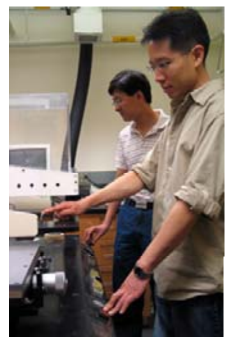
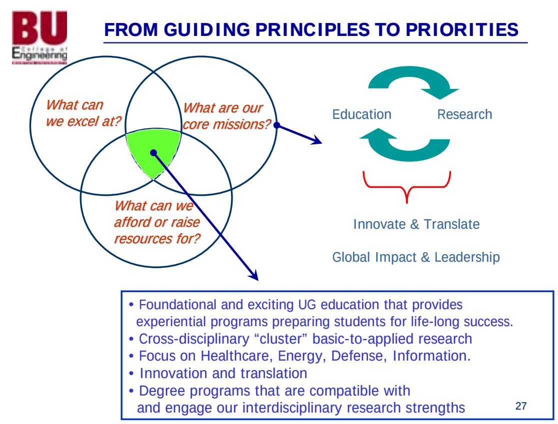
The College of Engineering

Strategic Vision 2008: Growth in Excellence



1. Executive Summary

The College of Engineering at Boston University is embarking on an ambitious plan focused on a theme of "***Growth in Excellence***." In 1990, the College committed to establishing graduate programs to complement our existing four departments and six accredited undergraduate degrees. Over the past 17 years the College has grown in student body and faculty size to be on par with other urban-oriented world class research institutions that have liberal arts and sciences at their core, interactive with a spectrum of professional schools. In that short time, the College has entered the top tier of graduate engineering programs in this nation. Research strengths were created primarily by growth within our existing departments and our undergraduate programs have been relatively consistent since our inception. Over this time, the College and University have built an astonishingly effective culture of collaboration across disciplines and departments.



Our strategic vision for the next ten years will leverage our culture of collaboration. We are committed to coupling research to education in a continuous cycle at both the undergraduate and the graduate levels. Our investments will prioritize interdisciplinary research at the faculty and graduate levels. At the undergraduate level we will prioritize foundational and experiential education that prepares students for innovation and success in engineering and beyond. We will recognize that our strengths lay along a spectrum of engineering science clusters that engage faculty from all departments. These cluster are: Bioengineering, Advanced Materials, Micro- and Nano-Systems, Information and Networked Systems, and Sensors and Imaging. These clusters in turn will support high impact research applications in four grand challenge areas: Healthcare and Biology, Energy and Environment, Information Technologies, and Security (Defense and Homeland). We will also transform our undergraduate programs to insure that they engage our faculty strengths and experiences and that the students are empowered with the excitement of engineering. Our roadmap to achieve our vision will need to rely on resources derived not just from our faculty and our administration but strategic philanthropic partnering with our alumni and friends.

This document develops six major goals and a set of action items and financial needs to achieve them:

Goal 1: To transform undergraduate engineering education experiences to ensure opportunity for life-long success, innovation and leadership. Retention will be maximized.

Goal 2: To enhance research excellence and graduate programs that embrace cross-disciplinary challenges while leveraging our core strengths.

Goal 3: To restructure the college to a) sustain excellence in undergraduate education for those disciplines & departments that are consistent with our faculty research strengths; b) support emerging interdisciplinary graduate strengths (e.g., create new Materials Science and Engineering and Systems Engineering programs); and c) facilitate cross-disciplinary research and education.

Goal 4: To establish programs, processes and infrastructure to stimulate and support innovation coupled to faculty interests and career goals.

Goal 5: To insure that the college attracts, engages and retains a diverse community of students and of faculty and that we commit to outreach programs to connect us to the community while advancing appreciation of math, science and engineering.

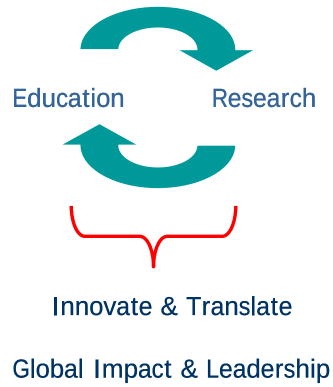
Goal 6: To work institutionally and with alumni, leadership and visiting boards to engage visionary advice on initiatives and priorities, and to identify and acquire the crucial resources necessary to achieve and sustain excellence.

2. Introduction

2.1 Mission

Boston University is a world-class institution in an urban setting with a substantial sized liberal arts and sciences at its core surrounded by 17 professional schools. The College of Engineering, as one of these professional schools is committed to being a top-tier research college engaged in undergraduate and graduate education. Our primary missions are:

1. To ***educate*** the new generations of engineers to lead in all facets of society
2. To ***advance*** the frontiers of knowledge via engineering science➔ ***research***
3. To ***translate and innovate*** new technologies motivated by research
4. To participate as ***global leaders*** in all dimensions of science, education, technology and society.



2.2 The College at a Glance

The College currently consists of four departments offering six ABET approved bachelors degrees and eight graduate degrees. These include Biomedical, Aerospace, Mechanical, Electrical, Computer and Manufacturing Engineering at the BS level and all of these as well as Systems and Photonics Engineering at the graduate levels. There are approximately 1,200 undergraduate and 500 graduate students and 115 full-time faculty. The are 14 interdisciplinary research centers that are directed or co-directed by engineering faculty. The College has renowned faculty and state-of-the-art facilities in several prominent areas, including photonics, micro- and nano-technology, materials, information and networked systems, imaging at the nano-through-macro scale, bioengineering, and computational modeling.

The College continues to be recognized as a premier engineering school. In the 2007 U.S. News and World Report rankings of *America's Best Engineering Graduate Schools* the College was ranked 41^{st} and of the top 50 graduate engineering schools, the College was 21^{st} in research dollars per faculty member per year. The College graduated the 18^{th} highest percentage of female Ph.D.s in the nation.

The College's most evident strength is in Biomedical Engineering and, more generally, Bioengineering. The BME department is ranked 6^{th} in the nation and Boston University is one of only three institutions in the nation to have received the Whitaker Foundation's Leadership Award ($14 million), one of only nine to receive the Coulter Foundation's Translational Research Partnership ($15 million potential), and the only institution to have received both. Exciting and well-funded integrations of engineering with biology and medicine are occurring throughout all of the College's departments. Most notably, visible efforts exist in bioimaging, biomedical optics, biomechanics, orthopedic engineering, microsurgery and robotics, bioMEMS, and biomaterials. These efforts are supported by superb state of the art core facilities in biointerface technologies, micro and nanobioimaging, cell and tissue engineering, and biomedical computing. Among many other accolades, the College faculty are principal investigators on two NIH Biomedical Engineering Research Partnership grants, an NIH Pre-Doctoral Training Grant in Quantitative Biology and Physiology, and an NSF IGERT on Bioinformatics and Biological Networks.

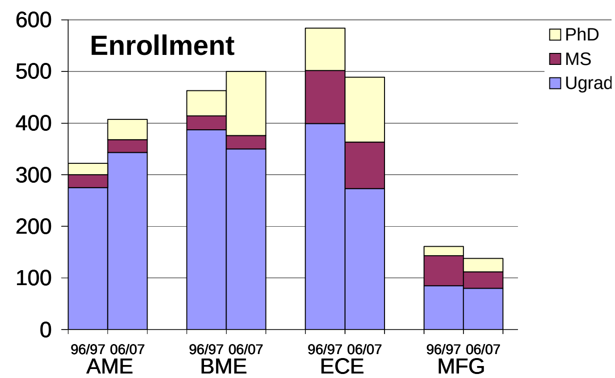
The Electrical and Computer Engineering department has been steadily rising in quality, impact and the rankings. Last year the EE graduate program was ranked 43^{rd} and the CE program 46^{th} , both substantial improvements from previous years. This department boasts 14 NSF Career Award winners and 6 IEEE Fellows and is particularly strong in the areas of optics-electronics, information systems and networks. In concert with several centers, the departments, College and University boast some of the best photonics, microfabrication and computational facilities in the nation.

