IOWA STATE UNIVERSITY
Department of Mechanical Engineering

Vision 2025

A Strategic Plan for Iowa State University's Department of Mechanical Engineering

The 2025 Planning Committee
Ted Heindel (Chair)
Robert Brown
Greg Maxwell
Hap Steed
Sriram Sundararajan
Eliot Winer

and the

Department of Mechanical Engineering's faculty and staff

Last revision: May 6, 2008

Table of Contents

1 EXECUTIVE SUMMARY

Children born today will enter our department in the year 2025. Why will they chose to study mechanical engineering at Iowa State University? What kind of department will we be when they enroll? As a community of scholars, how do we envision the department's research, education, and service in the future?

According to demographic trends, today's over-65 population in the United States will nearly double by the year 2025, and state and federal funding for education and research will be far more pressured. The National Science Board has remarked that we now live in a knowledge-intensive economy. How will our department adapt and lead in this changing environment?

To address the above issues, the mechanical engineering department began a broad planning initiative in fall 2007, coordinated by the 2025 Planning Committee. The committee's objective was to outline a path forward so the department can continue to deliver superior performance, make a distinctive impact, and be known for enduring contributions in education, research, and service. The specific charges to the 2025 Planning Committee were to:

- Identify the research areas where we are already strong and best poised for impact, and develop a plan to support and grow those areas into recognized pillars of research excellence
- Evaluate the current status of the graduate and undergraduate educational programs and make plans for their improvement
- Outline professional development opportunities for faculty and staff members
- Recommend initiatives to strengthen the department's shared vision, culture, and sense of community

The planning committee developed ideas and recommendations during: individual meetings with faculty members; lunch-time meetings with faculty and staff on key operational issues; general faculty meetings; 2025 Planning Committee meetings; the department's retreat on January 7, 2008; and other informal meetings and discussions. To assess our current status, we had benchmarking studies of our department conducted relative to other College of Engineering departments; national research-intensive public and private mechanical engineering departments; and mechanical engineering departments at peer and aspirant institutions. Together, these planning activities have set an excellent foundation that we can build upon to reach our objectives, as well as those objectives we share with the college and university.

Our path to 2025 is provided in this roadmap, and it contains plans that can be operationalized in the short term, as well as long-term, more strategic initiatives (see Figure 1.1 for a summary of the ideas captured in this document). In each case, we have emphasized specific and actionable recommendations. The department's top five priorities are to:

1. **Extend our pillars of research excellence.** The department's research portfolio encompasses programs in biological and nanoscale sciences; clean energy technologies; complex fluid systems; design and manufacturing innovation; and simulation and visualization. Our hiring and investments will be strategically driven to support mature and develop emerging research areas.
2. **Strengthen our graduate program.** We strive to enhance the quality and impact of our doctoral degree program, which is the backbone of our research enterprise. Through recruiting targeted students; investing in fellowship and teaching

assistantships; and making programmatic changes, we will increase the quality and productivity of the PhD degree to compete more effectively and better position our research programs for extramural funding and graduate student placement. We will also offer a coursework-only MS option to better serve distance education students, working professionals, alumni, and corporate partners.

3. **Enrich our undergraduate program.** Enrollment in mechanical engineering programs grew significantly both for the department and nationally from 1994–2004, but that trend has recently flattened. Healthy enrollment is welcome recognition of the important role mechanical engineering plays in our society and of our department being a destination of choice. The key challenge facing the undergraduate program is managing our enrollment level while maintaining our heritage of leadership and innovation in education. We will review our program and update our curriculum to ensure it remains fresh and relevant. We will continue to introduce our students to globalization and societal and technological trends; enrich the program with innovative ways of delivering engineering education through technology and pedagogical research; increase the participation of women and traditionally underrepresented minorities in the program; and increase students' quality of life and satisfaction at graduation.

4. **Develop our people.** We are committed to the principle of lifelong learning not only for students, but also for faculty and staff. We will provide both informal and structured mentoring opportunities to support our untenured faculty as they develop successful academic careers. Tenured faculty members will aspire to become widely recognized leaders in their chosen dimension of scholarship. Staff members will pursue opportunities for training and learning new skills to reach their career advancement goals.

5. **Build our community.** We are committed to maintaining and enhancing a culture within the department that is constructive, collegial, prideful, and collaborative. We will organize ourselves and our physical space in a manner that looks to the future and meets our aspirations. We will communicate our goals and accomplishments to our constituents and provide opportunities for our alumni and corporate partners to work with us to attain our shared vision.

Through these five initiatives, we will strengthen our department, our people, our position relative to competing institutions, and the impact we make on society through our research, education, and service.

We believe the department is healthy and strong, and we are well poised for the future. Our students are highly sought-after by industrial employers, and our undergraduate program is particularly impactful, ranking in the top 10 nationally in terms of number of bachelor's degrees awarded, as well as being the most popular major on the Iowa State campus. We are already widely recognized for a number of research programs, and our newly-hired faculty are contributing to these areas, as well as building exciting research programs of their own. We are committed to maintaining these positive indicators.

The mechanical engineering faculty enthusiastically endorsed this roadmap document during a faculty meeting on May 1, 2008.

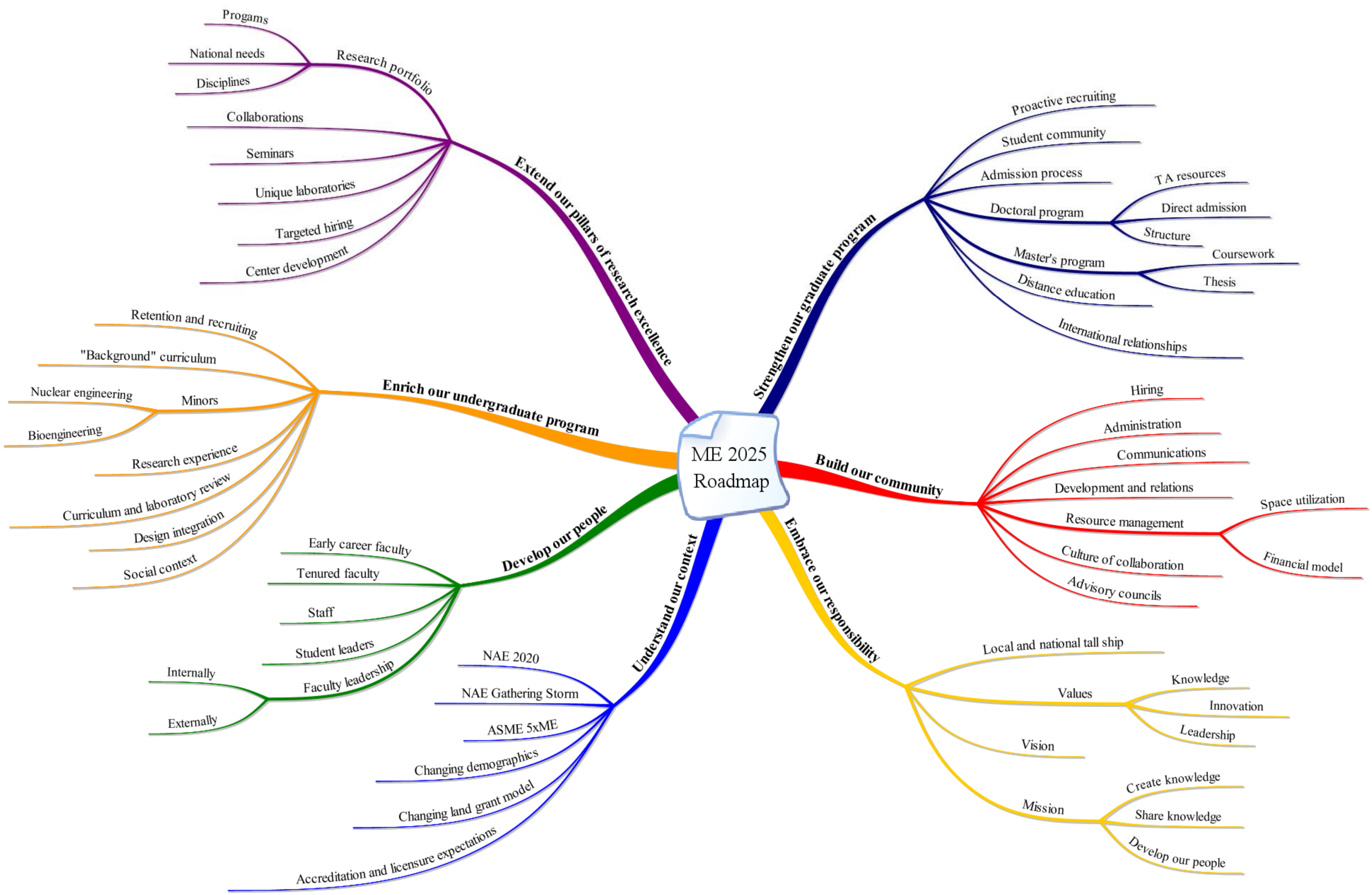


Figure 1.1: Summary of our roadmap.

2 PROCESS

Jonathan Wickert, Chair of the Department of Mechanical Engineering, appointed a strategic planning committee on August 16, 2007. The committee's members were: Ted Heindel (chair), Robert Brown, Greg Maxwell, Sriram Sundararajan, Eliot Winer, and Hap Steed. The committee, identified as the 2025 Planning Committee, was charged with reviewing the department's current status with respect to research, education, and operations, and with developing actionable recommendations for strengthening the department, making it more impactful, and aligning its strategic goals with those of the College of Engineering and Iowa State University.

In addition to multiple meetings as a group, the committee's members held one-on-one discussions with faculty and staff in the department. Each committee member served as a point of contact for several other faculty and staff members. The objective of those individual discussions was to solicit ideas, suggestions, and feedback from across the department. The 2025 Planning Committee Chair regularly briefed the department chair to receive direction and discuss various initiatives, many of which are described in this roadmap.

As specific issues were identified, the committee held lunch-time meetings for all interested parties to discuss ideas, develop recommendations, and catalyze a shared vision. The lunch-time discussions addressed the issues of: the graduate program; design throughout the curriculum; energy as a research thrust area; the undergraduate program; staff development; research and teaching areas of emphasis; and communications, public relations, and advancement. The planning process included benchmarking against other departments within the College of Engineering; research-intensive public and private mechanical engineering departments nationally; and mechanical engineering programs at aspirant institutions.

Faculty discussed ideas developed through this planning process at faculty meetings on August 30, 2007, September 27, 2007, December 6, 2007, March 13, 2008, and May 1, 2008; during lunch-time meetings on September 13, 2007, September 27, 2007, October 4, 2007, October 11, 2007, October 18, 2007, October 25, 2007, November 1, 2007, and April 24, 2008; during weekly committee meetings in the fall semester; during individual and informal discussions among committee members and faculty and staff; during the faculty retreat on January 7, 2008, and through many e-mail exchanges. The planning process was intentionally open, wide ranging, and one in which each faculty member was provided many opportunities to contribute.

The mechanical engineering faculty endorsed this roadmap document on May 1, 2008. This document was written by many people, not just those serving on the 2025 Planning Committee, and it reflects the shared contributions of our community. We consider this to be a "living document" that will be periodically updated.

3 OUR CONTEXT

The mechanical engineering profession and universities in the United States are experiencing a period of rapid change.

More students graduate nationally in mechanical engineering than in any other engineering discipline, and our profession continues to rank among the top-10 fields nationally for employment prospects. Mechanical engineers today work not only in many of the traditional fields one typically associates with the profession, but they increasingly find employment in the emerging areas of communications, information technology, nanotechnology, entertainment, and the life sciences. Information, transportation, transactions, networks, and economic realities have altered the engineering landscape in ways that were unimaginable just a decade ago. Our profession has adapted and responded to those changes, and the national press recently deemed the discipline as being "cutting edge again."[1] Mechanical engineering is a strong, diverse, and impactful discipline, in part, because of its breadth and foundation in engineering science.

The mechanical engineering profession—like many others—is experiencing a period of rapid change. Our planning activity positions us well to prepare now for the future, and we do so cognizant of the broader and changing context that today frames our educational and research programs:

- **Changing times.** With the disappearance of many international barriers and the "flattening" of the world, the department is now judged on an international scale, and we must be able to respond rapidly to change. We think of our competition as being in Europe and Asia, as well as in the United States. We are challenged by the need to narrow the resource and productivity gap with our competing institutions and compete internationally for the best minds through proactive student and faculty recruiting.
- **Changing expectations for engineering practice.** A movement is developing at the national level to require a fifth year of formal education, in addition to professional experience, for one to become a licensed professional engineer. The National Council of Examiners for Engineers and Surveyors supports a requirement—colloquially referred to as "BS plus 30"—that will take effect in 2015 and affect students entering Iowa State today.
- **Changing demographics.** Universities nationwide have seen a record number of applications this year. The high school classes of 2008–2009 represent the tip of the so-called baby boomlet, and fewer students will be graduating from high school in coming years. The Iowa Department of Education forecasts an 8% decline in graduating high school seniors by 2012, and then modest return growth through 2025 to a level some 4% below today's level. These factors highlight the need for retention initiatives and recruiting beyond Iowa's borders. Further, with pressures from healthcare and pensions associated with the aging of the baby boom generation in the United States, it is difficult to foresee an increase in state support of higher education significantly beyond today's level.
- **Changing land-grant model.** In the past, at Iowa State and other public institutions across the country, it was sufficient to expect that state allocations would fully cover operations and new initiatives. Land-grant universities were created to serve the people of the states and support their economic development. That arrangement lasted until just after World War II, when the national responsibility for basic research was passed to universities under funding from the federal government. The corporate sector and others joined the sponsorship of research, which became both a revenue stream and a source of pride.

  Some 25 years ago, states began withdrawing their support as measured by the fraction of state budgets devoted to higher education. As a consequence, many public universities took two steps under the encouragement of their legislatures: they began to charge students more than nominal tuition and they began to raise private funds. The pullback of the state from financial responsibility for higher education is striking. Some "state" universities now refer to themselves as being only "state-affiliated." The fraction of the overall budget from the state for the College of Engineering at the University of Michigan is said to be some 7%. State funding now accounts for some 27% of Iowa State's total budget and 55% of the general fund operating budget. As our Provost has pointed out, state support for higher education was a radical idea when the Morrill Act was ratified in 1862, and it seems that it has become a radical idea again today.

