that women are selective in their interest in engineering. They are well represented in disciplines such as agricultural, biomedical, chemical, environmental, industrial/manufacturing, and metallurgical and materials engineering. Women account for between 32 and 43 percent of bachelor’s degrees in each of these fields. But, these six disciplines comprise only 17 percent of the total bachelor’s degrees in the 22 disciplines used by ASEE in their analysis. Thus, we not only need to look at the character of the programs we have at present, but also look at potential programs in the future. For example, the start of a new BS degree program in Bioengineering is expected to increase the number of women entering in the Baskin School of Engineering.

⁷ National Science Foundation. (2006). *Science and Engineering Indicators 2006*.
<http://www.nsf.gov/statistics/seind06/c3/c3s1.htm>

The recent initiation of the B.S. in Computer Game Design exemplifies the development of an instructional program that balances responsiveness to California's economic priorities and appeal to prospective students. This program also responds to societal interests, in that computer game technology could be applied in the design of learning resources^{6,7}, disaster relief training and medical diagnostics, to name a few potential applications.

We believe that the programs we are initiating and the ones which are evolving will have a positive impact on our enrollments. For example, the expected new undergraduate enrollment in the SOE this fall is about 50% higher than last year.

D. Achieve/Maintain Diversity of Student Population

Gender Diversity. The School has a special commitment to gender diversity, and its record in this regard compares well with other engineering schools, although we have a long way to go.

- ❖ In 2005-06, women were well represented among degree recipients of the School: women received 12.2% of the School's bachelor's degrees, compared to 14% nationally, and 24% of the graduate degrees compared with 20% nationally.^{8,9}
- ❖ According to a 2007 study by the American Society of Engineering Education (ASEE), the BSOE graduates the third highest percentage of women recipients of master's degrees in engineering *among all schools in the country*¹⁰.
- ❖ At the doctoral level, in 2004, among PhD-granting engineering institutions, the Baskin School of Engineering graduated the 16th highest percentage of women in engineering in the country, and had the 8th highest percentage of female engineering faculty¹¹.
- ❖ With the help of the EVC's campus diversity fund, the School recently established the graduate student group, eWomen¹², which has formed a new community for graduate students, researchers, and faculty. Each quarter, eWomen holds lunches and featured talks and discussions. The success of eWomen has encouraged campus level activities that support female graduate students. In addition, the School has an active Society of Women Engineers student group.
- ❖ During this past recruiting season, more than half the offers for faculty positions in the BSOE have been to women. One offer has been accepted and we are awaiting the outcome of four others.

⁸Institutional Research and Policy Studies, Office of Planning and Budget, University of California, Santa Cruz. (2006). <http://planning.ucsc.edu/irps/>

⁹ Computing Research Association. (2006). 2003–2005 CRA Taulbee Survey. <http://www.cra.org/CRN/articles/may06/tables.1to8.html>.

¹⁰American Society for Engineering Education. (January, 2007). Many Master's. *Prism*, 16(5).

¹¹ American Society for Engineering Education (October, 2004). Doctorate enrollment Up. *Prism*. 14(2).

¹² <http://ewomen.soe.ucsc.edu/>

Ethnic Diversity. The School is committed to the ethnic diversity of its student body, and this represents a challenging task.

- ❖ We are developing a variety of outreach strategies, including a multimillion dollar NSF funded program in “Developing Effective Engineering Pathways (DEEP)” aimed at increasing the number of women and underrepresented students transferring into the School from community colleges.
- ❖ The NSF funded SURF-IT program run by the BSOE is a summer undergraduate research program aimed at bringing underrepresented minority and first generation college students to the BSOE for a summer research experience working with BSOE faculty.
- ❖ BSOE faculty participate in the UC LEADS program which strives to transition underrepresented students into graduate school¹³. Typically there are several UC LEADS students in BSOE research laboratories;
- ❖ This coming year, the BSOE will fund part of an administrative coordinator position for the CAMP program, so that we can take a more active role in that program.
- ❖ The Multicultural Engineering program (MEP) is the university level component of the statewide system Mathematics, Engineering and Science Achievement (MESA) program, a program of UCOP. At UCSC, MEP is run by the BSOE and it is an integral part of our undergraduate advising unit.
- ❖ BSOE also runs the Success in Engineering and Research Pathways program, a summer bridge program which welcomes new, incoming BSOE students prior to the start of the fall quarter. It targets students from backgrounds that are traditional underrepresented in engineering. This weeklong one week residential program targets 25 of these students and gives them a comprehensive introduction to the BSOE, the research, programs and resources w3hat are available to them to provide a foundation for success.
- ❖ We are developing a program with Hartnell College (a predominantly Hispanic serving institution in Salinas) to open up a pipeline to engineering at UCSC. Two members of the BSOE (M. Isaacson and A. Harrell, BSOE Director of Undergraduate Programs) sit on the advisory board for the Hartnell College program on engineering management.
- ❖ The Baskin School houses two minority-serving student engineering groups: the National Society of Black Engineers (NSBE) and the Society of Hispanic Professional Engineers (SHPE).
- ❖ The Center for Biomolecular Science and Engineering Minority Outreach Coordinator participates in research and recruitment events that target minority students from the California State University and other institutions;
- ❖ Although these initiatives are only the beginning, the Baskin School has compiled a reasonable record: in 2004–05, underrepresented minorities earned about 10% of the School’s bachelor’s degrees in, compared with 8.1% nationally, and 4% of the master’s

¹³ <http://surf-it.soe.ucsc.edu/>, <http://graddiv.ucsc.edu/research/LEADS.php>,
<http://marcmbrs.ucsc.edu/>

degrees in compared with 4.4% nationally¹⁴¹⁵. In 2006-07, 20.8% of our undergraduates and 11.5% of our graduates were underrepresented minorities. Our goal is to have an underrepresented population (who complete degrees) which significantly exceeds the national average in BS, MS and PhD programs in the next 5 years. Towards this end we have created the position of Director of Undergraduate Programs to oversee some of these efforts and have appointed a Faculty Director of Outreach. We plan to develop more ties to traditionally underrepresented institutions in order to increase the throughput of the pipeline to engineering at UCSC. Although our NSF funded DEEP program ends in a year and a half, we are developing other proposals to extend these efforts.

- ❖ The Dean of Engineering acts as the advisor to the National Society of Black Engineers student group, which at the moment is quite small. We are in the process of planning programs to increase the size and activity of this group. In particular, in conjunction with the Division of Physical and Biological Sciences we would like to become more involved with the Society for Black Physics Students with the aim of having their national meeting here within five years.
- ❖ BSOE faculty were *the only UCSC faculty* to participate at the UC/CSU summit organized by UCOP held this May at the UCSF Mission Bay Campus. The purpose of this summit was to increase the URM pipeline from CSU's to UC graduate schools.

E. Retention

The School's principal challenge with respect to the retention of graduate students is the small size of the faculty and our ability to be able to offer a wide range of graduate courses in the newer departments. This has been improving over the last few years as the size of the faculty has been increasing, but we are still not at the critical size at which we can have the breadth of offerings across all curricula that are necessary for a first rate graduate program. In addition, because a reasonable fraction of our graduate students commute from Silicon Valley, we are planning the development of more academic offerings at the Silicon Valley Center.

The School has also been a sponsor of two related conferences: the Grace Hopper Celebration of Women in Computing and the Richard Tapia Celebration of Diversity in Computing Conference. As a result of these sponsorships, the School has been able to send several graduate students to these events every year. Students who attend the conferences typically return with great enthusiasm and ideas for continuing to improve our efforts to increase graduate retention diversity.

The critical challenge in retention of students at the undergraduate level is the poor mathematics preparation that many students have when entering UCSC. In order to enter the first level courses

¹⁴ Institutional Research and Policy Studies, Office of Planning and Budget, University of California, Santa Cruz. (2006). <http://planning.ucsc.edu/irps/>

¹⁵ Computing Research Association. (2006). 2003–2005 CRA Taulbee Survey. <http://www.cra.org/CRN/articles/may06/tables.1to8.html>

in many engineering disciplines, students need to begin the calculus and physics courses the first quarter they are here, otherwise they cannot take many of the required engineering courses the second year they are here. If that happens, this usually means that the students' time to graduate is 5 years or more, or they drop out of engineering into some other discipline. We have been in the process of developing introductory courses in engineering at the freshman level to keep the students' interest alive in that first year. Examples include, CMPE1, "Hands-on Computer Engineering", CMPE8, "Robot Automation", CS80, "Game Design", EE80T, "Modern Electronic Technology" and EE80J, "Renewable Energy Resources". In addition, we are emphasizing the math skills that are absolutely critical to begin most engineering courses and trying to give them more mathematics in context, so that the math is not merely symbol manipulation but rather looked upon as having some bearing to physical reality.

Instructional Relationships

A. Relationships within the Baskin School of Engineering

The graduate, undergraduate, and course programs within the Baskin School form an interleaved spectrum across traditional disciplines, interdisciplinary studies, and our strategic research areas. Among many possible examples: Applied Math and Statistics provides important foundational material for all of the Baskin School's degree programs, the Bioengineering Program spans four departments across two divisions. Moreover, since the intellectual areas on which we have chosen to focus are at the intersection between disciplines, these areas typically tie academic departments together

At the undergraduate level, the intra-School collaboration is apparent. During their first and second years, engineering students in all majors have many common courses. These courses help to strengthen the students' critically important ability to move between majors as they develop their interests in each of the available fields. Indeed, during the third year, students may postpone a final commitment between any pair of related majors, as long as they work with the Baskin School's Undergraduate Advising Office, the undergraduate directors, and their faculty advisors.

The Baskin School's common accreditation processes also bring the undergraduate programs together. Preparation for the 2003 accreditation visit brought greater integration of the Electrical Engineering and Computer Engineering undergraduate programs, highlighted by the development of a joint senior design course that satisfies both the Major Design Experience requirement of Engineering accreditation by ABET (Accreditation Board of Engineering Technology) and UC Santa Cruz's Senior Exit Requirement. This design experience will grow with the proposed accreditation review of the new BS degree programs in Bioengineering and Computer Science: Computer Game Design, scheduled to take place in the next three-to-six years. (Note: ABET requires a program to have its first cohort of graduates before it is eligible for accreditation.)

At the graduate level, several courses serve as either core requirements or electives for multiple programs. More importantly, the Baskin School has school-wide graduate advising. That is,

students in any of the School's programs may work with thesis advisors who are primarily associated with another program, within or outside of the School. These student interactions form some of the strongest ties within and between the School's strategic research areas and with faculty in other divisions. Many PhD dissertation committees include faculty primarily associated with different programs.

B. Relationships with Other UCSC Divisions

The Baskin School of Engineering has numerous instructional collaborations with the sciences. These include extensive relationships with the life sciences, including cross-listed courses, cross-advising, the Bioengineering, BS degree program which is jointly administered by the School of Engineering and The Division of Physical and Biological Sciences, overlapping graduate training programs (the NIH training programs in Bioinformatics and MCD Biology, and the Stem Cell Training program), and the proposed creation of the Interdisciplinary Biomedical Research Group. In addition, the Department of Biomolecular Engineering is in discussion with the Department of Molecular, Cellular and Developmental Biology in having one of its new potential hires teach courses for MCDB.

The School's relationships with the physical sciences are broad and growing, including advanced elective cross-over between the Physics and Electrical Engineering programs, undergraduates working on senior design and other research at the Santa Cruz Institute for Particle Physics (SCIPP) and the Center for Adaptive Optics (CfAO), and growing efforts to develop a campus wide program in materials and biomaterials. Curricular relationships with Earth, Marine, and Environmental Sciences also are expanding. There are a multitude of senior design projects related to these areas. A course in "Environmental Sensing," is planned to lead to a new minor, with Environmental Studies, Ecology and Evolutionary Biology, and Earth Sciences.

The School is also participating in the development of curricula in "Sustainability Engineering and Ecological Design" with Sociology, Environmental Studies, and Politics. One of the required courses in this new "sustainability" curriculum will be Electrical Engineering 80J, "Renewable Energy Sources." Other courses in that curricula will be jointly taught by BSOE faculty and faculty from other divisions. We expect these initiatives to grow in concert with their growing importance to California and society in general.

Further interaction with the Social Sciences Division is evident in the Baskin School's undergraduate major in Information Systems Management which involves collaboration with Economics, as well as the Technology and Information Management (TIM) program. Many TIM courses play a role within the various Economics degree programs. In addition, the Department of Applied Math and Statistics teaches statistics courses for economists as well as biostatistics courses.

With the Humanities Division, the Baskin School has growing relationships in the area of science ethics. The popular course, BME80G/PHIL80G: *Bioethics in the Twenty-First Century*:

Science, Business, and Society, is co-taught by Philosophy and Biomolecular Engineering. More advanced courses are integrated in the graduate Bioinformatics degree program and the stem cell training program.

With the Arts Division, Computer Science's Computer Game Design major and planned master's level certificate in Computer Game Design represent considerable collaborations with several programs within the Arts, particularly, Digital Arts and New Media. The School is planning significant growth of these programs that cross the boundaries of Arts and Engineering. And we are actively having dialog between the BSOE and the Arts Division about potentials joint teaching and joint hires between these two divisions.

Finally, the Baskin School is collaborating with the Divisions of Social Sciences and Physical and Biological Sciences to develop programs in Public Health, with one of the eventual goals being the creation of a School of Public Health. The engineering component to this proposed program could be unique in the country.

C. Relationship with Private Industry

The Baskin School has strong educational relationships with several companies, including Altera, Cisco, HP, Microsoft, National Semiconductor, and Xilinx. Moreover, stronger links to these and other companies such as Agilent are being planned. As an example, CISCO has provided over \$400,000 of equipment and funds to update the School's networking curriculum. We are working currently with CISCO to develop a formal internship program for undergraduates who are pursuing a networks concentration.

D. Silicon Valley Initiatives

The Baskin School of Engineering has provided leadership in establishing UC Santa Cruz's presence in Silicon Valley, first with the delivery at University Extension of a MS program in Computer Engineering, focused on Network Engineering (MSNE).

The Baskin School has proposed a new graduate program in Technology and Information Management (TIM), focused on the educational needs of engineers in Silicon Valley and the firms that employ these engineers. This proposal has been revised and has been submitted for review. This will be a unique program, since its delivery must originate in Silicon Valley in order to serve the needs of Silicon Valley professionals.

The growth of UC Santa Cruz's presence in Silicon Valley has been given momentum by the development of the Silicon Valley Center at NASA Ames Research Park. UC Santa Cruz serves as the lead academic partner of the Center, in collaboration with the NASA University Affiliated

Research Center (UARC) and the UC Bio-Info-Nano R&D Institute (BIN-RDI). BSOE faculty are critically involved in the development of these programs and are planning the integration of the research and academic programs at the Silicon Valley Center.

UC Santa Cruz's ITS / Media Services and the Silicon Valley Center are partnering in developing the "pairing" of campus and Center classrooms via video streaming. The addition of the CENIC network enhances the delivery of quality video and audio between the Center and campus, bringing the Center's courses and lectures given by leaders from Silicon Valley industry to on-campus students, and bringing campus courses to the students at the Center.