The Aerospace and Mechanical Engineering and Manufacturing Engineering departments sustain world-class research in the areas of acoustics, dynamics and control, systems engineering, and micro and nano technologies. Together they boast more fellows of the Acoustical Society of America than nearly any other department in the nation.

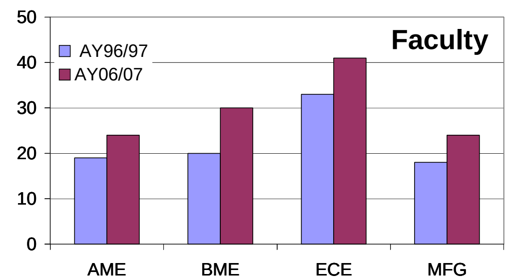
Funding for research throughout the College derives mostly from NIH (35%), NSF (25%) and DOD (18%). The BME department enjoys the most funding success (around $18 million) and dollars per faculty (around $650 thousand), with a majority of their funding coming from NIH (~58%).

Two of the most exciting growth areas in the College are the emerging, highly visible and highly cross-disciplinary research strengths in Materials Science and Engineering, and in Clean Energy and Environmental Sustainability.

Culturally, the College has built a wonderful community of faculty and students that operates with unusually low barriers to communication and collaboration. Multi-investigator funded research are plentiful not only across departments, but with colleagues in virtually all cognate department including physics, chemistry, biology, mathematics, computer science, business and management, and the medical and dental schools.

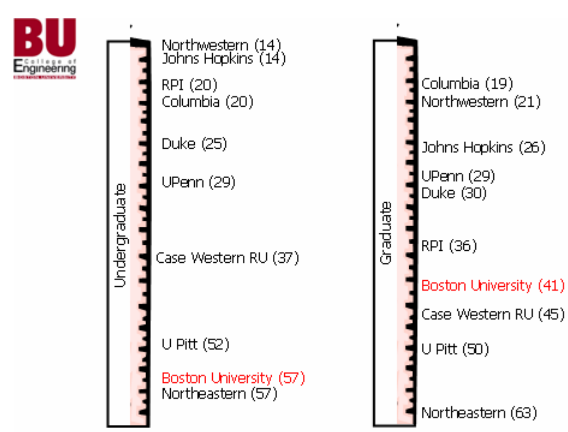


When examining the past 10 years of changes in the student and faculty numbers we see that faculty size of all departments has increased, with BME and ECE having the largest total faculty growth. Total undergraduate size has dropped slightly, but BME and ECE have experienced substantial growth in the size of their graduate programs. These data suggest that faculty growth has been primarily driven by enhancements in research funding and graduate education rather than by size of the undergraduate programs. Moreover, these investments have had explicit and substantial impact on our graduate rankings.



2.3 Peer Comparisons

In establishing peer institutions we look for top-tier colleges of engineering that are a) part of a larger full-service university; b) consist of a faculty and student body size similar to ours; c) are in an urban-like environment; d) have biomedical engineering programs that are highly ranked; and are ranked both below and above us. We included in this list Columbia, Northwestern, Johns Hopkins, University of Pennsylvania, Duke, Case Western Reserve University and University of Pittsburgh. While not urban we also include RPI because it satisfies all other criteria and its geographic location (Northeast) makes it a common competitor for students. Northeastern University represents another Boston area institution.



Acknowledging the dubious nature of such rankings, several key points emerge. First, rankings are not simply reflective of faculty size. U. Penn and Duke are smaller in faculty size yet ranked higher than us (29^{th} and 30^{th} respectively) at the graduate level whereas Case Western Reserve University is larger in size but ranked below us at 44^{th}. Second, Boston University "boasts" the greatest disparity between undergraduate and graduate rankings with our undergraduate ranking (57^{th}) lagging considerably behind our graduate ranking (41^{st}). The UG rankings are based only on a survey of deans of engineering and industry, while the graduate rankings incorporate some quantitative metrics. Perhaps many engineering schools and the industrial community are not as sufficiently informed regarding the excellence we have achieved at the faculty and curricular levels.

2.4 Challenges and Opportunities.

Organizational : Extramural research funding needs to increase. Our ECE department is emerging as a top-tier program at the graduate and undergraduate levels. Our AME department needs to advance its national impact and recognition to levels on par with the other departments. Several excellent junior faculty create an excellent foundation for the future. Nevertheless, the AME department remains under-sized and under-resourced. A particular challenge is sustenance of its Aerospace bachelors program since virtually none of their faculty are actively engaged in research related to aerospace engineering. Similarly the MFG department boasts excellent junior-thru-senior faculty engaged in a variety of research themes, but the majority of these are not manufacturing engineering per se. While the MFG curriculum provides elements of foundational experience in design of complex technologies, very few freshman students select this major. The growth in Materials Science and Engineering has already exceeded critical scientific mass and needs to expand into a formal academic graduate program. The challenge is how to structure such an effort so that it engages all faculty active in this field.

Educational: There is an increased obligation to transform the undergraduate educational experience from its current approach of providing only traditional pedantic curricular design in explicit disciplines to a more eclectic and foundational experience for life-long success, innovation and leadership in a global society. The College must enhance the interdisciplinary experience at the graduate level while attracting fellowship resources necessary to recruit the most creative applicants.

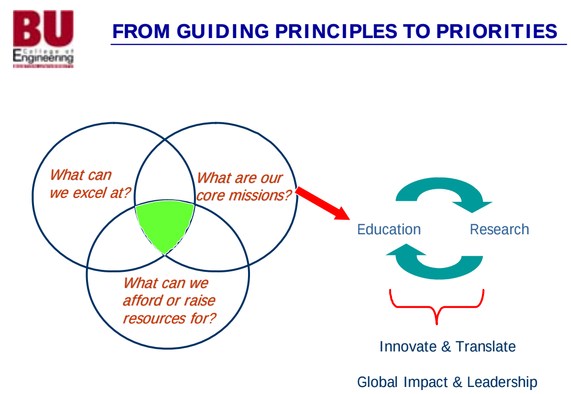
Resources: The foundation of excellence and impact of the College derives explicitly from the quality of our **faculty**. *How do we retain our best faculty and continue to recruit the exceptional ones?* Boston University must compete with institutions that may be peer in reputation but are superior in financial resources, alumni giving and endowment. Extensive **facilities** have been established in the areas of photonics and bioengineering. Future research thrusts motivate the need to acquire some high-end equipment (e.g., a transmission electron microscope, TEM). Long-term maintenance and sustenance of these facilities requires more stable influx of funds. We anticipate the college will hire 25-30 faculty over the next 10 years. Many of these will derive from replacements, several of which will replace formally research inactive faculty. We are challenged to develop new hard and/or wet-lab **space**. There is also substantial need for more student-learning space, teaching facilities and core-facility space.

2.5 Summary

The College is now poised for change. We have emerged from an era of steady growth in faculty hired into a department structure that was created over 40 years ago. Our new direction will leverage its strength in interdisciplinary education and research with a firm anchoring in the theme of "***Growth in Excellence*.**" This theme will couple excellence and impact in undergraduate education to excellence in research. Such coupling will be achieved by insuring that future faculty hires and investments align with our vision.

