



The College of Engineering

Strategic Vision 2010: *Growth in Excellence*

Transforming Boston University's Impact on Society's Challenges



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Note from the Dean of Engineering

There is a widespread perception from all our constituents that the College of Engineering has the promise to help Boston University engage in educational and research programs that can advance society. Our themes resonate around creating the “Societal Engineer” able and passionate about the intersection of multiple engineering-science and non-science disciplines and leading in addressing society’s challenges. With strategic hiring, investments, and philanthropy our faculty and students can advance fundamental understandings that eventually contribute in meaningful ways to sustainability, quality of life, health, and security.

The plan in this document is the culmination of an extraordinary set of ideas and efforts by faculty and colleagues in and outside of Engineering, our program leaders inside Engineering, our students, our alumni and our advisory boards. We first created ad hoc working groups associated with each of the six goals. These groups included appropriate faculty from all engineering departments and divisions and from cognate departments and schools. For example, for Goal 1 on undergraduate education we included representatives from Physics and the School of Management. For Goals 2 and 3 on research and graduate education we included leaders from the Medical School, Chemistry, Physics, Management, and the directors of the Centers for Photonics, Nanoscience and Nanobiotechnology, and Information and Systems Engineering. Summaries from these meetings were distributed back to committee members as well as a pre-identified subset of members of my Deans Leadership Advisory Board for further comments and ideas. The executive committee of the College (department chairs and division heads) had a separate, extended meeting to compare and discuss programmatic plans in the context of the College’s plans. Afterward, we convened three separate working committees of current students, young alumni, and more senior alumni, all of which contributed their reactions and new ideas (these groups were wonderfully engaged and offered passionate ideas). All these interactions were synthesized into a working draft that was distributed once more to the ENG faculty at large and our main advisory boards, including the Leadership Advisory board meeting on April 21 for a final round of feedback and revisions.

This report is extensive. Achieving brevity and removing redundancy proved highly challenging in light of the breadth of constituents and ideas and aspirations that emerged. Indeed, in building from our Vision from 2008, I have chosen to incorporate many of these detailed ideas and initiatives and metrics into the action plans associated with each goal. The net effect is increased density, but hopefully increased substance and focus for steps we should be taking as we move forward.

I thank every single person for giving of their time and deep thoughts.



1. Executive Summary

The College of Engineering at Boston University is embarking on an ambitious plan focused on “**Growth in Excellence**” and creating the “**Societal Engineer**.” We will emphasize **experiential education, research in grand challenges with translational impact**, and the creation of **engineers as leaders in society**. The plan, which will require about \$95 million, motivates the hiring of 20-30 new and replacement faculty over 5 years, and 40 over 10 years, and the need for about 30,000 square feet of new space for students and faculty.

In 1990 the College established graduate programs to complement our existing accredited undergraduate degrees. Over the past 20 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. 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 10 years will leverage our culture of collaboration and the full spectrum of what Boston University can offer. We are committed to coupling research to education in a continuous cycle at both the undergraduate and the graduate levels. Our investments will ensure that interdisciplinary research at the faculty and graduate levels is a high priority. At the undergraduate level we will prioritize foundational and experiential education that prepares students for

innovation and success in engineering and beyond. We brand our approach creating the “*Societal Engineer*.” We recognize that our strengths lay along a spectrum of engineering science clusters that engage faculty from all departments. These clusters 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 largely aligned with the Grand Challenge areas identified by the National Academy of Engineering: living systems and quality of life; sustainability; information technologies; and security (defense and homeland). We will also transform our undergraduate programs to ensure that they engage our faculty strengths and experiences and that the students are empowered with the excitement of engineering. Our roadmap to achieve this vision will need to rely on resources derived not just from our faculty and our administration, but strategic philanthropic partnership with our alumni and friends.

BU College of Engineering

Key Attributes for “Societal” Engineers: Desired Qualities for Life-long Impact/Success

- Grounded in Engineering Fundamentals & depth in well-known discipline
- Inter & Multi-disciplinary Design → Teamwork
- Quantitative/Statistical Problem Solving
- Communication Skills
- Systems Thinking
- Global Awareness
- Entrepreneurial Mindset → Passion for Innovation
- Public Policy and Technology
- Social Consciousness → Economic value and quality of life

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

- Goal 1: To transform undergraduate engineering education into an “experience” that creates a “*Societal Engineer*” ensuring opportunity, passion, and ambition for innovation, leadership and life-long impact.
- Goal 2: To enhance basic-thru-translational research impact by: a) focusing on important problems and on societal challenges; b) enhancing cross-disciplinary areas that leverage and amplify the impact of Boston University as a whole; and c) implementing programs and infrastructure that support technology innovation and transfer.
- Goal 3: To strengthen and catalyze (interdisciplinary) graduate programs that prepare students for leadership in research and/or technology development.
- Goal 4: To retain a diverse community of students and faculty with a commitment to the advancement of STEM education in K-12.
- Goal 5: To engage alumni, leadership and visiting boards for visionary advice and help in acquiring the crucial resources for sustaining excellence at BU and impact on society.

2. Introduction

2.1 Mission

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

1. To **educate** new generations of engineers to impact in all facets of society.
2. To **advance** the frontiers of knowledge via engineering science and **research**.
3. To produce innovations from research and translate them into use for the betterment of society.
4. To participate as **global leaders** in all dimensions of science, education, technology and society.



2.2 The College at a Glance

Structure: The College of Engineering has approximately 1,200 undergraduate and 500 graduate students, and 112 full-time faculty, of which 106 are tenured or tenure-track and six are teaching faculty. The College is fairly young. From the early 1960s through 1990 it was primarily an undergraduate institution. In 1992, the College created discipline-specific Ph.D. programs and committed to building a complimentary set of research areas consistent with supporting these programs. **With only 18 years at the Ph.D. level**, the College has joined an excellent set of peer institutions (see Section 2.3) among the nation’s top graduate programs. In 2009, **the College’s graduate programs were ranked 42nd in the nation by US News & World Report, and 19th in extramural research funding per faculty member**. The College graduated the 18th highest percentage of female Ph.D.s in the nation. We are also 14th in the nation in number of Ph.D.s awarded to domestic students.

Over the past three years, the College designed and implemented a major structural change to enhance its ability to educate engineers for the 21st century and to advance research that makes crucial contributions to addressing society’s key challenges. Our philosophy is that an undergraduate engineering degree should: a) ensure a foundational education for a potential career in engineering as well as virtually any other career path; and b) assure that graduates aspire to, and are prepared for, life-long learning and impact utilizing their powerful, quantitative problem-solving skills. Thus, while students must learn the fundamental core principals of engineering and learn how to develop some depth (at the BS level) along specific and well-accepted engineering disciplines, that alone would be insufficient. We must also ensure that students appreciate how a spectrum of engineering and non-engineering disciplines needs to intersect to solve complex technological and societal problems. Also, we need to provide opportunities for undergraduates to engage emerging engineering sectors, especially those that intersect multiple disciplines. Finally, students need to gain skill sets for interacting with a wide spectrum of people and organizations that engage society, to better understand how technology, society and public policy intersect, and develop a sense of social consciousness. At the graduate level, programs and structure must facilitate disciplinary and interdisciplinary research simultaneously and in a fashion that can amplify the quality of our undergraduate education. These programs must prepare students to be leaders in research or technology development in industry and academia.

Our structure has three major departments and two major graduate divisions. The departments are **Biomedical, Electrical & Computer**, and **Mechanical Engineering**. These support four ABET-approved bachelor’s degree programs. The Mechanical Engineering department has three variations on its ABET program. By careful selection of three or more electives and an appropriate Senior Design project, students can concentrate in **Aerospace** or **Manufacturing Engineering**, which is officially recognized on their transcript along with their base BS in Mechanical Engineering. Leveraging this concept, we have created two new, College-wide interdisciplinary

concentrations that address emerging areas likely consistent with substantive new global economic or research sectors. These are **Energy Technologies and Environmental Engineering** and **Nanotechnology**. We have designed these so that the required technical courses are acceptable electives from any ABET major. Hence, students interested in concentrating in Energy or Nanotechnology can do so without changing majors.

At the graduate level, we offer MS and Ph.D. programs in the same disciplines associated with the departments. We have also created two graduate divisions which support MS and Ph.D. programs in **Materials Science and Engineering** and in **Systems Engineering**. These divisions represent fields that are highly interdisciplinary at the graduate level and draw from faculty from all the Engineering departments, as well as several science, math, and even management departments outside the College. We also offer graduate MS degrees in **Manufacturing Engineering** and in **Photonics**. Finally, the College is designing a suite of professional Master of Engineering programs in all existing disciplines (see below).