The Silicon Valley locale for the MSNE program (network engineering) has been shifted to the Silicon Valley Center at Ames and the TIM program has initiated a certificate program in Knowledge Services and Enterprise Management (KSEM) at the Center. The importance of the TIM program and the KSEM certificate to Silicon Valley companies is demonstrated by the significant enrollments in its classes in fall of 2006 and winter of 2007. At that time, the Center's facilities were still under development and the courses were scheduled with very limited advance notice and advertising to the Silicon Valley community. In spite of that, the enrollment of the first cohort of students has exceeded our projections. The core courses of the KSEM program are regular approved graduate courses taught primarily by ladder rank faculty. (An estimated 20% of the School's faculty live in Silicon Valley, and also are involved with private companies as consultants or in other advisory roles.) The TIM KSEM courses are attracting some students from the MSNE program, using these courses as electives in their program. This broadens the appeal and value of the MSNE offering.

The TIM faculty and other Baskin School of Engineering faculty are engaged in research with Silicon Valley firms and currently receive research support from Cisco, HP, Microsoft, Yahoo and Google as well as NASA. Graduate students working with TIM faculty are working out of offices in the Center, to be close to their private industry sponsors.

Computer Engineering is also planning expansion of its offerings at the Center. Both Electrical Engineering and Computer Science are considering offering classes there as well, and Electrical Engineering is in the process of developing a MEng/MS degree program at the Silicon Valley Center.

CITRIS has used the Center for several important meetings with industry. For example, a recent meeting, which was chaired by the director of CITRIS, addressed "Services Science" with presentations by representatives of IBM and MIDI of Japan, as well as faculty from UC Santa Cruz and other CITRIS campuses.

A consultant's recent report for the proposed School of Management underscores the importance to Silicon Valley's high-technology industry of the offerings proposed and initially delivered by the School through TIM/KSEM. From this report, it is clear that there will be a strong interaction between the TIM program and the proposed School of Management if it is implemented, and the Social Sciences Division.

Structures

BSOE currently offers seven undergraduate degrees and five graduate degrees:

- ❖ Bioengineering, BS (to begin Fall 2007)
- ❖ Bioinformatics, B.S., MS/PhD
- ❖ Computer Engineering, B.S., MS/PhD
- ❖ Computer Science: Computer Game Design, B.S.
- ❖ Computer Science, B.A.
- ❖ Computer Science, B.S., MS/PhD
- ❖ Electrical Engineering, B.S., MS/PhD
- ❖ Information Systems Management, B.S.
- ❖ Statistics and Stochastic Modeling, MS/PhD

In addition, the BSOE administers the Dual-Degree 3/2 program in cooperation with the UCB College of Engineering. This program was initiated at the formation of the SOE and is being planned at being phased out as the BSOE reaches maturity towards the end of the time frame of this academic plan.

Our current plans for expanding our degree offerings at the undergraduate level include the new B.S. degrees in Bioengineering (approved February, 2007), proposed programs in Applied Mathematics, Mechatronics, and a minor in Environmental Technology (still in the planning stage).

During the next five years, the School plans to expand two graduate degree programs, introduce a graduate emphasis (possibly to become a program), and two new graduate programs. The new graduate programs include Technology and Information Management (TIM) which is just being submitted, and the proposed Interdisciplinary Graduate Research Group (IBRG) for biomedical sciences.

The IBRG, a joint venture with the PBS division, is an umbrella graduate group for biomedical research. The group has integrated the graduate curricula of, initially, bioinformatics, biomolecular engineering, chemistry and biochemistry, and molecular, cell & developmental

biology to enable students to easily move between programs during the first year. The program includes program-wide rotations, as well as IBRG-focused graduate student advising.

The expansions of graduate programs include broadening the new Statistics and Stochastic Modeling MS/PhD program to include Mathematical Modeling, expanding the Bioinformatics MS/PhD program to include biomolecular engineering, introducing an Autonomous Systems concentration or program available to students in engineering graduate students and a MEng program in Electrical Engineering.

The School has begun to supplement research funding with targeted externally funded graduate training grants. These include an NIH training grant in bioinformatics, Department of Education GAANN training grant in computer science, and the CIRM training grant in stem cell research (joint with the Division of Physical and Biological Sciences). We will continue to develop interdisciplinary training grant program as components of our various current and new degree programs. The IBRG is a particularly likely candidate for future training grants. We plan to place a greater effort in the next few years in proposing several large scale cross-disciplinary graduate training grants for external funding (e.g., NIH training grants, NSF IGERT, Department of Education GAANN grants and others), since we believe that such grants give the flexibility to allow us to award multi-year financial support to graduate students thus improving our competitiveness in attracting the best graduate students to BSOE at UCSC.

STRUCTURAL DEVELOPMENT OF THE BASKIN SCHOOL OF ENGINEERING

Departmental Organization

It should be emphasized that engineering is not a static discipline and is constantly evolving over time due to new scientific knowledge and changing societal needs. Thus, the nature of the field of engineering is ever changing in its emphasis of intellectual focus areas and curricular material. Engineering of the 21st century will be much different than the engineering of the 20th century.

With this in mind, the BSOE must adapt a hierarchy of change in its structural organization. Research areas will evolve over time with the introduction of new technologies, problems, industrial and national priorities. The BSOE must be able to change directions accordingly. For this reason, we have focused our academic plan through 2011 on intellectual focus areas rather than departments and use the department structure to provide the stability for delivering the research and instruction.

In the instructional domain, courses probably change most rapidly, incorporating new tools, technologies and problem domains. Although, there are still core courses needed to provide the curricular base, the curricula need be refreshed regularly to address the needs of a changing discipline. Less frequently, do new degree programs need to be produced, and such programs need careful scrutiny to ensure a program of lasting value and not just a passing fad.

Within this framework of curricular change, BSOE relies upon its five existing departments (Applied Math and Statistics, Biomolecular Engineering, Computer Engineering, Computer Science, and Electrical Engineering) and one program (which will shortly be proposed to be a department, Technology and Information Management) to provide stable homes for degree programs and faculty personnel actions. As noted earlier, these units provide the stable base from which to launch interdisciplinary programs. The boundaries between these units are often fluid as courses required by one unit are taught by another unit. This interdependency reduces the hurdles to cross-departmental interactions and cooperation.

The topic of departmental organization (or reorganization) within the BSOE has been a constant topic for those outside the BSOE since before the formation of the School. However, we feel the current organization has worked well in the first ten years of the School's existence with joint curricula, little course redundancy and interdisciplinary research areas. As an example, the new BS degree program in Bioengineering is a joint effort between three departments in the BSOE and one department in the Division of PBSci. We feel that this structure should serve us well for the near future, and we will be constantly evaluating for improvement. The structure we have in place should work even better as the campus begins to remove the current (unintentional) hurdles to interdisciplinary research and education related to joint appointments across divisions, cross-listed courses and multi-unit degree programs.

Our ultimate aim is to create an engineering school size of at least 130 FTE. (The Terman Report noted that a size of at least 125 FTE was the minimum needed to create a first rate engineering program in a public university.) In fact, recent analyses by the UC Engineering Deans Group show that faculty size is directly correlated with national ranking of engineering schools in public universities. For example, of the UC engineering schools ranked in the top 20 in the country, all have faculty sizes of 130 or more (UCSB ranked at 20 with 130 FTE and UC Berkeley ranked top with 250 FTE). The structure of six departments should allow us to achieve our ultimate FTE goal with reasonable department sizes and get the BSOE into the top 25 engineering schools in the country within the next decade.

Hiring Plan

In developing a hiring plan through 2011, we have concentrated on hiring within our six intellectual focus areas. However, since hiring actually takes place in departments, we will have fractional FTE's in some of these areas.

At the time of this writing, the BSOE has 71 ladder rank faculty FTE. Currently we are undergoing recruitment for 9 more (including two forwarded from 08-09). Thus, we show below the current FTE's in the six focus area:

1.	BIN Technologies	11.50
2.	Bioengineering*	12.75
3.	Cyberinfrastructure	14.50
4.	Mathematical and Statistical Modeling	13.50
5.	Software and Service Engineering	15.75
6.	Systems Design	12.00

**Including the two recruitments forward funded this year.*

In our plan through 2011 we plan on hiring within these six clusters. Although our original plan called for 113 FTE by 2011 (with 105 filled slots), under the new reduced allocation of 105 FTE, we will affect the reduction in FTE by shifting the 113FTE to 2013-14, thus keeping the same distribution as originally planned.

Since we are not finished with the 06-07 recruitments yet and we are still undergoing discussion regarding how we will affect the distribution through 2011, it should be kept in mind that this

hiring plan is still somewhat tentative. An addendum will follow, once we have the results of this recruiting season. The point to note is that at this time, our planned FTE distribution will just take 1-2 years longer than anticipated. In the table below, we show the proposed hiring plan based upon intellectual focus area.

TABLE 4

BSOE Hiring Plan Based upon Intellectual Focus Areas: 2007-2012

	2007-08	2008-09	2009-10	2010-11	2011-12
M&S Modeling	2	0	1	1	0
Bioengineering	2	2	0	2	0
Cyber Infra	0	0	1	1	2
Software Srvc	2	2	0	1	0
BIN Tech	2	1	1	0	1
System Design	1	1	1	1	1
Yearly Total	9	6	4	6	4

In the next table we show the hiring plan in terms of individual departments. One needs to keep in mind that depending upon the individual to be hired, we may have more FTE's split between departments in the future. Our goal is to have at least 6-7 unfilled FTE's in reserve at the end of 2011.

TABLE 5

Hiring Plan in Terms of Academic Departments

Dept	FTE F05	Hire 06	FTE F06	Hire 07	FTE F07	Hire 08	FTE F08	Hire 09	FTE F09	Hire 10	FTE F10	Hire 11	FTE F11	Rsv F11
AMS	9	1	10	2	12	0	12	1	13	1	14	0	14	
BME	4.2	2	6.2	2	8.2	2	10.2	0	10.2	2	12.2	0	12.2	
CE	15.8	1	16.8	1	17.8	1	18.8	0	18.8	1	19.8	1	20.8	
CS	19	1	20	0	20	1	21	2	23	1	24	2	26	
EE	12	1	13	2	15	1	16	1	17	0	17	1	18	
TIM	4	0	4	2	6	1	7	0	7	1	8	0	8	
Sum	64	6	70	9	79	6	85	4	89	6	95	4	99	6
Rsrv	15.2		14.2		11.2		12.2		12		9		6	
Total	79.2		84.2		90.2		97.2		101		104		105	

Space Plan

The BSOE Space Plan matches emerging space needs with a series of potential solutions so as to establish a blueprint for detailed programmatic planning and cost analysis—all within the framework established by the Provost’s Office to emphasize occupation and utilization of existing and planned facilities already part of campus capital planning efforts. Resource availability and the timing of campus actions will influence progress in accommodating BSOE space requirements, including determination of which specific solutions to implement.

The BSOE Space Plan estimates space utilization demand for the continued expansion of the school. The primary factors driving this expansion are a combination of evolving programmatic needs and projected overall growth of the school. Engineering in the 21st Century is a dynamic interdisciplinary field of inquiry driven by technological advances and subject to constant change and adaptation. The nature of the discipline is continually evolving, requiring instruction and research endeavors to evolve as well. As BSOE evolves and matures as a professional school, growth will occur along several dimensions: adding faculty (ladder rank, adjunct, and visiting), increasing extramurally funded research and associated research centers/institutes, adding professional researchers and post-docs, increasing undergraduate and graduate enrollment, and expanding administrative and technical support staff and services.

Space Planning Goals

1) Create and sustain distinct and adaptive space that fosters emerging technologies and changing patterns of inquiry.

The technology-driven nature of 21st century engineering requires BSOE faculty and students to constantly re-invent problem solving processes and the paradigms used in instruction and research. BSOE was founded specifically for this purpose—to be a unique professional school structured and focused in new directions. Consequently, the configuration and utilization of space will never be static, requiring on-going reallocation adaptation. As BSOE continues to grow and develop, sustaining a distinct identity and sense of community requires flexible and adaptive space for academic programs and support services.

2) Increase utilization of space within the Basking Engineering (BE) and Engineering-2 (E2) Buildings.

As requested by the Provost's Office, a central component of the BSOE Space Plan is to make greater use of space presently allocated to non-engineering programs and services within the BE and the E2 buildings. As disclosed in the attached graphs, only 56% of the available asf in BE and 53% of the available asf in E2 is presently allocated to BSOE (an additional 27% of E2 is allocated to Cal-ISI research that is closely affiliated with BSOE). During the next ten years, the primary source of on-campus expansion space for BSOE derives from relocation of non-engineering programs and services out of BE and E2. Occupation of non-engineering space by BSOE is recommended to follow three phases:

Phase I—Relocation of Mathematics from the 1st, 2nd, and 3rd floors of BE

Phase II—Relocation of non-engineering services and programs from the basement of BE

Phase III—Relocation of Economics from the 4th floor of E2

3) Upgrade and expand instructional and research laboratories.

The changing nature of engineering research and education requires an on-going process to expand and update instructional and research laboratories utilized by undergraduate and graduate students. Expanding undergraduate majors in Bioengineering, Computer Game Design, and Mechatronics and Autonomous Systems all require specialized instructional laboratory space, while new and existing graduate programs in AMS, BME, CE, CS, EE, and TIM also will require new laboratory space for graduate student instruction and research. The increasing curricular emphasis on Senior Projects as a Capstone experience within CE, CS, and EE necessitates creation of dedicated laboratory space for undergraduates.

4) Expand instruction and research presence in Silicon Valley.

The unique opportunities and circumstances afforded by the Silicon Valley are a critical component of BSOE space planning, as both engineering instruction and research can flourish through connection to a diverse range of industrial partnerships. This includes attracting graduate students into professional degree programs that otherwise would not have been enrolled at UCSC, such as the TIM Program.

5) Consolidate academic programs in contiguous space.

Although faculty are mindful of the value of interdisciplinary collaboration, consolidating academic programs in contiguous space is essential. In the near term this is best accomplished through increased utilization of existing non-engineering space within BE and E2, plus other nearby facilities. For example, consolidating the BME department is a particularly important objective, as it is presently spread across several buildings. Expansion plans for AMS, CE, CS, EE, and TIM focus on consolidating each of these departments as much as possible.

6) Secure essential campus support and timely decisions to facilitate necessary expansion of BSOE.

Many aspects of projected BSOE growth (as summarized below) require careful coordination and support from the campus. Campus actions to relocate non-engineering programs and services from BE and E2 in a timely manner, and to provide adequate resources to renovate and occupy the vacated spaces is essential. Campus attention to providing infrastructure at remote sites such as the Silicon Valley Center or the Delaware Building Complex also is necessary to help BSOE instruction and research programs.