3. VISION: *Breaking Down the Barriers*

Overview: As we embark on a vision for engineering education and research at Boston University we embrace two guiding sets of principals. First, as suggested by Jim Collins (Good to Great , 2001), in setting priorities we examine those initiatives and investments that lie at the confluence of three basic questions: *What can we excel at? What can we afford or raise resources for?* and *What are our core missions?* Our missions already embrace the fundamental notion that education needs to support and stimulate excellence in research and that research, in turn, needs to feedback to amplify the impact, effectiveness and experience of both our undergraduate and graduate educational programs. To this end we will need to take a hard look at the traditional approach of setting up independent and distinct departments and degree programs, each responsible for designing their own curriculum and research impact without knowledge or interaction of what the other disciplines and departments have in mind.



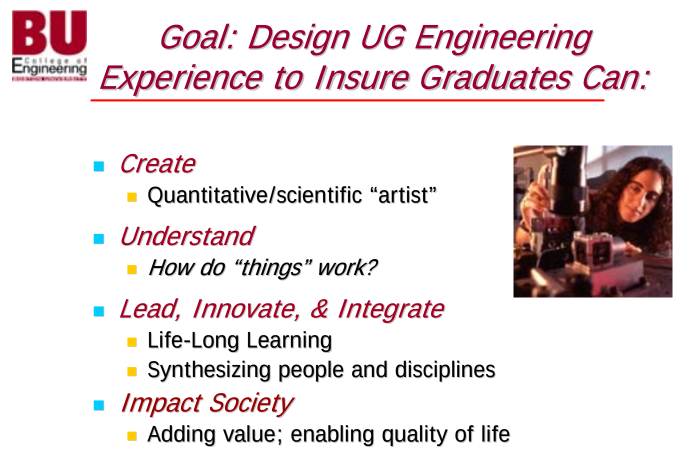
There is tremendous opportunity for identifying and leveraging synergisms. Indeed a crucial reason for the great strides made by the College to date has been the low barriers to collaboration between departments inside and outside the College. Crucial technological, scientific and innovation challenges of the future are all inherently inter- or cross-disciplinary. As noted by Tom Friedman (The World is Flat, 2006), we should not be striving to contribute new generations of specialists. Instead, we need to create the so-called "*versatilist*" engineer who may have a bit more depth or inclination in a particular discipline of engineering, but is quite comfortable integrating and communicating with substantive skill and knowledge sets across other engineering or scientific domains. ***Our intent is to transform the way we approach education and research to maximize the success and benefits of this new paradigm.***

3.1 Undergraduate Education:

Goal 1: To transform undergraduate engineering education into an "experience" that ensures passion and opportunity for life-long success, innovation and leadership, thereby maximizing retention.

The College currently has six ABET undergraduate programs. To first order, they all have the same structure and goals: namely to insure that ABET criteria are met and that students become substantively knowledgeable in the specific engineering underpinnings of their respective programs. All programs first require a core base in mathematics, physics, chemistry, programming, and basic circuits and mechanics. The College has held this common core as sacred, so much so that each course in it is identical regardless of a student's pre-selected major. Beyond the core, students take discipline-specific engineering science courses and finally a senior capstone design course. Engineering students also take two writing courses and four other sociohumanistics of their choice from CAS. This approach is remarkably ubiquitous among undergraduate engineering colleges nationwide. The result is an "acceptable" undergraduate experience that remains fairly specialized without engaging the creative opportunities associated with a cross-disciplinary and contextual problem solving approach. Moreover, there is an opportunity and obligation for our faculty to bring their research and innovations into the classroom. ***Our undergraduates should learn what our faculty do, not just what they know.***

To transform these programs we consider the following questions: *What are we trying to achieve with an engineering bachelors degree?*; and: *Why should a student that is interested and adept at math and* *science choose engineering?* Our answers lead to four fundamental tenets that should guide our program. First, we must address and embellish the notion that the essence of being an engineer is to combine fundamental mathematic and science knowledge and techniques to ***create*** something new. They want to be artists, not with traditional paint and brush, but with these quantitative and scientific knowledge tools. Second, engineers are uniquely positioned to ***understand*** how the world works, from the basic natural and biological laws to the principals that govern all forms of technology. Society is dependent on technology, and yet the majority of the world's people are ignorant of its underpinnings. Third, the ability of an engineering student to be creative and understand the domains of science and technology empowers them in principle to ***lead, innovate and integrate*** at levels that few other fields could claim. This trait, in turn, empowers them for life-long learning and success regardless of their eventual profession. Finally, engineering is a profession explicitly expected to ***impact society*** by advancing new creations which will directly improve quality of life. Our commitment is to insure that all engineering degree programs imbue these four tenets into our students from the time they enter as freshmen and throughout their four years at the College.



There is increasing acceptance that in a global society and economy, the number of engineers created world-wide will rise exponentially. The United States will not compete for the number of engineers that enter the work force, nor should we. But we must insure our curriculum and experiences produce individuals with the versatile skill-sets to lead innovation and this requires the capacity to integrate and communicate across engineering disciplines as well as other non-engineering fields such as business, law, government, communications, etc. A significant percentage of BS engineering students in this nation are not going to be practicing engineers 10 or 15 years thereafter. Nevertheless, we aspire to insure that all engineering graduates are capable of exploiting their unique problem-solving, innovation, leadership and integration skills to be successful for any career choice. Therefore, while engineering is a "professional" degree program at the undergraduate level, it should no longer be designed exclusively or even primarily to create a series of compartmentalized mini-experts in specific engineering sub-disciplines of choice. While we retain the challenge of insuring that the core-competencies of any chosen discipline are provided (i.e., that the students are "good" engineers), we must also embrace the challenge to provide a foundation experience enabling life-long success in a global, integrative, multi-disciplinary world. Taken together, a revised engineering "experience" at the undergraduate level should:

- be more dynamic and engaging early in the core curriculum so that first- and second-year students can envision how math and science can advance a variety of engineering challenges.
- renovate courses so that students naturally engage the creative power of modeling and computation and visualization for problem solving and communication.
- insure that engineers can communicate with all sectors of society, be they engineers or not.
- provide the opportunity for engineers to appreciate the power of integrating their education with related fields, even those not grounded in science and technology (e.g., performing arts, law, etc.).
- offer undergraduate students the experience of cutting-edge and enabling technologies.
- specify that all engineers participate in activities that integrate their engineering backgrounds in venues outside the classroom such as other global settings, internships, undergraduate research, community groups, etc.

- assure that all engineers appreciate and become excited by the role that business and innovation practices play to motivate and advance new technologies so that society can benefit.

<u>Action Items for Goal 1:</u> Create an Undergraduate Engineering Education Task Force. The charge of this task force will be to create a road map to accomplish the following with positive implications on retention and yield.

<u>RETENTION:</u>

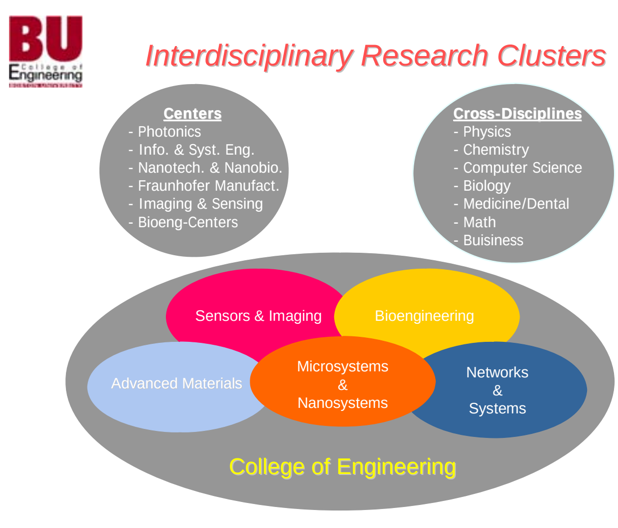
- Engage CAS-COE faculty to partner for contextual enhancement of math, science & physics ➔ *excite and retain from Day 1.*
- Enhance our *"intro to engineering"* experiences.