Key Research Strengths: The College has renowned faculty and state-of-the art facilities in several prominent programs and areas:

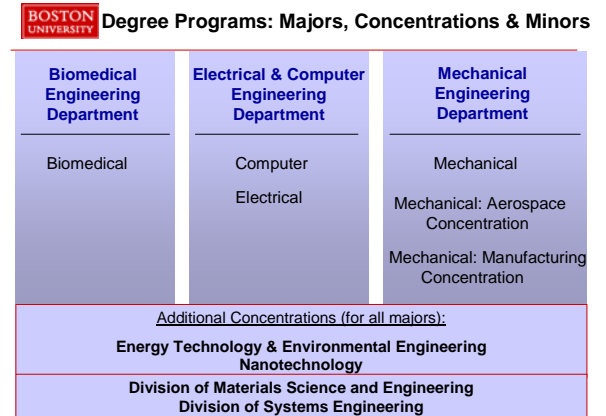
The BME department is ranked among the top 10 nationally and is one of only three institutions in the nation to have received the Whitaker Foundation’s Leadership Award (\$14 million), one of only nine to receive the Coulter Foundation’s Translational Research Partnership (\$15 million potential), and the only institution to have received both. There are superb state-of-the-art core facilities in biointerface technologies, micro- and nano-bioimaging, cell and tissue engineering, and biomedical computing. The BME department has been awarded two separate NIH Pre-Doctoral Training grants -- one in quantitative biology and physiology (from NIGMS), and one in biomaterials (NIBIB).

The Electrical and Computer Engineering department has been rising steadily in quality, impact and the rankings. Last year the EE graduate program was ranked 46th and the CE program 48th. This department boasts 17 NSF CAREER Award winners, one NSF PECASE winner, and nine IEEE fellows, and is particularly strong in the areas of optics-electronics, information systems and sciences, and networks. In concert with several centers, ECE boasts some of the best photonics, microfabrication and computational facilities in the nation.

The Mechanical Engineering department sustains world-class research in acoustics, photoacoustics, dynamics and control, micro- and nano- technologies (including MEMs and NEMs), computational and theoretical fluid mechanics, and materials engineering. ME is ranked 51st in the country (up from the mid-60s just four years ago). The ME department boasts more fellows of the Acoustical Society of America than any other department in the nation.

The divisions draw from faculty throughout the College and beyond. The Systems Engineering division is well funded in the areas of sensor networks and cyber-physical systems, and leverages the very strong information and systems science cluster in the ECE department that focuses on signal processing, information theory, and communication networks. The Materials Science and Engineering division has strengths in hard materials -- most notably optical, fiber optics, and solid-state materials for lighting -- and in energy materials associated with fuel cells, gas separation membranes and energy from waste processing. This group also leverages the wide strength in biomaterials.

With the low barriers to collaboration, some of the strongest research programs lie within “clusters” that transcend engineering and science expertise throughout every department in the College, cognate departments outside the College, and research centers. Primary clusters are in:



- ***Bioengineering***: This research is prevalent and diverse, and while central to our renowned department of Biomedical engineering, is being practiced in all four Engineering departments, as well as the Medical School. Applications range from genomics to cell and tissue engineering, to biomaterials, to integrated biomechanics, to bioimaging and optics, to visual and hearing systems, to biocontrol, to bioacoustics and ultrasound, to name but a few.
- ***Sensors and Imaging***: This area captures our leading efforts in optics, acoustics and nanotechnology through macro sensing and imaging systems. Faculty in virtually every department work with the Photonics Center to develop novel ways to use light-coupled excitation to extract highly resolved information at the nano-to-meso scales. Applications range from defense to medical diagnostics to materials characterization.
- ***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 for Nanoscience and Nanobiotechnology 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 the Division of Materials Science and Engineering derive from every engineering department, as well as from Physics and Chemistry. Current research foci span electronic materials, polymers, green manufacturing, new energy materials, biomaterials, structural materials, and chemical materials, for example.
- ***Networks and Systems***: The College has established substantial prominence at the interface of information theory and systems engineering. This effort engages the Center for Information and Systems Engineering, the Information and Systems Science group within ECE, and the Division of Systems Engineering. Current focal activities include communications and networking, optimization, signal processing, image and video processing, robotics and control.

These clusters are supported by 14 interdisciplinary research centers that are directed or co-directed by engineering faculty. These include centers related to the intersection of engineering, biology and living systems (e.g., Center for Applied Biotechnology, Hearing Research Center) as well as the Photonics Center and the Center for Nanoscience and Nanobiotechnology, the Center for Information and Systems Engineering, and the Center for BioDynamics. Finally, the Fraunhofer Center for Manufacturing Innovation provides a uniquely extraordinary capacity to support cutting-edge design and innovation by faculty and students.

Additional Interdisciplinary Research Programs and Initiatives: Several interdisciplinary undergraduate programs have recently been, or are being, developed. Our new concentration in Energy Technologies and Environmental Engineering engages all our departments and allows students to take electives in energy policy or environmental science in CAS. Our new Nanotechnology concentration engages Physics and Chemistry and all departments in ENG. We continue to partner with SMG to develop courses and experiences in Technology Innovation and Entrepreneurship. Of course, the two divisions represent interdisciplinary graduate programs and research initiatives. Two emerging and highly complimentary research areas for the college are ***Engineering Synthetic and Systems Biology*** and ***Clean Energy and Sustainability*** (See Sect. 3.2)

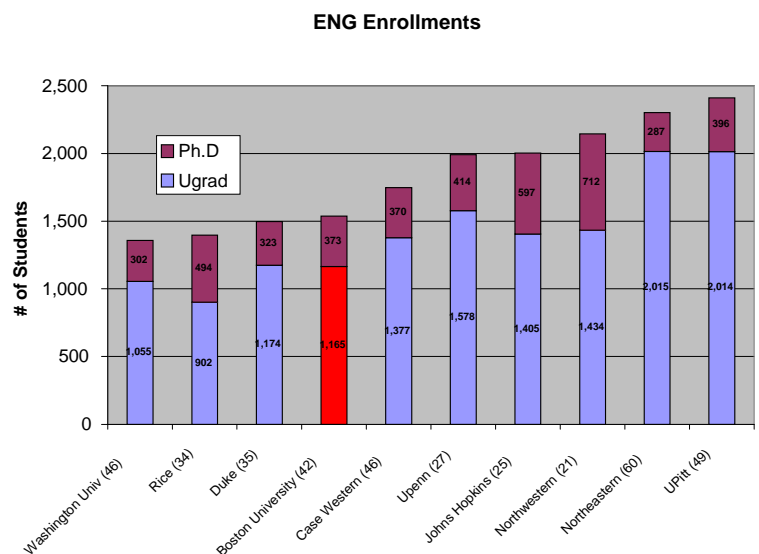
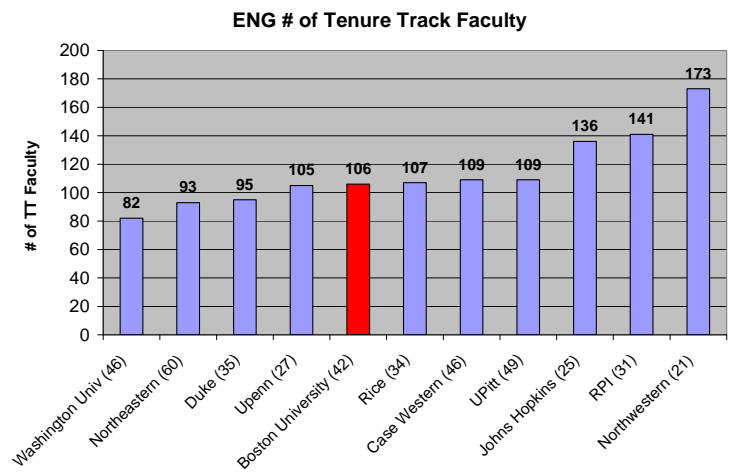
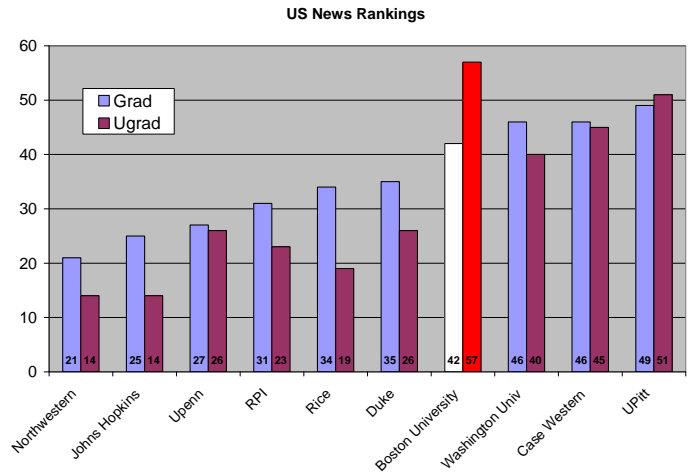
Faculty Quality : The College continues to assemble a superb faculty. Indeed, while total faculty size has not changed much over the past five years, faculty, and consequently College, reputation has improved steadily. Among other accolades our primary and affiliated faculty include: **6** National Academy (Engineering or Science) members; **2** MacArthur Award winners; **9** fellows of IEEE; **17** fellows of AIMBE; **11** fellows of Acoustical Society of America (ASA); **3** ASA Silver Medal winners; **4** fellows of AAAS; **5** fellows of Optical Society of America; **27** NSF CAREER Award winners; **1** NSF PECASE awardee; **1** winner of President's

Citizens Medal; 2 Sloan fellows; 1 winner of the Drexel Award; and 1 Howard Hughes Medical Investigator. Our faculty has also succeeded in winning an NIH Pioneer Award, an NIH Transformational Grant, two NSF-ERCs (Smart Lighting and SubSurface Imaging), several MURI grants, and a Homeland Security Center (ALERT) award. In addition to the two NIH Pre-doctoral training grants, our faculty has attracted an NSF IGERT on Bioinformatics and Biological Networks.