APPENDICES

BSOE and Academic Departments at a Glance - Pages 52-64

BSOE Space Plan – Pages 65-95

Baskin School of Engineering

2005/06 Division Snapshot	
Faculty FTE	Filled: 65 ¹⁶ Reserved: 15.2
Degrees <i>Source: 2005-06 Instructional Load Summary</i>	Graduate [34%]: 75 Undergraduate [66%]: 145
Student Majors [declared and proposed majors for ugrad] <i>Source: Datawarehouse Headcount History</i>	Graduate [33%]: 292 ¹⁷ Undergraduate [67%]: 590 ¹⁸
Instructional Workload (FTE) <i>Source: 2005-06 Instructional Load Summary</i>	Graduate [21%]: 251.2 Undergraduate [79%]: 920.5
Extramural Awards and Gifts	\$23,456,722 ¹⁹
Awards and Gifts per FTE	\$360,873
Academic Plan	
Proposed Faculty FTE by 2011/12 See departmental snapshots for proposed new programs.	Filled faculty: 99 Reserve: 6 Total: 105

¹⁶ Total includes Haussler

¹⁷ UCSC 2005-06 Graduate Majors Report by level, *Datawarehouse* (excluding AMS/CMPE)

¹⁸ UCSC 2005-06 Annual Report of Majors, *Datawarehouse* (excluding AMS/CMPE)

¹⁹ Includes \$99,569 in gifts to BSOE; and \$1,741,573 total awards from HHMI, QB3, and CITRIS

Applied Mathematics & Statistics

Program Milestones	
2001	AMS program established
2004	Minor in Statistics established
2006	AMS Department established
2006	Statistics and Stochastic Modeling MS/PhD programs established
2005/06 Program Snapshot	
Faculty FTE	9
Degrees <i>Source: Department provided</i>	Graduate: 9 <i>AMS students who received degrees from the Departments of Computer Science or Ocean Sciences²⁰</i>
Student Majors <i>Source: Department provided</i>	Graduate: 24
Instructional Workload (FTE) <i>Source: 2005-06 Instructional Load Summary</i>	Graduate [12%]: 36.2 Undergraduate [88%]: 253.9
Extramural Awards and Gifts	\$2,242,130
Awards and Gifts per FTE	\$249,125.56
Research Areas	
<ul style="list-style-type: none"> • Applied Mathematics: <ul style="list-style-type: none"> ○ Astrophysical and Geophysical Fluid Dynamics ○ Control Theory ○ Mathematical Biology 	<ul style="list-style-type: none"> • Statistics: <ul style="list-style-type: none"> ○ Computationally-intensive Bayesian methods of inference, prediction and decision-making ○ Bayesian spatial-temporal modeling, with environmetric applications ○ Bayesian nonparametric methods
Collaborations	
<ul style="list-style-type: none"> • At UCSC (outside the School of Engineering): <ul style="list-style-type: none"> ○ (a) Ph.D. advancements and thesis committees for graduate students in Economics, Environmental Studies, Ocean Sciences and Physics [Draper, Lee, Mangel, Sanso]; (b) memberships on the Board of Directors of the STEPS Institute for Innovation in Environmental Research [Mangel, Sanso], and collaborative STEPS grants on climate change with faculty from Earth and Planetary Sciences 	

[Sanso]; (c) joint work with faculty in **Ocean Sciences** and the **Institute for Marine Sciences**, developing adaptive high-resolution spatial-temporal sampling methods to study the ocean surface [Cortes]; (d) a collaboration with researchers in **Ocean Sciences** and the **California Sea Grant** on a study to quantify the exposure of fish caught from the Santa Cruz Wharf to a neurotoxin [Prado]; (e) joint work with faculty in **Astronomy and Astrophysics** and in **Earth and Planetary Sciences** on modeling planet formation in proto-stellar disks and the dynamical structure of the solar interior, funded by a \$1.1 million **National Science Foundation** (NSF) grant on supercomputing in astrophysics [Garaud]; (f) projects with faculty (i) in **Earth and Planetary Sciences** on creating ensembles of permeability configurations for modeling the ocean floor crust and water flows through the floor, (ii) with faculty from **Community Studies** on the geographical distribution of obesity, and (iii) with faculty from **Environmental Toxicology** on the toxic health effects of manganese on laboratory animals [Lee]; and (g) a collaboration with investigators in **Ocean Sciences** funded by a \$985K grant from the National Marine Fisheries Service to found and maintain the **Center for Stock Assessment Research** (CSTAR) at UCSC [Mangel].

- Beyond UCSC:
 - a) Funding from **NSF** in collaboration with researchers at **MIT** to improve the estimation of climate system properties using the *MIT 2D* climate model [Sanso]; (b) joint work with investigators at the Research Division of **Kaiser Permanente Northern California**, working on the measurement of the quality of health care and new treatments and methods for data analysis for improving care, funded by a \$1.35 million grant from the **National Institutes of Health** (NIH) [Draper]; (c) collaborations with researchers at **NASA Ames Research Center** and the **University of Arizona**, working on statistical methods for modeling biophysical processes associated with the interaction between light and vegetation [Kottas]; (d) joint work with researchers at **SUNY Stony Brook** on statistical methods for assessing model uncertainty in ecological dynamics and population forecasting [Kottas, Mangel]; (e) a collaboration with investigators at **Arizona State University**, funded by a \$516K grant from the **NIH**, working on developing Bayesian statistical models for studying genetic variability in malaria antigens, with a goal of developing a vaccine against malaria [Prado]; (f) a project with researchers at **Los Alamos National Laboratories** on inverse problems in computer simulation, with applications in physics and engineering [Lee, Sanso]; (g) joint work with investigators at **Sandia National Laboratories, Lawrence Livermore National Laboratories** and **NASA Ames**, on (i) optimization of physical and computer experiments (with applications including circuit board design and penetrator reliability studies), (ii) the modeling of multivariate point processes using Bayesian spatio-temporal models, and (iii) sequential design of computer experiments for the development of a new rocket booster [Lee]; and (h) collaborations with researchers at **SUNY Stony Brook**, funded by a \$1.03 million grant from the **CalFed Science program** and a \$730K grant from the **Lenfest Foundation**, to study life history variation in steelhead trout and investigate the implications of climate change for the life history, predators and fishery management practices for krill [Mangel].

Academic Plan

Proposed Faculty FTE by 2011/12	14
Proposed New Programs or expansion of existing programs	<ul style="list-style-type: none"> • Graduate program will be renamed <i>Statistical and Applied Mathematical Modeling (MS/PhD)</i> with two parallel tracks: concentration in Applied Mathematics or Statistics • Applied Mathematics (BS) • Statistics (BS)

Biomolecular Engineering

Program Milestones	
2001 Human Genome Assembled	
2003 BS in Bioinformatics (1 st in CA, originally a CE program)	
2003 Establishment of QB3/CBSE Research Institute	
2003 MS/PhD in Bioinformatics	
2003 Department Established	
Program Snapshot (2005/6)	
Faculty FTE	5.2
Degrees <i>Also, X CS PhD, Y CS MS, Z</i> <i>Source: 2005/06 Instructional Load Summary</i>	Graduate (62%): 5 Undergraduate: 3
Students <i>Majors/premajors for ugrad</i>	Graduate (xx%): xx Undergraduate: xx
Instructional Workload (FTE) <i>Source: 2005-06 Instructional Load Summary</i>	Graduate (34%): 30 Undergraduate: 59
Extramural Awards and Gifts	\$7,036,794
Awards and Gifts per FTE	\$1,353,230
Research Areas	
Bioengineering Mathematical and Statistical Modeling <ul style="list-style-type: none"> • Comparative Genomics • Protein structure prediction • Microarrays • Archae genomics • Gene networks 	Bioengineering BIN Technologies <ul style="list-style-type: none"> • Nanopores for DNA analysis • Protein Design
Collaborations	
AMS, BME, CS, EE, ISM, CHEM, ETOX, MCDB, PHIL, CBSE/QB3, UARC	
Affymetrix, Broad Institute at MIT and Harvard, DOE Joint Genome Institute, ENSEMBL, ENCODE Consortium, HP, LBNL, National Center for Biotechnology Information (NCBI), National Human Genome Research Institute , NASA/Ames, Sperling Biomedical Foundation, Stem Cell & Brain Research Institute (France), Wellcome Trust Sanger Institute	

UCB, UCD, UCLA, UCSF, U M Amherst, Baylor, Université Claude Bernard (France), Cornell, Free University of Brussels (ULB), Harvard, McGill U, U Md, NC State, Penn State, Washington University SL, U Washington	
Academic Plan	
Proposed Faculty FTE by 2012	12.2
Proposed New Programs or expansion of existing programs	Bioengineering (BS) BME,CE,EE,MCD Interdisciplinary Biomedical Research Graduate Group (PhD) BME,CBC,ETOX, MCD,PHYS Biomolecular Engineering (MS/PhD)

Highlights

- Genome.ucsc.edu
- Archaeal genome browsers and sequencing
- NAS & other awards
- Protein structure prediction
- CIRM Stem Cell training program
- NIH Bioinformatics training grant
- New chair
- Codevelopment of courses with Philosophy on bioethics
- Exceptionally strong collaborations with AMS, MCD, ETOX, CHEM.

Future Plans

- Expand graduate program to include biomolecular engineering
- Interdisciplinary Biomedical Research Graduate Group
- Discuss possibilities of a School of Public Health

Computer Engineering

Program Milestones	
1988 Department Established	
198x BS in Computer Engineering (Accredited 19xx)	
1988 MS/PhD in Computer Engineering	
1998 Distance Learning MS Program in Silicon Valley	
1998 Launch of EE, leading to establishment of the SOE	
2001 CITRIS/INI Research Institute founded	
2003 BS in Bioinformatics (1 st in CA, now a BME program)	
2005 Minor in Computer Technology	
Program Snapshot (2005/6)	
Faculty FTE	16.8
Degrees <i>Source: 2005/06 Instructional Load Summary</i>	Graduate (41%): 25 Undergraduate: 36
Students [majors/premajors for ugrad]	Graduate (30%): 75 Undergraduate: 184
Instructional Workload (FTE) <i>Does not include graduate thesis advising (298/299)</i>	Graduate (22%): 59.1 Undergraduate: 273.5
Extramural Awards and Gifts	\$3,916,711
Awards and Gifts per FTE	\$247,893
Research Areas	
System Design <ul style="list-style-type: none"> • VLSI/FPGA CAD & Design • Computer Architecture • Embedded Systems • Autonomous Systems & Control Bioengineering <ul style="list-style-type: none"> • Assistive Technology • Environmental Monitoring 	Infor. & Comm. Infrastructure <ul style="list-style-type: none"> • Computer Networks • Sensor Networks • Network infrastructure BIN Technology <ul style="list-style-type: none"> • Computer vision • Dynamics and Control of Biomolecules
Collaborations	
AMS, BME, CS, EE, TIM, ECON, EEB, EART, ENV5 ETOX, MCDB, OS, CBSE/QB3, COSMOS, EPC, INI/CITRIS, IGPP, LML, SCIPP, STEPS, UARC	

Acceleron Technologies, Aerospace, Agilent, Altera, Apple, BBN, Bloom Energy, Canesta, Cisco, Cypress Semiconductor, Doran Center for the Blind and Visually Impaired, Harbor Wing Technologies, HP, Honda, Honeywell, IBM, Intel, INRIA, Mango DSP, MBARI, Meru Networks, Microsoft, NASA/Ames, NVideo, National Park Service, National Semiconductor, NEC, Nokia, Orion Microelectronics, PARC, Plantronics, Raytheon, Realtek Microelectronics, Rockcliffe, SAIC, Sonicwall, SRI International, Smith-Kettlewell Eye Research Institute, Sun, Vena, Vidient Systems, USGS, Xilinx, Xylim	
UCB, UCD, UCI, UCLA, UCM, UCR, UCSB, UCSD, U Bahcesehir, U Birmingham, Cal Tech, CMU, U Co, U Del, EDPF, UIUC, Instituto Superior Technica, U Ky, U Liege, U MD, U Mass Amherst, MIT, U Mich, U Minn, U Naples, NPGS, U Pierre et Marie Curie (Paris VI), U Rochester, Stanford, Santa Clara, U Twente, U Utah, U Wash	
Academic Plan	
Proposed Faculty FTE by 2011/12	20.8
Proposed New Programs or expansion of existing programs	Bioengineering (BS) BME,CE,EE,MCD Autonomous Systems (MS/PhD) Mechatronic Engineering (BS)

Highlights

- JJ Garcia-Luna-Aceves leads a team from Maryland, MIT, UCB, UCLA, UIUC, and Stanford in developing the new science of ad hoc networks. UCSC co-PIs include Obraczka (CE) and Sadjadpour (EE).
- Richard Hughey directs an NSF Research Experiences for Undergraduates summer program in the Baskin School, surf-it.soe.ucsc.edu.
- Roberto Manduchi has worked with Psychology Professor Dom Massaro to create a new topical course, CMPE80A: Assistive Technology and Universal Access, examining the physiology, psychology, and technology of disability, as part of the bioengineering B.S. program.
- Graduate student and postdoc placements include faculty positions at UMass Amherst, Georgetown, Irvine, and 3 South American and 2 European universities.
- Computer Engineering has established 2 new first-year courses (CE1, Hands-On Computer Engineering, and CE8, Robot Automation) geared to undergraduate retention, and supports a variety of SOE student organizations.
- Gabriel Elkaim has developed a new upper-division course in mechatronics as part of the program in autonomous systems.

Plans

- Graduate and undergraduate programs in autonomous systems and robots. At the undergraduate level, this will take the form of a major in mechatronic engineering, a potential starting point for mechanical engineering.
- Expansion of our small but internationally-recognized networking group, one of the BSOE's two top producers of faculty-placed PhD's.
- Developing critical mass in assistive technology, a field of bioengineering and system design, through our 2006-7 recruitment.
- Creation and execution of a multifaceted plan to increase in national rankings, including an aggressive publicity campaign to improve reputation-based criteria.
- Interdisciplinary development of courses, such as current discussions with ENV5 and EEB about a course in environmental technology.
- Expand graduate program in Silicon Valley in collaboration with TIM.