[1] US News and World Report, Best Graduate Schools Edition, March 28, 2008.

- **Changing expectations for engineering education.** Within the last few years, and in response to globalization and demographic and economic factors, several blue-ribbon studies have outlined visions for the future of engineering education.[2,3,4,5] Collectively, these studies highlight the realization that although the higher education system in the United States is the envy of the world, science-based engineering education has become a commodity, available to students all over the world. In some locations, engineers may be considered low-wage workers, as they command only 20% of the salary of their U.S. counterparts. A renewed focus on innovation, intellectual capacity, leadership, and societal challenges can differentiate domestic programs and the students they educate.

  The National Academy of Engineering and the professional licensure establishment view the bachelor's degree as introducing engineering as a discipline in a broad and preparatory manner akin to the traditional liberal arts degree, and the master's degree as being the first professional degree. The Accreditation Board for Engineering and Technology has recently authorized "dual level" programs, which will enable departments to seek accreditation for master's as well as bachelor's programs. In this climate, an emphasis on lifelong learning opportunities will become more important than ever for our students and our department.

4 OUR RESPONSIBILITIES

We have a special responsibility to lead and embrace the ideals of a modern land-grant institution.

The Department of Mechanical Engineering is one of Iowa State University's crown jewels, and we trace our heritage to the university's founding. The Morrill Act authorized the donation of public land to the states to provide higher education, accessible to anyone who aspired to it, in the areas of agriculture and the mechanic arts. Indeed, the university's first diploma was awarded in 1872 to Edgar Stanton in the discipline of "mechanic arts including mechanical engineering." Stanton went on to become a faculty member and chair of the mathematics department, and he served four times as acting university president. His heart was truly in his work, and he and his family contributed the bells of the central campus's carillon. "The Bells of Iowa State," quite literally, has its heritage in the mechanical engineering department.

As one of the largest and most vibrant departments on campus today, we have a special responsibility to lead and embrace the ideals of a modern land-grant institution. The department continues to grow in its reputation and scale. Faculty members of the department have an extraordinary ability to pursue new lines of thought and knowledge, and our focus on education, research, and service is very much a part of who we are.

4.1 Values

The Department of Mechanical Engineering at Iowa State University is a community of faculty, staff, students, and alumni—and industrial and governmental partners—working together to improve Iowa and society in the broadest terms through mechanical engineering research, education, and service.

As a community of scholars, we create and share **knowledge** at the highest levels through our educational and research programs. We are committed to improving lives and livelihoods through research in the science and technology of mechanical engineering, and delivering a superior and forward-looking education to our students. We strive to be discipline-leading in our

[2] *Rising Above the Gathering Storm*, N.R. Augustine (editor), Report of the National Academies, 2006.
[3] *Educating the Engineer of 2020: Adapting Engineering Education to the New Century*, G.W. Clough (editor), National Academy of Engineering, 2005.
[4] The "5XME Workshop: Transforming Mechanical Engineering Education and Research in the USA, Edited by A.G. Ulsoy, May 10-11, 2007, National Science Foundation, Arlington, VA.
[5] Duderstadt, J.J., "Engineering for a Changing World: A Roadmap to the Future of Engineering Practice, Research, and Education," The Millennium Project, The University of Michigan, 2008.

endeavors, and our scholarship values center on the concepts of **innovation** and impact that is distinctive, recognized, and enduring.

As a community of professionals, we promote the virtues of teamwork and an exemplary standard of conduct that defines a collegial and respectful environment. We recognize our responsibility to accept prominent **leadership** roles to build the department's broad respect as a valued source of advice and technical expertise.

4.2 Vision

Through the excellence of our people, the Department of Mechanical Engineering will be recognized as a leader of its discipline in a manner that exemplifies the land-grant traditions of learning, discovery, and engagement. The department will be a desirable place to study and work, with our community comprising the best and the brightest, because of research and educational programs grounded in the mechanical engineering sciences and set within the context of meeting important societal needs.

4.3 Mission

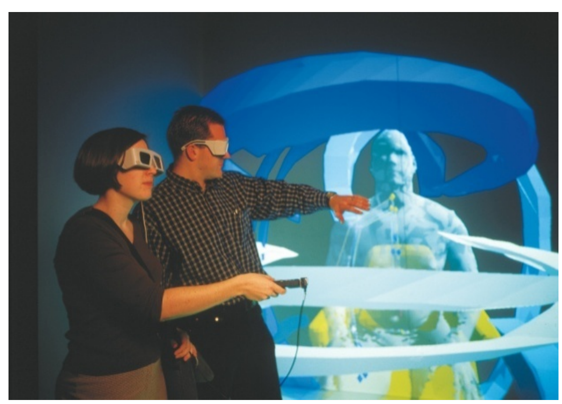
The mission of the Department of Mechanical Engineering has three tenets that center on the principle of improving lives and livelihoods: to create knowledge through research in the science and technology of mechanical engineering; to share knowledge through educational programs and the dissemination of our new discoveries; and to develop the professional potential of faculty, staff, and students.

4.3.1 Create knowledge through research in the science and technology of mechanical engineering

Our department expands the frontier of human knowledge in the discipline of mechanical engineering through fundamental and applied research conducted by faculty and students. As skilled researchers, we bring the principles of mechanical engineering to bear on important problems of national, and even global, implication: energy and the environment; health and safety; information and cyber-infrastructure; and national security. Our research portfolio encompasses traditional areas of mechanical engineering, as well as emerging and interdisciplinary ones. Through initiative and innovation, we expand the frontiers of the mechanical engineering profession.

4.3.2 Share knowledge through educational programs and the dissemination of our new discoveries

Our land-grant mission is based on the premise that knowledge is beneficial to mankind and the greatest benefit comes from dispersing knowledge as widely as possible. We share knowledge with our students through educational programs and all of society through disseminating our research findings in scholarly publications, presentations, patents, entrepreneurship, and technology transfer. Through classroom, laboratory, and project-based instruction, undergraduate and graduate students are well-served by a curriculum that is based upon the fundamental principles of mechanical engineering, as well as forward-looking and set within the context of our profession's social mandate. Our curriculum prepares students for diverse and successful careers across the global engineering marketplace, and it further fosters creativity and critical thinking skills through research and design experiences.



4.3.3 Develop the professional potential of faculty, staff, and students

The success of any organization can be measured by its ability to develop and realize the potential of its most important asset—its people. Students grow through their educational experiences in and out of the classroom, as well as through their relationships with faculty and each other. Staff members learn new professional skills and apply them through active engagement in the department's operations. Mentoring opportunities and embracing leadership opportunities that magnify contributions beyond the department's and university's borders develop the scholarly careers of faculty members.

4.4 Align our path with the visions and missions of the university and college

Our growth path is well-aligned with the university's and college's respective visions and missions, which are reproduced below for reference.

4.4.1 Vision and mission of Iowa State[6]

Vision: Iowa State University will be the best at advancing the land-grant ideals and putting science and technology to work.

Mission: Create, share, and apply knowledge to make Iowa and the world a better place.

The visions of the university and our department both focus on the land-grant ideals of learning, discovery, and engagement, and both missions are centered on improving the lives of people by addressing societal needs. Iowa State and our department carry out our respective visions and missions by creating knowledge through world-class scholarship in research and creative endeavors; sharing knowledge through outstanding undergraduate, graduate, professional, and outreach programs; and applying knowledge to improve the quality of life for Iowans and others. The success of the university depends on the people it serves and those who serve it, namely, our students and alumni, as well as the faculty and staff within our department.

4.4.2 Vision and mission of the College of Engineering[7]

Vision: The college will be internationally acclaimed as a leader in producing innovative graduates and research that focuses on meeting the present and future needs of society.

Mission: Provide leadership through innovative education, research, and public engagement to improve the quality of life in Iowa, the nation, and the world, while leading the 21st century mission of land grant colleges of engineering.

The vision of the college is to be a recognized leader in engineering, and by association, the vision of our department as a subset of the college is to be a recognized leader in mechanical engineering. The first priority of the college is "our human capital." One of our department's missions and priorities is to develop our faculty, staff, and students. The missions of the college and department likewise identify the importance of educational and research excellence in the best traditions of land-grant institutions.

[6] Iowa State University Strategic Plan 2005-2010, http://www.public.iastate.edu/~strategicplan/
[7] Iowa State University College of Engineering Strategic Plan, http://www.eng.iastate.edu/assess/stratplan.asp

4.5 Track our progress

As we implement our plans, it is important for us to track our progress. We will use a set of metrics—such as those outlined in the sections that follow—that enable us to measure our progress in meeting objectives and satisfying our missions in research, education, and professional service. We are not seeking perfect indicators of our trajectory; rather, we want to develop reasonable measures that can be accurately and consistently tracked. We will first establish a baseline using our current state, and then we will measure against it to see if we are improving. If we do not see improvement, it is our responsibility to identify and address the matter. If we are improving, the data will help us identify ways to advance toward our goals faster.

We will measure our progress relative to our mission, looking at how effectively we deliver on our mission and make an enduring and recognized impact relative to our resources. To the extent that we are an enterprise based on creating and disseminating knowledge, we are mindful of the qualitative nature of factors like external reputation; impact in advancing mechanical engineering science and technology; contribution toward improving professional careers; and service to the profession. As a result, our performance measures will include both quantitative and qualitative indicators. These benchmarking and tracking functions will provide information that is needed to measure the department's growth, and also to measure and acknowledge the contributions made by individuals to further the department's mission.

5 EXTEND OUR PILLARS OF RESEARCH EXCELLENCE

5.1 Aspirations for our research programs

Our research brings the principles of mechanical engineering to bear on technologies that improve lives and livelihoods.

We have successfully identified research niches where we bring the principles of mechanical engineering to bear on important technologies that improve our society. Like those of many mechanical engineering departments, our research portfolio has traditionally been classified according to the disciplines of mechanical engineering. Reflecting faculty expertise, societal needs, and trends in the funding climate, some areas of our research have attained a level of significant recognition and impact while others are burgeoning into maturity, collectively offering significant potential for growth and impact. This position allows us to frame our research enterprise in terms of focused programs that build upon traditional disciplinary strengths and are directed at the mission of improving lives and livelihoods. We aspire for our research to apply the fundamentals of mechanical engineering science to programs that focus on and address societal needs.

The challenge we now face is formalizing and expanding our programs to advance them to the next level. We will address this challenge by building on our expertise and leadership, acting on those research programs that are most mature, and laying the foundations for emerging and opportunity-rich programs. These programs define our pillars of research excellence and collectively have the following characteristics:

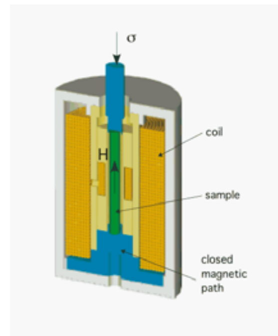
- *Comparative advantage* over other institutions that we will continue to develop and maintain
- *External recognition* that we will further develop to solidify our reputation and maximize impact
- *Opportunity and promise with favorable and externally-recognized momentum* that we will strengthen with an eye to the future

5.2 Current status

We conduct fundamental research that applies to a wide range of technologies. We have experienced and creative researchers who work on significant problems and make important and lasting contributions. Further, we benefit from a collegial environment in which we collaborate and organize ourselves into teams.

Our research portfolio has traditionally been classified in a manner analogous to the following core mechanical engineering educational disciplines:

- Thermo-fluid sciences, encompassing experimental and computational fluid mechanics; multiphase flows; engine emissions; industrial energy efficiency; laser diagnostics; biofuels; and heat transfer and refrigeration
- Dynamic systems and controls, comprising smart materials; vibration and noise control; multibody dynamics; nonlinear control; and precision positioning
- Materials processing and mechanics, including acoustics and vibration; mechanical response of micro/nano scale structures; surface engineering; tribology; and material behavior
- Design and optimization, concentrating on surface modification; deformation and forming; design optimization and methodology; laser processing; process automation; and virtual reality applications



We greatly value the research contributions made in each of these areas and are justifiably proud of all research in the department.

Our research also extends far beyond the department's boundary. We have active research collaborations with 24 other departments across all seven colleges on campus, hold five courtesy appointments in other departments, and are affiliated with 17 campus institutes and research centers. Additionally, two faculty members lead new Regent-approved institutes on campus, the Bioeconomy Institute and the CyberInnovation Institute, and two of our faculty champion the College of Engineering's cluster initiatives. Our faculty are professionally engaged in off-campus endeavors as well, having more than 125 collaborations outside Iowa State with colleagues at other domestic and international universities, national laboratories, research institutes, consortia, and companies. These factors are positive indicators that our research enterprise is strong, and we are well-poised to advance our visibility and impact.

5.3 Context and directions for our research programs

The National Science Board releases a comprehensive biennial report entitled "Science and Engineering Indicators,"[8] which we view as a valuable resource in understanding our context. The board recently remarked that our economy is transitioning to a knowledge-intensive environment in need of research to discover ways to sustain it. Our nation's universities and colleges help in this discovery process through contributing significantly to the United States' research and development enterprise. A National Science Foundation sponsored workshop[9] further noted that investment in mechanical engineering research has fueled our nation's economy for decades, and this research will continue to play an important role as an engine of economic growth.

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[8] National Science Board, 2008. *Science and Engineering indicators 2008*, Two volumes. Arlington, VA: National Science Foundation, released January 15, 2008: http://www.nsf.gov/news/news_summ.jsp?cntn_id=110984&govDel=USNSF_51

[9] The "5XME Workshop: Transforming Mechanical Engineering Education and Research in the USA, Edited by A.G. Ulsoy, May 10-11, 2007, National Science Foundation, Arlington, VA.

Against that backdrop, the College of Engineering set an ambitious goal in spring 2007 through the 2050 Challenge,[10] which defines wide-ranging educational, research, and public engagement initiatives to address global-scale societal needs. The challenge positions engineers with an enabling role in ensuring nations and people are prosperous in the year 2050, addressing daunting questions, including:

- How can clean water, universal access to information, health care, and robust economies be provided for 9.5 billion people?
- How can our crumbling infrastructure be restored?
- How can our agriculture and manufacturing be made sustainable?
- How can global warming be reversed while developing nonpolluting and renewable energy sources?