2.3 Peer Comparisons

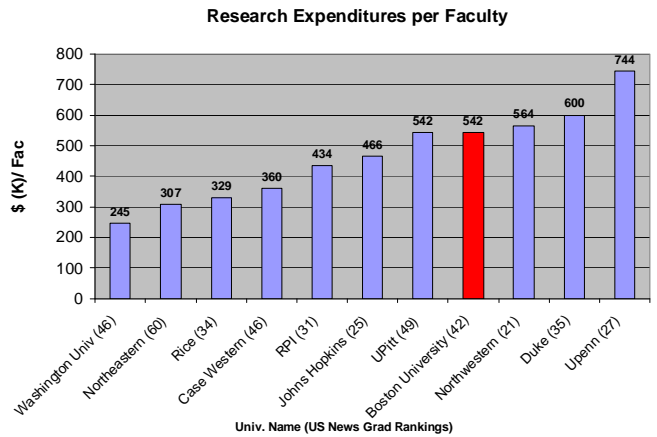
Our core peer institutions consist of top-tier colleges of engineering that are: a) part of a larger full-service university; b) have faculty and student body size similar to ours; c) are in an urban-like environment; and d) have strong biomedical engineering programs. This group includes Johns Hopkins University, the University of Pennsylvania, Case Western Reserve University, Washington University of St. Louis, Duke University, Rice University, the University of Pittsburgh, and Northwestern University. Most of these schools are also consistent with the peer institutions at the departmental levels (see appendices). Some comparisons are also made to RPI because its geographic location makes it a common competitor for students. Acknowledging the dubious nature of such rankings, several key points emerge. First, rankings are not simply reflective of faculty size. Interestingly, except for Northwestern, the size of the faculty among the core-peer group are remarkably similar. Penn and Duke are slightly smaller in faculty size, yet ranked higher than us (29th and 30th respectively) at the graduate level, whereas Case Western Reserve University is larger in size but ranked below us at 46th. Second, Boston University is unique in its disparity between undergraduate and graduate rankings. The UG rankings are based only on a survey of deans of engineering and industry executives, while the graduate rankings incorporate some quantitative metrics.

The core peer schools are similar in student size. Here Washington University, Rice, Duke and BU all have between 1,000 and 1,200 undergraduates, while Case, Penn, Northwestern and Hopkins all have between 1,300 and 1,600 students. RPI is not shown and has over 3,000 undergraduates. The Ph.D. program sizes of the core-peer group, excluding Northwestern, are also of similar size, ranging from 302 at Washington University to 597 at Hopkins, with BU at 373. One area of distinction is in the size of the master's programs. While not shown, this ranges from as

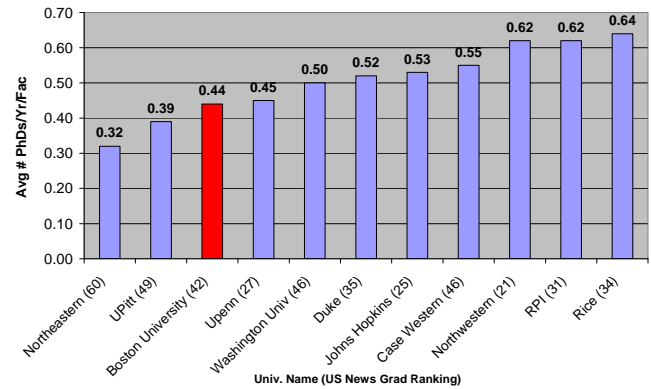


little as 59 at Rice to 2,100 at Hopkins. This huge range reflects schools that have chosen to offer only standard Master of Science programs, as well as those that have also committed to building substantive professional master’s programs (such as Hopkins or Penn at 542).

Two key measures of research success and impact are extramural research funding and the number of Ph.D. students produced per year. Our funding portfolio is excellent (**\$542,000 per faculty member**) exceeded only by Northwestern, Duke and Penn. While our Ph.D. production in total numbers and in Ph.D.s produced per year, per faculty member are competitive, given our funding levels, we should be aiming to produce closer to 0.6 Ph.D.’s per year, per faculty member (about 55-60 in total) within five years rather than our current level of 0.44 (47 in total).



*18th of top 50



2.4 Challenges and Opportunities

Educational: We have been very active during the past three years in transforming the undergraduate educational experience from 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. This includes the development of several cross-cutting concentrations, access to minors in the interdisciplinary areas of Materials and Systems Engineering, and the enhancement of experiential opportunities, especially undergraduate research and service learning. **In fact, over the past three years the number of students paid as undergraduate research assistants has increased from 39 to 81 and the amount spent by the College and its faculty increased from \$86,000 to \$242,000 per year.** These efforts are also designed to attract more students and to impact retention of our entering freshmen. We have seen substantive recent increases in our applicant pool and class size, but time will tell how sustainable these are. Also, currently, 82% of our incoming freshmen stay at Boston University through their senior year. Our challenge has been to improve programs and services so as to maximize student enthusiasm for having selected Engineering. The College must also continue to enhance the interdisciplinary experience at the graduate level while attracting resources necessary to bring the most creative and excellent graduate applicants into an array of programs. The challenge is to ensure sufficient faculty size to simultaneously provide all the features of our ABET disciplines, our concentrations, and our master’s and Ph.D. graduate programs.

Entering Freshman Yr	% Returning As Sophomore	% Returning As Senior
2003	85	74
2007	94	82

Faculty and Student Body Size vs. Distribution: Prelude to Hiring Strategy

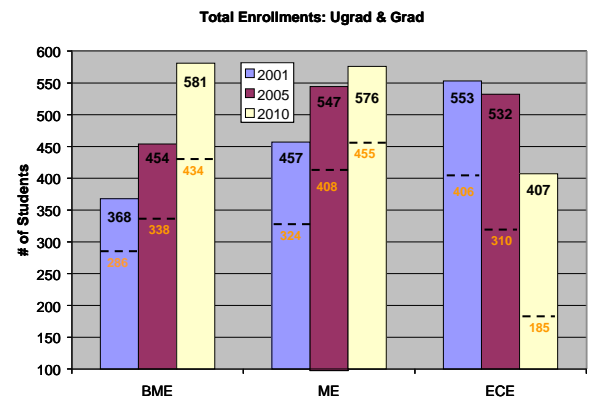
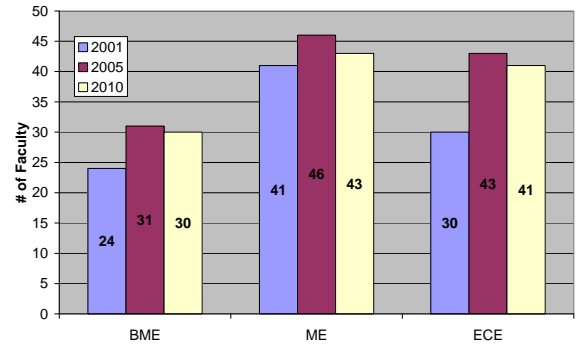
While the total number of students (undergraduate and graduate) has stayed relatively constant over the past 10 years, their distribution has not. It is clear that the Biomedical and Mechanical Engineering departments have achieved substantive and sustainable growth in their undergraduate student size, although Electrical and Computer Engineering has decreased and is likely to stay at reduced levels for some time. Both ECE and BME have seen growth in their graduate student populations, but ME has not. The ME department has the largest number of faculty with course and service commitments to the divisions. BME has many faculty members who are not FTEs due to the nature of their appointments. In sum, both BME and ME need a net growth in faculty size. The divisions draw from faculty in all departments, but the College must ensure that sufficient numbers of faculty are available to sustain these programs while allowing for potential fluctuations due to sabbaticals, retirements, etc. In Section 4 we lay out a strategy for prioritizing future hiring between departments, division programs, concentrations and research areas in light of our research vision, current structure that embraces several interdisciplinary graduate program initiatives, and our more robust undergraduate structure that embraces several flavors of degree programs and concentrations to produce a societal engineer.