<u>YIELD:</u>

- Expand capacity of "experiential" opportunities and consider requiring at least one of the following semester- or summer-long programs:
    - *Study abroad; semester or summer research; internship; community service; other.*
- Partner with SMG to offer a required course and optional experience in business-to-innovation.
- Enhance the roles of modeling, visualization, and systems integration and design in pedagogy and in our curriculum.
- Establish holistic approach for career and professional development.
- Develop a suite of minors/concentrations inclusive of cutting edge engineering science/technologies.
- Insure that all students internalize technical and professional communication skills.
- Partner with School of Education for combined BS in Eng-MS in Education.

<u>3.2 Research and Graduate Education:</u>

Goal 2: To enhance research excellence and graduate programs that embrace cross-disciplinary challenges while leveraging our core strengths.



The low barriers between departments within and outside the College have fostered the emergence of several core research "clusters." Each cluster transcends engineering and science expertise throughout every department in the College, cognate departments outside the college, and research centers.

- *<u>Bioengineering</u>*: Research in bioengineering connotes the practice of synthesizing engineering, mathematics, computation, and the life, physical and medical sciences to a) advance new knowledge of how life works at every scale; and b) exploit this understanding to develop new technologies or methodologies that interface with living systems. This research is prevalent and diverse and while central to our renowned department of biomedical engineering, is being practiced in extraordinarily successful and exciting fashion in all four engineering departments. Current applications span from genomics to cell and tissue engineering, to biomaterials to integrated biomechanics to bioimaging and optics to visual and hearing systems, to biocontrol and microsurgery to bioacoustics and ultrasound, to name but a few.

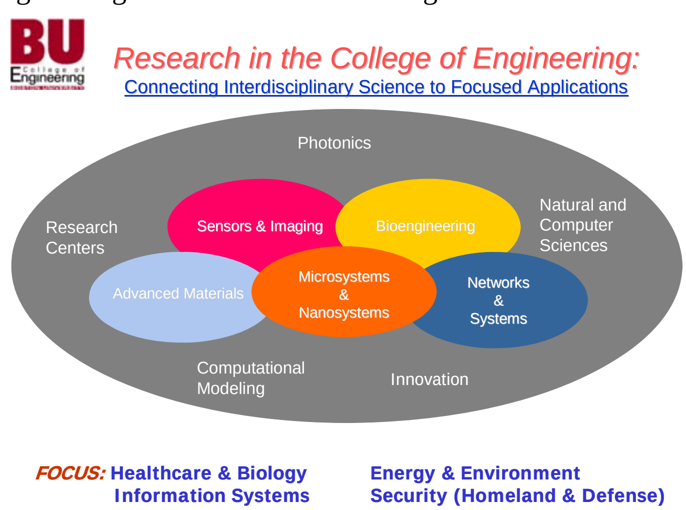
- *Sensors and Imaging:* This area captures our leading efforts in optics and acoustics and nano- through macro-sensing and imaging systems. Optical-acoustic combined systems are being developed as well. Faculty in virtually every department work with the Photonics Center to develop novel ways to use light-based or acoustic-based excitation and physics to extract highly resolved information at the single molecule to cellular levels. Applications range from defense to medical diagnostics to materials characterization. At larger scales, novel image and signal processing and excitation methods are being advanced for target detection, medical imaging systems (e.g., ultrasound) or medical therapy (e.g., lithotripsy)

- *Micro & Nanosystems:* This area captures work in the emerging area of nanotechnology and the somewhat more mature area of micro-electromechanical systems (MEMS). It is intimately related to the efforts in sensors, materials, networks and bioengineering. The Photonics Center and the Center of Nanosystems and Nanobiology support the research activities in this field. Past research foci have included nano-system building blocks, diagnostics, imaging, optics, fluidics, biomechanics, self-assembling devices and traditional MEMS.

- *Advanced Materials*: The community of faculty involved in materials at Boston University is growing and every department within the College is engaged in this inherently interdisciplinary field. Current research foci span electronic materials, polymers, green manufacturing and new energy materials, biomaterials, structural materials, and chemical materials, for example.

- *Networks and Systems:* The College has established substantial prominence at the interface of wireless networks and systems theory. These efforts are closely linked with the strengths and mission of the Center for Information and Systems. Current activities include fundamental information systems theory, networking, optimization signal processing, image processing, robotics and control. Until recently, the center primarily engaged faculty from Aerospace and Mechanical Engineering, Electrical and Computer Engineering, and Manufacturing Engineering as well as cognate departments of Computer Science, Mathematics and Statistics, and Operations Management. However, throughout the College there is a growing emphasis at the interface of network and systems theory and gene, protein and cell regulation (i.e., systems biology).

Research Priorities and Impact for the Future: *How can our clustered scientific strengths have maximal impact?* We will conceive the College of Engineering as a continuum consisting of research colleagues in engineering, science, math, medicine and business. Faculty within and across cluster areas will connect seamlessly with colleagues and facilities in the natural and computer sciences, with research centers, with our excellence in photonics and computational modeling, and with innovation and entrepreneurial expertise throughout the university. Taken together this continuum has converged on four societal grand challenge focus areas for the College:



- ***Healthcare and Biology:*** One of the most robust and well-developed areas for College of Engineering and Boston University resides at the intersection of biology, engineering and medicine. By leveraging existing research strengths in biomedical engineering, all other engineering disciplines, bioinformatics, mathematics, chemical biology, biological physics, computer science and our School of Medicine, especially the new NIH funded BSL4-Level National Emerging Infectious Disease Laboratories, we will play a major role in advancing fundamental discoveries in biology-thru-physiology in tandem with advancing new technologies to probe and manipulate living systems for research or clinical practice.

Healthcare and Biology:

- Design and control of molecular and cellular systems.
- Synthetic-Systems Biology & Infectious Diseases.
- Cell and tissue engineering and Biomaterials.
- Biomedical imaging: molecular-thru-whole organ.
- Integrated systems for cancer detection, advanced diagnostics, and diabetes control.
- Enhancement of Neuro-sensory systems
- Wireless sensors for home health care and rehabilitation.
- Microrobotics for surgery on infant hearts.
- BioAcoustics: detection & treatment.
- Novel drug delivery systems that exploit nanotechnology.

- ***Energy and the Environment:*** The bulk of energy consumption is obtained from fossil fuel combustion, which generates high levels of greenhouse gases and air pollutants such as NO_x, SO_x and particulate matter. Projected increases in the demand for energy are thus likely to worsen the negative environmental and social impacts of pollution unless we find ways to shift to more environmentally sustainable energy supplies. Using a broad range of research approaches throughout the College of Engineering, we can target specific initiatives that can address our nation's energy and environmental sustainability challenges.

Energy and the Environment:

- Generation, efficient use & management of clean or renewable energy.
- Candidate technologies include:
  - fuel cells for stationary and mobile applications.
  - low-energy solid-state devices.
  - hydrogen generation and separation.
  - hydrogen storage, novel/effective carbon dioxide sequestration.
  - renewable energy: geo-thermal, wind, solar and bio-energy.
  - environmentally friendly synthesis and processing of materials.

- ***Information Systems:*** Our deepening ability to design or manipulate small systems (e.g., biological processes at the molecular level, micro/nano-electromechanical systems, micro and nanosensors) is intimately coupled to our ability to acquire and analyze information from an extraordinary number of networked sources. The end result will be an extraordinary revolution in expanding how we interact and control our environment over a continuum of spatial and time scales. This revolution will embrace wireless networked communities and sensor systems for a wide range of societal applications.