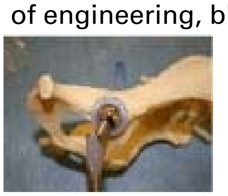
The goals of the 2050 Challenge are well-aligned with the recently released Grand Challenges, which were outlined by a blue-ribbon panel commissioned by the National Academy of Engineering[11]:

- Make solar energy economical
- Provide energy from fusion
- Develop carbon sequestration methods
- Manage the nitrogen cycle
- Provide access to clean water
- Restore and improve urban infrastructure
- Advance health informatics
- Engineer better medicines
- Reverse-engineer the brain
- Prevent nuclear terror
- Secure cyberspace
- Enhance virtual reality
- Advance personalized learning
- Engineer the tools of scientific discovery

According to the academy, "the challenges facing engineering today are not those of isolated locales, but of the planet as a whole and the entire planet's people. Meeting all those challenges must make the world not only a more technologically advanced and connected place, but also a more sustainable, safe, healthy, and joyous—in other words, better—place." Indeed, challenges of the college and academy highlight the social mandate that underpins all engineering disciplines, as well as the need for research to be directed at improving society and individual lives. Mechanical engineering as a discipline and profession provides the foundation to address such a mandate.

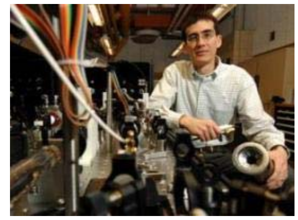
With consideration to our context and environment, we have identified and defined our department's research programs that address major societal needs.

- The **Biological and Nanoscale Sciences** program investigates problems at the interface of engineering, biology, and nanotechnology, allowing us to apply the fundamental

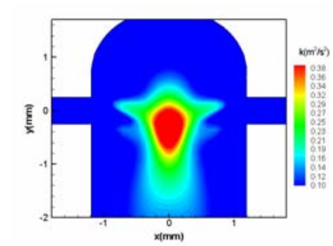


principles of mechanical engineering to expand opportunities for new science and engineering breakthroughs. By merging the engineering fields of dynamics, materials, mechanics, fluid flow, and heat transfer with the scientific fields of chemistry, materials science, and biology, we pursue experimental and computational strategies to understand the physical principles specific to small scale and biological phenomena. This enabling research uses unique physics at the nanometer scale with a view toward revolutionizing areas such as biomedicine and biotechnology.

[10] See INNOVATE, Spring 2007 (http://www.engineering.iastate.edu/innovate)
[11] Press release February 15, 2008: http://www.engineeringchallenges.org

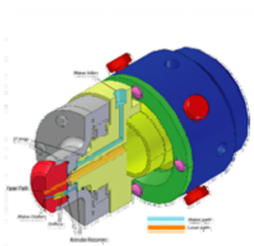


- The **Clean Energy Technologies** program investigates alternative energy, energy efficiency, and advanced processes and materials that have reduced resource demand and environmental impact. America's prosperity depends upon its ability to remain the global leader in energy systems, and the fast-growing needs of emerging economies cannot be met over the long term without advances in the energy sciences. Driven by the escalating price of fuel, geopolitical instability, and air and water pollution, we are developing a new technological paradigm to power the world's economy of 2050. Our research on alternative energy encompasses solar, wind, biomass, geothermal, and advanced nuclear energy systems, and our work on energy efficiency technologies encompasses building energy use; fuel cells and distributed power systems; advanced hybrid vehicles and transportation systems; and low carbon emission power systems. Our work is directed at innovations that reduce carbon emissions and water consumption, while providing low cost, high performance substitutes for depleting natural resources.



- The **Complex Fluid Systems** program investigates non-Newtonian, multiphase, turbulent, and/or chemically reacting flows over multiple length and time scales. We develop unique experimental and computational techniques that advance our understanding of fluid flow phenomena and enable engineering applications, including fuel and chemical production; biomass transport; particle dispersion; and heat exchangers in evaporators, boilers, and condensers. The efforts of this program pioneer new theories and models of complex fluid processes and validate these processes through novel experimental techniques and exploration tools.

- The **Design and Manufacturing Innovation** program centers on transforming resources into useful and desirable products, cutting across all phases of the design and manufacturing cycle. In each phase, the transformation process is characterized in terms of innovation, quality, and efficiency. Novel experimental, computational, and analytical techniques are developed to advance our understanding of these transformation processes, as well as to study practical applications, including chemical mechanical planarization, laser processing, tribology at the micro/nano-scale, surface engineering, and characterization for biomedical applications. The interplay among engineering, the marketplace, and the regulatory environment influence design and manufacturing decisions. Our efforts contribute to better theories, models, and technologies that improve the realization of products.



- The **Simulation and Visualization** program investigates advanced computational and experimental techniques to understand and predict physical phenomena, as well as unique image rendering methods to enhance the interpretation of complex systems and data sets. This program develops and advances simulation and visualization capabilities, and applies them in a societal context. One goal is to enable scenarios for products or processes to be altered and tested in a virtual environment before any physical models are created. Such capability will significantly reduce the time and cost associated with product development, while improving the accuracy, efficiency, and robustness of a product or manufacturing process.

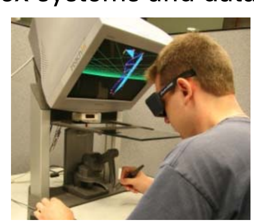


Photo courtesy of the Virtual Reality Applications Center

To begin addressing the global changes we face, the college's 2050 Challenge identifies five interdisciplinary cluster areas:[12] biosciences, information sciences, energy, sustainability, and engineering for extreme events. Each cluster has a group of faculty from the College of Engineering with common scholarship interests in a technology or science area who, through their collaborative efforts with our current faculty, advance the state of the art. Our research programs and the cluster areas are strongly aligned. We have two faculty members who are co-champions for two of the five cluster areas and several colleagues involved in many of the cluster areas. This alignment with the cluster areas will help the department continue making impact with our research programs.

Specifically, our research programs create scientific findings, tools, and technologies; are based on existing and developing areas of expertise; and engage groups of collaborating faculty. Table 5.1 defines each research program, describing our comparative advantage, our existing external recognition, and indicators of our favorable and externally recognized momentum that offer opportunity and promise. As summarized in Table 5.2, we are involved in many programs directed at meeting societal needs in the areas of energy and the environment; health and safety; information and cyberinfrastructure; and national security.

The traditional mechanical engineering disciplines outlined in section 5.2 are the foundation upon which our research programs are built. These disciplines drive discoveries in our research programs, which are then targeted at the societal needs outlined in challenges of the college and academy, as represented in Figure 5.1. Table 5.3 outlines our link between core disciplines and research programs, while Figure 5.2 summarizes our entire research portfolio, including context and direction.

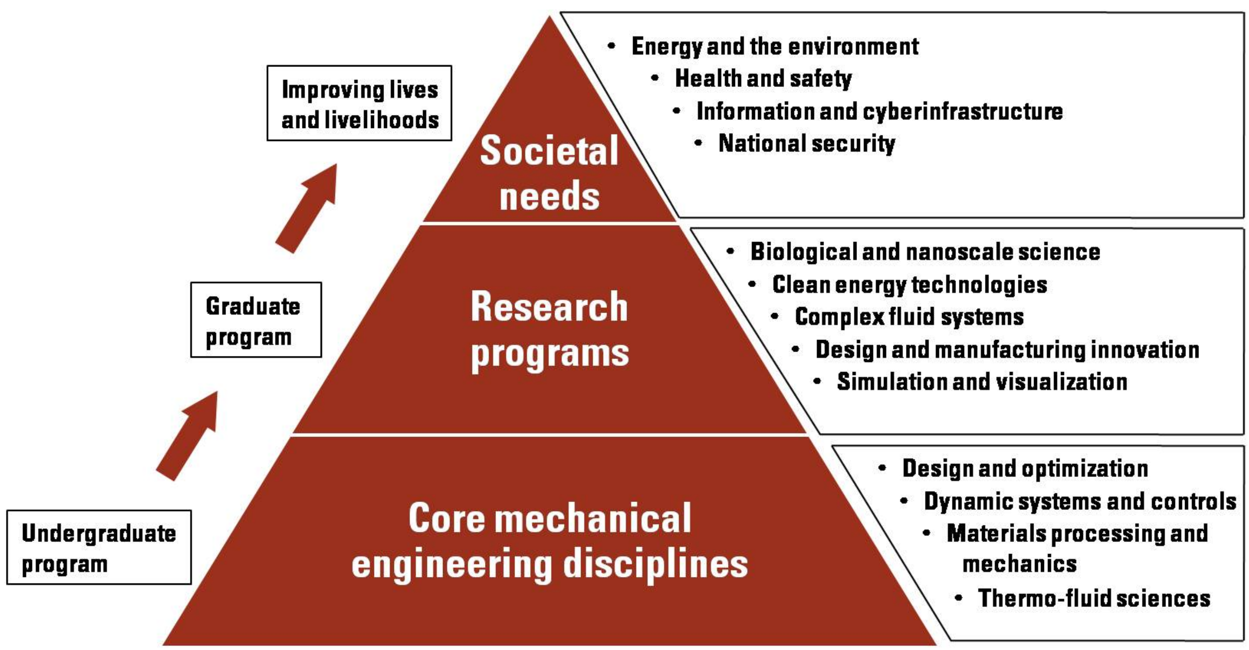


Figure 5.1: Core mechanical engineering disciplines are the foundation on which our research programs are based, and these programs address major societal needs to improve lives and livelihoods.

[12] http://www.engineering.iastate.edu/clusters/cluster-areas.html

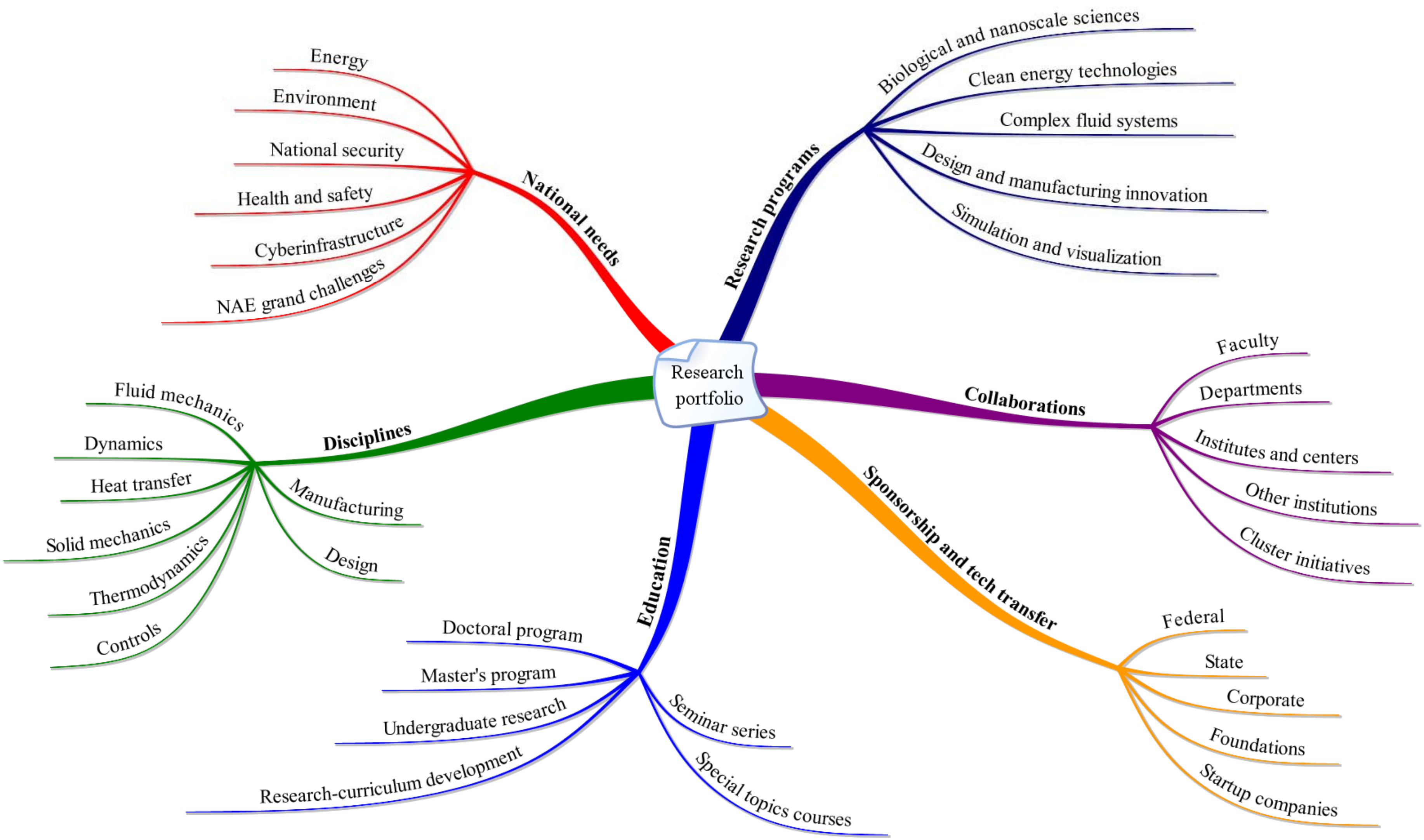


Figure 5.2: Summary of our research portfolio.

Table 5.1: Defining our strategic research programs.