Resources: The foundation of the College’s excellence and impact derives primarily from the quality of our **faculty** who, in turn, have served to attract an increasingly higher quality of **students** at all levels. Sustenance of a world-class program requires resources. Extensive **facilities** have been established in the areas of photonics and bioengineering, and these serve to attract high-caliber new faculty and graduate students. However, Boston University must compete with peer institutions that have superior financial resources, particularly via alumni giving and endowment. We are the only college of engineering ranked in the top 50 without a single endowed professorship. As a prelude, our vision projects a need to:

- Via replacement and net growth hire 40 faculty members over the next 10 years, including 20-30 over the next five years. Many of these will derive from replacements, several of which will replace research-inactive faculty. This hiring will require nearly 40,000 net square feet of new space.
- Attract 8-10 endowed professorships to retain our star faculty.
- Create more student-learning space, teaching facilities and core-facilities.

2.5 Summary

The College is poised for change. We have emerged from an era of steady growth with faculty hired into department structures that were created more than 40 years ago. Our vision for the future identifies a number of key focus areas of excellence in education and research driven to address key societal challenges. In nearly all cases these represent interdisciplinary challenges that will add excellence to Boston University as an institution with Engineering playing a crucial role. Our new direction will leverage our 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 with excellence in research.

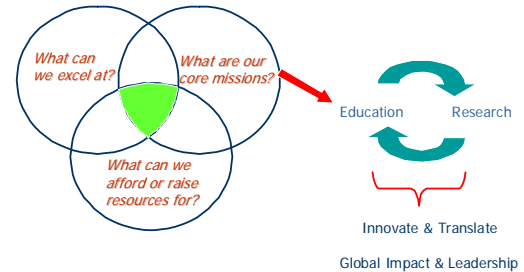


3. VISION: Breaking Down the Barriers

Overview: As we embark on a vision for engineering education and research at Boston University we embrace the approach 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? 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. ***Our undergraduates should learn what our faculty do, not just what they know.*** To this end we have moved beyond the traditional approach of setting up independent and distinct departments and degree programs, each responsible for designing their own curricular and research impact without knowledge or interaction of what the other disciplines and departments have in mind. 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.***



FROM GUIDING PRINCIPLES TO PRIORITIES



3.1 Undergraduate Engineering Education

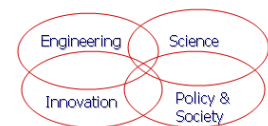
GOAL 1: To transform undergraduate engineering education into an “experience” that creates a “Societal Engineer” ensuring opportunity, passion, and ambition for innovation, leadership and life-long impact.

The College has created a structure consistent with the philosophy that an undergraduate engineering degree should create the “Societal Engineer,” an individual who will appreciate how the cultural and public policy aspects of societies relate to the way engineering and applied science drive the innovation ecosystems that advance quality of life.

Why should a student who is interested and adept at math and science choose engineering? Our answers lead to four fundamental tenets that should guide our program. First, the essence of being an engineer is to combine fundamental mathematical and scientific 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, yet the majority of the world’s people are ignorant of its underpinnings. Third, the ability of engineering students to be creative in the domains of science and technology empowers them in principle to

BU College of Engineering

Impacting the Future



The Societal Engineer

Why Engineering?

More than Math & Science; More than Just Engineering!

- **Create**
 - Quantitative/scientific “artist.”
- **Understand**
 - How do “things” work?
- **Innovate & Integrate**
 - Life-Long Learning
- **Impact: Galvanize Organizations and Society**
 - Leading and Problem Solving




Turning Ideas Into Reality: Advancing Our Quality of Life

lead, innovate and integrate at levels few others can 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.

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, and should not, compete to produce the greatest number of engineers who enter the work force. Instead, we must ensure our curriculum and experiences produce individuals with the versatile skill sets to lead innovation. This requires the capacity to integrate and communicate across engineering disciplines, as well as other non-engineering fields like 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 after graduation. Nevertheless, we aspire to ensure that all engineering graduates are capable of exploiting their unique problem-solving, innovation, leadership and integration skills to be successful in any career. Therefore, while engineering is a “professional” degree program at the undergraduate level, it should not be designed exclusively, or even primarily, to create a series of compartmentalized mini-experts in specific engineering sub-disciplines of choice. While we must ensure that the core competencies of any chosen discipline are provided (i.e., that the students are technically competent engineers), we must also embrace the challenge of providing a foundational experience enabling and motivating life-long success in a global, integrative, multi-disciplinary world. Taken together, the actions and initiatives described below intend to address the following specific aims:

- 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, computation and visualization for problem solving and communication.
- Ensure that engineers can communicate with all sectors of society.
- 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 innovation practices play in motivating and advancing new technologies so that society can benefit.

 College of Engineering

**Key Attributes for “Societal” Engineers:
Desired Qualities for Life-long Impact/Success**

- Grounded in Engineering Fundamentals & depth in well-known discipline
- Inter & Multi-disciplinary Design → Teamwork
- Quantitative/Statistical Problem Solving
- Communication Skills
- Systems Thinking
- Global Awareness
- Entrepreneurial Mindset → Passion for Innovation
- Public Policy and Technology
- Social Consciousness → Economic value and quality of life

All of these aims seek to instill a set of fundamental attributes in all our engineering graduates. To achieve these aims we plan to prioritize the following actions:

Excite first- and second-year students about engineering as a pathway to extraordinary impact on society’s grand challenges.

One of the most complex challenges in engineering education is to provide first- and second-year students with an understanding and passion for how engineering uses math and science to enable powerful new ways to innovate and solve real problems. The solution to this challenge largely lies in transforming and/or complementing the manner in which the base calculus, chemistry, physics, and biology courses are taught. The goal is not to make these basic subjects pre-engineering courses (i.e., designed only for engineers), but to provide a complementary pedagogy that makes these subjects more fun because of exposure to context and real-world meanings of mathematical, chemical or physical constructs. To achieve this goal, we must collaborate across units and colleges. Our specific initiatives will include:

- The creation of a committee of the undergraduate chairs of math, physics, chemistry, and all engineering departments to communicate common goals, challenges, deficiencies, etc.

- Assess the idea of designing a novel course for first or second-year students called (for now) “Applied Math and Science.” This would be team taught and required for all engineering students. Each week or two, a professor would present a real-world challenge or problem that could be addressed with some of the concepts already learned in their math and sciences courses. The course would engage student teams in design like tasks that are extensions of the lectures.
- Create new Introduction to Engineering Modules dedicated to service learning and global health.
- Bring alumni back to lecture in the EK130 Introduction to Engineering Modules as domain specialists who can convey how their engineering education led to their career.

Maximize experiential opportunities for students, including co-op, internships and undergraduate research opportunities, and international programs.

Specific actions and metrics are:

- Have at least 100 students per graduating class experience **study abroad** (40-50% of the graduating class) and ensure that these programs include guest lecturers from the host country on that country or region’s challenges grounded in engineering solutions.
- Insure that 40-50% of our students can engage co-op or internship experiences.
- Aspire for 100% of students to perform some experiential activity.
- Develop a more coordinated process for engaging undergraduates in experiential activities, perhaps guided through our Career Development Office and with Web site support for guiding students on how to get involved. Assess the creation of a faculty and/or staff director of Experiential Programs.
- Partner with School of Public Health to create a suite of global health and public health challenges and projects that require engineering solutions, and enhance service learning opportunities in general via our Engineers Without Borders.

Continue to develop and enhance concentrations for Energy Technologies and Nanotechnology.

These are the first cross-departmental concentrations accessible from any degree program. An essential component of these concentration is the requirement for an experiential component ranging from internships, research in a faculty lab, a mentored project (e.g., compatible with the BU Sustainability Initiative), or the student’s formal senior design project. Our plans to further stabilize and enhance these concentrations include:

- Acquire funding for experiential portions of the program which can derive extramurally (e.g., an NSF-REU, DOE Career Development, etc.), internally, or via philanthropy.
- Identify staff support for the concentration students, including coordinating the availability, matching and accomplishment of the experiential components.
- Expand and adapt these concentrations to attract students from a broader base of engineering disciplines, as well as physics or chemistry.