Computer Science

Program Milestones	
1968 Program Established: Information and Computer Science established in (Dave Huffman) -included elements of CS and EE	
1975: First PhD Dr. Hans Kron	
1980: Change to Computer and Information Science with emphasis on Computer Science (Chair Ira Pohl)	
1989: Change to Computer Science	
2001:SSRC established (Director Darrell Long)	
2005: First Endowed Chair Darrell Long – Malavalli Chair	
2006: Degree established in Computer Game Design	
2005/06 Program Snapshot	
Faculty FTE	19
Degrees <i>Source: 2005-06 Instructional Load Summary</i>	Graduate[35%]: 28 Undergraduate: 52
Student Majors [declared and proposed majors for ugrad] <i>Source: Datawarehouse Headcount History</i>	Graduate[36%]: 108 Undergraduate: 191
Instructional Workload (FTE) <i>Source: 2005-06 Instructional Load Summary</i>	Graduate[23%]: 75.4 Undergraduate: 250.9
Extramural Awards and Gifts	\$2,874,482
Awards and Gifts per FTE	\$151,289
Research Areas	
<ul style="list-style-type: none"> • Mathematics and Statistical Modeling: Machine Learning, Analysis of Algorithms, Logic, Formal Methods, and Complexity Theory, • Software and Services: Computer Game Design, Software Engineering, Programming Languages, 	<ul style="list-style-type: none"> • Information and Communication Infrastructure: Storage Systems, Real-Time Systems, Database Systems, Distributed Systems • Other: Scientific Visualization, Graphics, AI, CS Education

Collaborations	
<p>The CS researchers have a large number of industrial collaborators including: NASA Ames, Microsoft, IBM, Intel, HP, Network Alliance, Yahoo, LSI Logic, Seagate Technology, Symantec, Apple, BAE Systems, Financial Scientific, Telic Incorporated, and Mozilla.</p> <p>University and other institutional collaborations include: Lawrence Livermore National Laboratory, Los Alamos National Laboratory, Sandia National Laboratory, Oak Ridge National Laboratory, National Energy Research Scientific Computing Center, Carnegie Mellon University, Williams College, Cambridge University, UC Berkeley, UC San Diego, Stanford University, Georgia Tech, Hunter College, Cornell University, Columbia University, Princeton University, Brown University, University of Kentucky, University of Michigan, Stony Brook University, Santa Clara University, University of Houston, Saarland University, Rice University, Microsoft Laboratories, IBM Research, Hierarchical Systems Research Foundation, Iowa State University, Stevens Institute of Technology, Kansas State University, Rose-Hulman Institute of Technology, and University of Texas at El Paso.</p> <p>In addition, many CS researchers have a large number of collaborations with universities outside of the United States, including: University of Toronto (Canada), Polytechnic University of Catalonia (Spain), University of Tel Aviv (Israel), University of Ioannina (Greece), University of Peloponese (Greece), INRIA (France), Max Planck Institute (Germany), and National ICT (Australia).</p>	
Academic Plan	
Proposed Faculty FTE by 2011/12	26
Proposed New Programs or expansion of existing programs	Computer Game Design(MS) Software Engineering (MS/PhD)

Recent Highlights

- GAANN grants 2004-2007 Multi-year support for PhD student from underrepresented groups. Pohl and Brandt
- SSRC LALN collaboration xyz Long, Miller and Brandt
- David Haussler receives Howard Hughes award and goes on to found Bio-Informatics
- Cormac Flanagan awarded a Sloan 2005

Future Plans

- Grow the new computer game design major and add a Master’s degree program
- Software Engineering professional degree in concert with Silicon Valley Center

Electrical Engineering

Program Milestones	
2000 EE Department established. BS degree program	
2002 MS/PhD program established	
2003 BS.EE program accredited by ABET until 2009	
2003 NSF, Engineering Research Center in Biomimetic Microelectronic Systems established (with USC and CalTech)	
2004 ONR Center for Thermionic Energy Conversion established (UCSC lead institution with UCB, UCSB, Purdue, Harvard, MIT and NC State)	
2005/06 Program Snapshot	
Faculty FTE	12 ²¹
Degrees <i>Source: 2005-06 Instructional Load Summary</i>	Graduate [46%]: 19 Undergraduate [54%]: 22
Student Majors [declared and proposed majors for ugrad] <i>Source: Datawarehouse Headcount History</i>	Graduate [31%]: 54 Undergraduate [69%]: 119
Instructional Workload (FTE) <i>Source: 2005-06 Instructional Load Summary</i>	Graduate [36%]: 43.2 Undergraduate [64%]: 75.8
Extramural Awards and Gifts	\$5,171,980
Awards and Gifts per FTE	\$430,998
Research Areas	
<ul style="list-style-type: none"> • Photonics, electronics and instrumentation • VLSI, Microelectromechanical Systems (MEMS) • Nanotechnology 	<ul style="list-style-type: none"> • Communications and Signal Processing • Biomedical devices and materials • Renewable energy

²¹ Excludes Dean

		sources
Collaborations		
<p><i>Selected intra UCSC/</i> AMS, CE, BME, TIM, Chemistry, MCDB, Physics, Earth and Marine Sciences, SCIPP, CIMT, CBSE, UARC, COSMOS, CfAO, EPC, Division of Social Sciences.</p> <p><i>Other educational institutions/</i> QB3, CITRIS, UCSF, UCB, UCSD, UCI, Cornell, SCU, USC, Caltech, Harvard, Purdue, Stanford, BYU, Technion, Univ. Bordeaux, EPL, ETH, Seoul Nat'l University, Nat'l Univ. Singapore, Foothill/DeAnza College, Hartnell College, SJSU, Carnegie Mellon</p> <p><i>Government Labs/</i> Wadsworth Center, Sandia, LBL, LLNL, NASA, NPS</p> <p><i>Industry and other non-governmental organizations/</i> Agilent, Intel, IBM, National Semiconductor, Altera, Trellis Biosciences, Hitachi High Technologies America, Second Sight, Mitsubishi, Xilinx, Multigig, AMD, MBARI, NYState Photonics Center</p>		
Academic Plan		
Proposed Faculty FTE by 2011/12		18
Proposed New Programs or expansion of existing programs	<p>Meng, Electrical Engineering BS, Bioengineering</p> <p>BS Curriculum in Sustainable Technology (with Soc., PoliticalSci, Environ. Science)</p> <p>Work towards a Materials Science and Engineering Research Center (with Physics, Chemistry)</p> <p>Participation in efforts to create a School of Public Health</p>	

Highlights (selected):

- NSF CAREER Awards to Ali Shakouri, Holger Schmidt, Peyman Milanfar
- ONR Young Investigator Award to Claire Gu
- IEEE Millennium Medal to Ben Friedlander
- IEEE Fellow, Ben Friedlander
- AAAS Fellow, Mike Isaacson
- SPIE Fellow, Claire Gu
- Rank Prize to Mike Isaacson
- Packard Fellowship to Ali Shakouri
- NAS/NRC Naval Studies Board (John Vesecky)
- National Chiao Tung University Distinguished Alumnus Award to Wentai Liu

Technology and Information Management (Proposed Department)

Program Milestones	
1998 BS in Information Systems Management inaugurated (with CS and Economics)	
2002-05 Hiring of (4) faculty	
2005 SOE given oversight of ISM program	
2006 Technology and Information Management (M.S. and PhD) program proposal submitted for campus approval	
2006 Silicon Valley TIM / ISM courses initiated, KSEM Certificate initiated with UNEX	
2005/06 Program Snapshot	
Faculty FTE	4.x?
Degrees <i>Source: 2005-06 Instructional Load Summary</i>	Undergraduate: 30
Student Majors [declared and proposed majors for ugrad] <i>Source: Datawarehouse Headcount History</i>	Undergraduate: 58
Instructional Workload (FTE) <i>Source: 2005-06 Instructional Load Summary</i>	Graduate[17%]: 7.2 Undergraduate: 35.4
Extramural Awards and Gifts	\$373,483
Awards and Gifts per FTE	\$93,371
Research Areas	
System and Service Engineering	
<ul style="list-style-type: none"> • Management of Technology <ul style="list-style-type: none"> - Supply Chain Management - Risk Management in Product Development - Networking / Wireless Product and Services: Optimization and Pricing 	<ul style="list-style-type: none"> • Technology of Management <ul style="list-style-type: none"> - Knowledge Management - Information Retrieval - Data Mining - Call Center Optimization - Telecollaboration - Decision Support Systems
Collaborations	
Cisco, Hewlett-Packard, Yahoo, Google, Microsoft, IBM, NASA CITRIS (Berkeley, Merced, Davis) Carnegie-Mellon West	

Economics, Linguistics	
Academic Plan	
Proposed Faculty FTE by 2011/12	8
Proposed New Programs or expansion of existing programs	<i>Undergoing review.</i> Technology & Information Mgt (MS/PhD)

Highlights

- Research Funding: Cisco, HP (Akella), Yahoo and Google (Zhang), NSF (Musacchio)
- KSEM Certificate at SVC
- Strong Graduate Student interest (ahead of program approval)
- Growth in enrollments in ISM undergraduate courses
- Connections with CITRIS and IBM: *Services Science Management and Engineering*

Future Plans

- Hiring of Department Chair and additional faculty hiring (one senior, two junior)
- Creation of ISM minor
- Graduate proposal approval and establishment of TIM graduate program
- Creation of TIM department
- Participation in creation of School of Management (in Silicon Valley)

June 2007

SPACE PLAN



Baskin Engineering  UC SANTA CRUZ

SPACE PLAN: Baskin School of Engineering

June 2007

OVERVIEW

This document presents the Baskin School of Engineering (BSOE) Space Plan in support of the BSOE Academic Plan.

The BSOE Space Plan matches emerging space needs with a series of potential solutions so as to establish a blueprint for detailed programmatic planning and cost analysis—all within the framework established by the Provost's Office to emphasize occupation and utilization of existing and planned facilities already part of campus capital planning efforts. Resource availability and the timing of campus actions will influence progress in accommodating BSOE space requirements, including determination of which specific solutions to implement.

The BSOE Space Plan estimates space utilization demand for the continued expansion of the school. The primary factors driving this expansion are a combination of evolving programmatic needs and projected overall growth of the school. Engineering in the 21st Century is a dynamic interdisciplinary field of inquiry driven by technological advances and subject to constant change and adaptation. The nature of the discipline is continually evolving, requiring instruction and research endeavors to evolve as well. As BSOE matures as a professional school, growth will occur along several dimensions: adding faculty (ladder rank, adjunct, and visiting), increasing extramurally funded research and associated research centers/institutes, adding professional researchers and post-docs, increasing undergraduate and graduate enrollment, and expanding administrative and technical support staff and services.

Estimates of future space are based on projected growth in the six BSOE academic departments (campus approval of the TIM Department is expected in the near future):

- Applied Mathematics & Statistics (AMS)
- Bio-Molecular Engineering (BME)
- Computer Engineering (CE)
- Computer Science (CS)
- Electrical Engineering (EE)
- Technology & Information Management (TIM)

SPACE PLANNING GOALS

Six goals underlie space planning for instruction and research:

1) Create and sustain distinct and adaptive space that fosters emerging technologies and changing patterns of inquiry.

The technology-driven nature of 21st century engineering requires BSOE faculty and students to constantly re-invent problem solving processes and the paradigms used in instruction and research. BSOE was founded specifically for this purpose—to be a unique professional school structured and focused in new directions. Consequently, the configuration and utilization of space will never be static, requiring on-going reallocation adaptation. As BSOE continues to grow and develop, sustaining a distinct identity and sense of community requires flexible and adaptive space for academic programs and support services.

2) Increase utilization of space within the Basking Engineering (BE) and Engineering-2 (E2) Buildings.

As requested by the Provost’s Office, a central component of the BSOE Space Plan is to make greater use of space presently allocated to non-engineering programs and services within the BE and the E2 buildings. As disclosed in Figures I & II below, only 56% of the available asf in BE and 53% of the available asf in E2 is presently allocated to BSOE (an additional 27% of E2 is allocated to Cal-ISI research that is closely affiliated with BSOE).

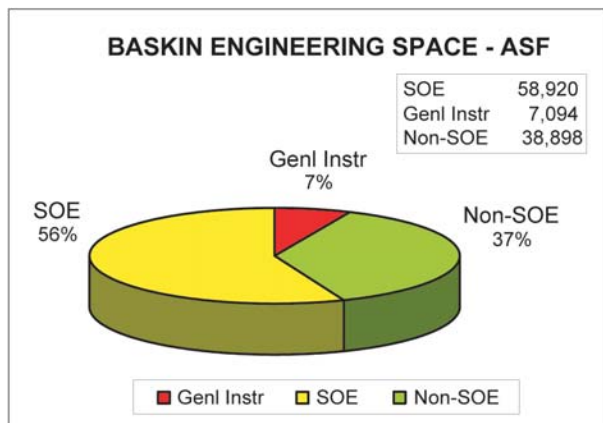


Figure I. Baskin Engineering Space – ASF

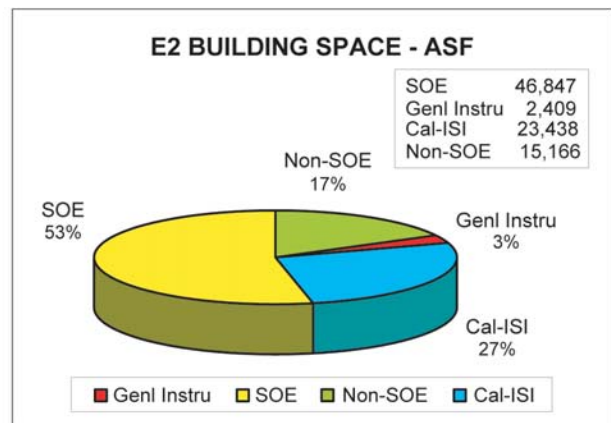


Figure II. Engineering 2 Building Space - ASF

During the next ten years, the primary source of on-campus expansion space for BSOE derives from relocation of non-engineering programs and services out of BE and E2. Occupation of non-engineering space by BSOE is recommended to follow three phases:

Phase I—Relocation of Mathematics from the 1st, 2nd, and 3rd floors of BE

Phase II—Relocation of non-engineering services and programs (Printing, Mail, & PBCSci) from the basement of BE

Phase III—Relocation of Economics from the 4th floor of E2

3) Upgrade and expand instruction and research laboratories.

The changing nature of engineering research and education requires an on-going process to expand and update instructional and research laboratories utilized by undergraduate and graduate students. For example, expanding undergraduate majors in Bioengineering, Computer Game Design, and Mechatronics and Autonomous Systems all require specialized instructional laboratory space, while new and existing graduate programs will require new laboratory space for instruction and research. The increasing curricular emphasis on Senior Projects as a Capstone experience also necessitates creation of dedicated laboratory space for undergraduates.

4) Expand instruction and research presence in Silicon Valley.

The unique opportunities and circumstances afforded by the Silicon Valley are a critical component of BSOE space planning, as both engineering instruction and research can flourish through connection to a diverse range of industrial partnerships. This includes attracting graduate students into professional degree programs that otherwise would not have been enrolled at UCSC.

5) Consolidate academic programs in contiguous space.

Although faculty are mindful of the value of interdisciplinary collaboration, consolidating academic programs in contiguous space is essential. In the near term this is best accomplished through increased utilization of existing non-engineering space within BE and E2, plus other nearby facilities. For example, consolidating the BME department is a particularly important objective, as it is presently spread across several buildings. Expansion plans for AMS, CE, CS, EE, and TIM also focus on consolidating each of these departments as much as possible.

6) Secure essential campus support and timely decisions to facilitate necessary expansion of BSOE.

Many aspects of projected BSOE growth require careful coordination and support from the campus. Campus actions to relocate non-engineering programs and services from BE and E2 in

a timely manner, and to provide adequate resources to renovate and occupy the vacated spaces is essential. Campus attention to providing infrastructure at remote sites such as the Silicon Valley Center or the Delaware Building Complex also is necessary to help BSOE instruction and research programs.