		Comparative Advantage	Existing External Recognition	Opportunity and Promise
Strategic Research Programs	Biological and Nanoscale Sciences	• Leadership and participation in institutes and centers o Institute for Combinatory Discovery o Bioeconomy Institute • Unique equipment and laboratories o Keck Laboratory o Carver Laboratory o Ames Laboratory o Atom Probe Microscope o Microelectronics Research Center • Highly collaborative across several departments	• Invited talks • Conference organization • Journal associate editorship	• Active publication record • Internal and external grants exceeding $5M • Four new graduate courses • Several co-authored journal papers and co-investigator grants • NSF CAREER awardee
	Clean Energy Technologies	• Leadership and participation in institutes and centers o Bioeconomy Institute o Center for Building Energy Research o Center for Sustainable Environmental Technologies o Industrial Assessment Center • Sloan Center for Biobased Products Industry • Biomass Energy Conversion Facility • Iowa Energy Center • Biorenewables Research Laboratory Building • Biorenewable Resources and Technology Graduate Program	• Biorenewable fuels • Building energy • Chair or co-chair of several national society committees • Invited talks • Conference organization • R&D 100 awardee	• Big 12 Nuclear Engineering Minor program • Selected for the Department of Energy Solar Decathlon House • Internal and external grants exceeding $4.5M
	Complex Fluid Systems	• Unique x-ray and laser-based flow visualization capabilities • Computational Fluid Dynamics Center • High performance computing facilities • Scalable Computing Laboratory in Ames Laboratory • Highly collaborative across several departments	• Leadership in several national societies • ASME Journal Associate Editor • Journal editorial board member • Several invited talks	• Active publication record • NSF CAREER awardee • Department of Energy Early Career awardee • Active funding from several national competitive programs
	Design and Manufacturing Innovation	• Center for Industrial Research and Service • Virtual Reality Applications Center • Institute for Combinatory Discovery • Human-Computer Interaction Initiative • CyberInnovation Institute	• Two Journal Associate Editorships • ASME Design Division Chair • Several invited talks and national awards	• Two spin-off companies • Active publication record • Internal and external grants exceeding $6.8M
	Simulation and Visualization	• Virtual Reality Applications Center • CyberInnovation Institute • Unique x-ray and laser-based flow visualization capabilities • Computational Fluid Dynamics Center • High-performance computing facilities • Human-Computer Interaction initiative	• Computational fluid dynamics textbook author • R&D 100 awardee • Leadership in national societies • ASME Journal Associate Editor	• World's highest resolution immersive environment • Spin-off company

Table 5.2: Societal needs addressed by our strategic research programs.

		Societal Needs			
		Energy and the Environment	Health and Safety	Information and Cyber Infrastructure	National Security
Strategic Research Programs	Biological and Nanoscale Sciences	Brown, Heindel, Mann, Maxwell, Molian, Subramaniam, Sundararajan	Bryden, Faidley, Shrotriya, Subramaniam, Sundararajan, Wang, Winer, Zou	Bryden, Chandra, Subramaniam, Wang, Wickert, Winer, Zou	Faidley, Shrotriya, Sundararajan, Zou
	Clean Energy Technologies	Brown, Bryden, Chandra, Heindel, Heise, Kong, Maxwell, Meyer, Nelson, Wickert, Zou	Heise, Kong, Mann, Maxwell, Nelson	Bryden, Kong, Mann, Nelson	Brown, Bryden, Heise, Kong, Meyer, Nelson, Wickert
	Complex Fluid Systems	Brown, Heindel, Kong, Mann, Meyer, Olsen, Subramaniam	Heindel, Mann, Olsen, Subramaniam	Mann, Subramaniam	Mann, Meyer, Olsen
	Design and Manufacturing Innovation	Chandra, Faidley, Heise, Kim, Luecke, Molian, Shrotriya, Sundararajan, Zou	Heise, Kim, Luecke, Molian, Shrotriya	Chandra, Oliver, Vance, Winer	Heise, Oliver, Kim, Shrotriya, Starns, Sundararajan, Zou
	Simulation and Visualization	Bryden, Heindel, Heise, Kelkar, Kong, Luecke, Mann, Maxwell, Meyer, Nelson, Subramaniam, Vance	Bryden, Faidley, Heise, Kelkar, Mann, Shrotriya, Starns, Vance, Wang, Winer, Zou	Bryden, Kong, Luecke, Mann, Nelson, Oliver, Subramaniam, Vance, Wang, Wickert, Winer	Bryden, Heise, Kelkar, Mann, Meyer, Oliver, Shrotriya, Starns, Vance, Wickert, Winer

Table 5.3: Alignment of our strategic research programs with the core disciplines of mechanical engineering.

		Strategic Research Programs				
		Biological and Nanoscale Sciences	Clean Energy Technologies	Complex Fluid Systems	Design and Manufacturing Innovation	Simulation and Visualization
Core Mechanical Engineering Disciplines	Design and Optimization	Bryden, Winer	Bryden, Chandra, Heise, Kong, Maxwell, Nelson	Kong, Mann	Chandra, Heise, Luecke, Oliver, Starns, Vance, Winer	Bryden, Heise, Kelkar, Kong, Luecke, Mann, Oliver, Starns, Vance, Winer
	Dynamic Systems and Controls	Faidley, Kelkar, Mann, Wickert, Zou	Brown, Kelkar, Luecke, Mann, Nelson, Wickert, Zou	Kelkar, Mann	Chandra, Faidley, Heise, Kelkar, Luecke, Wickert, Zou	Bryden, Faidley, Kelkar, Luecke, Mann, Wickert, Zou
	Materials Processing and Mechanics	Faidley, Kim, Mann, Molian, Shrotriya, Sundararajan, Wang	Chandra, Heise		Chandra, Heise, Kim, Molian, Shrotriya, Starns, Sundararajan, Wang, Wickert	Bryden, Chandra, Heise, Mann, Shrotriya, Starns, Wang
	Thermo-Fluid Sciences	Brown, Heindel, Maxwell, Olsen, Subramaniam, Wang	Brown, Bryden, Heindel, Kong, Maxwell, Meyer, Nelson, Olsen, Subramaniam, Wang	Brown, Bryden, Heindel, Kong, Mann, Meyer, Olsen, Subramaniam	Olsen, Subramaniam, Wang	Bryden, Heindel, Kong, Mann, Maxwell, Meyer, Nelson, Olsen, Subramaniam, Wang

5.4 Support program champions

Faculty champions will spearhead new initiatives that come from our research programs. These champions will engage faculty members who are affiliated with each program to share ideas, co-author publications, identify and respond to funding opportunities, and invite speakers for seminar mini-series in each program area. The affiliated faculty will develop white papers, write joint proposals, pool admission of graduate students, and collaboratively supervise graduate students and research laboratories. These activities will enable us to pursue major grant opportunities and establish new research centers.

5.5 Develop focused seminar series

We have several areas where we can strengthen our departmental seminar program. The series should include some high-level presentations, as well as focused seminars, to catalyze research in a particular area and showcase our activities to others. Each research program will identify one or two seminar speakers each year to continue building our research areas. Untenured faculty will particularly be encouraged to invite and meet with visiting speakers to showcase current research achievements and develop a professional network. An active seminar series also improves the education of our graduate students, and we will encourage our graduate students to attend departmental seminars as a means to broaden their education.

5.6 Pool admission of graduate students

From time to time, faculty members receive a grant that is not in phase with the graduate admission process. A limited number of graduate students who are interested in each research area should be accepted into the program each year without an a priori commitment to a particular advisor. When a new funding opportunity arises during the semester, faculty members can recruit the otherwise uncommitted student.

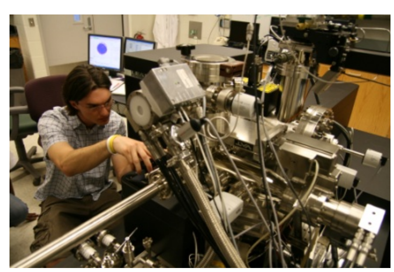
5.7 Prepare joint proposals

Our research programs enable our faculty to prepare larger joint proposals through encouraging collaboration within and outside the department. Program champions will be responsible for identifying and coordinating interdisciplinary research and educational proposals. We will pursue seed funding from the college and university to develop center-level proposals.

5.8 Enhance undergraduate and graduate courses

We will develop undergraduate and graduate courses in each research program to provide our students with opportunities at the leading edge of knowledge. The recently developed courses applicable to the biological and nanoscale sciences program are a model for such curricular innovation (ME 560X—Surface Engineering; ME 561X—Scanning Probe Microscopy; and ME 563X—Micro and Nano Mechanics). Other areas we will develop include virtual reality applications in design; biorenewable resources and technology; and modeling and simulation. Curricular development proposals will be submitted through the Miller Grant program to develop program-themed coursework.

5.9 Develop unique laboratories and equipment



Unique experimental and computational capabilities enable strong research programs. Faculty will develop NSF Major Research Instrumentation proposals to acquire major equipment resources, increasing capabilities within each program. Once acquired, these resources will be fostered with common laboratory space and user facilities. Computer clusters can be shared among the faculty and students within a research program, and research and graduate student office space will be organized to enhance collaboration.

5.10 Encourage discussion groups

Discussion groups will promote a sense of community among the faculty and graduate students within each program. Graduate students will be encouraged to present their research during these meetings to increase intellectual interactions.

5.11 Recruit expert faculty to grow research programs

We plan to hire strategically, driven by our plans to develop program-level research activities, increase research productivity, grow the size of our PhD program, and collaborate across the university, including participation in the college's cluster hire initiative. The program champions and affiliated faculty have identified specific hiring objectives.

- Biological and Nanoscale Sciences. We currently have several faculty members with excellent experimental skills in this research program. Our department needs faculty expertise in the areas of computational mechanics and/or biological materials, including nanomaterials modeling and synthesis and the mechanobiology of cells, to significantly strengthen our research enterprise both in terms of collaborative efforts and in building our comparative advantage. This program will benefit from hiring at the senior level to catalyze and champion collaborative efforts, and such leadership will position us for large proposal and center activity.

- Clean Energy Technologies. This program will benefit from hiring in the areas of fuel-cell technology; hydrogen generation and storage; biofuels; carbon sequestration; hybrid vehicles; mass public transportation systems; wind energy; and nuclear power. A mix of both junior and experienced faculty would provide an appropriate combination of leadership, ideas, and energy to move this program forward.
- Complex Fluid Systems. This program will be enhanced by hiring in the areas of numerical method development for computational fluid dynamics of complex flows, applications, biological and/or slurry flows; experimental rheology of slurry, biological, or food-based flows; experimental multiphase microfluidic flows; and biofluids (agricultural-based or biomedical). Hiring assistant or associate professor-level faculty will meet the needs of this program.
- Design and Manufacturing Innovation. This area will benefit from hires in multi-scale and multi-physics modeling of manufacturing processes; bio-manufacturing with biomedical applications; process innovations in micro/nano fabrication; inverse problems and avenues for transforming inductive design process into deductive logic; design methodology and theory, such as decision-based design; and energy and sustainability-related manufacturing, including fuel cells and "green" manufacturing. Both junior and senior faculty will complement faculty currently in this program.
- Simulation and Visualization. This area will benefit from hiring in the areas of computational fluid dynamics development and application in the thermal/fluids area; computational solid mechanics; computer vision; human-computer interaction; molecular and multiscale simulations of complex systems; and game theory development and application (for example, computer game and training development). A mix of faculty ranks, with an emphasis on junior hires, is appropriate for this program.

5.12 Track our progress

We will track our research progress using quantitative and qualitative measures, including:

- Archival journal papers published
- Conference papers published
- Patents awarded
- Keynote, plenary, and invited presentations
- Active, newly-awarded, and collaborative research grants and contracts
- Graduate students, particularly PhD students, supported on extramural grants and contracts
- Feedback from our Industrial and Academic Advisory Council
- References and citations to our research findings in the public press

6 STRENGTHEN OUR GRADUATE PROGRAM

6.1 Aspirations for our graduate program

The graduate program is a cornerstone of our department, and we all benefit from its expansion and quality.

The National Science Board states[13] that basic research provides the foundation for a vibrant and flexible science and technology based economy, with more than half of all basic research being conducted at universities and colleges. The key product of this research, in addition to new knowledge, is having young researchers educated through graduate training.

Our graduate program is a cornerstone of our department, and every faculty member benefits from its expansion and quality. The success and visibility of the department's research enterprise is largely dependent on a thriving graduate program that emphasizes rigor, innovation, and scholarship. To this end, we will focus on:

- Building recruitment pipelines and an efficient admissions process that will serve the department's growing needs
- Strengthening and significantly growing the PhD program (A National Science Foundation workshop[14] concluded that "doctoral education in engineering is essential to national prosperity")
- Developing a coursework-only MS degree program
- Improving participation and success of traditionally under-represented students

[13] National Science Board, 2008. *Science and Engineering indicators 2008*, Two volumes. Arlington, VA: National Science Foundation, released January 15, 2008: http://www.nsf.gov/news/news_summ.jsp?cntn_id=110984&govDel=USNSF_51

[14] The "5XME Workshop: Transforming Mechanical Engineering Education and Research in the USA, Edited by A.G. Ulsoy, May 10-11, 2007, National Science Foundation, Arlington, VA.

6.2 Current status

- **Recruitment and enrollment.** Recruiting graduate students is primarily performed at the application stage and is done by individual faculty based on their access to extramural funding. We also participate in the College of Engineering recruiting trips to regional schools and facilitate campus visits from interested students.

  Over the past three years, we have found that some 30% of all inquiries result in applications to the department. We receive inquiries predominantly from domestic students in the Midwest and students in China, India, and Korea. Roughly 67% of our applications are for the MS degree and 33% are for the PhD degree. We make assistantship offers to about 12% of our applicants, and our yield rate is typically 65% of the number of offers made. The admissions yield is disproportionate between degrees, as 94% of our MS offers are accepted, but only 56% of the PhD offers are accepted. To improve our applicant pool, we seek to actively recruit graduate students, particularly at the PhD level.

  We currently enroll 63 PhD students and 67 MS students. As shown in Figure 6.1, our MS enrollment compares favorably with our peer and aspirant schools. Our PhD enrollment, however, is considerably lower than the benchmark average on a per capita basis (Figure 6.2). We currently supervise 0.9 PhD students for every MS student, and we supervise 2.2 PhD students per tenured or tenure-stream faculty member. By comparison, the benchmark averages are 1.1 and 3.2. These measures indicate that we should place greater emphasis on recruiting and supervising PhD students to be organized more like our aspirant programs.

- **Program structure and offerings.** The PhD degree requires 72 credits, of which 48 credits are from coursework and 24 credits are from research. The MS degree can be pursued either with a thesis option or a non-thesis option (also called a creative component) that requires independent project work. In either case, the MS degree requires a total of 30 credits. The thesis option requires 21 course credits and 9 research credits and culminates in a formal written thesis and presentation. The creative component option requires 27 course credits and 3 credits of an independent study project and culminates in a final on-campus presentation without the need to publish a thesis.

