

Department of Mechanical
and Industrial Engineering
(MIE)

Strategic Plan
2011-2016

January 24, 2011

Northeastern University
Boston, MA

Executive Summary

Mechanical and industrial engineers have traditionally led the design, development and manufacturing of products and devices for improvement and enrichment of human life. As a community we continue to expand this role, moving into areas as diverse as health systems engineering and renewable energy. Accordingly, student interest in Mechanical and Industrial Engineering (MIE) has seen an unprecedented rise, with little indication of slow-down.

The ***Mechanical and Industrial Engineering (MIE) department*** at Northeastern University instills technical knowledge and lifelong learning capabilities to our graduates through cooperative education and inspires students toward ethical conduct in their professional and personal lives. In addition, our faculty members with their graduate students pursue ***use-inspired and fundamental research*** in many emerging fields. We pursue the highest level of scholarship in key core technologies for the future, including alternative energy, nano-bio-physiology, and sustainable materials engineering. In addition, we maintain ***two highly visible federally-sponsored Centers***, the Center for High-Rate Nanomanufacturing (CHN) and Center for Healthcare Optimization Technology (CHOT).

This Strategic Plan, developed by the faculty of the MIE department, and clearly aligned with both the University agenda and the *Grand Challenges of the National Academy of Engineers*, describes a set of specific and overarching goals to further enhance our extremely productive and nationally and internationally recognized faculty. Our *Vision* is to capitalize on our current strengths, and opportunities for student and faculty recruitment, to transcend disciplines and attack relevant scientific and societal needs via research, and maintain a student-centered curriculum driven by an individual's own educational agenda, to train the citizenry necessary to expand and implement new solutions. To that end, ***our goals over the next 5 years are ambitious***; they include: (a) a multi-thrust research agenda that leverages key strengths of individual faculty to synthesize interdisciplinary investigations, (b) a sustainable plan to ensure and promote balanced composition and (c) a novel educational plan that allows us to address student ambitions directly via a multi-tiered and flexible undergraduate curriculum. To realize these goals a recurring theme of this strategic plan is a ***demonstrable and fully-justified need for additional faculty resources in targeted areas***. Such support from the University is critical to enable us to disseminate cutting edge knowledge to a burgeoning number of students keenly interested in the degree programs we offer and to continue to excel in knowledge creation through translational, visible and highly-relevant research.

The Plan is structured in the following way: After the *Departmental Mission* and a statement of *Degree Offerings*, we discuss the *State of the Department*, including current degree offerings, student enrollment and faculty hiring, as well as research expenditures and successes over the last decade. Departmental metrics are directly compared with leading institutions and NSF-tabulated national figures, providing context for the next section, *Strategic Issues and Blueprint for the Future*. Here we will present specific goals and action items to meet our aggressive goals in the above *Vision*, as well as potential hurdles and metrics for success.

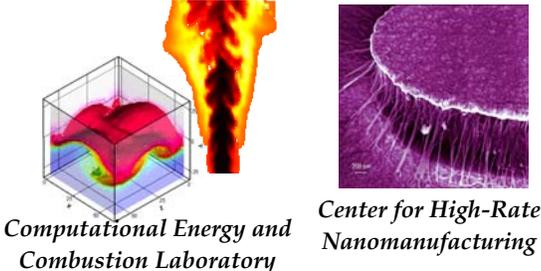
Departmental Mission

The departmental mission has been developed in conjunction with students, faculty, alumni and industrial constituents. These participants serve to characterize the Mechanical and Industrial Engineering programs at Northeastern University and to guide the educational activities of the department in its support of the college and university missions.

Our mission is to educate persons for professional and technical excellence, to perform research to advance the science and practice of engineering, to engage in service activities that advance the department, the university and the profession, and to instill in ourselves and our students habits and attitudes that promote ethical behavior, professional responsibility and careers that advance the well-being of society.

Graduates of our programs will demonstrate technical excellence in their chosen fields, anticipate and respond to societal changes and develop careers with depth and flexibility, while retaining a professional and intellectual thrust throughout.

The remainder of the plan will illustrate further specificity to the Departmental Mission.