ANTICIPATED GROWTH

Growth is a major factor facing BSOE in the years ahead. Below are estimates of growth from current levels through 2013/14:

<u>Area</u>	<u>Projected Growth</u>	<u>%Change</u>
Faculty	80 FTE to 113 FTE	+41%
Other Academic	103 FTE to 130 FTE	+26%
UG Students	920 FTE to 1445 FTE	+57%
GRAD Students	251 FTE to 514 FTE	+105%
Staff	41 FTE to 66 FTE	+60%
Research Awards	\$21.2 M to \$28.0 M	+32%
Gifts	\$2.3 M to \$10.7 M	+365%

The BSOE Space Plan accounts for anticipated growth in ladder rank faculty, plus the associated growth in other academic staff (adjunct faculty, research scientists/visitors, and post-doctoral scholars). This associated growth in part reflects the increasing positive reputation of BSOE and the interest of other scholars to visit and collaborate with our faculty. Undergraduate and graduate student FTE are projected to increase; the positive change in undergraduate enrollment is due in part to new majors such as Bioengineering and Computer Game Design, plus additional service course enrollments for the campus, while growth in graduate enrollments is expected to continue the historical pattern of growing at a pace exceeding most non-engineering programs on campus. BSOE anticipates that administrative and service staffing will increase in response to workload generated by growth in faculty and student enrollment. Expansion of extramurally funded research activities will continue, while gifts are expected to grow rapidly.

SPACE REQUIREMENTS

Figures III and IV below summarize projected new space requirements for BSOE as the school grows to 113 faculty FTE. BSOE estimates requiring approximately 62,000 asf of additional space over present allocations using identified buildings and facilities both on and off campus. This includes projections of unique space requirements beyond average standards for offices and laboratories, plus space needed to accommodate research, technical and support staff FTE along with unique instructional facilities.

This projected total of 62,000 asf does not include the long-term need for another Engineering building within ten to fifteen years to house expanding research endeavors, or the unknown square footage requirements from potential BSOE use of space at DBC or MBEST if opportunities materialize at those off campus locations.

BSOE ESTIMATED NEW SPACE REQUIREMENTS TO ACCOMMODATE ACADEMIC PLAN GROWTH TO 113 FACULTY FTE										
Department	New Faculty FTE	Faculty Office ASF	Faculty Basic Lab ASF	Faculty Special Lab ASF	Total Faculty ASF	Class Lab ASF	Other Academic ASF	New Staff FTE	Staff ASF	Total New ASF
AMS	6	810	3000	0	3810	0	175	0	0	3985
BME	7	945	3500	6000	10445	0	775	0	0	11220
CE	5	675	2500	10000	13175	0	125	0	0	13300
CS	8	1080	4000	0	5080	0	275	0	0	5355
EE	6	810	3000	4500	8310	0	525	0	0	8835
TIM	4	540	2000	0	2540	0	200	0	0	2740
Other/Schoolwide	7	945	3500	0	4445	4650	0	20	2700	11795
Sub-Total On Campus	43	5805	21500	20500	47805	4650	2075	20	2700	57230
SVC	0	540	0	2500	3040	750	1020	3	405	5215
DBC (Space TBD)	0	0	0	0	0	0	0	0	0	0
MBEST (Space TBD)	0	0	0	0	0	0	0	0	0	0
Sub-Total Off Campus	0	540	0	2500	3040	750	1020	3	405	5215
BSOE TOTAL	43	6345	21500	23000	50845	5400	3095	23	3105	62445

Notes:

- Faculty FTE include 7 faculty reserve FTE (reflected schoolwide/not distributed by department).
- TIM faculty FTE are counted once in total FTE, but the space ASF are calculated twice to reflect needs both on and off campus (SVC).
- Faculty Basic ASF is 135 asf/office & 500 asf/lab.
- Special Lab ASF for faculty reflects additional space beyond the basic 500 asf/lab for lab intensive specialties.
- Class Lab ASF is for new undergraduate instructional labs based on projected enrollments (reflected schoolwide/not distributed by department).
- Other Academic ASF includes post docs, adjunct and visitor offices, plus stations for graduate students unattached to faculty research groups.
- Staff ASF is for projected new staff (reflected schoolwide/not distributed by department).
- CE Special Lab @ 10,000 ASF for Autonomous Systems Testing Facility.
- Amount of DBC space is unknown; to be determined.
- Amount of MBEST space is unknown; to be determined.

Figure III. Projected new space requirements for BSOE as the school grows to 113 faculty FTE.

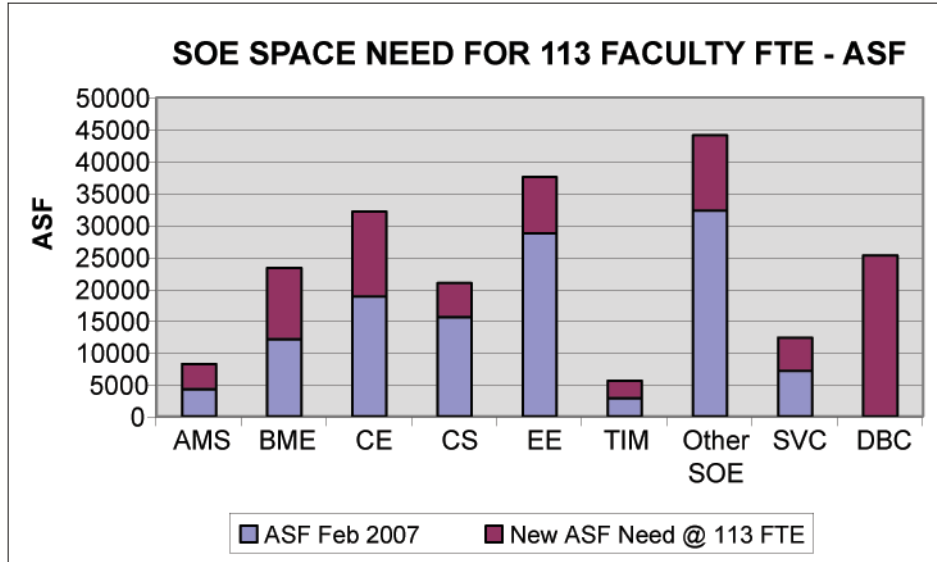


Figure IV. SOE Space Need for 113 Faculty FTE - ASF

ESSENTIAL CAMPUS ACTIONS

Successful growth and development of BSOE is dependent upon campus actions to implement relocation of departments and services from existing space, creation and expansion of new space, and renewal of long-term lease arrangements. Delays in implementing these actions by the campus will impede development of instruction and research programs as addressed in the BSOE Academic Plan.

The specific campus actions and projected timeframe are as follows:

- 2006/07: Completion of the Alterations 2/3 Project in BE
- 2008/09: Relocation of the Mathematics Department from BE
- 2008/09: Renewal of SVC long-term lease at NASA/Ames
- 2009/10: Completion of BMSEB
- 2009/10: Opening new facilities at DBC
- 2010/11: Relocation of Printing Services and the Mail Room from BE
- 2011/12: Relocation of PBSci basement laboratories from BE
- 2012/13: Completion of new Silicon Valley Facility
- 2013/14: Relocation of the Economics Department from E2
- 2018+: Planning and Construction of new Engineering Building

PROPOSED DEVELOPMENT AND USE OF SPACE

The focus of BSOE's space planning is on nine potential building or facility locations:

- 1) Baskin Engineering Building
- 2) Engineering-2 Building
- 3) Physical Sciences Building
- 4) Bio-Medical Sciences & Engineering Building
- 5) Autonomous Systems Testing Facility
- 6) Delaware Building Complex
- 7) Silicon Valley Center
- 8) Monterey Bay Education, Science & Technology Center
- 9) New Engineering Building

The convergence of evolving programmatic needs coupled with anticipated future growth underlies estimated space demands in each building or facility. The order does not reflect priorities, but attempts to account for current campus capital plans and resource possibilities. Items 1 to 4 are major campus buildings on Science & Engineering Hill (three occupied and one slated for construction), while items 5 to 9 involve specialized off campus sites or possible new campus facilities for which planning has yet to begin.

1) Baskin Engineering Building (BE)

BSOE plans to utilize additional space within BE as it becomes available in accordance with the timeline for campus actions. BSOE currently occupies 58,920 asf, or 56% of the BE, making it the primary source of expansion space for BSOE among existing facilities on campus. Non-engineering uses of BE include Mathematics (1st, 2nd, 3rd floors), Printing Services, Mail Services, PBSci Shops and Laboratories, and building systems (basement), and general assignment classrooms (1st floor). It should be noted that planned growth of CE and CS, along with various research centers and institutes (e.g., QB3, SSRC, CITRIS, etc.), all will require more office and laboratory space within the E2. This limits BSOE's options to accommodate other programmatic development without allocation of additional space within BE.

Space vacated by the campus Financial Aid Office: The office suite and adjacent space recently vacated by the campus Financial Aid Office on the BE 3rd floor totals 4,900 asf. BSOE will use this to create the Computer Game Design Laboratory for the new undergraduate computer gaming major in Computer Science. As enrollments grow in this popular field, further expansion of the laboratory space will be essential. Use of the former Financial Aid Office space also will create some flexibility on the 3rd floor for reassignment and expansion of office space for a variety of functions. This includes possible relocation of the BSOE Dean's Office, faculty and graduate student space for AMS, EE, or TIM, the Office of Sponsored Projects satellite office, Information Technology Services staff serving BSOE faculty and students, BSOE Business

Services staff, BSOE Development Office staff, and BSOE student organizations. Space for student organizations is critical for student outreach, retention and adaptation, as well as sustaining valuable networks with industry partners for student project work and eventual post-graduate employment.

Space renovated in the Alterations 2/3 Project: Completion of the Alterations 2/3 Project on the BE 2nd floor and basement provides 13,600 asf of additional laboratory space for both BME and EE research. Some of the laboratory space is fully furnished and ready for occupation, while other spaces will require completion as new faculty are hired. The basement renovations create laboratories for two existing EE faculty, whose research has been stalled awaiting adequate space. The 2nd floor renovations create five additional wet laboratories for BME, two of which accommodate existing faculty, one that will be used to handle relocation of a research project currently occupying temporary space on loan from PBSci in Sinsheimer Lab, with the remaining two laboratories targeted for new faculty recruitments. The 2nd floor renovations also create five additional wet laboratories for EE, two of which accommodate existing faculty, with three targeted for new faculty recruitments. The Alterations 2/3 Project includes new Clean Room facilities and common service rooms to support the research laboratories.

Space vacated by relocation of Mathematics Department: Mathematics presently occupies 15,580 asf on the BE 1st, 2nd and 3rd floors, including 32 academic offices, instruction (192 class lab stations) and research laboratories, and administrative support space. Under the original campus capital plan, BSOE and PBSci are to equally divide (50/50) the released space; but this provision should be revisited as BSOE program growth can easily utilize all of the released space (there have been no discussions with PBSci regarding assignment of this space). Much of the space occupied by Mathematics as currently configured could be utilized at relatively low cost since it is appropriate for BSOE programs and services. Academic office space would be assigned to AMS, EE, and TIM. Growth in AMS includes new faculty, researchers and graduate students associated with the newly approved M.S. and Ph.D. degrees in Statistics and Stochastic Modeling. Growth in EE includes new faculty, researchers and graduate students in Nano-Technology and Bio-Materials, all of whom will require office space nearby the new research laboratories constructed as part of the Alterations 2/3 Project. Both the TIM faculty and the Digital Arts faculty (participating in a cross-divisional collaboration) will need to relocate from temporary office space currently on loan from CITRIS in E2 as that institute grows. Space released by Mathematics also is suitable for the Senior Projects Laboratory to be used for completion of annual Capstone projects by undergraduates in CE, CS, and EE. This is an area of increasing emphasis in the curriculum of all three departments (senior projects are temporarily accommodated using space on loan from CITRIS within E2, but this will require relocation as the research institute grows). Research laboratory space in BE would be assigned to faculty and graduate students in AMS, BME (Bioinformatics), EE, and TIM as each of these departments expands and graduate enrollments increase. In the case of Bioinformatics, BE is the sole source of additional dry laboratory space, as BMSEB will be exclusively wet laboratories, and PSB offers no options for future augmentations of dry laboratory space. More administrative space for technical and laboratory support, departmental services, student advising, business operations, and facilities management would be necessary. This could include creating separate departmental offices for support staff (if BSOE elects to adopt this approach).

Space vacated by relocation of data center clusters to DBC: The data center computer clusters within BE currently utilize 1,932 asf. If the campus proceeds with plans to accommodate the relocation and integration of existing BSOE computer clusters at DBC (along with other campus academic and administrative computer clusters), the released space in BE can be utilized to develop BME instructional laboratories for the new BS degree in Bio-Engineering. During the initial years of the new degree, existing space in several collaborating departments within BSOE and PBSci can be used to handle instruction, but growth is expected to increase rapidly due to unmet demand for this major statewide. Instructional laboratory facilities will be critical to accommodating students, and the space used for data centers clusters in BE is adjacent to new wet laboratories for BME research being constructed as part of the Alterations 2/3 Project. If the creation of an integrated data center at DBC does not materialize, BSOE would explore relocating the BE clusters to E2, where capacity is greater for handling expansion of a data center. This would require using E2 space otherwise designated for research laboratories. Long-term operation of the clusters requires the campus to resolve on-going problems with providing consistent and reliable electric power, cooling, and redundant generator back-up capacity to Science & Engineering Hill.

Space vacated in basement by relocation of Printing Services and Mail Services plus PBSci Shops and Laboratories: Campus Printing Services and Campus Mail Services presently occupy 10,000 asf in the BE basement. PBSci shops and laboratories presently occupy 5,700 asf in the BE basement. BSOE recommends developing a specific plan for converting all this space to academic use. Much of the basement has been evaluated as appropriate for accommodating vibration sensitive instrumentation and laser technology experiments by EE faculty, and is the only suitable space identified in either BE or E2. It is probable that reduced scale shop operations—a joint venture between BSOE and PBSci—could be developed in the basement to accommodate undergraduate instruction in both divisions. Additional faculty recruitments in EE plus expansion of research programs in Nano-Technology will depend on this space. The basement also could be the location of a laser-cutting laboratory and instrumentation facility for use by faculty and students in the emerging CE program in Mechatronics and Autonomous Systems. Current space within E2 is insufficient and poorly suited for these purposes. Additional space would allow relocation of BSOE facilities management from the 2nd floor and out of space that can be used for expansion of undergraduate student advising services. The loading dock and adjacent mail storage/processing facilities in the basement would be invaluable to BSOE for school-wide receiving and long-term storage.

Space Occupied by ACE: The space currently assigned to the Academic Excellence Program (ACE) on the BE 1st floor effectively serves students in both BSOE and PBSci; it is assumed ACE would retain this space unless suitable replacement space easily accessible to students can be identified by the campus.

2) Engineering-2 Building (E2)

BSOE currently occupies 46,847 asf, or 53%% of the total building asf within E2. This provides office and laboratory space on the 2nd and 3rd floors for CE, CS, EE, and TIM, along with the BSOE Department Service Center that serves faculty and students in all six academic departments. Specially funded space for Cal-ISI sponsored research institutes (including CITRIS and CBSE/QB-3) occupies an additional 23,438 asf, or 27% of the total building asf, primarily on the 5th floor. Non-engineering uses of E2 include Economics (4th floor) and general assignment classrooms and building systems (1st floor). BSOE has been able to utilize some temporary space on loan from CITRIS to provide offices and/or dry laboratory space for several faculty, researchers and graduate students in TIM, Digital Arts, and SSRC. CITRIS also provides temporary office space to the campus for ITS administration.