- **Productivity.** Our productivity of MS and PhD graduates (in absolute terms and as normalized by the number of tenured and tenure-stream faculty members) generally falls below the corresponding averages of our benchmark peer and aspirant schools, and as shown in Figure 6.3, the differential is greatest with respect to the PhD program. We award, on average, 0.3 PhD degrees per tenured or tenure-stream faculty member per year, compared to the group average of 0.6. This differential is consistent over several years and is not an artifact of annual fluctuations. We note the strong correlation of the strength of our research enterprise and the productivity of our PhD program with our external reputation.

  Figure 6.4 shows that only some 5% of the graduate students in our department are women, which is substantially lower than the national average for mechanical engineering MS students of 13.6% and PhD students of 13.3%. The discipline of mechanical engineering has historically struggled to engage women and minority students, particularly when compared to other engineering disciplines, such as chemical, environmental, and biomedical engineering. The national average for the participation of women in all engineering graduate programs in 2006 was 22.5% for MS students and 20.2% for PhD students. In terms of minority graduates in mechanical engineering, the national average in 2006 was 24.9% for MS students and 14.7% for PhD students.[15] Improving diversity in our student enrollment presents another growth opportunity for our graduate program.

[15] http://www.asee.org/publications/profiles/upload/2006ProfileEng.pdf

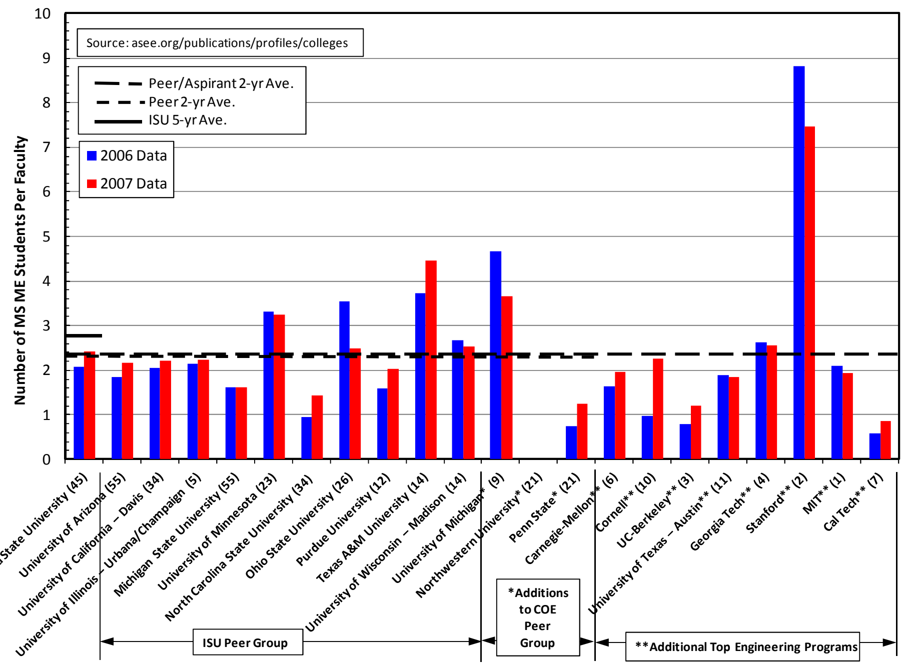


Figure 6.1: Number of MS students per tenured and tenure-stream faculty member. Our five-year average is slightly above that of the group.

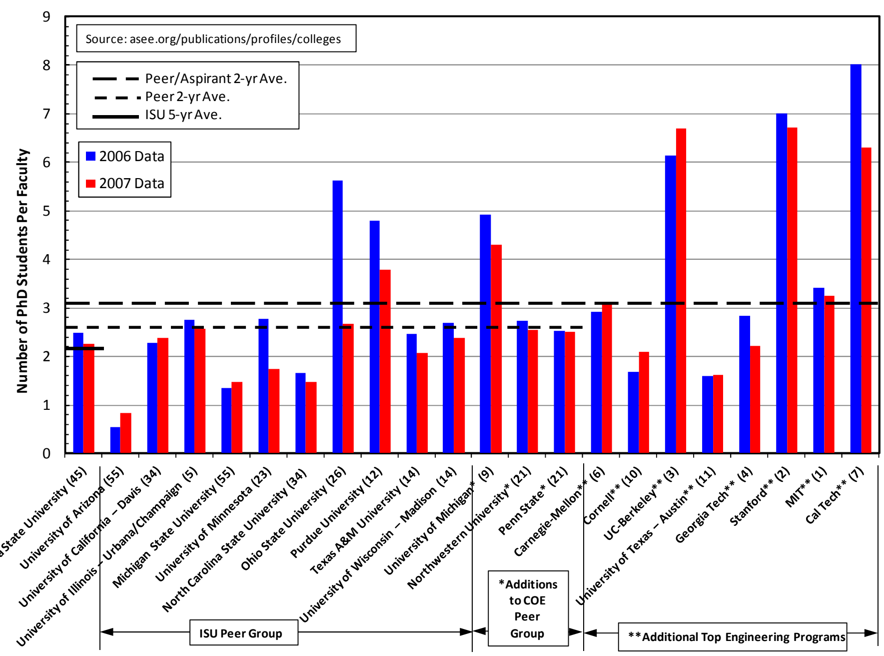


Figure 6.2: Number of PhD students per tenured and tenure-stream faculty member. Our five-year average is below that of the group.

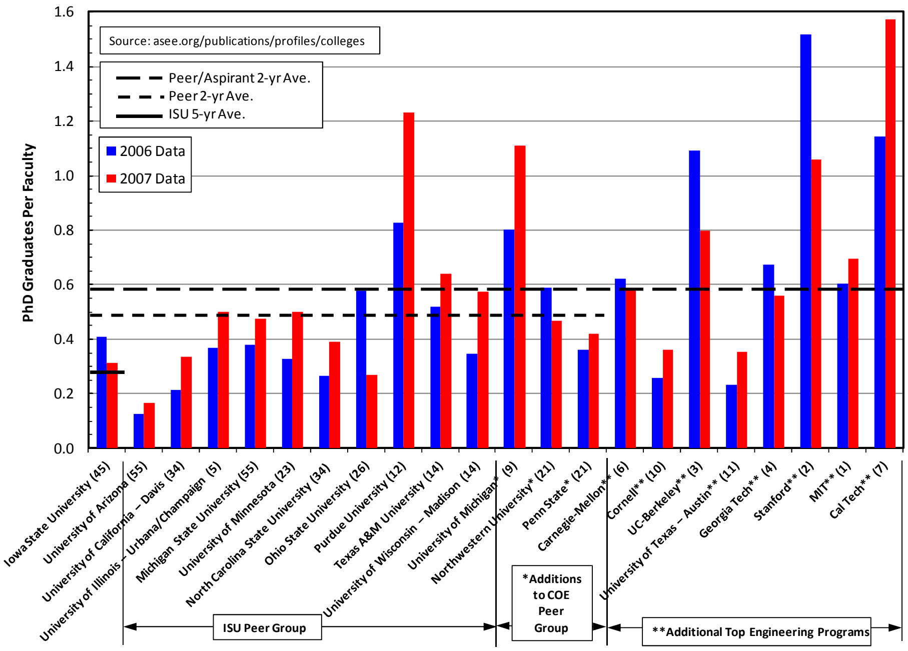


Figure 6.3: Number of PhD graduates per tenured and tenure-stream faculty member. Our five-year average is about half that of the group.

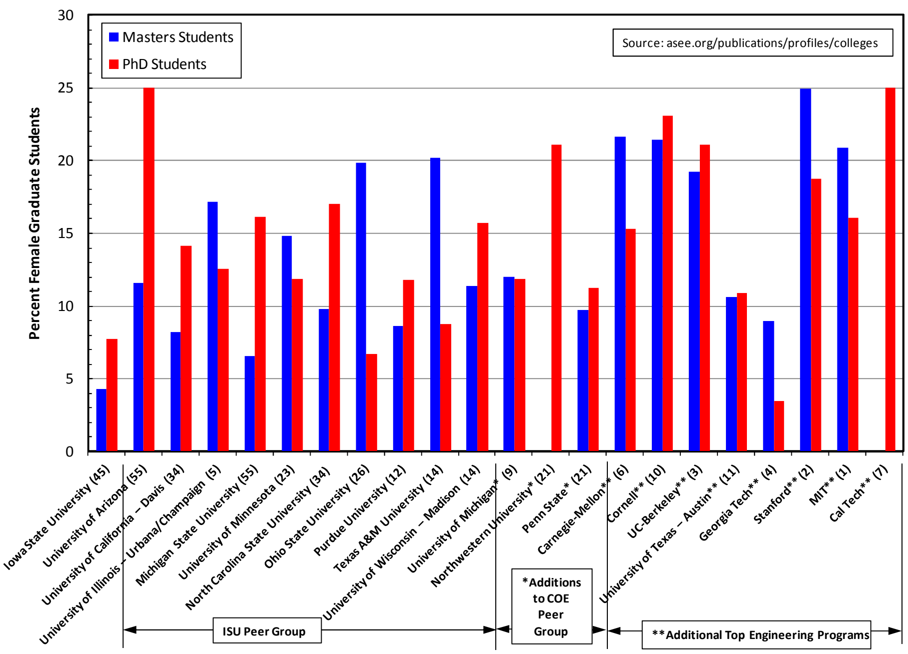


Figure 6.4: Participation of women in graduate programs. The national average for MS graduates was 13.6% female students, while the national average for PhD graduates was 13.3% female students.

6.3 Build program's administration

By building the graduate program's administrative structure, we will improve our program's quality and impact. The Graduate Studies Committee will be responsible for managing all day-to-day aspects of the graduate program and recommending new initiatives directed at the program's improvement. The committee will comprise a group of faculty who represent the intellectual diversity of our research programs. The Director of Graduate Education (DOGE) is responsible to lead the committee's activities as chair. The DOGE will serve the department as the associate chair for graduate studies and research, and will bring perspectives of the graduate and research program into the department's planning activities.

The graduate program also includes the graduate program secretary, who is responsible for assisting students with applications; maintaining and processing student records; tracking degree progress; processing admissions; and serving as a general point of contact for students and faculty. The program assistant for graduate studies, a newly-created position, also supports the graduate program, overseeing functions such as promotions, recruitment, graduate course offerings, student office space, and distance education. This structure enables us to improve our delivery of services and pursue new initiatives.

The department chair, the associate chair for graduate studies and research, and the program assistant for graduate studies will meet regularly with members of the graduate student body, collectively called the Graduate Student Leadership Council, to garner student input on all aspects of the graduate program and obtain student-level feedback and ideas on various initiatives.

6.4 Recruit students proactively

We seek to increase the impact of our research enterprise, and by doing so, our external reputation will grow. A vibrant graduate program is key to this effort. For the research program to reach its full potential, we must recruit excellent students into the PhD program. Admissions to the department are presently made on the basis of individual faculty members. As the research programs described in section 5 develop into group-level activities, and potentially into centers, we will begin admitting applicants to those areas on a pooled basis. There are valuable advantages in pooling admission, as recruitment risk is distributed. Additional issues we will address with respect to admissions include:

- **Increasing the prospective applicant pool.** A deeper pool of quality applicants is always desirable, and one way to reach more applicants is to increase the marketing activities of our program. We will pursue various communication avenues, including targeted contact with students. Faculty relationships with regional schools, such as Dordt College, South Dakota State University, and University of Wisconsin—Platteville, will help us establish sustainable pipelines of applicants. Our efforts will be complemented with an open-house recruiting weekend each fall to which we will invite potential domestic applicants who are ranked above a certain threshold. We will focus our efforts on PhD, graduate women, and minority applicants.
- **Recruiting Iowa State undergraduates.** Our advising center will help identify our top undergraduate students so that we can aggressively recruit them. Planned initiatives to help with this effort include promoting research experiences for undergraduates. Greater research participation will broaden the undergraduate educational experience and also foster transition into our concurrent BS/MS program. We will consider incentives with respect to application costs, and proactively support fellowship applications.

- **Increasing the admissions yield.** We will implement a timeline-based process of admissions that will help us maximize opportunities afforded by national, university, college, and department fellowships and scholarships. These scholarship offers will be accompanied with an invitation for a campus visit to interact with our students and us. To more effectively compete against top-ranked institutions, we will consider financial incentives to applicants to the extent that prospective students are said to look carefully at dollar value when comparing competing admissions offers.
- **Recruiting women and traditionally underrepresented minorities.** The graduate program is intellectually diverse by the very nature of our research enterprise, but we can do more to improve the gender and racial diversity of the graduate student body. In the year 2025, our nation's population will be far more diverse in those respects than today, and we should actively engage students from underrepresented groups and develop programs for recruitment and success. We will consider incentives for women and minority students in terms of application fee waivers and other financial offers, and we will strategically allocate teaching assistantship and fellowship offers for recruiting purposes.
- **Providing stipends to external fellowships bearers.** With a view toward recruiting the very best students, we will consider options for providing supplemental stipends to students holding prestigious external fellowships.

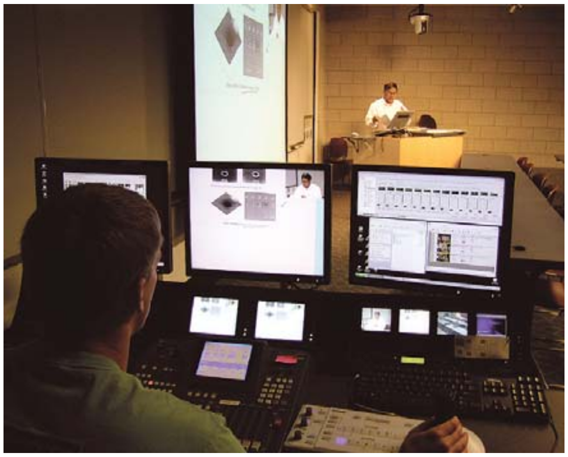
6.5 Restructure the PhD program

The PhD degree will continue to serve as our ultimate professional degree and as the backbone of our scholarly research enterprise. We can differentiate our department relative to competing institutions by raising our PhD productivity rate. We will focus our efforts, as described below, in terms of program structure and incentives to increase enrollment, the PhD graduation rate, and the quality of our doctoral program.