<u>EDUCATION</u>	<u>RESEARCH</u>	<u>SERVICE</u>
		
<i>Student presentation & 3D drafting</i>	<i>Computational Energy and Combustion Laboratory</i>	<i>(PACT) Project for Assistive Canine Technologies</i>
		
<i>Quality Managers: in-class peer facilitation</i>	<i>Virtual Environments Laboratory.</i>	<i>BELLA – Bringing Education & Lifelong Learning to Adults</i>

The MIE department is committed to the excellence of knowledge *dissemination*, knowledge *creation*, and responsible *interaction with society*. Our activities include (left) award-winning, nationally recognized education and educational research, (center) cutting-edge interdisciplinary research to meet key challenges of the next century, and (right) innovative outreach activities to link research to practice & societal benefit.

Departmental Degree Programs

The department of Mechanical and Industrial Engineering offers programs of study leading to two Bachelors, five Masters and two Doctoral degrees as follows:

1. BS programs in both *Mechanical Engineering* and *Industrial Engineering*, accredited by ABET, Inc.
2. MS programs in *Computer Systems Engineering*, *Engineering Management*, *Industrial Engineering*, *Mechanical Engineering* and *Operations Research*.
3. PhD programs in both *Mechanical Engineering* and *Industrial Engineering*.

Two faculty members, Professors *Kowalski* and *Ruberti*, direct degree-granting programs administered at the college level: the MS in *Energy Systems Integration* (Kowalski) and the MS and PhD in *Bioengineering* (Ruberti). In addition, several of our faculty members chair and participate in doctoral dissertation committees in the Interdisciplinary PhD program.

Right: The MS degree program in Energy Systems integrates *technological fundamentals* with critical aspects of *implementation* and financial planning.



Left: The new PhD in Bioengineering integrates research and expertise across several departments to *train the next generation* of clinically and medically relevant engineering innovators.

Current State of the Department

I. Students

a. Undergraduate Students

The undergraduate student body has been steadily increasing in size in both Mechanical and Industrial Engineering for about the last ten years. **Figure 1** shows the number of students in each graduating class from 2004 through 2010. The data shown for 2011-2015 give the current number of students in the classes scheduled for graduation in those years. The number shown for 2015 includes a projected 45% of 160 freshmen that are currently undecided, and are predicted to choose either ME or IE. January admissions and transfer students can be expected to increase this number even further. It is important to note that the increase in ME student enrollment over the last ten years is greater than 210%; this number is significantly larger than any of the enrollment or degrees-granted *nationally*, as reported by ASEE in 2009 (see **Table 1**).

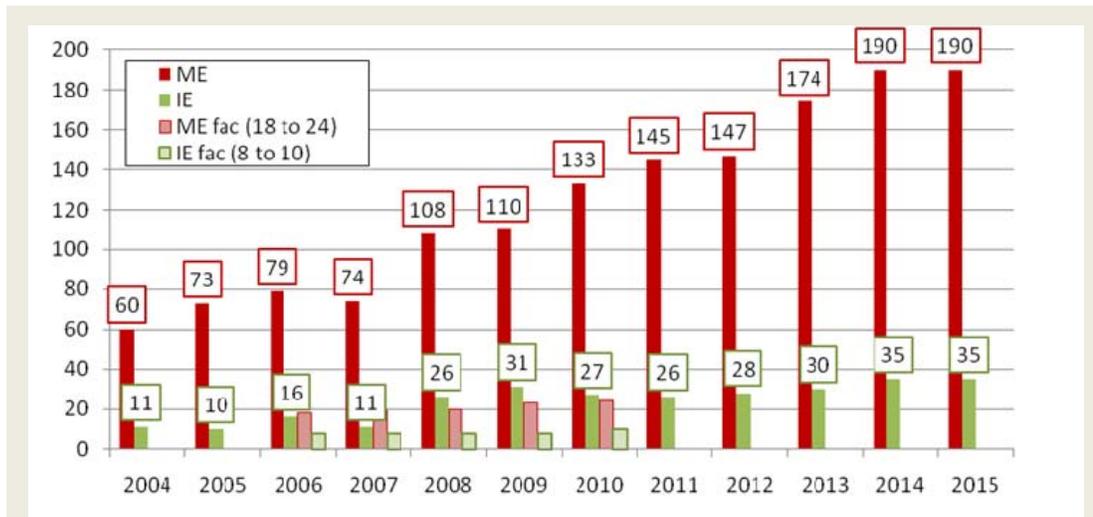


Fig.1. MIE Enrollment by graduation year. Red and green bars indicate ME and IE, respectively. Note that the number in 2015 includes a projection of approximately 59 ME and 13 IE students who are currently undecided. Note that between 2006-2010 ME S/F climbed from 4.4 to 5.5, and IE S/F climbed from 2 to 2.7.