Information Systems:

- Advanced sensor-network technologies.
- Wireless systems to connect the family to intellectual, educational, cultural, and health resources.
- Traffic and parking control.
- Environmental and energy monitoring.
- Systems to expand public safety and convenience.
- Advanced new information systems that permeate:
  - Entertainment.
  - Medical care (e.g., imaging systems and analyses).
  - Hand-held communication devices.

- ***Security (Defense and Homeland):*** A key mission of our defense in the 21st century is to combat emerging threats from biological and chemical attacks with the insertion of innovative technologies that integrates sensing, communication, actuation and control functions into our defense infrastructure. The College, in concert with our Photonics Center, has considerable strength to exploit the rapidly emerging field of MEMS to address this challenge along with the development of integrated

Security (Defense and Homeland):

- Combat emerging biological and chemical threats.
- Micro/Nano systems to provide integrated intelligence, communication, and control.
  - Radio frequency MEMs (RF MES)
  - Micro-opto-electro-mechanical systems (MOEMS)
  - Multi-sensor technologies and systems
- Integrated Microsystems as "platform on a chip" to sense, process, and act on battle space data.
- Cyber-infrastructure, network security and reliability.

micro-platforms to enhance battle space performance. Similarly, we will advance security systems that lie at the interface of sensor technologies, networking and infrastructure.

By exploiting the unique culture of collaboration throughout the college and university and the capacity to expand and exploit our prominence in the cluster areas identified, we propose the following action items to achieve Goal 2:

Action Items for Goal 2:

- Stimulate communications across disciplines to catalyze new initiatives and advise on hires.
- Create and stabilize new interdisciplinary Ph.D. programs in *Materials Science & Engineering* and *Systems Engineering*.
- Recruit excellent faculty at the interface of engineering and science disciplines
    - Conduct select searches within research clusters and focus areas simultaneously with specific department/program searches
- Resource new initiatives that connect scientific clusters to focus areas in *healthcare, energy, information systems* and *security*.
- Invest in interdisciplinary seed projects for faculty and in interdisciplinary graduate fellowships.
- Add excellence, visibility and fellowship funding to all Ph.D. programs: e.g.,
    - Training Grants
    - Industry-College of Engineering consortium
    - Endowed Fellowships

3.3 Restructuring the College of Engineering

Goal 3: Restructure the college to a) sustain excellence in undergraduate education for those disciplines and departments that are consistent with our faculty research strengths; b) support emerging interdisciplinary graduate strengths (e.g., create new Materials Science and Engineering and Systems Engineering programs); and c) facilitate cross-disciplinary education and research via an agile college structure and experiences.

Despite astonishing growth in an eclectic set of traditional and emerging research areas, the College has had the same structure and programs for over 30 years. Ideally, we want the College to produce premier undergraduate students educated in programs that complement or at least are aligned with faculty research. We are also committed to quality graduate education. It is becoming increasingly inefficient and undesirable to maintain accredited BS degree programs that do not adhere to this perspective. We project a future College of Engineering that will offer foundational undergraduate accredited programs that are augmented by a suite of programmatic concentrations and/or minors in several engineering areas. Simultaneously, we will design new interdisciplinary graduate degree programs that leverage our emerging strengths in Materials Science and Engineering and in Systems Engineering. Furthermore, we will stabilize these new interdisciplinary degree programs by creating administrative entities that are accountable for their excellence and for facilitating smooth connectivity to departments and research centers via these programs.

Action Items for Goal 3:

- Merge the departments of Manufacturing Engineering and Aerospace-Mechanical Engineering into a single department of Mechanical Engineering that will work to design concentrations in aerospace and manufacturing engineering while sustaining an accredited BS degree in ME.

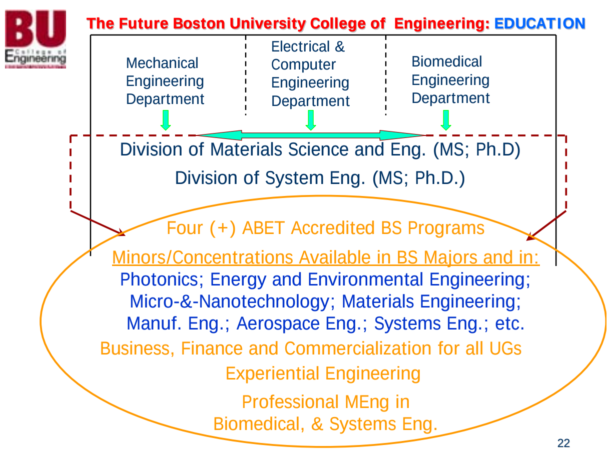
- Create new Divisions of Materials Science and Engineering and Systems Engineering each of which have distinct administrative structure, budget and portions of faculty lines with such faculty necessarily appointed jointly in a department and division. These divisions will be designed to engage faculty in cognate departments (e.g., physics, chemistry, computer science, math) for education and research experiences for graduate students in these disciplines.

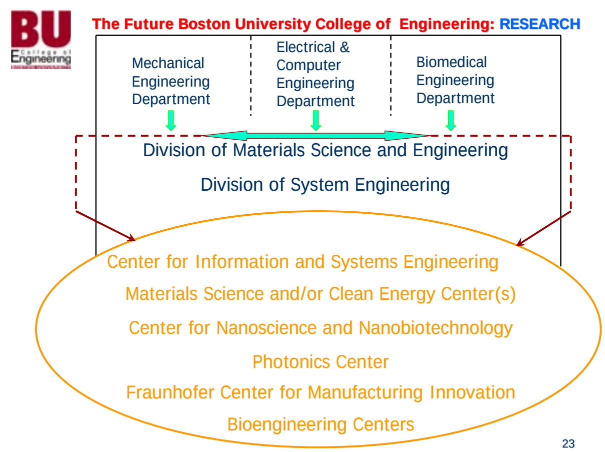
- Develop courses that can serve to offer a suite of minors or concentrations at the undergraduate level in a fashion that is compatible with meeting ABET requirements. Areas for minors or concentrations could include Materials Science and Engineering, Systems Engineering, Aerospace Engineering, Manufacturing Engineering, Photonics, Micro-and-Nano Technology, and Energy-Environmental Engineering. We should allow minors in existing ABET BS program.

- Explore the creation of a new BS degree in Energy and Environmental Engineering and in Engineering Science (which may be designed as an Honors Engineering Program as well).

- Retain the MS degree in Manufacturing and Photonics while adding a professional (1-year) Masters Degree in Systems Engineering and Bioengineering which also create new revenue.

- Prioritize research center creation and interactions that are most compatible with a wide spectrum of faculty and graduate degree programs aligned with the College's focus areas.