Release of space temporarily on loan from CITRIS: In the future, faculty in both TIM and Digital Arts will require relocation due to expansion of CITRIS activities that will necessitate reclaiming space temporarily on loan. This could include office space in BE to be vacated by Mathematics. Faculty growth in CE and CS initially can be handled using available space on the 2nd and 3rd floors of E2, while growth in EE must be accommodated in BE. Eventually, additional space in E2 will be essential for program development of CE and CS, by relocation of Economics in accordance with campus plans.

Space vacated by relocation of data center clusters to DBC: The data center computer clusters within E2 currently utilize 1,069 asf. If the campus proceeds with plans to accommodate the relocation and integration of existing BSOE computer clusters at DBC (along with other campus academic and administrative computer clusters), the released space in E2 can be utilized for research laboratories needed by CE, CS, and EE. If the creation of an integrated data center at DBC does not materialize, BSOE would explore relocating the BE clusters to E2, where capacity is greater for handling expansion of a data center. Long-term operation of the clusters requires the campus to resolve on-going problems with providing consistent and reliable electric power, cooling, and redundant generator back-up capacity to Science & Engineering Hill.

Space vacated by relocation of the Economics Department: Economics presently occupies 16,800 asf on the 4th floor of E2, and will eventually relocate to a new Social Sciences facility in accordance with campus capital plans. By that time, BSOE will have completed the process of occupying BE space currently assigned to non-engineering programs and services, so the E2 4th floor will represent essential on-campus expansion space for the school. This will include offices and laboratories for faculty, visitors, researchers, post docs, graduate students, and technical staff, plus allow BSOE to redistribute space among all floors to accommodate creation of separate departmental offices for support staff (if BSOE elects to adopt this approach). Technical service functions now housed exclusively in BE could also be distributed to E2.

3) Physical Sciences Building (PSB)

BSOE presently occupies 5,045 asf within PSB that provides office and dry laboratory space for BME faculty, researchers and graduate students. The dry laboratory space is utilized by Bioinformatics, while wet laboratory space for BME is being made available in BE through the Alterations 2/3 Project. In accordance with campus plans, there are no options for expansion space in PSB as BME grows. To support growth in BME, future wet laboratory space will be provided in the new BMSEB, and future dry laboratory space for Bioinformatics will be provided in BE (through relocation of non-engineering programs and services).

As BME continues to grow, a vital objective will be to consolidate the department in contiguous space. Present arrangements and near-term campus plans have BME faculty scattered in several buildings. One near-term option for consideration is exchanging BSOE's space in PSB (since there appears to be no likelihood of acquiring additional space within PSB as BME grows). For example, PBSci has indicated interest in occupying the space used by BME in PSB; this could be possible in exchange for a portion of PBSci's space in BE to be released by Mathematics on the BE 1st, 2nd or 3rd floors. With completion of BMSEB, this could facilitate location of BME in only two locations, BE and BMSEB.

4) Bio-Medical Sciences & Engineering Building (BMSEB)

Campus plans call for completion and occupation of BMSEB by the end of 2009/10, which will help accommodate much of the anticipated growth in BME for new faculty and researchers needing wet laboratory space. This new building assigns approximately 13,000 asf to BSOE for BME, including six faculty research labs, six faculty offices, plus adjacent technical support space. This will augment the new BME wet laboratories in BE currently being completed as part of the Alterations 2/3 Project. The limited space available to BME in PSB affords no opportunities for expansion of office or laboratory space, making the BMSEB wet laboratories critical. In addition, instructional wet laboratory space for BME will not be provided in BMSEB, so this eventually will require construction in BE. As previously noted, office and dry laboratory space for faculty and graduate students in Bioinformatics also will be required in BE.

As previously noted, as BME continues to grow, the department would benefit from consolidating into as much contiguous space as possible. In the near term, this could be accomplished with the completion of BMSEB coupled with possible relocation of BME faculty offices and Bio-Informatics dry laboratories from PSB to BE. If funding challenges persist with completion of BMSEB, development of BME would be delayed due to the absence of wet laboratory space.

5) Autonomous Systems Testing Facility

BSOE anticipates submitting a proposal for a new undergraduate Mechatronics major within CE to complement the Autonomous Systems research currently conducted by CE faculty. Besides creating space in the BE basement to locate a laser-cutting laboratory and instrumentation facility for use by faculty and students in Mechatronics and Autonomous Systems, space also is required to accommodate storage and testing of robotic vehicles. BSOE proposes creation of a specialized free-standing facility of up to 10,000 asf for storage and testing of CE's Autonomous Systems robotic vehicles and devices. There is no space in either BE or E2 adequate for these purposes. At present, one donated robotic vehicle is stored in space on loan from TAPS in the Core West Parking Structure, but this site cannot accommodate equipment storage or testing, and there is no room for additional robotic vehicles. BSOE expects to eventually have three faculty and associated graduate students with research programs focusing on robotic vehicles and devices that would be served by this 10,000 asf facility.

6) Delaware Building Complex (DBC)

BSOE is currently working with the campus to evaluate options for academic space at DBC. The potential amount of overall square footage that BSOE could utilize is unknown, and depends upon the provision of infrastructure services and utilities as well as collaborative opportunities. A primary consideration is the feasibility to integrate and consolidate existing computer clusters in one location, while providing necessary space and technical support to accommodate future expansion of cluster activity. The combined BSOE data center space currently allocated in BE and E2 totals 3,001 asf. Projected growth in research and instructional use of computing will require up to an additional 5,000 asf (8,000 asf total) over the next ten years to support research efforts in all BSOE departments as well as CBSE and SSRC, and collaborations with Los Alamos and Lawrence Livermore National Laboratories. Within the next two years, BSOE anticipates requiring another 1,000 asf of data center space. Long-term operation of the clusters in either BE or E2 requires the campus to resolve on-going problems with providing consistent and reliable electric power, cooling, and redundant generator back-up capacity to Science & Engineering Hill.

BSOE also is interested in creating research laboratories at DBC for use by faculty in BME, CE, CS, and EE, through cooperative arrangements with commercial partners sponsoring joint projects. Another possible option for the campus to explore is relocating some portion of Cal-ISI activities (e.g., CBSE/QB-3) to similar facilities at DBC, thereby releasing 5th floor space in E2 for BSOE academic programs. This could prove complementary to creating an integrated data center at DBC. Lastly, BSOE is exploring the potential for DBC to house faculty and student laboratories for CE's program in Mechatronics and Autonomous Systems, particularly as a testing and maintenance location for robotic vehicles and devices.

7) Silicon Valley Center (SVC)

The SVC administration has presently allocated 7,133 asf to BSOE within Building 19 at the NASA—Ames Research Center in the Silicon Valley for TIM instruction and research programs. This BSOE space is leased through the end of 2008/09, and is in addition to classroom, laboratory and administrative space in Building 19 coordinated by the SVC administration in support of academic programs. BSOE is strongly supportive on creating a single presence for UCSC in Silicon Valley that integrates various instructional and research efforts including UARC and UNEX, whether such facilities are located at NASA—Ames or other suitable space. BSOE anticipates requiring another 5,215 asf of office and laboratory space (12,348 asf total) as academic programs grow in the next five years. This focuses on continued use of existing SVC facilities in Building 19, and does not address how BSOE would make use of the proposed new SVC Facility targeted for construction in 2012/13 or later (which would replace the current leased space).

TIM has submitted a proposal to establish M.S. and Ph.D. programs in Technology & Information Management to be jointly operated at SVC and the main campus. This is a unique endeavor in establishing off campus academic degree programs targeted at a potential student audience that otherwise would not be enrolled in UCSC academic programs. Beginning in fall 2006, BSOE offered instruction in two programs at SVC through University Extension: the new Knowledge Services and Enterprise Management (KSEM) Certificate, and the existing MS in Network Engineering graduate program previously taught at the UNEX Cupertino Facility. These classes are allowing BSOE faculty to develop effective distance learning methods for simultaneously telecasting courses from the main campus to SVC and vice-versa, while also initiating marketing and recruitment of industry professionals for graduate study in the new degree programs. All courses are offered in late afternoon or evening to facilitate enrollment by working professionals.

Plans are underway beginning with summer 2007 to experiment at SVC with lower division course offerings in CE or CS in efforts to attract community college students interested in transferring to BSOE to complete a bachelor's degree. There also is consideration of submitting a proposal to create an M.S. degree in EE targeted at working professionals in the Silicon Valley.

TIM faculty have been assigned shared offices at SVC as well as assigned offices on campus in E2, usually dividing their time equally between both locations while conducting instruction and research. TIM Teaching Assistants and Certificate Program faculty also have shared office space at SVC, along with selected BSOE faculty in CE, CS, and EE. These faculty are conducting affiliated research at NASA or with industrial partners in the Silicon Valley. A unique feature of the faculty office assignments within Building 19 is that all faculty share offices, regardless of department or teaching load (contrary to office space provided to ladder rank faculty on the main campus).

Anticipated growth in TIM will require more space than provided under the current lease arrangement. BSOE also anticipates success in selected course offerings from other departments, as well as continued growth in research programs affiliated with UARC and NASA/Ames. BSOE estimates expansion in all these areas will require over 12,000 asf in total space, not including necessary space for additional technologically equipped classrooms, computer laboratories for faculty and graduate students, and administrative and service space. Over the long run, it will be advantageous for the SVC administration to provide office space suitable for ladder-rank faculty to have private offices, but continuation of shared office arrangements are acceptable as long as sufficient space is provided to allow TIM and other programs to grow as planned.

8) Monterey Bay Education, Science, and Technology Center (MBEST)

As part of long-term planning, BSOE intends to explore opportunities to create joint academic ventures and partnerships at or near the existing campus MBEST location. This could include graduate instruction and research endeavors with the Naval Post-Graduate School in Monterey, CSU Monterey Bay, or industry partners.