Table 1. NATIONWIDE ENROLLMENT IN ENGINEERING PROGRAMS (ASEE)

US Metric	2000	2009	% Increase
Eng. College Enrollment	342,000	427,000	25
ME Enrollment	64,000	91,900	44
IE Enrollment	12,300	14,200	15
Eng. BS Degrees	63,800	74,400	17
ME BS Degrees	13,000	17,400	34
IE BS Degrees	3,500	3,500	--
Eng. MS Degrees	30,200	41,600	38
Eng. PhD Degrees	6,000	9,100	52
ME MS Degrees	3,400	4,000	18
ME PhD Degrees	800	1,200	50
IE MS Degrees	2,500	3,000	20
IE PhD Degrees	230	300	30

b. Graduate Students

The numbers of students in both the Masters and Doctoral programs have been steadily increasing as well. **Table 2** shows the Fall 2010 number of enrolled students in each of the five MS programs offered by the department.

Table 2. MIE MASTERS PROGRAMS and ENROLLMENT

Computer Systems Engineering	64
Engineering Management	97
Industrial Engineering	60
Mechanical Engineering	121
Operations Research	21
Total	363

Figure 2 shows the Fall semester count of students enrolled in PhD programs in the MIE department for each of the last eight years. It can be seen that this number has more than doubled from 2003-2010.

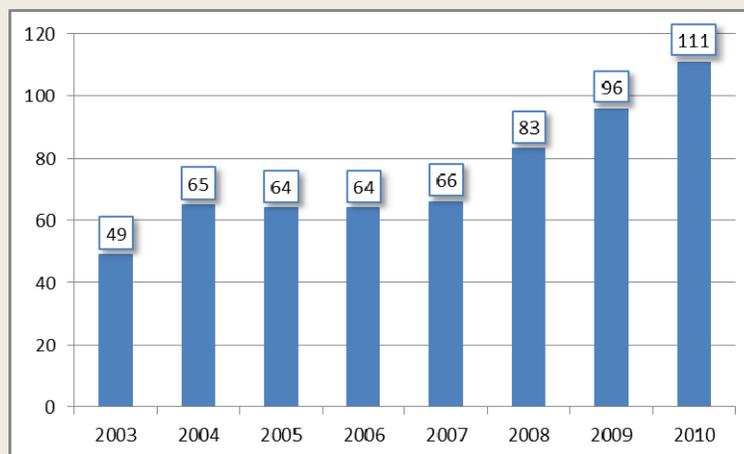


Fig.2. Fall semester count of students enrolled in MIE Ph.D. programs, per year.
Increase rate doubles the national increase rate.

II. Faculty

The departmental faculty members are nationally and internationally recognized in their research fields and are active in teaching, research and service. There are 24 Mechanical Engineering faculty and ten Industrial Engineering faculty members in the department. Among them, 15 faculty members are Fellows of professional societies such as the American Society of Mechanical Engineers (ASME), American Society of Engineering Educators (ASEE), American Society for Metals (ASM) International, Institute of Industrial Engineers (IIE), Society of Tribologists and Lubrications Engineers (STLE) and Society of Automotive Engineers (SAE). Several are Fellows of two professional societies. Many of our faculty members are involved in editorial boards of technical journals. Four members of the faculty hold the designation *College of Engineering Distinguished Professor* and two professors hold endowed Chair positions (right).