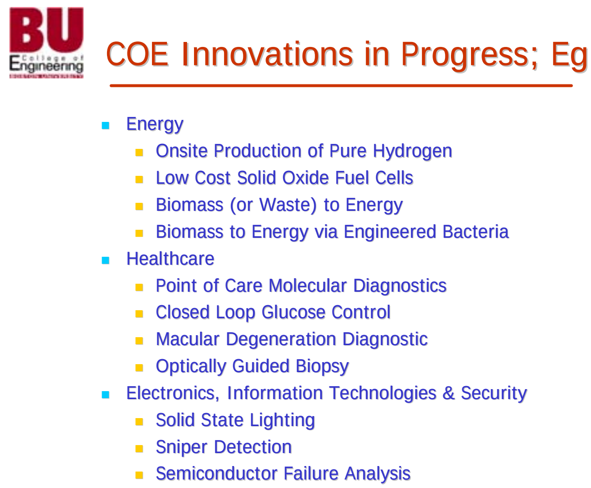




The new College of Engineering structure will facilitate inter- and intra-college education and research at Boston University. It will have low barriers between three foundational department "pillars." The divisions will catalyze cross talk among faculty and students in all three departments and outside the College in many cognate science, math, management and medical campus departments. Specifically, we will focus on developing undergraduate educational programs, tracks, certificates and formal minors that are compatible with and help engage faculty in basic or applied research or both. The new College will retain six foundational ABET BS programs. Three of these will be variations of the ABET accredited mechanical engineering: e.g., ME; ME with a concentration in Aerospace; or an ME with a concentration in Manufacturing. ABET BS degrees will exist in Electrical, Computer or Biomedical Engineering. All of these programs will be complemented by a suite of other minors or concentrations aligned with faculty research strengths. All degrees are expected to incorporate substantive exposure to innovation/commercialization concepts as well as a required experiential engineering component outside the classroom. The graduate programs in the traditional departments would be complemented by the interdisciplinary graduate programs supported by the divisions and these will naturally leverage the robust set of research centers related to these divisions. We will also create new professional Masters programs in Manufacturing Engineering and Biomedical engineering while sustaining the MS in Photonics.

3.4 Innovation across Boundaries

Goal 4*:* Establish programs, processes and infrastructure to stimulate and support innovation coupled to faculty interests and career goals.



One of our core missions is to innovate new technologies. The College already has an exciting portfolio of innovations that have engaged the technology transfer process. But past practices have seen limited success. Our process needs to leverage the excellence in research among our faculty while educating and engaging students and faculty in innovation in a balanced fashion relative to other missions. To achieve goal #4 we need to create programs that finance and stimulate translational research, that provide expertise in the innovation and commercialization pipeline, and that can connect these innovations and faculty with the right opportunities. This endeavor should not be driven primarily to make money for the university. Certainly, effective measures and processes need to be in place to protect intellectual property. But the driving motivation should be to minimize barriers to entry for entrepreneurial or non-entrepreneurial faculty that periodically discover ideas with innovation potential, and then to maximize the probability that good ideas for improving society quality of life become commercialized.

Action Items to Achieve Goal 4:

- Invest and raise funds for programs that provide seed funding for translational research opportunities. Such investment includes sufficient staffing of technology transfer experts to assess and then shepherd the best concepts along the commercialization pathway. These programs should include (among others):
  - Coulter Foundation Partnership Program
  - BU-Fraunhofer Alliance for Medical Instrumentation and Diagnostics
  - Engineering Dean's Catalyst Awards
  - University Ignition Awards
  - CIMIT (Center for Integrated Medical and Innovative Technologies)
  - Photonics Center and Biosquare Incubator Facilities

- Partner with the School of Management to develop new courses and programs that educate students and faculty on the process and pathways for technology innovations.

- Work with research centers to create BU-Industry consortia in cluster technology areas. Existing and/or potential consortia are in Sensor Networks, Clean Energy, Photonics, MEMS or NEMs, Biotechnology/Biophotonics, or Information Systems.

3.5 Diversity, Community, Outreach, Society➔ Retention

Goal 5: Insure that the college attracts, engages and retains a diverse community of students and of faculty and that we commit to outreach programs to connect us to the community while advancing appreciation of math, science and engineering.

Action Items to Achieve Goal 5:

- The College is committed to working with faculty and student organizations to convey the excitement and potential for a foundational education in engineering. Engineering is not simply a discipline for students “good in math and science”. We must develop effective means of conveying that engineering is a discipline that integrates math and science and humanistic and social fields to solve important societal challenges and/or innovate exciting new technologies that improve humanity. We also must practice what we preach and insure that our curriculum captures the imagination and passion of entering freshman. We must maximize retention.

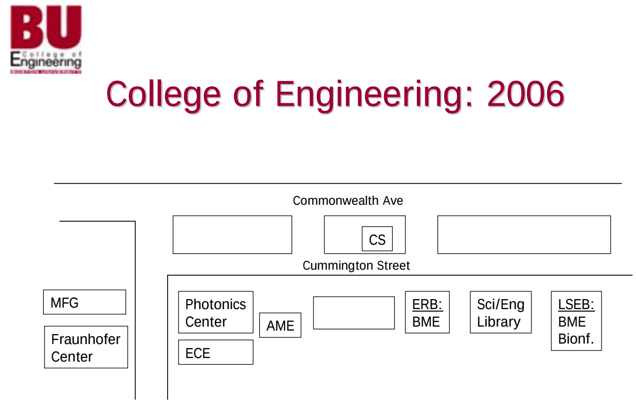
- We must work to increase the proportion of women that choose engineering as students and faculty. The national average for women enrolled as undergraduate engineers is less than 20%, far less than the life sciences (biology and chemistry). This is a huge loss of intellectual and creative firepower for our discipline. We have an obligation to identify how Boston University can address this disparity. Among other actions, to accomplish this goal we will advance a more effective communication as to the exciting role that engineering plays. We will work with the Women in Science and Engineering organization to improve our message and our environment for women students (with particular focus on how the first two years of the curriculum can better capture the imagination of students).

- We will identify more effective means to commit to and be effective at recruiting women faculty.

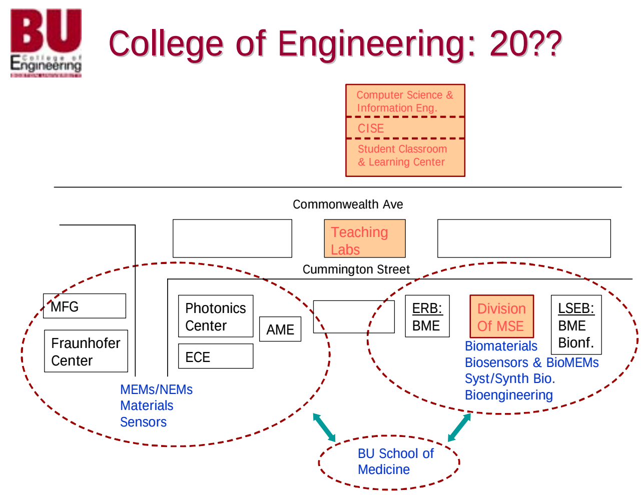
- We are committed to advancing diversity for underrepresented minorities throughout our faculty, staff and student body.

- We will continue to invest in and develop programs that have great potential to increase student awareness, involvement and selection of engineering, particularly those programs that attract a diverse pool of K-12 students. Examples of past successes or commitments are the College’s substantive role in hosting and supporting the regional FIRST competition, our Junior Science and Humanities symposium, our U-Design programs and our annual Design Competition for high school students.

3.6 Expanding our Physical Space



The College of Engineering currently resides in six buildings spread primarily along Cummington Street and St. Mary's Street. As the College recruits more research active faculty and expands its size and scope of research and education, we need to develop a more integrated vision for our expansion in physical-space and its functionality. This vision should attend to our model of emphasizing growth in clustered, interdisciplinary research areas while insuring that students can engage an integrated and reasonably convenient learning experience. We project that over the next five years the College will need to add approximately 25,000 square feet of research space for new faculty and 5,000 square feet of teaching and student-learning space.



We offer here just one possible concept for expansion. Our concept leverages existing space while stimulating increased synergism between computer science, information systems and computer engineering faculty and students throughout Boston University. This concept would suggest the prioritization of a new building to address these synergisms while enhancing the quality of student learning facilities in the heart of the academic center of Boston University. The assumptions for this vision are as follows:

- Create a new building across Commonwealth Avenue dedicated to computer, information and systems science and engineering along with student learning. The building would house the Computer Science Department with invited faculty colleagues in engineering that focus their research on information and systems engineering. The building would also house the interdisciplinary Center for Information and Systems Engineering (CISE). The lower floors would offer a Study/Learning Center and Classrooms. The design maximizes student educational networking and provides electronic access to the published and/or web-based literature and information.