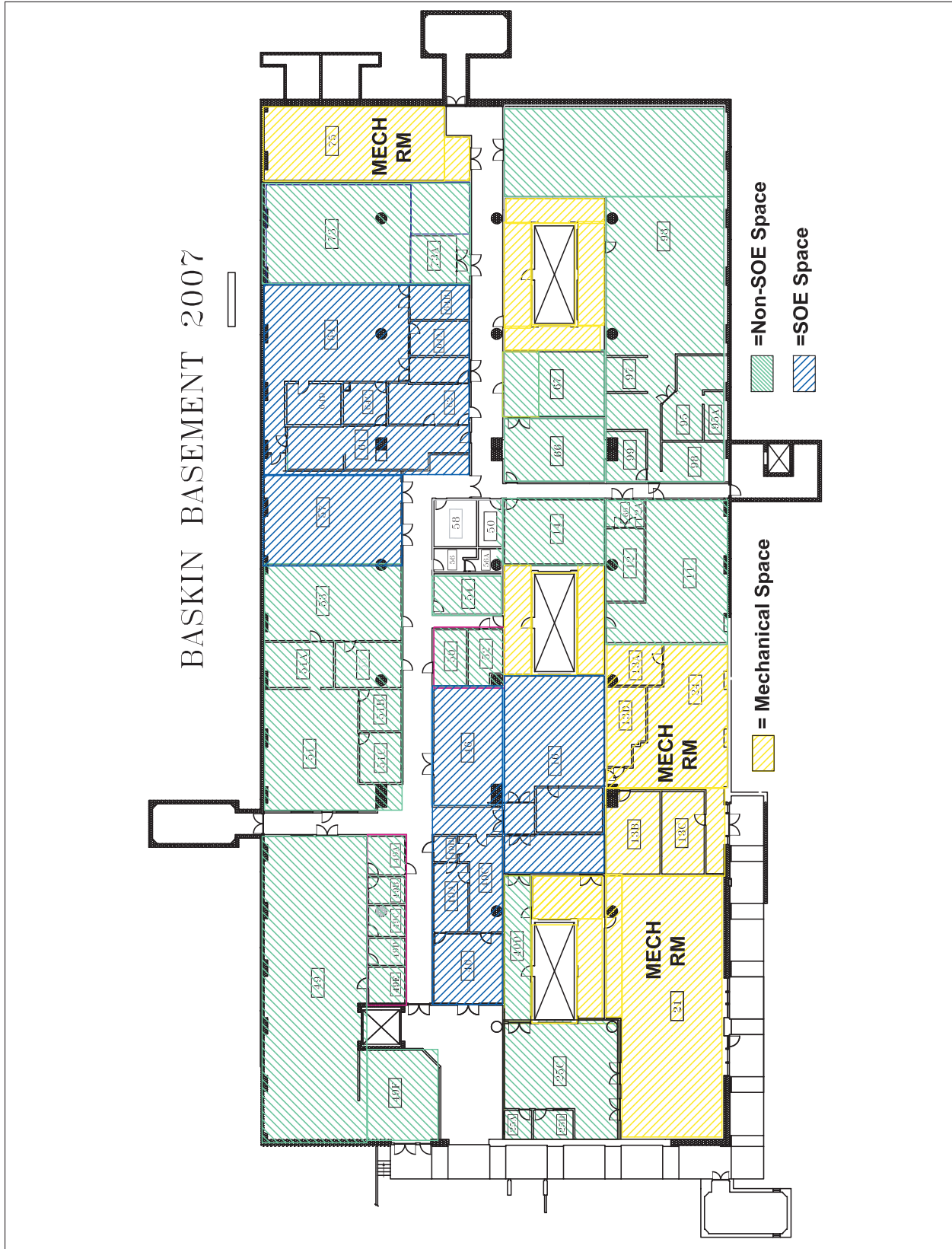
9) New Engineering Building

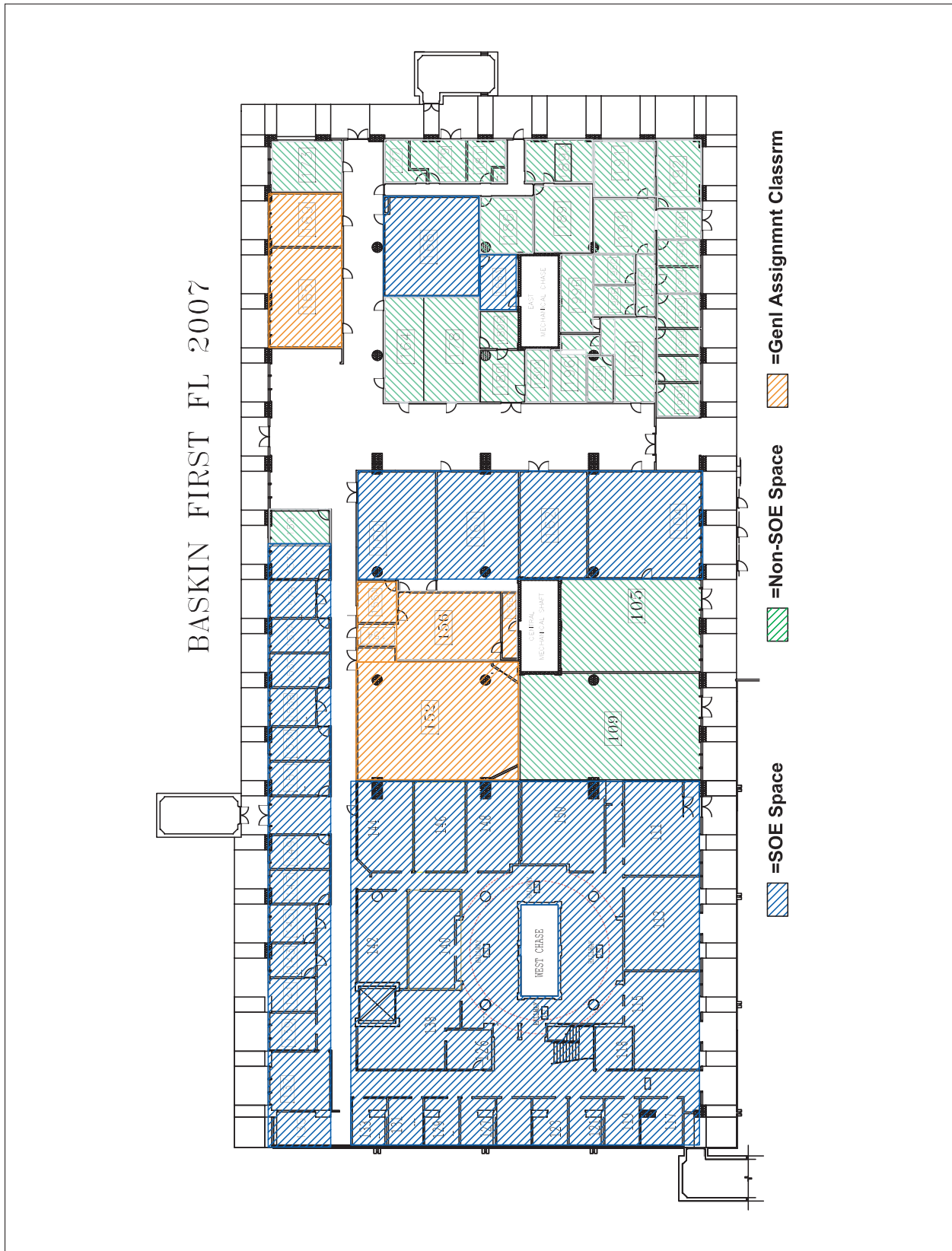
Long-term space plans for BSOE include creation of an additional engineering facility in approximately 10 years using one of the approved footprints nearby to BE and E2 consistent with the campus Long-Range Development Plan and the Science-Engineering Hill Plan. The new Engineering Building would help accommodate the evolution and expansion of BSOE instruction and research programs, with emphasis on specialized wet and dry laboratory facilities in Bio-Molecular Engineering, Bio-Materials Engineering, and Nano-Technology. To reach sufficient critical size for an established engineering school, BSOE will continue to add faculty in future years beyond the current growth target of 113 FTE, and the associated instruction and research endeavors will require additional space.

BUILDING FLOOR PLANS

Included in this document are floor plans for BE, E2, PSB, and SVC-Bldg 19, identifying current BSOE space utilization.

BUILDING	FLOOR	PAGE
Baskin Engineering	Basement	18
Baskin Engineering	1 st	19
Baskin Engineering	2 nd	20
Baskin Engineering	3 rd	21
Engineering 2	1 st	22
Engineering 2	2 nd	23
Engineering 2	3 rd	24
Engineering 2	4 th	25
Engineering 2	5 th	26
Physical Sciences	2 nd	27
Physical Sciences	3 rd	28
Physical Sciences	4 th	29
Silicon Valley Center	Bldg 19	30