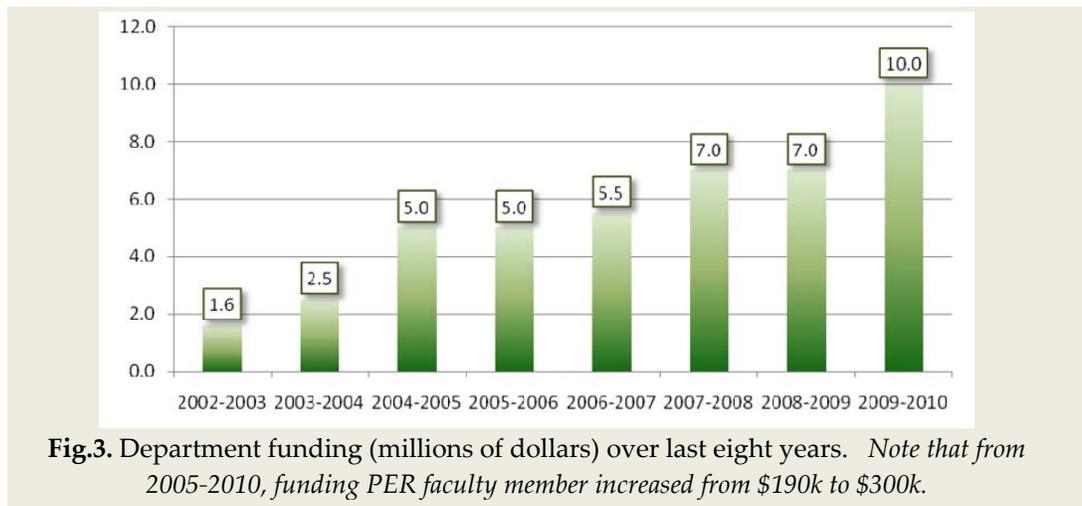


Ahmed Busnaina,
William Lincoln Smith
Professor



John W. Cipolla,
Donald W. Smith
Distinguished Professor

III. Research



Faculty members in the MIE department are leaders in use-inspired research in emerging fields, including *Nanotechnology* (National Science Foundation – NSF - supported Center in High Rate Nanomanufacturing, CHN), *Healthcare Systems Engineering* (Center for Health Organization Transformation, CHOT, supported by Veteran Affairs and NSF Industry University Cooperation Research Center), *Energy* (Combustion), *MicroElectromechanical Systems* (MEMS), *Materials Science*, *Virtual Reality*, *Prognostic Health Management*, *Robotics*, *Bioengineering*, *Physiology* and *Environmental Issues in Nanomanufacturing*. Most of our faculty members support their research from external sources such as federal agencies, foundations and private companies. **Figure 3** shows the funding history of the department for the last eight years. Note that when we consider the increase in faculty members, funding *per* faculty member still increased from \$190k to \$300k from 2005-2010.

Strategic Issues and Blueprints for the Future

I) GOALS FOR ACADEMIC PROGRAM

ACADEMIC VISION STATEMENT: A successful MIE department of the future will maximize its use of the advanced pedagogic tools, provide a more flexible, customizable and personalized undergraduate education, extend its academic reach through distance learning and generally provide more and better content in both undergraduate and graduate curriculum offerings. At the same time, economics dictates that a steady revenue source is cultivated through improved and expanded professional master degrees. The MIE proposed academic plan meets these challenges while maintaining the uniqueness of the integrated learning model and Co-op program which drive so many students to our program.

Implementation and Structure: Goals

MIE has developed and maintained an increased student demand and retention not only due to the highly visible nature of our research but also via the high quality of our undergraduate curriculum and its seamless coupling with extensive co-op, research and extra-curricular activities. Our overall goal for teaching is to expand our abilities and improve the attractiveness of our program, relative to peer institutions, while still maintaining our unique and highly positive characteristics. Specific goals follow, along with critical needs to meet these goals.

- 1) ***Increase student enrollment via improved visibility.***
- 2) ***Increase student retention via improved faculty-student interaction & program cohesion.***
- 3) ***Implement ASEE Research Findings into Teaching Best Practices***
- 4) ***Increase interdisciplinary and intellectual property (IP) aspects of Capstone design.***
- 5) ***Provide opportunities and infrastructure for students to study and work abroad***
- 6) ***Expand the number and effectiveness of professional MS programs.***
- 7) ***Create New PhD in Materials Science and Engineering (MSE).***
- 8) ***Increase the use of technology in instruction.***

The first five goals regard **undergraduate** education. As our Mission demands the effective education and training of engineers of the highest quality, it also demands that we continually ask the question, “to what end?” Graduating students are being attracted and recruited to new opportunities, as quantified in an NSF study showing that a large percentage are gainfully employed in traditionally non-engineering careers. These include medicine, law, business, entrepreneurship and diplomacy, for example. To

address this reality, we must not only continue to provide the robust engineering background necessary for NU graduates to contribute to technology and society, but we must recognize and cultivate the critical skillsets that attract other fields to our engineering graduates. In addition,



it would be extremely valuable to develop the means to determine what paths our students choose, early on, and allow personalized pursuit of those paths, via challenging research opportunities, flexible curriculum, and dedicated advising. Fortunately a recent influx of new research-centered faculty has led to a year-by-year increase in undergraduate opportunities for our students, and we will aggressively continue this practice. Dedicated advising is in place, both in name and practice, starting from our unique synergy with Gateway instruction, and continuing through Co-op. Thus, we must pursue a more flexible curriculum, but with the specific goal of efficacy in student training, career selection and post-graduate success. This will be enabled via the following blueprint.