Develop integrated program in technology innovation to instill an entrepreneurial mindset and increase the number of engineers who can engage our economic innovation ecosystem.

Engineers need to understand the distinction between a technology or invention and a product. The College would like to greatly increase the number of engineering students who become aware of and develop an entrepreneurial mindset. This is not the same as saying they should be entrepreneurs (which is much smaller subset). Rather, the intent is to make them passionate about participating constructively in the process, including appreciating how to assess and harness risk for innovations, and a desire to participate in some way to advance new technologies from a leadership perspective. This aim must go beyond simply a set of courses, but must ensure experiential components that allow the students to internalize the passion for innovation. The specific steps to achieve this aim are:

- Work with SMG to create a suite of key foundational courses (e.g., a freshman “Intro to Entrepreneurship” module, and upper class “The Business of Technology Innovation” and “Entrepreneurism for Technology”) increasing the number of ENG students exposed to these areas.
- Design experiential activities that create cross-functional teams of students from SMG and ENG.
- Develop an effective network of student and project mentors from friends and alums.

- Develop a new **Concentration in Technology Innovation** that can engage about 25 students per-class as innovation-scholars that immerse themselves in this complement to their degrees.

Amplify the opportunity for engineering students to learn and appreciate the relationship between technology, society and public policy.

Solutions to the majority of society’s grand challenges will be grounded in technology innovations. However, the innovation process and success in the great majority of these (e.g., energy, nanotechnology, IT or healthcare) will be intimately linked to public policy driven by perceived impact(s) of these technologies on our economic and cultural systems, and on society’s values. To amplify the potential for our students to become effective leaders in these technology sectors, they should be able to understand and navigate, in a collaborative fashion, these public policy issues. Our aim then is to:

- Sustain engineering faculty who want to and can partner with colleagues in CAS to create an exciting cross-college course in Technology, Society and Public Policy.

Stimulate sustainable advances in engineering education pedagogy.

- Provide incentives for faculty to develop new enhancements in engineering education.
- Provide teaching fellows to help faculty develop or revamp new courses, especially lab-based courses and approaches for hands-on learning (e.g., wireless sensor labs).
- Create a “brown-bag” series for faculty to convey exciting new styles or approaches in engineering teaching, including the use of new technologies, to their professor colleagues.

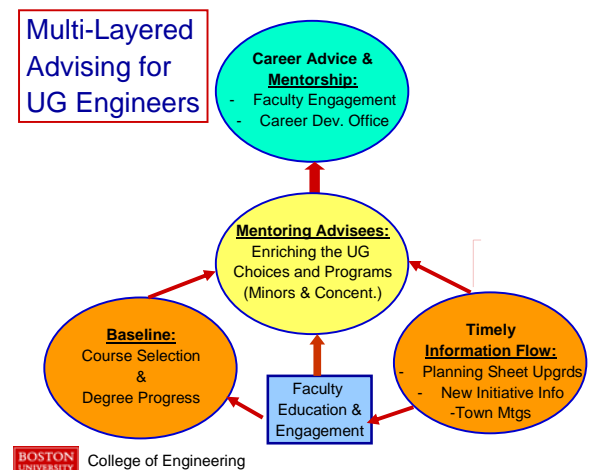
Increase undergraduate enrollments in Electrical and Computer Engineering programs.

A strong and exciting EE program is an essential pillar of any world-class engineering program. Our EE program must upgrade its marketing vehicles to convey the extraordinary exciting opportunities for students in ECE here at BU. They must evaluate curricular enhancements that are more clearly designed to prepare students for exciting careers in niche areas such as clean energy, biosensors and bioinstrumentation; robotics; entertainment and social media technologies; etc.

Build a more holistic ecosystem for academic mentoring and advising, including a more engaged faculty and a vibrant, multi-dimensional Career Development Office for engineering students.

We have an obligation to facilitate a) how our students can take advantage of our programs and experiential opportunities, and b) successfully transition to post-graduate positions. The advising/mentoring ecosystem must engage faculty, staff and our Career Development Office in a coordinated fashion. To ensure that Boston University’s College of Engineering is an extraordinary value proposition we will:

- Enhance the roles that faculty play as academic advisors, including ensuring that they educate their advisees on degree enhancements (via the concentrations, minors, etc.), experiential enhancements (internships, undergraduate research, study-abroad, etc.) and career planning (advising on graduate school or industrial career paths). Students will assess faculty effectiveness in these tasks.
- Enhance the effectiveness of our Career Development Office, including design of metrics to include touch points for students, programs and events with attendance, percentage of students applying and being placed in internships, career fair success, placement success, and assessment tools.



3.2 Research, Graduate Education, and Innovation

GOAL 2: To enhance basic-thru-translational research impact by: a) focusing on important problems and on societal challenges; b) enhancing cross-disciplinary areas that leverage and amplify the impact of Boston University as a whole; and c) implementing programs and infrastructure that support technology innovation and transfer

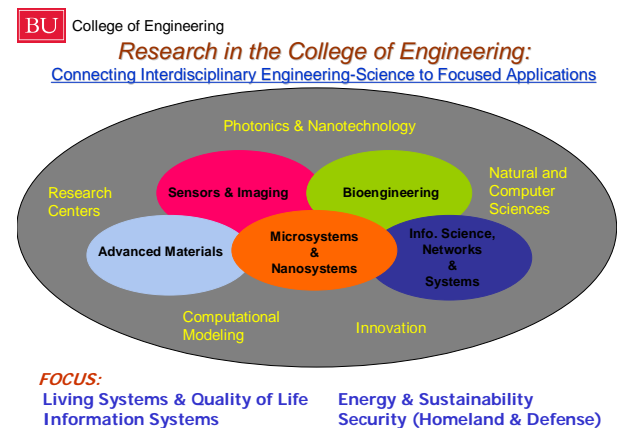
GOAL 3: To strengthen and catalyze (interdisciplinary) graduate programs that prepare students for leadership in research and/or technology development.

3.2.1: Research

Research Priorities and Impact for the Future *How can we build on our clustered scientific strengths to maximize their impact?* We 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 ubiquitous excellence in photonics, nanotechnology 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:

- 1) Living Systems & Quality of Life
- 2) Information Systems
- 3) Security
- 4) Clean Energy & Sustainability

As a College of Engineering and as a University, we need to be cognizant of the major economic growth sectors in society for the next decade and ensure that our faculty and students are prepared to impact these fields and work in them. Here, living systems and energy are particularly important. While we already have depth and breadth related to challenges (1) – (3), we do not yet have critical mass in clean energy. Our capacity to impact crucial challenges in each application area will be possible by developing world-class basic and applied research in several key interdisciplinary engineering-science areas that are heavily based on engineering but synergistic with other strengths and directions throughout Boston University. These include: **Bioengineering; Engineering Systems and Synthetic Biology; Photonics; Nanotechnology and Nanoscience; Information Systems and Sciences; System Engineering; Materials Science; Acoustics; Computational Modeling; and Micro/Nano Electromechanical Systems.** *How, then, can Boston University leverage these engineering science strengths to impact specific technology-based societal challenges?*



- **Living Systems and Quality of Life:** 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 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 -- Boston University is

BU College of Engineering

Living Systems & Quality of Life:

- Synthetic-Systems Biology to Combat Infectious Diseases and for Personalized Medicine
- Cell and Tissue Engineering & Biomaterials
- Biomedical imaging: molecular-thru-whole organ.
- Integrated systems: From Cancer Detection to Diabetes Control to Point-of-Care Diagnostics
- Enhancement of Neuro-sensory systems
- Wireless sensors for home health care and rehabilitation.
- Orthopedic Engineering and Regenerative Medicine
- BioAcoustics: detection & treatment.
- Novel drug delivery systems that exploit nanotechnology
- Biophotonics and Nanophotonics for Biomarker Detection

poised to 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 clinical applications or research.

- **Information Systems:** Society is poised to be able to acquire and analyze information from an extraordinary number of networked sources. The end result is an extraordinary revolution in expanding how we interact with and control our environment over a continuum of spatial and time scales. This revolution will embrace wireless networked communities and sensor systems for a range of societal applications.
- **Security (Defense and Homeland):** A key mission of our defense in the 21st century is to combat emerging threats from biological and chemical attacks innovative technologies that integrate sensing, communication, actuation and control functions into our defense infrastructure. The College, in concert with our Photonics Center, has considerable strength to develop integrated micro- and nano-platforms to enhance battle system(s) performance, and the reliability of information and security systems.
- **Energy and Sustainability:** We must find ways to shift to more sustainable energy supplies. Using a broad range of research approaches throughout the College of Engineering, we will target specific initiatives that can address the energy and sustainability challenges of our nation (see below).