- Review coursework requirements to align them with disciplinary areas and research programs in the department
- Examine course credit requirements (exclusive of research, reading, and project work) to ensure students can focus on their research in a more timely manner while allowing sufficient breadth and flexibility for career development
- Review milestone requirements (qualifying examinations and preliminary examination) to enhance timely progression to degree completion
- Use fellowship funds and teaching assistantships to strategically recruit and admit PhD students
- Enhance the graduate experience by requiring a teaching practicum for all PhD students
- Require extended participation in the department's seminar series
- Formalize a department-level insurance policy using teaching assistantships for PhD students to encourage and leverage pending grants
- Support PhD students travel to present papers at professional conferences
- Develop relationships for courtesy appointments to increase the pool of faculty able to serve as a primary thesis advisor

6.6 Develop a coursework-only MS degree

Increasingly, the MS degree is being seen as a replacement of the BS degree as the preparatory professional degree.[16,17,18] Professionals who are employed in industry and BS students who want advanced education in the disciplinary subjects of mechanical engineering beyond the BS degree seek such a professional degree. The Accreditation Board for Engineering and Technology recently approved the accreditation of MS engineering programs.



We will continue to strengthen our two-year MS degree, which involves research work culminating in a written thesis and presentation. We see the MS degree as feeding into our PhD program, which naturally has an emphasis on research. A coursework-based MS degree will primarily function as a terminal degree for self-supported students. Many mechanical engineering programs, including Carnegie Mellon, Stanford, Colorado, Virginia Tech, Michigan, Berkeley, and UC San Diego, have offered coursework-only MS degrees for years, and we do not compete with them in this regard. Some aspects of our initiative for a coursework-based MS degree include:

- Our position to use the proximity of several prominent industrial partners whose employees may be interested in this degree option.
- Self-funded education because there is no research project involved. Many see the “BS plus 30” level of education as beneficial in terms of educational value and opportunity cost over one’s career. This model would provide a new income stream to the department, and would be leveraged by our strong distance education program and infrastructure.
- Balance courses selected from a set of requirements, and electives.

6.7 Promote the graduate student community

A vibrant and professional graduate student body that acts as a community, rather than as distinct research groups, is important to the department’s culture and climate. To foster this environment, we will focus on:

- **Supporting a community of student scholars.** We will support a community of student scholars organized by students for students. The Mechanical Engineering Graduate Student Organization will be involved in organizing professional and cultural activities for the student body, helping coordinate student-based interactions in recruiting events, and acting as a sounding board in conjunction with the Graduate Student Leadership Council on graduate program issues.
- **Fostering a culture of professional interaction through seminars.** We will establish a graduate seminar course requirement for students to attend final thesis presentations by their colleagues to broaden our students’ research and presentation skills.

[16] *Educating the Engineer of 2020: Adapting Engineering Education to the New Century*, G.W. Clough (editor), National Academy of Engineering, 2005.
[17] The “5XME Workshop: Transforming Mechanical Engineering Education and Research in the USA, Edited by A.G. Ulsoy, May 10-11, 2007, National Science Foundation, Arlington, VA.
[18] Duderstadt, J.J., “Engineering for a Changing World: A Roadmap to the Future of Engineering Practice, Research, and Education,” The Millennium Project, The University of Michigan, 2008.

6.8 Track our progress

We will track our graduate program progress using quantitative and qualitative measures, including:

- MS and PhD student enrollment, on absolute and per capita bases
- MS and PhD degrees awarded, on absolute and per capita bases
- Participation of women and traditionally underrepresented minority students in the graduate program
- Number of applicants to our graduate program
- The number of offers made to applicants and accepted offers, to gauge the selectivity of our graduate admission process
- GRE scores of our admitted students
- Quality of the undergraduate programs from which admitted students graduated
- Feedback from our Industrial and Academic Advisory Council
- Feedback from our Graduate Student Leadership Council

7 ENRICH OUR UNDERGRADUATE PROGRAM

7.1 Aspirations for our undergraduate program

We periodically review our curriculum to align it with the evolving needs of our profession. Our Industrial and Academic Advisory Council has helped us to identify important trends and aspirations of our program that will become increasingly important over the coming decades.

We periodically review our undergraduate curriculum to align it with the evolving needs of the profession.

- Our curriculum will continue to be based on science and engineering fundamentals and applied analysis skills
- Our courses will be taught with a heightened awareness of societal needs, with examples that are nontraditional from a historical view but emphasize how mechanical engineering impacts the world around us
- We will offer new electives that are closely aligned with our research programs, and these electives will couple with courses at the graduate level
- Our curriculum will be flexible and prepare graduates to pursue careers that may be nontraditional by today’s standards
- Many students will be expected to have an international educational or work experience, or proficiency in a foreign language
- The number of women and students from underrepresented groups in our program will be significantly higher than today
- We will offer a wider selection of minor degree programs to our students

- We will integrate design throughout our curriculum and include interactions between engineering students and students in business, design, and marketing
- New technologies will enable alternative modes of instruction
- Interpersonal and business communication skills will become increasingly important, as will knowledge of different cultures and business practices
- We will emphasize team-based projects to a greater extent using collaborative technologies
- A greater portion of our undergraduate students will have research and self-directed learning experiences
- Our instructional laboratories will be decoupled from specific courses and provide multidisciplinary opportunities
- Students entering our program will be better prepared than today in math and science, and they will take more responsibility for their education
- Self-directed learning opportunities will be common and embraced

7.2 Current status

Mechanical engineering has been the most popular major at Iowa State for the past three years, and it has been either the most or second most popular major for the past five years.[19] One reason for this growth has been that students realize the value of our degree, and the variety of career opportunities that are available to them upon graduation. Examples of our graduates' careers include: energy production; transportation systems; environmental and sustainable technologies; food production and storage; medical devices; manufacturing systems and processes; finance; business; law; medicine; and entertainment. We have awarded some 20% of all College of Engineering degrees over the past decade, and our contribution to the college's productivity shows a recent upswing. This trend for the production of BS mechanical engineering degrees is mirrored nationally to the extent that some 20% of all baccalaureate engineering graduates are in the mechanical engineering discipline. We are extremely proud that many students aspire to graduate from our department and we are a destination of choice for study.

A national engineering education leader described mechanical engineering as the liberal arts degree of the 21st century.[20] We agree with this perspective to the extent that mechanical engineering remains the broadest engineering discipline. Based on the 2005–06 survey by the American Society for Engineering Education, our department ranks ninth nationally among *all* mechanical engineering programs in the country in terms of the number of undergraduate degrees awarded, and we are consistently among the top 10 of this measure. We are exceptionally and nationally impactful through our undergraduate program.

Our program is also strong and desirable when compared to all other majors on the Iowa State campus. In 1998, the percentage of mechanical engineering undergraduate students on campus was 3.7%. That ratio rose to its highest level of 5% in 2004 and is currently at 4.4%. For every 100

[19] ISU Office of Institutional Research, http://www.public.iastate.edu/~inst_res_info/
[20] Duderstadt, J.J., "Engineering for a Changing World: A Roadmap to the Future of Engineering Practice, Research, and Education," The Millennium Project, The University of Michigan, 2008.

undergraduate students attending an ISU football or basketball game, at least 4 are mechanical engineering students!

7.3 Curriculum

Our accredited program has a rich heritage in educating mechanical engineers for professional positions in Iowa, the nation, and the world, and is based on three educational objectives:[21]

1. The department will provide a sound foundation for graduates to pursue a variety of careers. Most graduates will find immediate employment in industry, government laboratories, or consulting, and some will pursue graduate or professional studies in fields such as engineering, business, law, or medicine.
2. Graduates will apply the problem-solving skills they have learned at Iowa State to meet the challenging demands and increasing responsibilities of a successful career.
3. Graduates will continue to learn as they grow in their profession, using modern technology and communication skills to contribute as team members or leaders in solving important problems for their employers and society.

To meet these educational objectives, our curriculum centers on four major outcomes that address and achieve ABET Criteria 3 (a)–(k).[22] The first program outcome is fundamental knowledge, which addresses mastering the general sciences of mathematics, physics, and chemistry to lay the foundation for our engineering curriculum. The second program outcome is engineering skills, such as problem analysis, problem synthesis, and experimentation, and all of our core courses address one or more of these outcomes. Career success is the third program outcome, incorporating teamwork, communication, and life-long learning. Finally, the fourth program outcome is social awareness, which includes contemporary issues and professional responsibilities. These outcomes encompass ABET Criterion 9, which states for the mechanical engineering curriculum:[21]

> “The program must demonstrate that graduates have the ability to: apply principles of engineering, basic science, and mathematics (including multivariate calculus and differential equations) to model, analyze, design, and realize physical systems, components or processes; and work professionally in both thermal and mechanical systems areas.”

Our curriculum requires 128.5 credits for graduation, which is summarized in Figure 7.1. Our requirements include: 26.5 credits from the basic program; 23 credits of additional basic program courses required by the department (Other ME in Figure 7.1); 46 credits from the ME Core program; 15 credits of general education, including the international perspective and diversity requirements; and 18 credits of technical electives, including a required capstone design experience.

Curriculum development committees (CDCs) direct our core courses, and each committee has developed a vision for the future of their respective courses as part of this road mapping process.

[21] ABET EC2006 Self-Study Report, June 30, 2006; available at http://www.me.iastate.edu/fileadmin/www.me.iastate.edu/assessment/2006-ABET_Self_Study_Report_final.pdf
[22] Criteria for Accrediting Engineering Programs, Engineering Accreditation Commission, ABET, Inc., Baltimore, MD, November 3, 2007; http://abet.org/Linked%20Documents-UPDATE/Criteria%20and%20PP/E001%2008-09%20EAC%20Criteria%2012-04-07.pdf

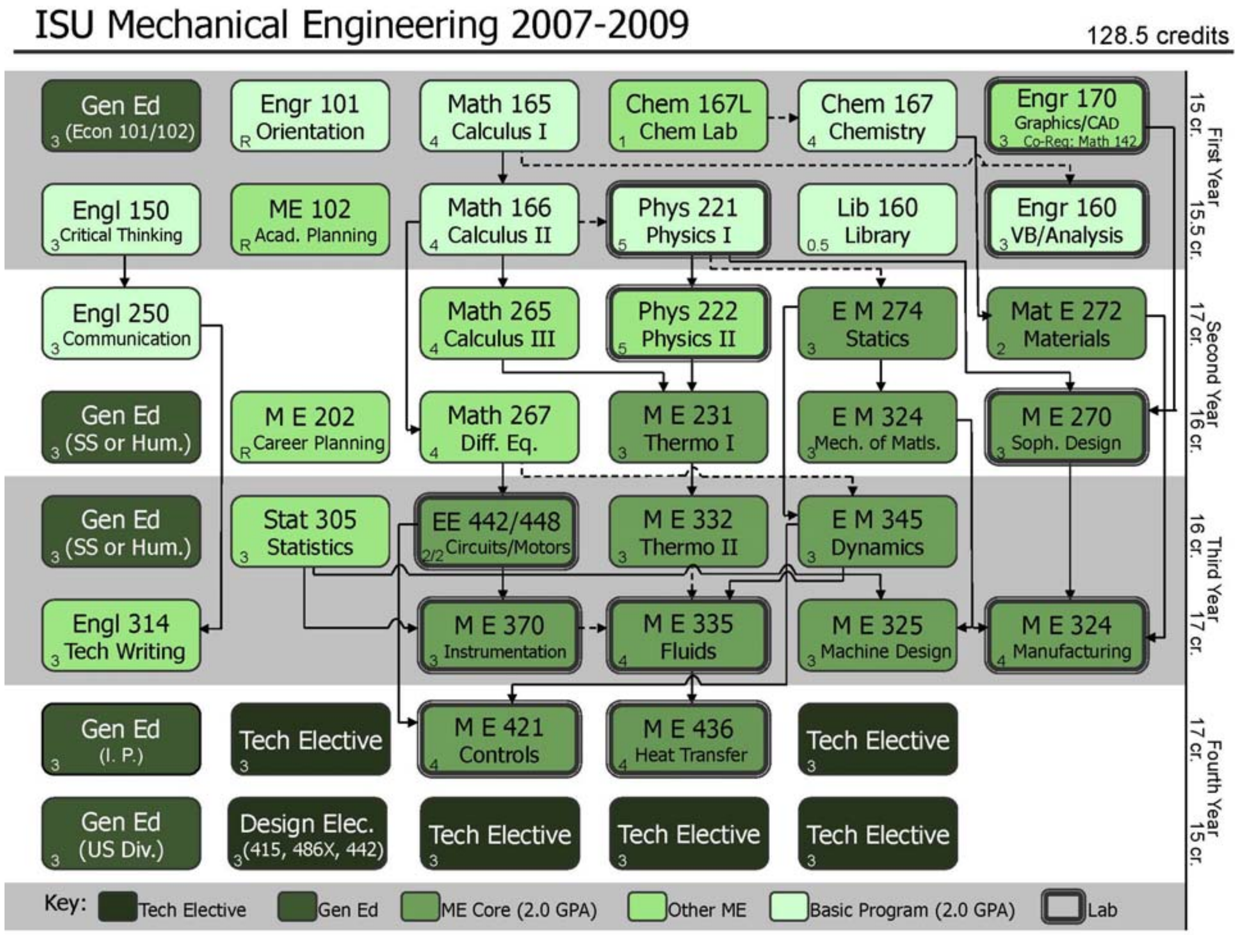


Figure 7.1: Iowa State mechanical engineering degree requirements listed in the 2007–2009 catalog.

The students in our program are highly recruited for employment in industry, with 80% of our students typically placed before graduation. In the past year, the average duration for a student enrolled to complete the BS degree was 10 semesters, corresponding to an average time-to-degree of 5.5 years. We see several reasons for the average time-to-degree exceeding the exemplary duration of four years. The most significant reason is that many of our students are involved in extracurricular activities or work part-time, and as a result, they tend to restrict the number of credits undertaken each semester to less than the nominal amount. Many of our students also complete co-ops or internship experiences. On average, at any point in the academic year, more than 50 students are away on a co-op or internship experience, and during the summer, that number increases by a factor of three.

In addition to the required courses mapped out in Figure 7.1, our students are presented other learning opportunities through our “background curriculum.” This informal curriculum operates in the background, just as a computer program may execute in the background while one is focused on another task, providing students with a range of opportunities in leadership; teamwork; technical and interpersonal communications; international and multicultural experiences; and lifelong learning.