1. Increase student enrollment via improved visibility. Enrollment is expected to continue to increase, not in the least part due to employment potential for MIE's. Despite the recent turmoil in the job market and economic recovery, there has been good news for both ME & IE job prospects. In 2008, a survey of college recruiters published in Job Outlook 2008, ME graduates were ranked second highest in market demand (behind Accounting). The mean starting salary for 2009 ME graduates (Bureau of Labor Statistics, BLS) was \$59K. For IE, the mean 2009 starting salary was \$58K, and according to the BLS, demand for Industrial Engineering graduates is expected to grow "faster than the average" among all occupations over the next decade. Nevertheless, we do not intend to be passive in this environment. We will continue to actively recruit new students via the following visible avenues:

- A dynamic, interdisciplinary and relevant research program (see **Section III**) with clear opportunities for robust undergraduate participation.
- Participation of MIE faculty in key aspects of the First Year experience.
- Participation of MIE upperclassmen in the First Year experience.
- Support and expansion of MIE-based extra-curricular activities and clubs, with integration of curriculum-based skills.
- Support for invited speakers and advisory board members comprising members of non-traditional and emerging fields for engineers.

How do the above enable career-minded curriculum flexibility? - The above bulleted strategies provide greatly improved contact with students, and plants the seed of choice in the students' minds. It starts them off on the remainder of the undergraduate career by strengthening a personalized context for all they will learn in the next four years. Note this is parallel to one of the NAE Grand Challenges.

2. Increase student retention via improved faculty-student interaction, and program cohesion. We continuously assess our program via indicators, objective markers, and student and Co-op employer surveys. We have targeted key opportunities for improvement, including relevant software instruction, extra-curricular activities and research opportunities, and will implement such changes over the next five years. Note that growing undergraduate and graduate programs has led to a high student-faculty ratio (**Table 3**). This is higher than several of our *private peer-institutions*, and significantly higher than some nationally ranked public

programs such as *Georgia Tech* (S/F = 4.2) and *Michigan State* (S/F = 4.2). More locally, the combined ME/IE programs at *UMASS-Amherst* has a BS degree/faculty ratio of 3.7 compared to NU's combined 4.9. Our department feels that this is an issue that must be addressed as both student retention and research productivity are at risk. Large section sizes and excessive use of part time faculty and graduate student assistants in teaching classes will have the effect of diminishing the attractiveness of attending NU for mechanical engineering. Additional faculty will require additional space (office/lab etc) as well as technical and office support staff.

Table 3. ME BS DEGREES 2009 – NATIONWIDE ASEE SURVEY

School	Degrees	Faculty	S/F Ratio
RPI	152	N/A	N/A
WPI	141	31	4.5
Drexel	139	26	5.3
Northeastern	138	24	5.8
RIT	123	24	5.1
MIT	121	69	1.8

*(RPI Department is joint with Aero and Nuclear)

** Further ASEE data showing ratios only:

Brown – 1.41; Stanford – 1.6; Caltech – 1.2; Yale- 0.9

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educating the S/F ratio of the MIE department is one necessary way to improve student retention via *connection*. **A further method that we will explore** is the threading of critical, useful and visible concepts throughout the curriculum, from first-year to Capstone. This can be done initially via pilot efforts to hit conceptual ‘anchor points’ in upper-class lectures that are tied to competencies from previous courses. It is expected that this simple effort in taxonomy would lead to further conversation and more robust threaded connections between instructors, resulting in a curriculum that builds upon itself, and results in increased student investment with each increasing year. The department may capitalize upon the efforts of our award-winning Gateway instructors to spur this effort. *Note that this last point aligns with the “Personalized Learning” NAE Grand Challenge.*

How does the above enable career-minded curriculum flexibility? - Flexibility in a curriculum can arise in several ways. The traditional method is to introduce several ‘tracks’ for students to pursue, based on a cluster of classes, and a finite number of choices. Our strategies to enhance student connection and provide individualized research and entrepreneurship opportunities will provide flexibility in another way, presenting a potentially limitless number of choices, by providing each student with the ability to select the *context* in which he or she absorbs our technical curriculum. The next two points bolster this new strategy to curriculum presentation.