Information Systems:

- Cyber-Physical Systems and Sensor-networks
 - Healthcare: Patient records; monitoring; personalized medicine
 - Homeland Security
 - Networked Communities: Education and Cultural, & Management
- Energy and Environmental Systems: Smart Grid
- Risk and Uncertainty Management: System Survivability
- Networks and Communications
- Data Compression and Smart Sensing
- Advanced new information systems that permeate:
 - Entertainment.
 - Medical care (e.g., imaging systems and analyses).
 - Hand-held communication devices.



Security (Defense and Homeland):

- Combat emerging biological and chemical threats.
- Micro/Nano systems to provide integrated intelligence, communication, and control.
 - MEMs and NEMs
 - 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.

Interdisciplinary Research and/or Graduate Program Initiatives for the next Decade

Engineering's Systems and Synthetic Biology: The College will leverage our excellent core of primary and affiliated faculty to create a leadership programs at the intersection of engineering and systems and synthetic biology. We will:

- Add more faculty in engineering who emphasize modeling, data generation and synthetic biology while leveraging the NEIDL and the School of Public Health to address crucial challenges in microbiology and infectious diseases in humans. These areas represent a unique niche from those of other institutions at the systems biology level (e.g., cancer).
- Pursue this initiative so as to amplify the success of other University efforts to grow in systems biology, including but not limited to a growth in chemical systems biology, biological physics and, of course, bioinformatics.
- Attract better infrastructure for core facilities in mass spectroscopy for proteomics and metabolomics, and data generation technologies from array technologies to microfluidics.
- Create an academic sequence (about four courses) constituting a certificate program in Engineering Systems and Synthetic Biology accessible from any engineering Ph.D. program. The program would require courses in molecular and cellular systems modeling, biological systems identification, synthetic biology and experimental methods (photonic, array, imaging, microfluidics, etc., applied to data acquisition).
- Evaluate the creation of a new center entitled the **Engineering's Systems and Synthetic Biology (ESSB) Center** that would serve as the umbrella organization for advancing this research field, designing and sustaining focused graduate educational tracks in engineering, and coordinating core facilities.

Photonics and PhotoAcoustics: Much of our “suite” of superb data and experimental generation capabilities for systems and synthetic biological engineering, nanomedicine and materials science will be photonics-based. Several major focus application areas for the coming decade reside at the intersection of the Center’s and the College’s goals:

- **Biophotonics** with applications from medicine to experimental physical chemistry to infectious disease to defense. This effort will advance small-scale, even individual molecular sensing, neural biophotonics with applications to neurological diseases.
- **Nanophotonics and Nanoplasmonics** with applications for biomarker detection (protein levels, protein structure, etc.), biosynthesis, telecommunications, computer communications and speed.
- **Fiber-Optics** to advance transformative technologies such as fiber lasers for defense or fiber-optics in tandem with biophotonics.
- **Quantum Optics and High-Resolution Microscopy.**
- Single-cell or **Intracellular Imaging** and optics (e.g., tracking transcription events or up/down regulation of proteins and their interactions within cells in real time).
- **Photoacoustics** with applications in medical diagnostics or treatment, defense or homeland security technologies (e.g., nuclear compliance, mine detection, etc).

Nano-technology, MEMs, NEMs for applications in defense, medicine, and energy.

The College has deep and broad expertise theoretically and experimentally in nanotechnology and nanoscience. Many of these faculty work at the intersection of nanotechnology/science and photonics, bioengineering, and materials with additional applications in communications. Over the next 10 years we will strategically emphasize the following:

a) **Nanomedicine**

- Cancer: Detection, drug delivery, monitoring of treatment efficacy from the molecular to the macro (tumor) level, uncovering fundamental mechanisms of cancer.
- Infectious Disease: Specific detection of viruses via breakthrough proteomics, novel manipulation and understanding of infectious disease, design and monitoring of new therapies.
- Micro/Nano devices for biomarkers, pathogen detection and point-of-care diagnosis.

b) **Nanomaterials and systems:** sensors for energy source detection, nano/bio photonics for biodefense, NEMS and MEMS for integrated processing and control related to defense applications, especially chemical and biological defense.

Clean Energy and Sustainability: The College needs to expand its efforts in energy and play a major role in the eventual transition of the **Clean Energy and Environmental Sustainability Initiative** to a formal **Clean Energy and Sustainability Center**. The center will be dedicated to facilitating research and complimentary educational tracks or programs at the intersection of technology, public policy, economics, and environmental science all from a systems perspective. Educationally, this effort will create an Energy Systems track within the Systems Engineering Division at the master’s level. The College should also consider Ph.D.-level concentration or certificate program in Energy Systems, or perhaps in Clean Energy and Sustainability, or both. Engineering currently boasts strength in energy materials for fuel cells, and SynGas generation, green manufacturing and LED lighting. An emerging area of University-wide strength is at the interface of **smart grid** technologies, and systems and energy adoption and efficiency.



Summary:
Areas of Potential Strength

- **Synthesis of Materials Science and Engineering, Photonics, and Nanotechnology:**
 - Solar and Photovoltaics (Thin film to Gallium Nitride-Based 3rd Generation)
 - Solid State (LED) Lighting
 - Nano & Micro technology and nano materials for energy devices
- **Synthesis of Materials Science and Engineering, Physics, Chemistry and Biology**
 - Solid Oxide Fuel Cells and Fuel Processing for Hydrogen and Syn-Gas
 - Green Manufacturing and Membrane Separation for clean fuel
 - Solar energy for photo-catalytic water splitting to provide a viable source for clean hydrogen fuel using corrosion resistant non-oxide semiconductors
 - Organic Semiconductors with potential applications to Solar Cells
- **Synthesis of Systems Engineering, Sensors, Business and Social Sciences**
 - Smart Grid Technologies, Integrated Systems, Sensing, Communication and Control
 - Efficient Building Design relative to Smart Grid
 - Energy Economics: Business models for Smart Grid; Regulatory Models
 - Energy Policy: Adoption of & Transition to new (renewable) energy technologies



Creating the Central Nervous Systems for Society: We are on the cusp of transforming the manner in which society interacts with our physical environment, societal infrastructure and our health. This core advance will

derive from a vast array of cyber-physical networks that can monitor and intelligently guide essential aspects of our life. These “sensor networks and systems” will address challenges in healthcare systems from the home to the hospital. They will create dramatic advances in how we use energy in society via smart grid intersecting with the emergence of renewable energy sources. The College already has depth in the information theory basics to the technologies of sensor networks to the control systems in the context of the complex social and economic forces and constraints that apply to each application. We will continue to recruit faculty and identify focused initiatives that leverage these strengths.

3.2.2: Graduate Education for Research and Technology Development

An overriding agenda is to develop world-class graduate education programs that engage intra and interdisciplinary problems and that produce students who understand how to succeed in a highly competitive intellectual community and world. In short students who appreciate how to identify important problems and successfully impact them. In this section we highlight our current efforts associated with the interdisciplinary division programs and the need to greatly increase our footprint of producing excellent professional masters of engineering graduates. The later are needed to impact the technology development sectors of private industry and/or embrace entrepreneurial or intrapreneurial activities

Enhanced impact of new divisions of Materials Science and Engineering, and Systems Engineering.

These divisions should serve as educational and intellectual hubs that allow faculty and (graduate) students to address challenges naturally crossing the more traditional disciplines. Hence, advancing their specific research vision fundamentally needs to be linked to complementary growth at the departmental levels.

Systems Engineering: Current strength derives from the two pillars of basic-science excellence: The Information and Systems Science group, mainly in ECE; and the Systems Engineering group. Research in these groups is enabled by our world-renowned Center for Information and System Engineering (CISE). Future growth will occur in tandem, primarily with ECE to prioritize areas of data compression, analysis and mining, and smart sensing, sensor networks, and cyber-physical systems. This growth will further prioritize faculty addressing key societal challenges, especially healthcare applications of telemedicine (from home monitoring to off-site biomedical image processing), energy systems (smart lighting and smart grid, inclusive of power distribution down to in-home sensing and components), and defense and homeland security systems. Our strategy is to recruit researchers who can bridge systems and communications researchers on common applications that will be based on integrated wireless sensor systems.

Materials Science and Engineering: The division currently boasts considerable strength in hard materials, such as optical, solid-state, lighting (LED), and nano-optics in silicon. There is also a coordinated effort to develop energy materials related to fuel cells, membranes for CO₂/SynGas separation and green manufacturing. The complementary biomaterials area resides primarily in the strong Biomedical Engineering department. Our strategic growth should emphasize faculty hires that bring an engineering component in the area of soft materials, potentially emphasizing conducting polymers and organic LEDs. The division must also work to create a Core Materials Characterization Facility, including high-end equipment such as a transmission electron microscope. The division needs to target center-level grants as well.