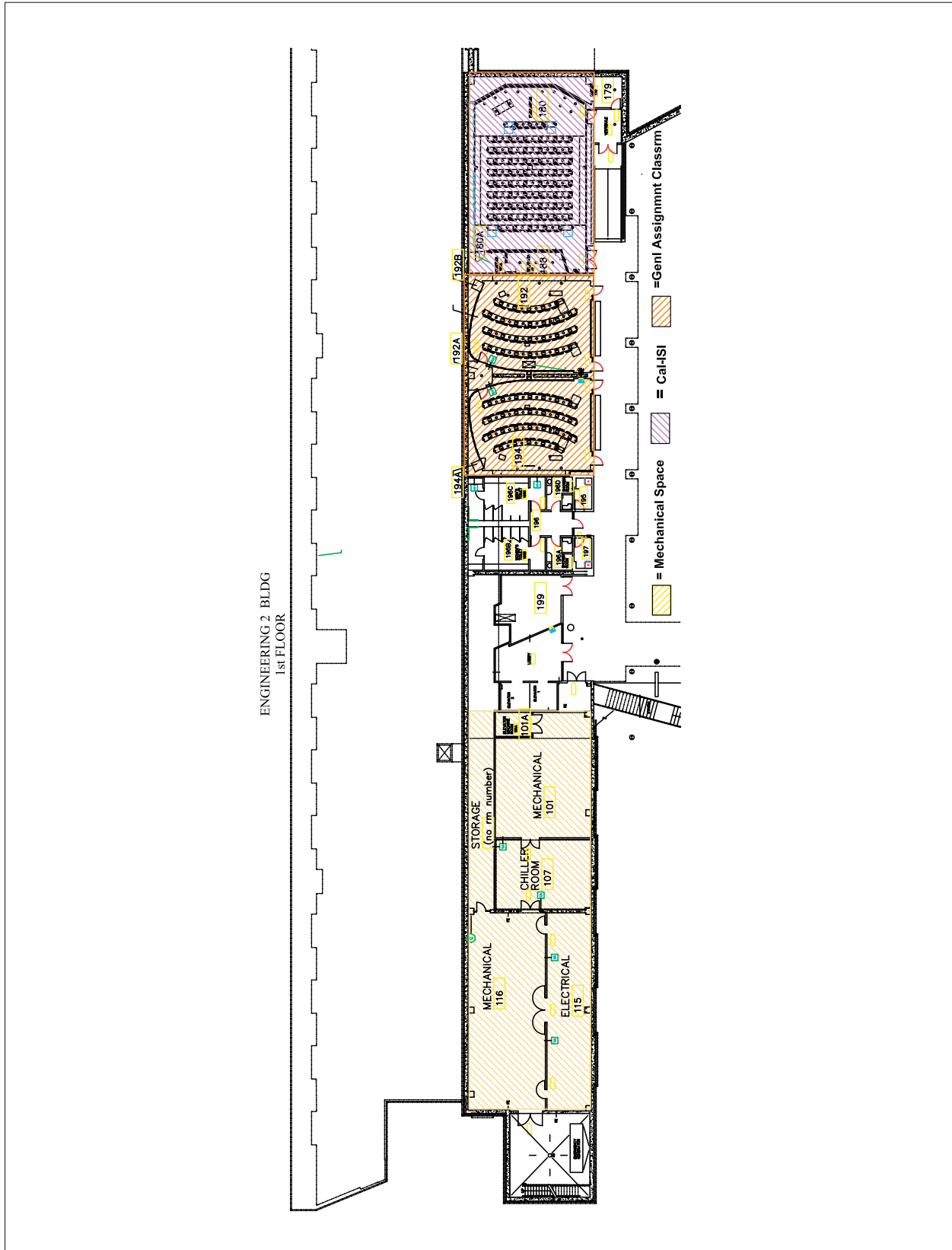


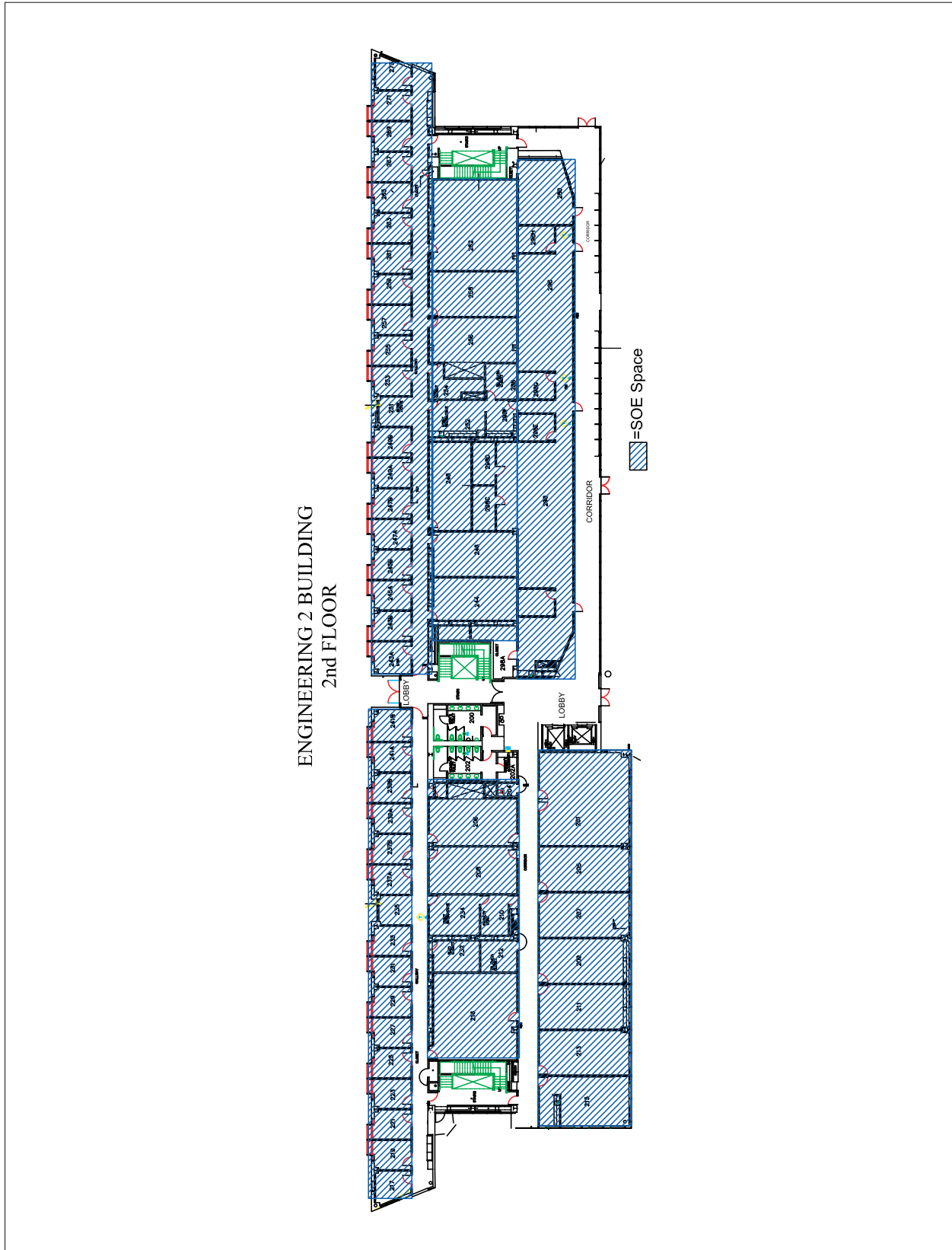


BASKIN SECOND FL - 2007

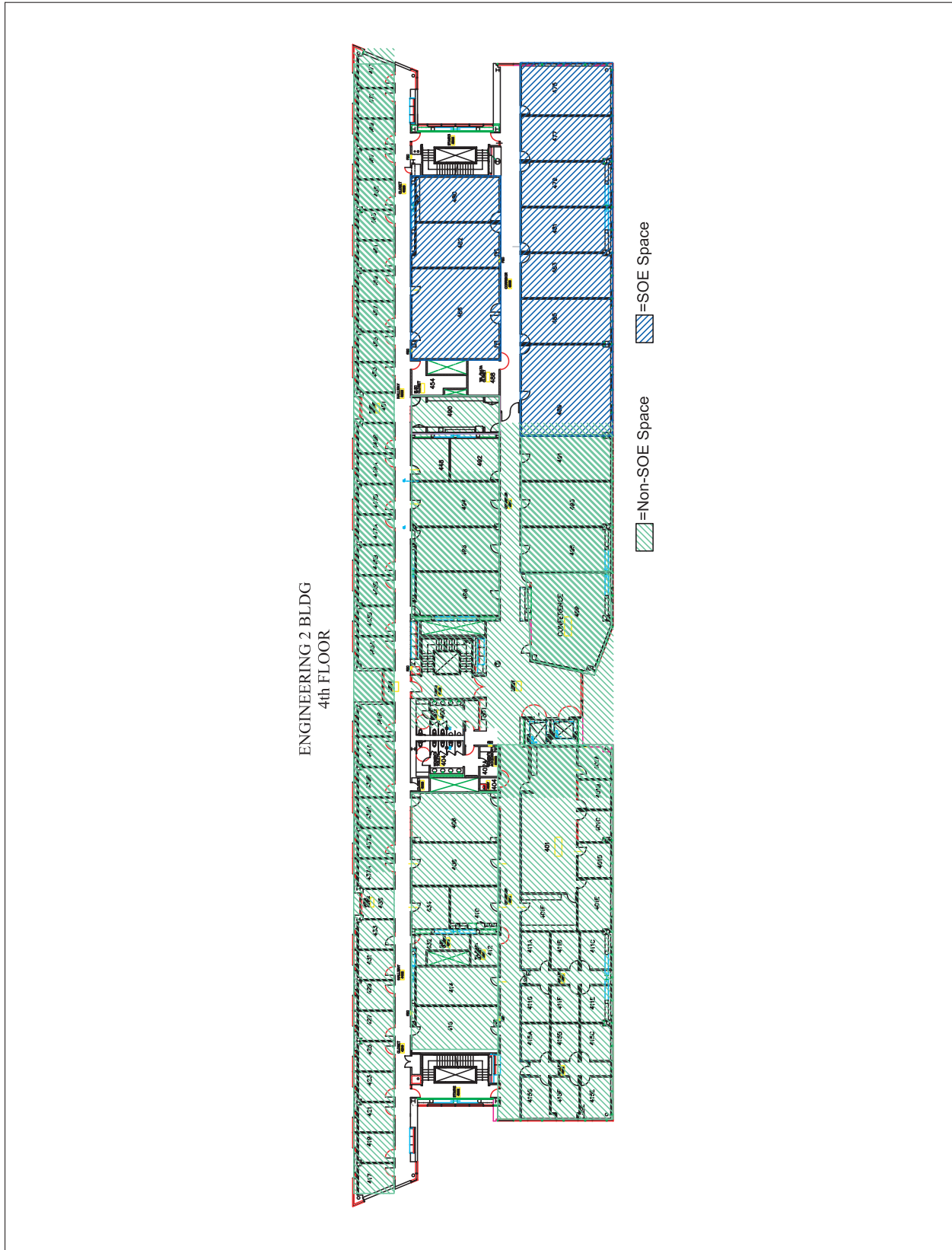


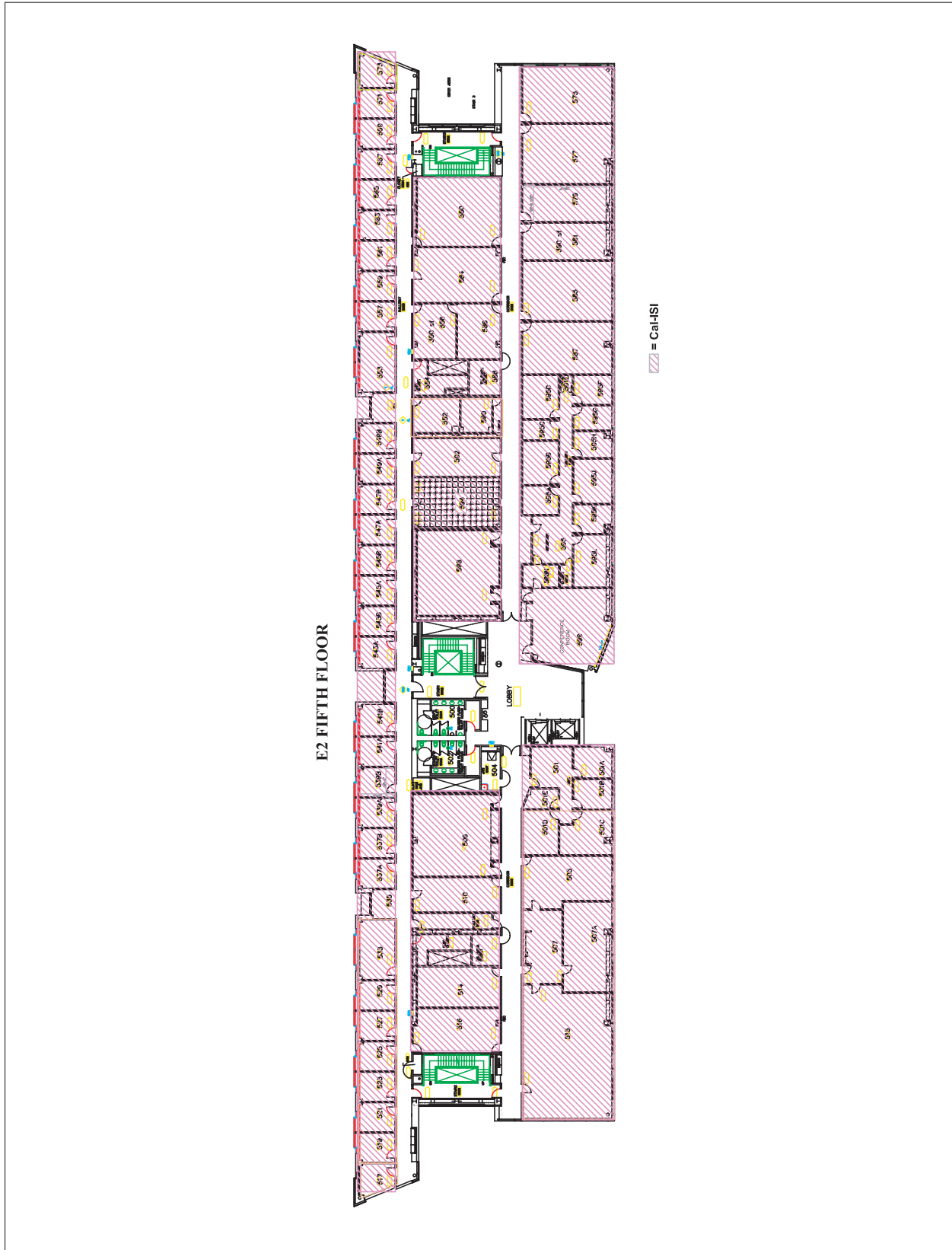


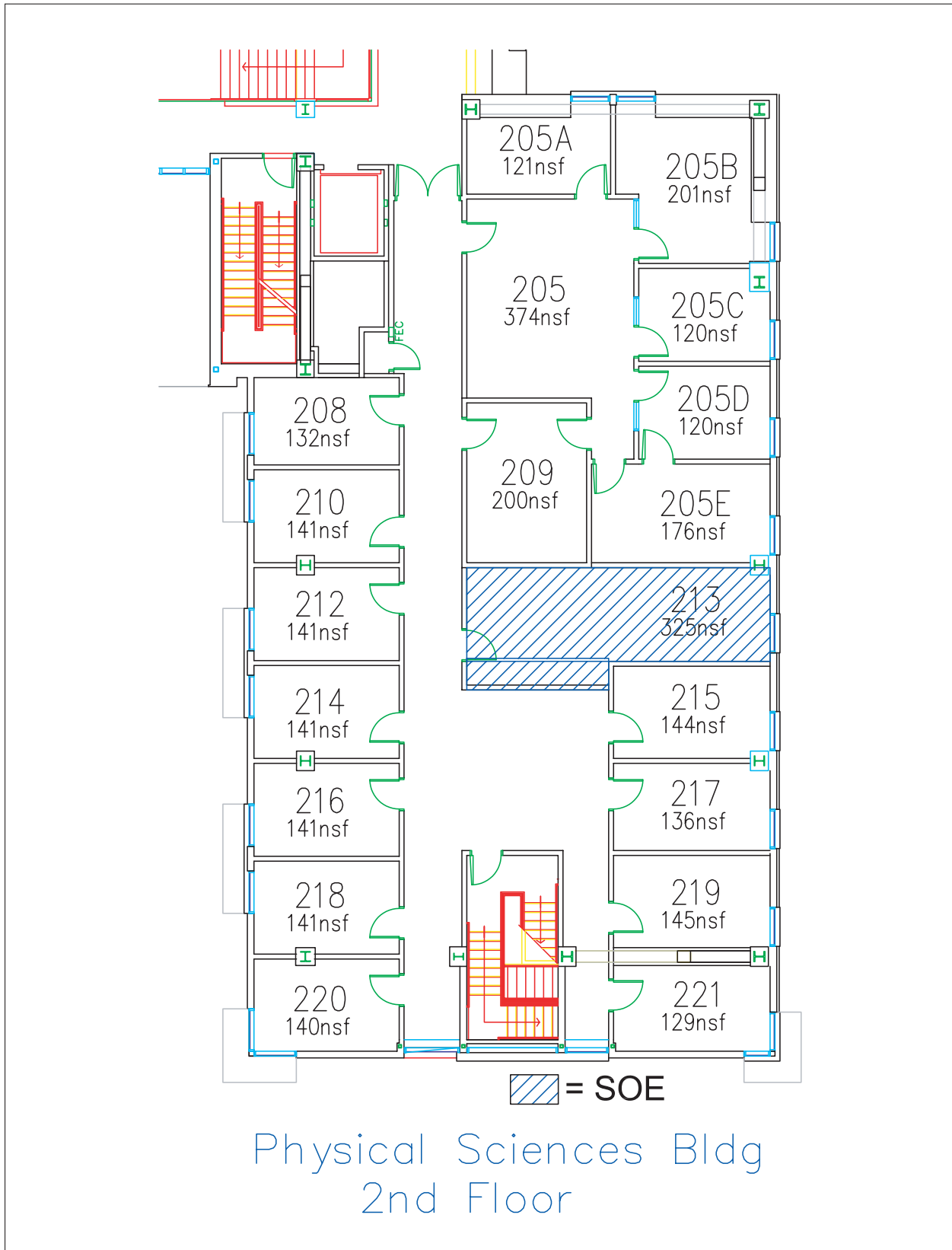


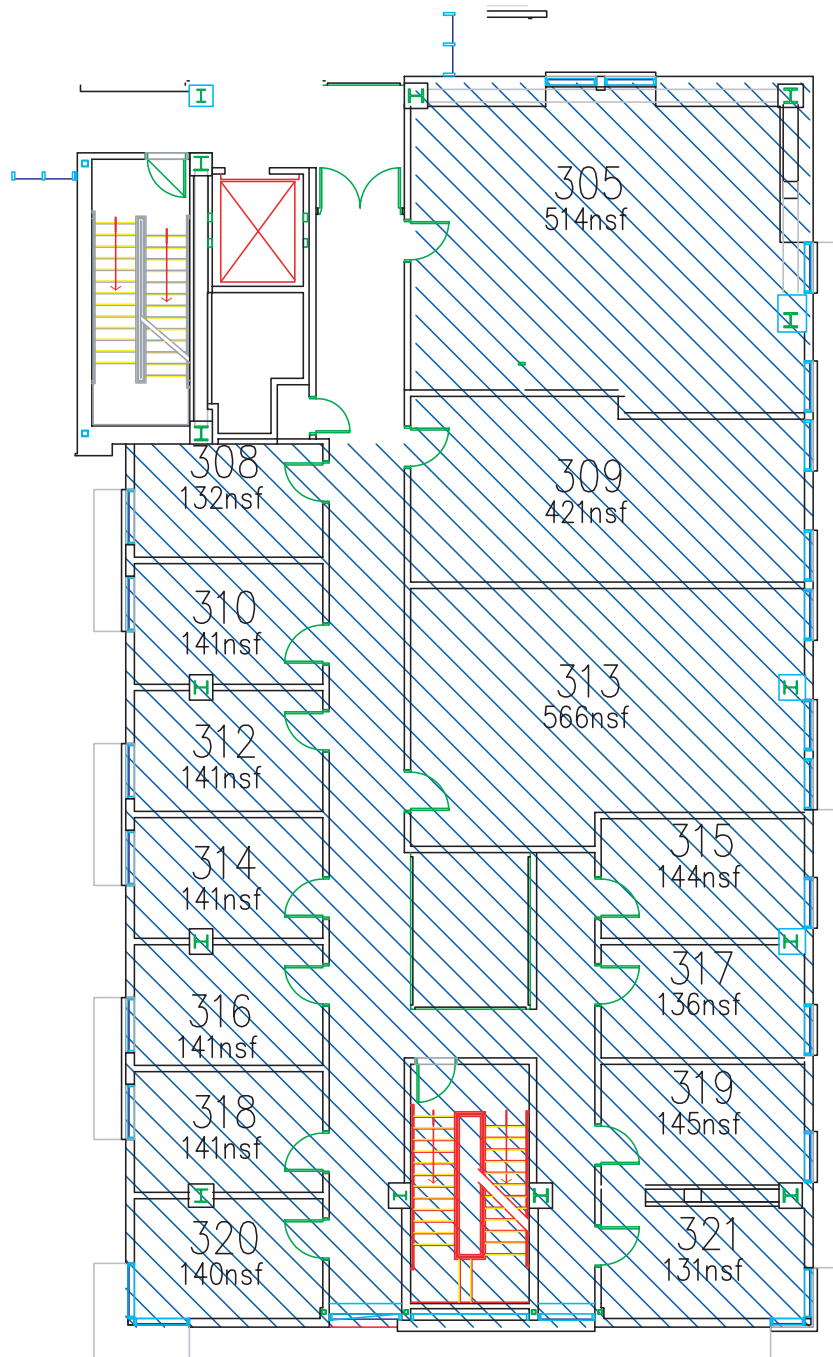




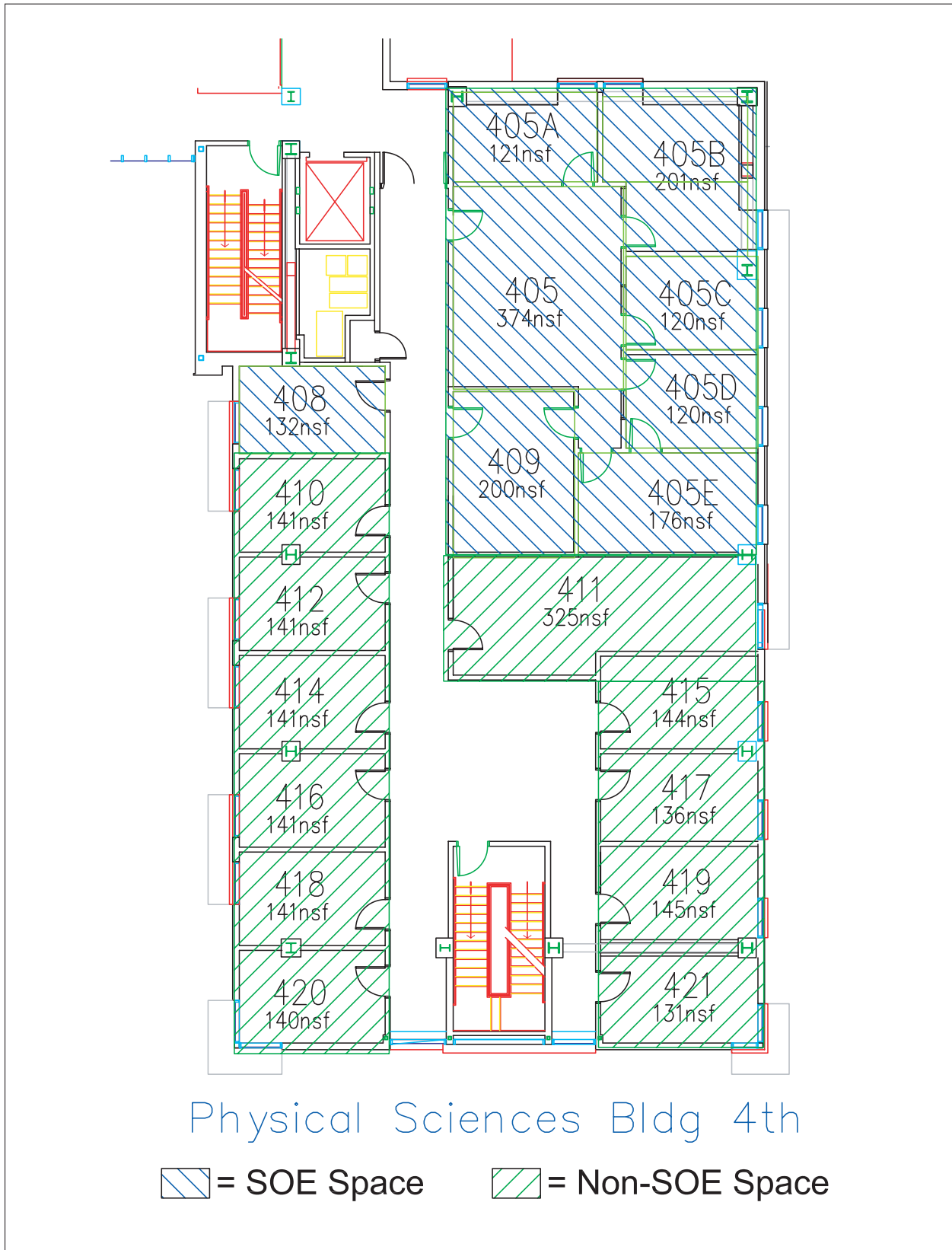








Physical Sciences Bldg
3rd Floor



SILICON VALLEY CENTER, Bldg 19

DRAFT SPACE ALLOCATION PLAN

The plan is based on the following assumptions:

1. Space is divided into functional units
 - o Faculty Wing
 - o Instructional Wing
 - o Administrative Wing
 - o UARC
2. All office space is shared.
3. Instructional wing
 - o Includes library / student services center
4. Copy room and kitchen space is split
5. Faculty office assignments will be assigned by the Dean.