3. Implement ASEE research findings into teaching best practices. Several members of the MIE Faculty are renowned and award-winning researchers in ASEE. Their

research focuses specifically on the effectiveness of new teaching styles and logistics, as well as varying needs of students at different levels of undergraduate careers. They consistently fold research discoveries into their own courses, and we will initiate such practice in core and elective courses in upper-level MIE curriculum.

4. Increase interdisciplinary and intellectual property (IP) aspects of Capstone design.

NU's Capstone program is already distinct from any comparable program at our peer institutions. With an influx of new research faculty and expanding definitions of ME and IE, we will capitalize upon this via an active and aggressive campaign for more externally-sponsored projects and more flexible projects tailored to align with the student's pre-career tracking. Note that at present the Capstone design facilities as well as appropriate design faculty are strained. Additional undergraduate project space and additional faculty with expertise in design will be required in the very near term.



5. Provide opportunities and infrastructure for students to study and work abroad. Students desire opportunities to study and do Co-op abroad. The ME and IE curricula will need to be rethought to allow for such interruptions in the normal classroom sequence of courses. Key to this will be a more flexible curriculum, and we are pursuing strategies for this, starting with a directed study of the students' first year. Note that this goal is in-line with the University's overall agenda to attract more high-quality students. This will be a significant undertaking, as we are constrained by ABET criteria for all changes in outcomes and objectives.

We expect the above goals will have the following positive effects:

- Attraction of higher-quality students to a personalized education.
- Increased retention of students who take control of their education.
- Increased in-class performance of students who learn for *individualized reasons*.
- Increased participation of students in research, and application of personalized classroom knowledge to laboratory and extra-curricular discovery.

The next goals/actions will help to expand our research visibility, intertwining of education with those research activities, and implementation of dissemination to a wider audience, elevating Departmental reputation in practice.

6. Expand the number and effectiveness of professional MS programs. This represents a significant opportunity for NU and MIE as it not only increases our visibility for directly translatable education, but also provides valuable financial support under the RCM budget model. New programs where we already have expertise are *Systems Engineering* (MS then PhD), *Healthcare Systems Engineering* (MS), *Nanoengineering* (MS), *Mechatronics* (MS) and *Materials Selection and Development* (MS). Paramount to the success of this effort will be an oversight activity, ensuring that we maintain quality by not diluting educational resources during expansion. The MIE department houses key faculty leaders in existing successful MS programs, and we will capitalize upon their experience for the seamless construction of these new candidate programs. To start this effort, the MIE department will appoint an interdisciplinary committee of 3-5 faculty to examine existing teaching and research expertise, and map this to growing national opportunities for MS programs.

7. New PhD in Materials Science and Engineering (MSE). Strategic hiring over the last 5 years has provided the MIE Department with a critical mass of faculty with expertise in Materials, including nanomaterials, biomaterials, and industrial material processing. A PhD in MSE would attract a new crop of talented graduate candidates to a competitive interdisciplinary program. While we will invite faculty from other Departments to participate in our curriculum, however, the center of the program will reside in MIE.

8. Increase the use of technology in instruction. Video streaming versions of three of our MS programs now enable students to complete their degrees fully online. In the next five years this flexibility must be further developed so that all departmental MS programs can be completed online. Online versions of some undergraduate coursework will provide additional flexibility for 4 year/2 Co-op students wishing to study abroad or on remote Co-op assignments. There are numerous emerging technologies designed to broaden the reach and improve the effectiveness of instruction. The MIE department will appoint a standing interdisciplinary committee of 3 faculty to continuously examine emerging pedagogical tools and provide recommendations for their implementation. *Note that this item aligns with the “Engineering the Tools of Scientific Discovery” NAE Grand Challenge.*

II) GOALS FOR COMPOSITION

COMPOSITION PLAN VISION STATEMENT: A more successful MIE department will be highly efficient, have global impact and will be appropriately diverse. Faculty members provide the critical deliverables of the MIE department (knowledge dissemination, knowledge creation and service) in the form of lectures, grant applications, manuscript submissions, external service and external speaking engagements. To reach the next level and achieve status of aspirant departments requires optimization of faculty effort along with *quality growth* of faculty in carefully targeted areas. The composition plan is designed to optimize the output of each faculty member through enhanced administrative support and improved graduate student quality. The aggregate research impact of the MIE faculty will be improved through continued careful hiring of high quality, diverse faculty members.