Create a suite of professional Master of Engineering programs for all majors.

The College of Engineering will commit to creating a population of graduates branded with the Boston University name to lead technology product development and innovation in the private sector. Our existing Master of Science programs are geared for careers in research and development. The suite of new, corresponding MEng programs would require experiential work in engineering project management, teamwork, presentation/communication skills for multiple constituents, and exposure to basic business acumen (i.e., how a company works). This effort will likely require that we partner with School of Management to hire new faculty and/or create the relevant courses, and that we develop a subset of faculty to sustain the courses and programmatic needs of the MEng programs. As an added value, these programs will generate new revenue for the College and the departments (See Section 5).

Additional Opportunities: We need to support the capacity of our faculty and students to engage **Translational Engineering** research, inclusive of funding mechanisms for seed projects, process-education programs, and mentoring systems to facilitate the innovation process. Most of our research and educational aspirations can explicitly impact challenges in **Global Health** and we will work with BU's Center for Global Health and Development to identify student and faculty projects and programs. Finally, the neuroengineering, photonics, and systems engineering strengths are highly synergistic with the University's Center for **Neuroscience**.

3.2.3: Translational Research and Practice: Technology Transfer and Innovation

The College already has an exciting portfolio of innovations that have engaged the technology transfer process. But past practices have seen limited success. We need to create programs that finance and stimulate translational research, that provide faculty expertise in the innovation and commercialization pipeline, and that can network these innovations and faculty to the right opportunities. This endeavor should not be driven primarily to make money. 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's quality of life become commercialized.

Action Items to Enhance Innovation and Translation

- **Educate Faculty:** Faculty need to be aware of the forms of funding and support, the process associated with their translational research, and the range of roles they should and could play.
- **Seed Funding Programs:** We need to sustain seed funds for translational research opportunities. These programs should include (among others):
 - Coulter Foundation Partnership Program in Biomedical Engineering
 - BU-Fraunhofer Alliance for Medical Instrumentation and Diagnostics
 - University Ignition Awards
 - CIMIT (Center for Integrated Medical and Innovative Technologies)
 - ITEC Johnson & Johnson Programs
 - Photonics Center: Defense and Biophotonics Industry Consortia
 - Biosquare Incubator Facilities
- **Build a Network of External Entrepreneurs, Venture Investors and Private Corporations to evaluate, mentor and partner with faculty innovation projects:** The expertise of these people (e.g., fund-raising, entrepreneurship, project management, start-up management, etc.) are crucial but typically outside the comfort zone of BU's existing staff.
- **Project Management:** A project manager could greatly enhance complex projects by setting and overseeing achievement of technical milestones, helping identify and overcome major technical hurdles, working with the Office of Technology Development to help define the market and patent landscape, and helping secure next-stage funding or partnerships. The College should consider hiring a "Professor of Practice" in translational engineering to oversee this.
- **Gap Funding:** Gap funding is necessary to address issues of manufacturability and design, or of acquiring sufficient field (or clinical) data. The College will explore establishing concrete partnerships with specific venture capital and/or private equity funds, perhaps each with a focus in a particular technology sector (healthcare, nanotechnology, photonics, sensors, etc.). Also, we will 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 and biotechnology.
- **Integration with our Educational Mission: (SMG and ENG):** Investments in technology translation and transfer for the faculty need to be synergistic with the educational mission of the College and the University. Hence, programs should partner with the School of Management to sustain concentrations, minors, graduate courses, etc. associated with technology innovation and entrepreneurship.

3.3 Diversity, Community, Outreach, Society → Retention

GOAL 4: To retain a diverse community of students and faculty with a commitment to the advancement of STEM education in K-12.

In the past three years the College has hired 11 faculty including three Women, 1 Hispanic, one African-American, and one Asian-American. Search committees are now educated in advance of the importance and the expectation to actively work to attract and engage a diverse pool of faculty candidate. Our incoming freshman class last year was comprised of 31% female, nearly double the national average. These are all good early indicators of a capacity to achieve a portion of Goal 4. Nevertheless, we cannot become complacent. Additionally, activity has increased for community service and outreach via the creation of an Engineers Without Borders chapter, presentations to local high schools on the “power” of engineering as a career for societal impact, and investments in the FIRST program. There are other K-12 initiatives as well but we need a more coordinated and resourced approach.

Action Items to Achieve Goal 4:

- 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 with humanistic and social fields to solve important societal challenge and/or innovate exciting new technologies that improve humanity. We also must practice what we preach and insure our curriculum captures the imagination and passion of entering freshmen. We must maximize retention.
- We must work to increase the proportion of women who 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 work to communicate more effectively the exciting role that engineering plays, and 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).
- Identify more effective means to commit to and be effective at recruiting women faculty.
- Advance 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, the Junior Science and Humanities Symposium, our U-Design programs and our annual Design Competition for high school students.

4. A Coherent Plan for Growth in Excellence and Impact at Boston University

This section summarizes Actions, Aspirations and Metrics to synthesize our educational goals, our research vision and our aspirations for engaging innovation into a coherent plan. The following section summarizes the approach to acquire the necessary resources. The core of our **Hiring Strategy** assumes:

- Net growth of 15 faculty to reach steady state of 125.
- Total hiring (growth and replacements): 20 faculty over five years; 40 over 10 years.

Future hiring should target the best and the brightest who passionately want to work on important problems in their respective fields. Added value to the College and University as a community is key -- individuals who take us to a new and/or more exciting level of impact in niche areas that Boston University can sustain. In that regard, we will consider three criteria. First, to sustain excellent educational programs at the undergraduate and graduate levels the data compel targeting net growth in BME and ME while stabilizing divisional faculty size. Second, we plan to recruit consistent with the College's and University's potential to impact the life sciences and quality of healthcare and life, energy, security and information systems. Thus, while faculty recruiting should sustain leadership or potential in interdisciplinary areas such as photonics, nanotechnology, MEMS/NEMS, bioengineering, materials, acoustics, etc., the College must prioritize strong efforts in these respective application areas. This calls for an immediate increase in hires in energy and healthcare. Finally, we need to create sustainable programs in technology innovation and in technology translation in a fashion that also impacts our new suite of professional master's programs. Taken together our hiring strategy will target:

- Net growth in faculty in energy & sustainability (~ 4-5 faculty).
- Net growth in faculty working on living systems & quality of life (~ 4 faculty).
- Some growth in information related challenges and in security systems (~ 3 faculty total).
- Distribute the remaining net growth (~ 4 lines) as needed.
- Ensure net growth in BME and ME of about 4 faculty each.
- Add ~ 2-3 faculty linked to both divisions which also enhance ECE and ME teaching and research.
- Create a Professor of Practice in Technology Innovation and a Professor of Practice in Translational Research, both of which will simultaneously help sustain our professional master's programs.
- Distribute the ~ 25 anticipated replacement hires over the next 10 years consistent with the above strategy and subject to periodic review based on program student sizes and research strengths.

Creating Undergraduate Engineering Education for the 21st Century: The Societal Engineer

ACTIONS & ASPIRATIONS

- Amplify student passion for engineering and addressing society's challenges in the early years.
- Provide a suite of degree/programmatic enhancements including:
 - expanding and enhancing our Energy and Nanotechnology concentrations;
 - creating a new Technology Innovation concentration and funding "Student Innovation Scholars";
 - amplifying ENG student awareness of the relationship between technology, society and public policy;
 - partnering with BU for "4+1" BS-Master's in ENG., Education, COM, SMG, and Public Health; and
 - creating a holistic program for student mentoring.
- Enable or require all students to engage in "experiential" components by:
 - creating more Undergraduate Research Fellowships and experience-linked scholarships;
 - amplifying internship and co-op opportunities;
 - increasing size and options for study abroad; and
 - increasing opportunities for Engineering students in community service and/or global health.
- Endow (name) Innovative Engineering Education Faculty Fellows.
- Explore creation of a Center for Innovation and Technology Education and endow a Professor of Practice in Technology Innovation and Entrepreneurship to lead the program.

METRICS & GOALS

- Entering class ~ 350 per year; total undergraduate population of 1,300.
- Yield 20-25%; retention of 90% through senior year.
- >95 % placement rate within six months post graduation.
- Evidence of student and employer satisfaction and passion for our programs.
- Portfolio of Alumni in Leadership Positions 5-10 year post-graduation including a suite of “Star Alumni” and Alumni Advancing the Innovation Ecosystem.