- Convert space that would be vacated by Computer Science into teaching laboratories for the College of Engineering and computer science as needed.

- Replace the current Science and Engineering Library with laboratories and faculty offices dedicated to the COE-CAS-SOM Division of Materials Science and Engineering (which we project will grow steadily). The "electronic" functions of the existing library will be absorbed into the new building.

- Focus much of the MEMs/NEMs and Materials Science core facilities within Photonics and the current Manufacturing Engineering space, while focusing much of the biomaterials, bioMEMS, and synthetic biology core-facilities within the three building sequence of 44-25 Cummington Street.

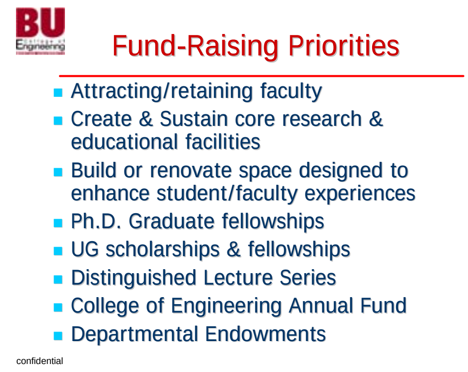
The above is simply a suggestion/target as we continue to expand the impact of the College in tandem with the University, particularly in areas that cut across engineering and science.

4. Achieving our Vision and Maximizing our Impact

Goal 6: Work institutionally and with alumni, leadership and visiting boards to:

a) engage vision and advice on COE initiatives and direction.

b) identify and acquire the crucial resources necessary to achieve and sustain excellence.



Achieving our vision will require resources to recruit and retain world class faculty; to build and maintain cutting edge core facilities; to create and equip educational and research space; to fund top quality graduate and undergraduate students; and to fund programs that impact quality of life for students, faculty and alumni. Regarding facilities, our cluster approach will enhance how we prioritize investing in core facilities, emphasizing materials characterization, imaging and computational modeling, and micro-to-nanofabrication. The College and University should and will finance a substantial portion of this growth in excellence, but a portion of it cannot be raised by internal budgeting or faculty initiatives alone. This portion will need to derive from alumni and friends. Our challenge is to convince them of mutual ownership in the desire to perpetually insure that Boston University's College of Engineering excels. For certain, our peer institutions have sustained a substantially higher level of donation from their constituents than has Boston University. Now is the time for our alumni and friends to partner in kind and we have terrific confidence that they will see the mutual benefit of doing so.

Action Items to Achieve Goal 6:

- Create an advisory board comprised of leaders aligned with and impassioned by the vision of Boston University and committed to helping the College identify and attain the resources needed.

- Create departmental visiting committees which engage successful alumni and friends from both academia and industry who are dedicated to advancing excellence and resources at the programmatic level.

- Identify and/or create new programs that can generate new revenue. Potential sources of new revenue include:
  - new professional master's degree programs
  - increases in external research funding attracted by the faculty
  - increased royalty return from faculty inventions
  - enhanced fund-raising and donations from alumni and friends

- Work with alumni to create a culture of commitment to the College of Engineering family that includes students, faculty, alumni and parents. Focus should be on
  - providing life-long learning programs,
  - networking for social and professional purposes,
  - access to University advice on technology transfer,
  - solicitation and involvement in activities that enhance student quality of life,
  - targeted fund-raising for specific projects that large segments of alumni identify with.

- Educate potential donors of the programs and activities supported by the College of Engineering's Annual Fund with a goal of tripling donations within five years.

To date, the College has worked hard to help establish its first Dean's Leadership Advisory Board comprised of an extraordinary set of innovators and leaders in technology innovation, engineering research, engineering management, technology entrepreneurship and academic leadership. Over the next year each of our major departments will be asked to create visiting committees comprised of alumni and friends that can advise and council explicitly in these disciplines and how they are performing and proposing to impact their field through education and research. The Dean's board has discussed establishing metrics of success for our vision. To first order several such metrics can be articulated, with the understanding that these necessarily will be both hard (quantifiable) and soft, but nevertheless all are identifiable as they contribute to our growth in excellence. Initial metrics include:

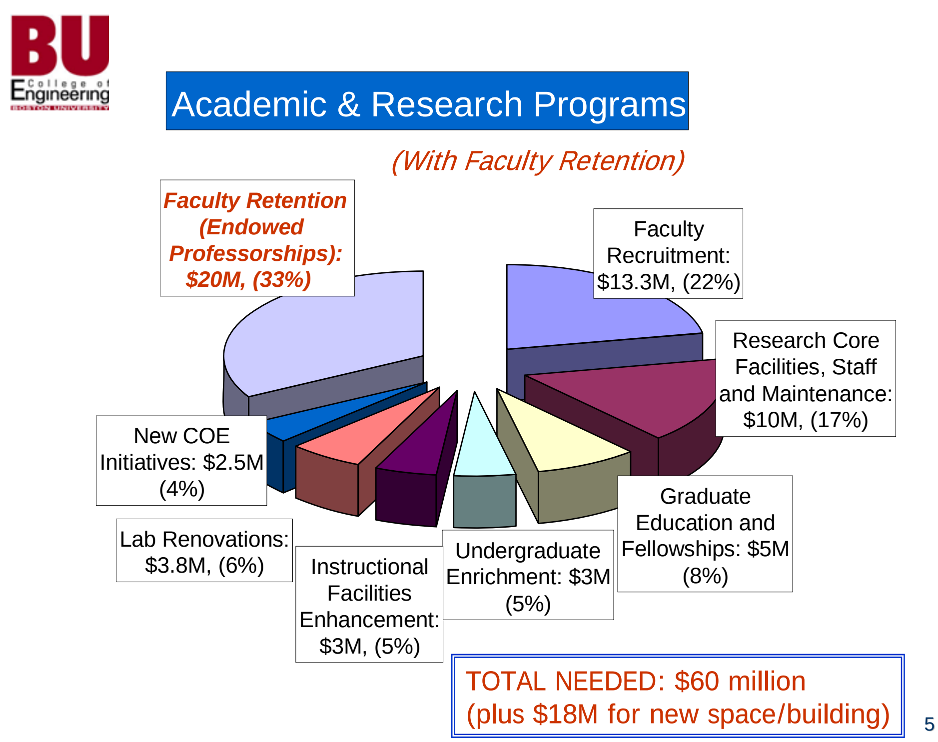
- Quality of faculty (measured via funding, publications, teaching and reputation)
- Selectivity, yield and discount rate for undergraduate and graduate students
- Quality of graduate students
- Specific funding success for graduate students (funded research assistants, training grants, endowed graduate fellowships, etc.)
- Success of graduates from undergraduate and graduate programs be they in or outside of engineering
- Winning funded and competitive high-visibility and high-impact research and educational initiatives
- High-impact publications
- High-visibility donations (e.g., named initiatives)
- Licensing and entrepreneurial success
- Other (e.g., # of Ph.D. students/year; faculty in national academies, etc.)