Implementation and Structure: Goals

The MIE department composition goals are to achieve a well-balanced spectrum of high-quality faculty, staff and students capable of efficiently producing high-quality deliverables to the customers of the department. The MIE department plans to rectify a significant imbalance in the faculty/student ratio and reduce excessive administrative burden on faculty. The composition plan is designed to achieve these goals while raising the already very high academic and diversity standards for hired faculty and incoming graduate students to those consistent with standards of aspirant departments. The MIE department specific goals for composition are:

- 1) Improve our graduating student (BS degrees)/faculty ratio to 3.5.**
- 2) Reduce excessive administrative burden on faculty**
- 3) Take advantage of economics to hire strong, diverse candidates in target areas**
- 4) Improve department aggregate research impact through strategic hiring**
- 5) Improve graduate student quality**

MIE has always strived for a balanced, well-represented spectrum of faculty, staff and students. Several of our faculty members (including our three most recent hires) are from typically under-represented demographics and serve as Associate Center Directors, PI's on multi-investigator research projects, Senior Teaching Associates, and award-winning educational researchers. Department leadership has demonstrated a commitment to mentoring, providing research and professional support, and will continue to promote a well-balanced practice. However, the Department is also seeking further urban engagement and research dissemination, to align ourselves with the University mission and expand the utility of our fundamental scientific activities. Several examples of this are collaboration/education activities with disabled or ex-military populations, or informal science education and policy discussions with senior citizens of Boston, via NSF-grants such as Bringing Education and Lifelong Learning to Adults (BELLA).

III) GOALS FOR RESEARCH MISSION

RESEARCH PLAN VISION STATEMENT: To complement the high-quality array of both disciplinary and interdisciplinary research being conducted in the MIE department, three thrust areas have been identified on which to focus the MIE research enterprise which will optimize available and prospective resources, maximize societal impact and significantly raise the visibility of Northeastern's Mechanical and Industrial Engineering department. There are well-recognized enormous challenges and opportunities for innovative, multidisciplinary research in Healthcare Engineering, Energy Systems and Bio/Nano Manufacturing and Mechanics. These three thrust areas take advantage of what Northeastern already does well, target highly relevant societal challenges and provide significant interdisciplinary research opportunities which are likely to persist well into the second half of the 21st century.

Implementation and Structure: Goals

The MIE department is aware of its responsibility to perform socially-responsive, leading-edge, use-inspired mechanical and industrial engineering research designed to produce a significant impact on the quality of life locally, nationally and globally. Specific goals are to:

- 1) Accelerate our rising international reputation in Health Care Engineering by successfully competing for an NSF ERC.**
- 2) Expand on recent efforts in Energy Systems and Sustainability to gain national prominence leading to a competitive application for a federally-funded center.**
- 3) Solidify national prominence in nanomanufacturing and nanomechanics; Expand nano efforts to include a strong biological component.**

Note that the three goals are tied to three different research thrusts. The MIE department houses faculty with a wide range of research expertise attendant to both Mechanical and Industrial Engineering disciplines. Faculty members in the department are pushing the boundaries in their respective disciplines, but are also becoming more collaborative to take advantage of opportunities at the interface between traditional fields. This is consistent with the global push for more interdisciplinary research efforts which combine the expertise of faculty within and across department borders. In the MIE department our goal is to incentivize existing faculty to explore the interface between disciplines and to hire new faculty with a history of interdisciplinary research. [We plan to align ourselves with the declared University research agenda of an interdisciplinary strategic focus on health, security and sustainability.](#) In addition, we are paying close attention to the research opportunities provided at the micro, nano and molecular levels. The MIE department plans to actively form or build on existing faculty clusters in three specific areas: healthcare systems engineering, energy systems and bio-/nano-engineering. Thrusts are listed here, along with anticipated faculty resource needs for critical mass and the ability to be competitive for national funding.