Graduate Engineering Education: Foundations for Transformative Research for Society

ACTIONS & ASPIRATIONS

- Stabilize divisions of Materials Science and Engineering, and Systems Engineering by:
 - ensuring sufficient faculty lines exist to offer program depth and breadth; and
 - establishing core facilities for enhancing research and cultural infrastructure.
- Create important cross-disciplinary certificate programs central to engineering, such as
 - Engineering Systems and Synthetic Biology; and Clean Energy and Sustainability.
- Resource a suite of professional Master of Engineering programs.
- Establish opportunities and mentors for education in translational research.
- Attract funding to recruit and retain high-quality Ph.D. students through
 - extramural research, training grants, corporate partnerships and endowed fellowships.

METRICS & GOALS

- Recruit ~ one new Ph.D. student per research-active faculty member each year.
- Graduate 55-60 Ph.D. students per year, or about 0.6 Ph.D.s per faculty member per year.
- Graduate >50 new professional master’s students per year.
- Aspire for graduates to become leaders in their fields within 10-15 years post-Ph.D.

Institutional Excellence: Addressing Crucial Challenges in Society Through Engineering Science

ACTIONS & ASPIRATIONS

- Recruit 40 faculty (new and replacement) who provide foundational scholarship while ensuring leadership in and impact on the applied life sciences and healthcare, sustainability, security and information systems for society.
- Enable translational engineering programs to catalyze innovations that impact our society and our economy, particularly in healthcare and energy.
- Create a *Center for Clean Energy and Sustainability* to generate research on clean energy technologies and systems that can rapidly be adopted by various sectors of society.
- Create an *Engineering’s Systems and Synthetic Biology Center* to impact personalized medicine and fight infectious disease world wide.
- Create a competitive vision to apply for a *Materials Science and Engineering Research Center*.
- Consider creating an *Assistant Dean for Corporate Relations* to run a coherent, exciting, and high-impact partnership program with Industry in research, distance learning, internships, etc.
- Create 8–10 endowed (named) professorships to retain and attract star faculty.
- Endow (name) the *Distinguished Faculty Fellows* to retain our best mid-career faculty.
- Create *Distinguished (named) Lecture Series* on energy, personalized medicine, future of engineering, etc., as well as named awards for students and faculty.

METRICS & GOALS

- Extramural research funding.
- High-impact publications and citations (scientific and mainstream media).
- Targeted major funding success (government, foundations or philanthropy).
- Licensing and entrepreneurial success.

Capital Projects and Capital Improvements

- Identify 20,000 net square feet (nsf) of growth space for the next five years, 35,000-40,000 nsf of growth space over the full 10 years, including space for several new research and education centers.
- Create new core facilities for Materials Science and Engineering (1,000 nsf).
- Increase student learning space (2,000 nsf).
- Upgrade Student (Machine) Design and Computational facilities (~ 5,000 nsf).
- Enhance division space(s).

5. Achieving Our Vision:

GOAL 5: 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

Achieving our vision will require approximately \$95 million over the next 10 years. We believe about \$30-35 million can derive from institutional investments, increased research funding success, and entrepreneurial programs consistent with our strategic mission and goals. The remaining \$60-65 million will need to derive from external sources. Generally, the funds will be used 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 the quality of life for students, faculty and alumni. 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.

Creating a Framework to Achieve Goal 5:

- Sustain College-level advisory boards comprised of leaders who are 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 at the programmatic level.
- Identify and/or create new revenue from sources such as:
 - new professional master's degree programs;
 - increased external research funding attracted by the faculty;
 - increased royalty return from faculty inventions;
 - workshops and/or short courses in thematic areas held at BU or at specific local companies.
- 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 about the programs and activities supported by the College of Engineering's Annual Fund with a goal of tripling donations within five years



Programs and Activities Supported by College of Engineering Annual Fund: *Enhancing Student Quality of Life*

- Undergraduate Research Fellowships
- Summer Internships and Housing
- Student Organizations
- Student Travel to Professional Meetings
- Career Mentoring, planning, placement activities
- Guest Speaker Series for Student Enrichment
- Teaching Facilities: Equipment, Computers, Communication
- Research & Educational initiatives to enhance student interactions
- Enhancement of student learning and social space
- Student-Alumni Networking and Social Events
- Newsletters and marketing initiatives
- Tutoring and teaching assistance

confidential

Financial Needs

We have parsed our financial needs to three broad categories. *Educational Excellence* includes the sustenance of first-class educational programs and facilities (e.g., teaching and research labs), including the capacity to attract high-quality undergraduate and 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

educational initiatives (such as in engineering pedagogy or technology innovation). Some specific Campaign goals would be:

- Endow *Innovative Engineering Education Faculty Fellows*: \$250,000/each or \$500,000 total;
- UG Programs: \$100,000/year or \$2 million endowed;
- Center for Innovation & Technology Education (CITE): \$5 - 7.5 million;
- Create (10) Endowed Graduate Fellowships at \$1M each: \$10 million;
- Major Research/Graduate Education Core Facilities For Materials Characterization: \$4 million.


Institutional Impact and Faculty Retention involves the endowment and naming of professorships to attract and retain our most extraordinary and most highly recruited faculty members, and creating and sustaining the capacity to practice world-class research that leads to transformative technologies to meet society’s challenges. Some specific goals would be:

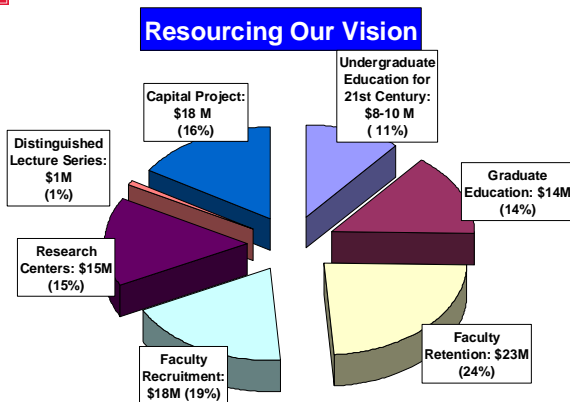
- Recruitment and Retention of Best Faculty
 - Create 8 Endowed Professorships at \$2.5 million each: \$20 million.
 - Endow 5 Distinguished Faculty Fellows at \$600,000 each: Total \$3 million.
 - Start-up funds to recruit 40 new faculty: \$18 million.
- Create High Impact Research Centers
 - Engineering’s Synthetic and Systems Biology
 - Clean Energy and Sustainability
 - \$7.5 – 10 million each: Total of \$15-20 million.
- Create 4 named Distinguished Lecture Series at \$250,000 each: Total \$1 million.

Capital Projects to improve the College environment relates to raising funds for new or upgraded space for the College to expand in faculty size, educational facilities, and research infrastructure. Some specifics:


- Identify and renovate 30,000 square feet of growth space for new faculty over the full 10 years @ \$400-500/sf: \$15 million. Possible Themes:
 - Mechanical Engineering & Materials Science OR
 - New Information Science and Systems Engineering
- Enhanced Division Space (~ 2000 sf): Total: \$500,000.
- Create new 500 sf Core Facilities for Materials Science and Engineering: Total \$400,000.
- Student Learning Space (2000 sf) @ \$250/sf: Total = \$500,000.
- Upgrade Student (Machine) Design and Computational Facilities (3000 sf @ \$500/sf): Total = \$1.5 million.

The above needs can be captured in two formats:

 College of Engineering



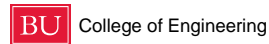
– \$95 Million of which 2/3 would derive from Capital Campaign, ~\$30M from BU

 College of Engineering

**Campaign Goals:
Alternative Presentation**

• Faculty:	\$41.0 Million
– Faculty Retention (\$23 M)	
– Faculty Recruitment (\$18 M)	
• Students & Education:	\$14.0 Million
– Innovative Educ. Faculty Fellows: (\$0.5 M)	
– UG Experiential Programs (\$2.0 M)	
– Educational Center for Innovation (\$5 Million)	
– Graduate Fellowships (\$10 Million)	
• Programs:	\$16.0 Million
– Research Centers in Syn. Bio & Energy (\$20 M)	
– Lecture Series (\$1 M)	
• Facilities:	\$22.5 Million
– Core Facilities (\$4 M)	
– New Thematic Faculty Space (ME or Info) (\$15 M)	
– Division Space (\$1 M)	
– Student Learning Center (\$1 M)	
– Student Machine Shops and Computational Facilities (\$1.5 M)	
• TOTAL:	\$93.5 Million

To finance these goals we will need a mixture of institutional investments, entrepreneurial activities by the College (e.g., professional master's program) and a well-designed and implemented approach to philanthropy. Generally funding the plan will can occur as follows:



Source of Funds

• Boston University	
– Annual Reinvestments \$2M/yr	\$20 M
– Professional MEng \$1.0 M/yr	\$10 M
• Annual Fund @ 0.4 M /yr	\$ 4 M
• Capital Campaign (targeted):	\$ 60 M
• TOTAL	\$ 94 M