This background curriculum forms a significant portion of the undergraduate experience, offering opportunities such as:

- Completing an internship or co-op
- Studying abroad
- Participating in student leadership groups, such as engineering student council, Engineers Without Borders, ASME, Pi Tau Sigma, and SWE
- Participating in student project teams, including SAE, Team PrISUm, and solar decathlon
- Completing a research project with a faculty member
- Service-learning experiences, including assisting with course grading
- Attending research seminars

The general structure of the undergraduate program is summarized in Figure 7.2, and it shows that the background and core curriculums are influenced by the social context and emerging technologies of our times to prepare our students for many future career options.

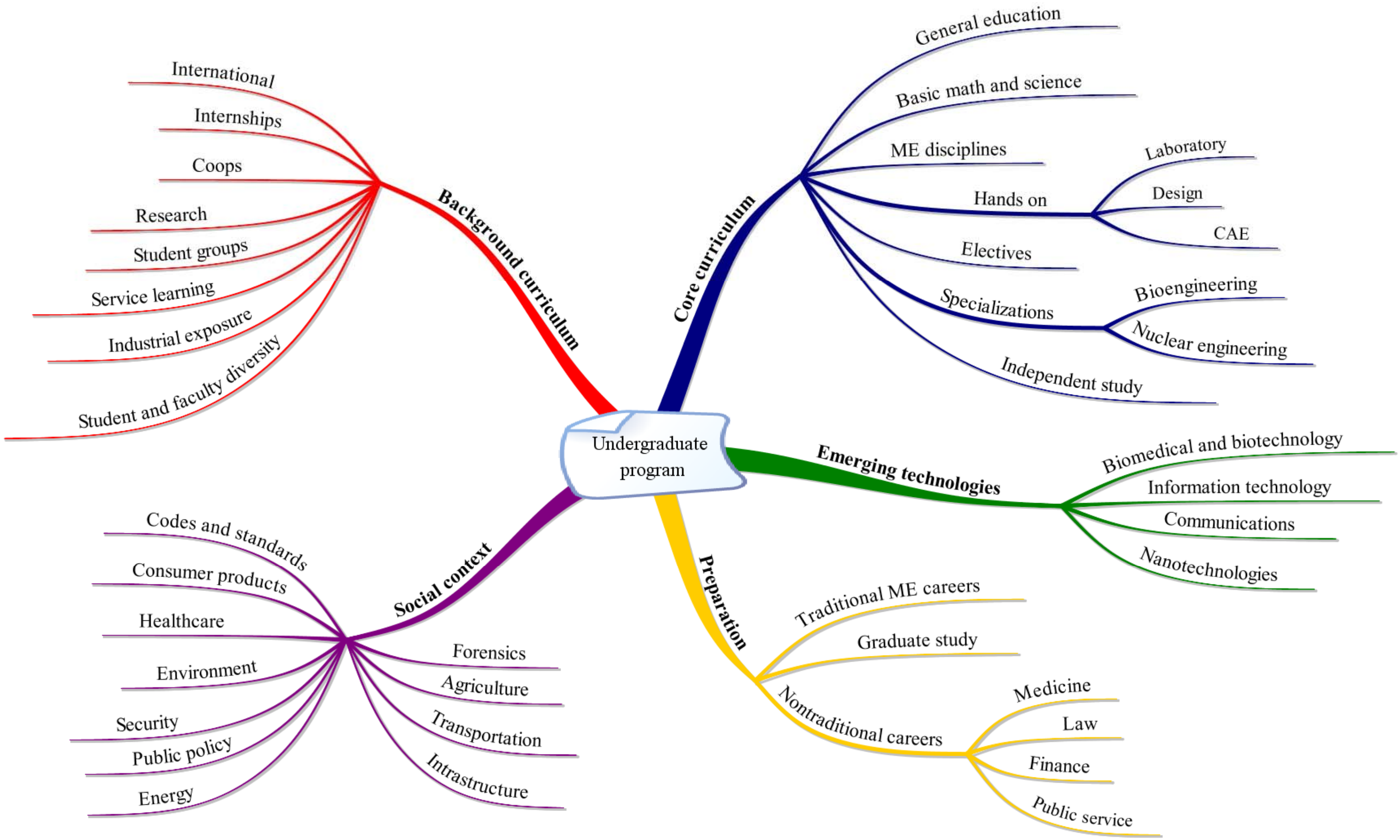


Figure 7.2: Structure of our undergraduate program.

7.4 Build program's administration

The department's program assistant for undergraduate education coordinates the operations of the undergraduate program, and responsibilities include drafting teaching assignments, tracking student credit hours taught, updating our course catalog, assigning course graders, preparing end-of-semester teaching evaluations, serving as the administrative contact for student groups, and organizing undergraduate functions, such as recruiting and retention programs.

Changes to our undergraduate program typically originate with faculty and are subsequently developed through one of three standing committees, a structure that serves our department well. The Curriculum Committee oversees curricular changes and approves new course offerings. The Academic Standards and Assessment Committee ensures transfer credits meet our standards and coordinates assessment for accreditation purposes. The Program Improvement Coordination Committee ensures we satisfy the accreditation requirements for continuous program improvement. In an alternative model, the committees could be combined to form an Undergraduate Program Committee with subcommittees tasked to complete the needed functions. We will review this committee structure to make sure our needs are met and the structure is not burdensome.

7.5 Support and strengthen student services

Professional academic advisors actively advise our undergraduate. Our advisors support a positive learning experience for our students by being available at any time during the day to assist with personal needs and answer questions. The Advising Center evolved during the last year, now comprising of an academic advisor and coordinator, two full-time academic advisors, a graduate student assistant, and a secretary. Advising contributes to many aspects of our undergraduate program, making this area an integral part of the department.

- **Recruiting new students**
  - Visit with prospective students anytime during the year. Our advisors do not blackout any dates and are always willing to meet with potential students.
  - Present at "Experience Iowa State" to provide an overview of our department to a large group.
  - Visit with students during "Transfer Student Visitation" days.
  - Present at "Scholars Days" to provide an overview to high school seniors who have been offered scholarships to Iowa State for the following semester.
  - Present at "Engineering and Beyond" days to high school juniors who visit Iowa State and explore different engineering disciplines.
  - Visit local community college campuses to speak with students who may be interested in transferring to Iowa State.

- **Recruiting undeclared students**
  - Provide an overview presentation every fall and spring to Engineering Undeclared 101 sections.
  - Encourage students of any major to take ME 102 to learn more about the department.
  - Assist the college's engineering undeclared advisors.
  - Host events for undeclared engineering women to learn more about the department.

- **Retaining current students**
  - Coordinate freshmen and sophomore learning communities.
  - Provide quality and accessible advising to all mechanical engineering students.
  - Coordinate sections of Engr 101, ME 102, and ME 202, inviting industry representatives and faculty to present to these classes.

In the coming years, the Advising Center will continue to transform to best meet the needs of our students and remain an integral part of our undergraduate experience. Their contribution to the overall success of our department is significant, as they are typically the first and last contacts our students have with the department.

7.6 Review curriculum directions and profession trends

We have a goal to complete a thorough curriculum review every decade to ensure our program remains fresh and relevant. We last reviewed and updated our curriculum in the late 1990s, and since then, we have made incremental changes to the overall curriculum. The visions of our course development committees; our Industrial and Academic Advisory Council; and the academy's and ASME's reports on engineering curricula will be starting points for our review. We expect that the degree requirements, course offerings, and course content will emphasize:

- Mechanical engineering fundamentals, with a heightened emphasis on examples and applications directed toward societal needs
- Instructional materials that can be published and shared with department's nationwide on the theme of "mechanical engineering taught in social context"
- Integrated undergraduate and graduate curriculums to provide courses at the leading edge of mechanical engineering science and technology
- More international educational or work experience before graduation, introducing students to other peoples, cultures, and languages
- Undergraduate courses offered live and through our distance education program to enable students away from campus for a semester to maintain normative progress toward the degree

We will also draw upon ideas articulated by our Industrial and Academic Advisory Council for additional curriculum directions. In fall 2007, the council was asked to describe the skills needed for one to be a successful mechanical engineer in the year 2025. Their main conclusions were:

- **Knowledge of mechanical engineering fundamentals will remain essential.** Students will be expected to assimilate even more knowledge than today; however, traditional technologies will remain important because engineers will be working on a wide range of systems. For example, mechanical engineers in 2025 may still have to know how a B-52 airplane is controlled, as well as understanding the controls of the newest jet fighters. Likewise, engineers may be designing the latest nuclear reactors for advanced power generation in 2025, while electricity is still generated in 1970s-vintage coal power plants that have been retrofitted with pollution controls.
- **Cultural awareness and knowledge of other languages will be traits of the most successful mechanical engineers.** As the world continues to flatten, heightened cultural awareness will become essentially mandatory to succeed in the global marketplace. Multi-national, multi-cultural, and multi-disciplinary teams will be the norm for successful engineers, and knowledge of global business, economics, international etiquette, and legal issues will be increasingly important. Although English may remain the base language of engineering, geographically-dispersed team members will speak many different languages.
- **Effective communication skills will be vital.** As product development cycles continue to shorten, project teams will be active around-the-clock and have members spread throughout the globe. The ability to communicate efficiently and accurately will be a characteristic of a successful team, including both face-to-face interactions as well as electronic communication modalities. The ability to speak before an audience and influence and convince people at all levels will be highly valued traits.

- **Creativity, problem solving skills, and project/team management skills will differentiate mechanical engineers who are educated domestically from those educated abroad**.
- **Systems-level engineering knowledge will be a competitive advantage.** Mechanical engineers who are skilled at integrating individual components into a system will excel, and an understanding of how systems of systems interact will become necessary for the prospective engineer in 2025. The ability to "see the forest *and* the trees" will set our students apart.

- **The baccalaureate degree will be only one element of an engineer's education.** An MS degree and lifelong learning skills will be even more important than today to differentiate our students from those educated overseas. We will develop certificate programs with a specific focus, such as nanoscale manufacturing or biomass energy conversion, to teach specialized skills, and several certificates can be integrated to satisfy the requirements of a coursework-only MS degree.
- **Sustainable solutions will be essential.** Climate change; the need for clean water and air; and renewable energy sources will drive many technological developments. The notion of sustainable engineering will create many business opportunities for existing and newly emerging, engineering companies.

Table 7.1: Future trends as identified by our Industrial and Academic Advisory Council and our curricular opportunities.

Profession trends	Curriculum opportunities
Knowledge of fundamentals will still be required	• Fundamental engineering science courses will continue to be the mainstay of our curriculum
Cultural awareness and knowledge of more than one language will be traits of most successful engineers	• A significant fraction of our students will have an international experience
Effective communication will be vital	• Proper communication will be emphasized in our courses • Students will be encouraged to participate in extracurricular activities to provide more opportunities to practice communication skills
Creativity, problem solving skills, and project/team management skills will set mechanical engineers educated in the US apart from those educated elsewhere	• Project/team management skills will be emphasized in all courses, particularly those with group-level projects and laboratory exercises • Design courses will require developing multiple options for a project with advantages and disadvantages of each option clearly identified
Systems-level engineering knowledge and ability will be a competitive advantage	• Systems-level design will be incorporated into our curriculum
A BS in mechanical engineering will be only one element of an engineer's education	• Concurrent BS/MS degree options will be marketed to the best students • A coursework-only MS degree will be developed
Sustainable solutions will be essential	• Design courses will include sustainability considerations in their design criteria

7.7 Enhance recruiting and retention

We seek to attract the best and brightest students to our department, and we strive to significantly increase the participation of women and traditionally underrepresented minorities through proactive recruiting. The 2006 national average for women graduates in all engineering disciplines was 19.3%, but the average for women graduates in mechanical engineering was only 13.1%.[23] We will develop a Women in Mechanical Engineering program to help attract this demographic to our program and make our department a better place. Additionally, the National

[23] http://www.asee.org/publications/profiles/upload/2006ProfileEng.pdf

Science Board indicates that future increases in enrollment in engineering programs are expected to come primarily from Asian and Hispanic students.[24] We will target Iowa communities with strong Hispanic populations and seek to expand our recruiting efforts to other regions. Our initiatives include:

- Targeted recruiting and retention programs, including scholarships
- A mentoring program between upper- and lower-level students, as well as between alumni and traditionally underrepresented minorities
- Coordinated networking opportunities

The retention rate for a freshman mechanical engineering cohort to its second year averages around 70%, while the university retention rate of a freshman cohort is on the order of 85–90% for this same period. The retention rate for this cohort to their third year is about 55% and to their fourth year is around 50%, while for the university it is approximately 80% for both years. Further, the six-year graduation rate for a freshman mechanical engineering cohort is less than 50%, while for the university, it is approximately 70%. Our program can be improved by providing:

- **Mechanical engineering-centered learning communities.** We have continually increased the number of learning communities in our program, as we currently have 10 learning communities organized by our Advising Center. We will continue to add more communities because participation has been shown to increase the success rate of undergraduate students.
- **Mechanical engineering student homework help service.** We will engage upper-level students to provide help to other students with mechanical engineering coursework. Members of ASME, Pi Tau Sigma, or other groups will be encouraged to serve as course tutors. Teaching assistants may also be assigned to monitor this program and provide additional support.
- **Mentoring opportunities.** We will develop a mentoring program for undergraduate students, pairing those interested with upper-level students and/or alumni. A mechanical engineering alumni society may be chartered to facilitate and promote student mentoring.

7.8 Develop minor degree options

We will develop and promote a Nuclear Engineering Minor in collaboration with the Big 12 Nuclear Consortium, as the nuclear industry is currently in need of students with this type of education. This minor will consist of a combination of Iowa State courses plus course offerings from the Big 12 Nuclear Consortium, which includes Iowa State, Texas A&M University, University of Missouri Columbia, Kansas State University, and University of Texas at Austin. Some of the courses for the minor will originate from our Big 12 colleagues and will be offered through distance education.

We will also develop additional minors to further enhance our program. For example, the biological and nanoscale science program will consider developing a minor in nanotechnology. Our faculty will develop courses for College of Engineering minors, including a biomedical- or biotechnology-related minor and the engineering studies minor for non-engineering majors. We also have opportunities to develop and support minor programs through external support from companies, foundations, and federal agencies.