1. Accelerate our rising international reputation in Health Care Engineering by successfully competing for an NSF ERC: Recent political and economic events have exposed a significant need to overhaul the US and Global healthcare delivery system, and *Health Informatics* was identified as one of NAE's Grand Challenges. The unsustainable and rising costs of keeping the population healthy is a significant risk to the nation's productivity and even to US National Security. Our goal is to take advantage of an excellent initial thrust in this area by Professor Benneyan. Two new centers are now in their initial stages but with only a single senior faculty (Professor Benneyan) member advancing the agenda. The extraordinary success of this preliminary initiative requires support to sustain its momentum and place Northeastern at the forefront of Healthcare systems engineering. We currently have an advantage, but this door will close quickly if we do not capitalize. In our estimate, a minimum of **three additional faculty** members are required over the next 5 years to exploit the current opportunities that have been generated and to push NEU towards the generation of an NSF/ERC in Healthcare Systems Engineering. The home discipline for the anticipated hires should be IE and which would support additional course offerings at both the graduate and undergraduate levels.

2. Expand on recent efforts in Energy Systems and Sustainability to gain national prominence leading to a competitive application for a federally-funded center: The end of the fossil fuel dominated global energy supply is a serious topic on the national agenda. Any forward looking Mechanical Engineering department should be aggressively addressing the impact of the dwindling supply of oil and gas through a number of initiatives (also aligned with *NAE Grand Challenges*). In addition, the specter of global warming should also strongly influence any MIE strategic plan. In the MIE department at NEU, there has been a long standing research effort centered on combustion and on the related areas of energy systems (three faculty currently). The department already hosts and manages the COE-based professional MS in *Energy Systems Integration* (run by Professor Kowalski). However, to support and sustain this effort requires an expanded faculty base to engage in research and ultimately to develop a strong PhD program centered on energy systems and sustainability. **Three new faculty** will be required over the next 5 years (excluding replacements) in areas such as energy harvesting, harnessing and storage technologies, green and renewable energy ("green" denoting such areas as carbon capture and sequestration or carbon-free systems). An effort will be made to find candidates who work on the molecular level or incorporate biological systems into energy production or emissions control. We expect that the drive will result in a core faculty capable of applying for a federally-funded center of green energy and sustainability. However, this is a lofty goal given parallel efforts across the nation and our relatively weak position at the moment.

3. Solidify national prominence in nanomanufacturing and nanomechanics; Expand nano efforts to include a strong biological component: This is an exponentially growing international field that is intensely fundamental, attracts

significant funding from multiple sources, is of interest to high-quality students and faculty and will raise the visibility of Northeastern as a leader in cutting edge engineering science. Northeastern has a currently successful NSF Center in *high-rate nano-manufacturing* (CHN) headed by Professor Busnaina. The current facilities are exceptional and should be used to attract faculty and to drive a sustained research effort which expands on the current one. *Biological systems* exert exquisite control at the nanoscale which could drastically accelerate production of molecularly organized systems. Our goal is to build on the current efforts of the CHN, but expand it to include biological self-assembly driven systems. Here we request **six additional faculty** members over the next 5 years, three of which will have a heavy biologically-driven self-assembly research focus and three of which will have a nanomechanical systems research focus, including drug delivery. An effort will be made to ensure that at least one of the biological assembly systems faculty has significant biomaterials training and the ability to successfully compete for NIH funding.

MIE Strategic Plan Summary

The MIE department has demonstrated leadership and growth in key areas of student enrollment and retention, demographic balance, and funded research activities. This *Strategic Plan* describes targeted and non-conservative activities to increase our visibility and excellence over the next five years. Some highlights of the plan include:

- 1. Capitalizing on our *clear strengths in education* for higher enrollment, and leveraging our most innovative teaching faculty to produce creative approaches to increased retention.**
- 2. Capitalizing on our successful professional MS programs, and establishing an infrastructure to pursue new MS programs as part of a departmental agenda.**
- 3. Capitalizing on two of our successful research enterprises in nano-manufacturing and healthcare, to attract new interdisciplinary faculty in line with University goals.**
- 4. Aggressive hiring of faculty is necessary to improve departmental research productivity (through achievement of critical mass in key areas) and to maintain teaching effectiveness (through reduction of the continuously increasing student/faculty ratio). Our analysis has demonstrated not only a need for growth, but also the ability of our department to capitalize on expansion by hiring effectively (illustrated by our consistent increase in funding *per* faculty member from 2005-2010; see Fig. 3)**
- 5. Critical consideration given to faculty hiring not only to enhance the research agenda of the MIE department, but also for continued excellence in teaching and dissemination.**