5. Financing the Vision

Our vision will require investments from the College of Engineering, from the central administration, from new revenue streams, and from fund-raising from alumni and friends. Taken together the vision anticipates resources for recruiting and retaining faculty, creation and maintenance of high-quality research and educational resources, establishing stable funding for Ph.D. fellowships, creating the capacity to catalyze new initiatives in a timely fashion, and longer term funding for major capital building projects related to student-faculty space. The college anticipates recruiting 25 – 30 faculty over a 10 year period depending on retention rates. The majority of these will be replacement faculty related to retirements or to the replacement of less research active faculty who leave. Some attrition of our top-tier faculty to recruitments by other institutions is unfortunately inevitable. Our predictions are that about 15 of these hires will replace faculty that had not maintained substantive research programs. This means that we need to find research space for these new people. We project a need of about 20,000-25,000 square feet of new space over the next 10 years. Eventually, space in a new building seems inevitable. As an initial and albeit rough approximation we predict the following financial needs and financing. The projection presumes that the college is invited to raise 50% of the cost for 20,000 square feet within a new building, perhaps one that combines a student learning center while integrating faculty from across the university engaged in research associated within the general areas of information science and systems.

Financial Requirements Projections

We have parsed our financial needs to three broad categories. ***Academic and Research Programs*** include the recruitment of faculty, the sustenance of first-class educational and research facilities (e.g., teaching and research labs), the capacity to attract high quality graduate students (via distinguished fellowships), the ability to invest in programs and experiences that enhance undergraduate quality of life, experiences and opportunity (e.g., annual fund gifts to sustain internships, and summer fellowships in faculty labs), and in seed funds for college initiatives (e.g., to catalyze forward looking novel high risk-high impact research initiatives). ***Faculty Retention*** involves the raising of named and endowed professorships to attract/retain our most extraordinary and most highly recruited faculty members. ***Capital Projects*** relates to raising funds for new space (perhaps in a shared facility) for the college to expand its educational and research infrastructure. The projected totals for these areas are shown below with a more detailed explanation on the following page.



The rationale assumes recruitment of some 25 – 30 research active tenure-track faculty (5 new slots and 20-25 replacements over 10 years):

Academic and Research Programs

	AMOUNT (Millions)
Salary additions to base budget for faculty (Assumes $140,000/faculty with 5 new lines at 100% and 25 replacements at 30% of $140K/hire;)	$ 1.7
Start-up for faculty at $400,000 per faculty………..	~ $ 10.8
Net for Faculty Recruitment…………………… ……….	$ 13.3
Renovations of existing Space for New Faculty at $125,000/lab ………………………………………	$ 3.8
Research Core Facilities ……………….……………….. ($400-500 K/yr for maintenance and staff)	$10.0
15 New Endowed Graduate Fellowships…………..…..… (Assuming $30,000/yr stipend per fellowship)	$ 5.0
Undergraduate Enrichment ($150,000/yr if endowed)… (student groups, community, facilities, etc)	$ 3.0
Upkeep/Enhancement of Instructional Facilities……...… (~$150,000/yr if endowed fund)	$ 3.0
New COE Initiatives (cost share, seed funds, etc) (~$125,000/yr if endowed)	$ 2.5
TOTAL (Exclusive of Retention or Capital Projects)	$ 40.6

Faculty Retention

8 Endowed Professorships (about 2 per program)………..$ 20.0

Capital Projects

Partner with CAS for a ~20,000 square feet of a new building this will require 50% another $20 million…$ 10.0
Additional "new" space converted to labs………………..$ 8.0

GRAND TOTAL……………………………………… $ 78.0 Million

In summary the above represents a total need of some $40 million for growth in faculty and facilities associated with academic and research programs, $20 million in retention/endowed professorships, and $20 million for major Capital Projects creating new-space totaling $80 million for the College as the ultimate goal. We next articulate a broad-strokes plan for financing this need.

<u>Resourcing COE's Financial Requirements for Next Decade</u>

<u>Internal Financing **($20 million)**:</u>

Approximately $20 million will derive from internal financing spaced out over 10 years: about $9 million from the College and $11 million from Central Administration. The latter is consistent with past annual additions to the base budget (about $1 million per year). The College's $9 million will derive from a combination of its existing discretionary account, projects on future additions to this account, and aggressive design of new revenue programs such as professional master's degrees, and licensing income, etc.

<u>Fund Raising Priorities: $60 Million</u>

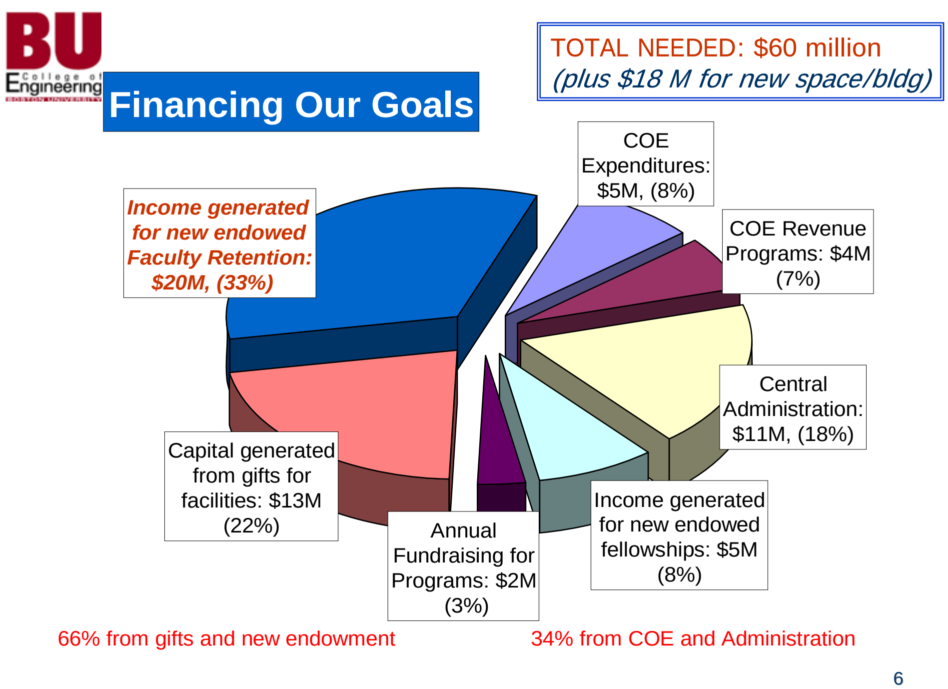
Endowed Graduate Programs/Fellowships **($5 million):** This will provide about $200,00-$250,000/year, adding about 8-10 first year distinguished fellowships (about two per Ph.D. program)

Endowed/Named Facilities **($13 million):** We have a list of core research and educational facilities. We project a need of about $500 annually to maintain these facilities inclusive of staff salaries and supplies. Some of these funds will be used to originally equip the facilities.

Annual Fund Expenditures **($2 million**): If we can achieve an Annual Fund giving level of $2 million within 10 years we can finance the remaining portion of the Academic and Research Program Needs outline in the previous section.

Endowed Chairs (**$20 million**): The goal is to attract eight new chairs used primarily to retain our very best faculty.

Capital Projects **($20 million):** We will strive to raise 50% of the costs for 20,000 square feet of space in a new building, approximately $10 million and a substantial portion of costs to renovate existing space into research-active space (estimate about $8-10 million).



To maximize the likelihood of retention and/or attraction of extraordinary faculty we absolutely must prioritize creating six to eight endowed/named professorships. This presents about an additional $20 million in fund raising challenge. This single issue is where we are least competitive with our peer institutions. With each successful professorship, we would then relieve some of the financial burden associated with the faculty recruitment line item. Also, the above does not project the perpetual need to increase the funds available for undergraduate scholarships in the College.

Finally, there is an increased national trend to raise funds to **name entire engineering departments or even the entire College of Engineering**. This process typically results in a donation of a substantial amount of funds to the department or College. Such funds simultaneously support a variety of essential needs ranging from endowed professorships, endowed discretionary funds for new initiatives, endowed fellowships and scholarships, and endowed and named core facilities for teaching and research.