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[24] National Science Board, 2008. *Science and Engineering indicators 2008*, Two volumes. Arlington, VA: National Science Foundation, released January 15, 2008: http://www.nsf.gov/news/news_summ.jsp?cntn_id=110984&govDel=USNSF_51

7.9 Enhance the undergraduate design experience

Design utilizes instruction based in engineering science to fuse knowledge from several courses into a seminal experience. This experience demonstrates to an engineer-in-training how several engineering disciplines come together in a coupled system to create a product or process. Design is a challenge to plan, implement, and instruct in regards to other core and elective courses.

Each of the stakeholders for our curriculum have expectations about what kind of design experience our students should have. Stakeholders include industries that hire our graduates, our accreditation board, and graduate schools that our students attend. In some cases, stakeholder requirements present additional challenges on proper instruction. For example, ABET lists specific program outcomes (Criterion 3, bullets (a)–(k) in the Criteria for Accrediting Engineering Programs). In addition, ABET also discusses design further in Criterion 5:

> **ABET Criterion 5**
> Engineering design is the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet these stated needs.

In short, we must prepare students for engineering practice through our curriculum, culminating their undergraduate academic careers with a major design experience based on knowledge and skills acquired in earlier course work and incorporating appropriate standards and realistic constraints.

A typical undergraduate student in our department takes a two-course design sequence. The first course, ME 270, is taken during the sophomore year, taking a student through a prescribed product design process. The course covers many topics, such as obtaining customer requirements, creating technical specifications, analyzing technicalities, marketing, creating a basic business case, and developing communication skills. The second course, the major design experience, is typically taken in the last year of the program to meet all accreditation requirements. ME 415 and 442 are two courses offered that meet ABET design criteria. Other design electives are offered, and they alone do not meet the requirements of a capstone design experience: ME 417—Advanced Machine Design I, ME 419—Computer-Aided Design, ME 445—Internal Combustion Engines, and ME 446—Power Plant Design. Our program is intentionally flexible, and students may specialize in a particular design area if they so choose.

Through our planning process, a survey of top ranked mechanical engineering programs, dialog among the Design CDC and Curriculum Committee, and recommendations from the our Industrial and Academic Advisory Council, we have developed the following goals for our design program:

1. **Formally identify a design project coordinator.** A design project coordinator will facilitate interaction between student design teams and companies wishing to provide design problems and become directly engaged in our curriculum.
2. **Improve cohesion of design throughout the curriculum.** Many of our courses exist as stand-alone courses and there is limited integration between them. A better coordination between courses in the curriculum will be incorporated into our curriculum review. For example, thermal stresses and component failure of dissimilar materials could be introduced in ME 325—Machine Design and then stressed again in ME 436—Heat Transfer.

3. **Increase emphasis of technical competencies.** While many of the design courses offer complex problems, even partnering with industries, there is always room to improve the level and sophistication of the analyses performed in design. For example, we will incorporate sustainability into design constraints.
4. **Integrate basic technological, business, and communication competencies.** Skills in communication, team building, management, computers, and software are fundamental for the practicing engineer. These competencies will be integrated and coordinated first amongst design courses and then throughout the curriculum.
5. **Create focus on globalization.** One of the newest constraints in design is the global scale on which it is practiced. Students should have the opportunity to participate in design projects that are distributed across countries, time zones, and cultures if they are to operate well in the shrinking global marketplace.

6. **Increase diversity of design course options.** Product and process design is complex, and it cannot be covered in a small number of courses. We will explore a diverse offering of capstone design experiences from which students can choose.
7. **Include virtual reality in the design process.** Our students have unique access to faculty affiliated with the Virtual Reality Applications Center, and we will make the most of those connections to provide our students unique opportunities in design education.

7.10 Draw undergraduate students into research experiences

Typically, 20–25 students per semester complete an independent study course (ME 490) that includes a research experience in a faculty member's laboratory. Several additional undergraduate students are employed in various research laboratories on a part-time basis. We will expand these research opportunities for our undergraduate students so that upon graduation, a large portion of our undergraduate students will have a research experience. This research experience is an opportunity-in-waiting for any student who is enrolled at a major research-intensive university, and it offers advantages for students, faculty, and the department.

- **Students gain an important educational experience**. They learn valuable troubleshooting, data presentation, and communication skills, and further learn the importance of functioning in an environment of sometimes ambiguous technical information.
- **Faculty may get exploratory data for new proposals or initiatives**. Students' research efforts can provide seed data for faculty to show a funding agency for support that a research direction is viable.
- **The department adds another excellent recruiting mechanism at both the undergraduate and graduate levels.** Undergraduates may see the opportunity as employment to offset the costs of college, or the research can be used to introduce undergraduates to graduate-level research to encourage them to pursue graduate study.

These advantages demonstrate the need to involve undergraduates in our research programs. Our proposals will include annual salaries for undergraduate research assistants, and we will use Research Experiences for Undergraduate (REU) supplements though funded NSF grants to employ undergraduates in our research, emphasizing efforts in one or more of our strategic program areas. Our advisors will encourage high-achieving students to get involved in research and match them to interested faculty. We will also participate in the Freshman Honors Research Program to engage freshman in our laboratories. Additionally, there are several programs on campus that facilitate undergraduate research experiences, including Providing Experiences in Research for Undergraduate Students in Engineering (PERUSE), Program for Women in Science and Engineering (PWSE), and Alliance for Graduate Education and Professoriate (AGEP). The department will supplement undergraduate research experiences through a research scholars program.

7.11 Invest in instructional laboratories

The demand for mechanical engineering education over of the past decade has placed pressure on class size, laboratory space, and faculty and staff energy. This demand has become particularly acute in the large number of laboratory experiments; design and fabrication experiences; and projects that are a staple of our rich curriculum. These experiences enrich the undergraduate program and are a necessary component for education.

On the other hand, managing these hands-on projects, while maintaining student satisfaction at graduation, is problematic because it adds to an already intense course load for students, and it requires more physical space from the department. To address the increase in educational demands, we will review instructional laboratory space use. We will consolidate various instructional laboratories and expand others to improve the students' experiences and operations in certain courses. Changes to the instructional laboratories outlined by the CDCs include:

- Incorporating more hands-on experiences, including using machine tools to design and build projects.
- Adding more simulation capabilities, such as computational fluid dynamics and finite element software, to compare predicted results to laboratory experiments.
- Upgrading equipment.
- Instituting continuous improvement measures through annually adding and deleting laboratory content to provide the most up-to-date experience possible.
- Integrating laboratory experiences from one course to the next, including decoupling laboratory experience from the classroom portion of the course. There are many advantages to this model, as experiments can focus on fundamentals presented in several courses. For example, controlling the temperature within a refrigerator could include concepts presented in ME 332—Thermodynamics II, ME 335—Fluid Flow, ME 421—Dynamic Systems and Control, and ME 436 —Heat Transfer. Similarly, courses that currently have a laboratory component could be offered through distance education to enable students on co-op, internship, or an international experience to complete the classroom portion of the course while they are off campus and the laboratory portion of the course when they return. Students who fail one portion of the course only have to retake that portion, not both the laboratory and classroom portion.

7.12 Track our progress

We will track our undergraduate program progress using quantitative and qualitative measures, including:

- Undergraduate enrollment on absolute and per capita bases
- Undergraduate degrees awarded on an absolute and per capita bases
- Participation of women and traditionally underrepresented minority students in our undergraduate program

- Participation of our students in international and leadership opportunities
- Feedback from recruiters, and co-op and internship supervisors
- Feedback from our Industrial and Academic Advisory Council
- Feedback from our undergraduate student leadership council

8 DEVELOP OUR PEOPLE

The department creates the infrastructure necessary for faculty and staff to excel, reach their potential, and develop and expand upon successful careers.

Continuing professional development is key to our future. Since the professional growth of our undergraduate and graduate students is accomplished primarily through our educational programs as described in sections 6 and 7, we also need to emphasize the development of faculty and staff, who directly impact our students as leaders at the university and within the profession. Faculty members benefit by continuously developing as scholars, seeking out and engaging in new opportunities for growth in research, education, and service. The department creates the infrastructure necessary for faculty and staff to excel, reach their potential, and develop and expand upon successful careers. We recognize the importance of setting and achieving significant individual professional goals, and we aspire that:

- The department will continue to be a vibrant community of scholars and a destination of choice for people to study, work, and learn
- Faculty will mentor and nurture each other in professional endeavors
- Faculty and staff will embrace lifelong learning opportunities and continuously develop their skills and expertise
- Faculty will advance through the professional ranks and take on leadership responsibilities
- Faculty, staff, and students will become leaders in their chosen form of scholarship

8.1 Mentor early-career faculty

We will facilitate the growth of our untenured faculty colleagues through a combination of informal and structured mentoring opportunities. Through our mentoring process, untenured and tenured faculty develop relationships based on individual needs and common interests. We feel these mentoring relationships should be encouraged and not forced. Our collegial environment offers many opportunities for interaction among the untenured and tenured faculty, enabling these mentoring relationships to arise naturally because of intrinsic value to both the untenured and tenured faculty.

As an annual practice, tenured faculty will review each untenured faculty member's career progress, and the department chair will provide timely feedback. At faculty retreats, we will organize roundtable discussions on issues of professional development. Led by one or two experienced faculty members, these discussions can be useful for creating dialogue and sharing best practices and lessons learned. Similarly, we will introduce a series of forums on career skills during the academic year. Each semester, we will organize one or two such forums on topics of greatest relevance to the untenured faculty. Tenured faculty will facilitate these forums, and everyone will be encouraged to attend and participate.

Potential forum topics include:

- Teaching best practices and lessons learned
- Choosing presentation and publication venues
- Developing new courses
- Managing time and responsibilities effectively
- Managing research group and mentoring graduate students effectively
- Establishing research collaborations
- Understanding expectations for promotion and tenure
- Generating new ideas for research projects
- Identifying sources of research funding
- Contributing to and participating in conferences
- Setting expectations for graduate student research assistants
- Setting priorities and annual goals for activities in research, education, and service
- Developing strategies for collaborating with industrial research partners
- Recognizing the different learning styles of students and motivating them
- Exploring the differences of supervising research by undergraduates, graduate students, post-docs, and visiting scholars

8.2 Establish development plans for tenured faculty

Driven in part by rapid changes in technology, the continuing professional development of our tenured faculty colleagues is likewise key to our future. To the extent that students need to be lifelong learners, faculty need to be as well. The landscape of the mechanical engineering field today is more collaborative and interdisciplinary, and the extramural funding climate is more competitive than ever before. Tenured faculty will articulate goals for their own career growth as scholars, researchers, educators, and administrators. In a constructive and forward-looking spirit, tenured faculty will participate in the university's post-tenure review process at least once every seven years, providing them with feedback and aiding them in defining vision and performance goals in research, education, and service.

8.3 Encourage faculty leadership

Our leadership magnifies the impact we can make on the profession and provides a valued contribution to the missions of the department and university. We seek out and assume leadership roles within the department and other campus units. With the right of self-governance comes our responsibility to be dutifully and positively engaged in activities, governance, and campus life at the department, college, and university levels. We must also lead transformative programs and initiatives. We are proud that mechanical engineering faculty lead two institutes on campus, the Bioeconomy Institute and the CyberInnovation Institute, as well as hold active leadership roles in several centers on campus, including the Center for Building Energy Research, the Center for Sustainable Environmental Technologies, the Industrial Assessment Center, and the Virtual Reality Applications Center. Leadership on-campus and across our profession contributes to the stature of the department, as do the scholarship achievements of individual faculty.

We aspire to fill prominent national leadership roles and be known throughout the profession as a source of technical innovation and constructive advice. Active participation in external leadership opportunities magnifies our impact across the profession, as well as furthers individual professional goals. Opportunities for our professional leadership include:

- Organizing conferences or symposia
- Organizing prestigious national workshops, or participating in programs that define the research agendas for funding agencies
- Serving as a division chair, executive committee member, or technical committee member within the structure of ASME or other professional organizations
- Serving as an editor or associate editor of a peer-reviewed journal
- Serving in a leadership role at the NSF or other organization

8.4 Support staff professional development

Our goals cannot be achieved without staff members who are well-skilled and proactively engaged in the department's operations. We encourage and support staff in developing individual skills and interests. In keeping with our commitment to professional development, all merit and professional and scientific staff members will participate in a minimum of 12 hours of professional development each fiscal year. Some examples of development opportunities include:

- Becoming active in a professional organization
- Taking graduate or undergraduate courses
- Taking university-sponsored training courses to develop new skills
- Taking courses through online organizations

8.5 Recognize student leaders

Student leaders are a source of excellent program ambassadors. Students at Iowa State actively participate in organizations, such as ASME, SAE, Pi Tau Sigma, Tau Beta Pi, Society of Women Engineers, engineering student council, and Team PrISUm. Through student-faculty interactions, we will identify, nominate, and foster student leaders, recommending to them that they participate in the many student groups that the department has to offer, including the Undergraduate Student Leadership Council, the Graduate Student Leadership Council, and the Engineering Policy and Leadership Institute. Student leaders will also be nominated for student leadership awards that provide a measureable impact of our students on the university community.

8.6 Track our progress

We will track our faculty, staff, and student development progress using quantitative and qualitative measures, including:

- Leadership positions held in the department, university, and throughout our profession
- Hiring in our strategic research areas
- Advancement of our faculty through the professional and lectureship ranks
- Advancement of our staff through their appropriate professional ranks
- Accomplishments and recognition of our student groups

9 BUILD OUR COMMUNITY

9.1 Aspirations for our community

We will continue to foster a sense of pride and a collegial environment in which faculty, staff, and students can grow professionally.

We aspire to:

- Organize ourselves and deploy our resources to achieve our goals
- Continue to foster a sense of pride and a collegial environment in which faculty, staff, and students can grow
- Develop collaborations and interactions based on our research and educational programs
- Communicate effectively, and broadly share our accomplishments and vision with others

9.2 Strengthen department operations

The department's operations will transform to address our needs and meet our aspirations. Some changes will naturally take place to recognize the financial structure and incentives associated with the university's new Resource Management Model. We recognize that some of our policies, procedures, and operational structure will change so we can adapt and meet our overall goals.

Figure 9.1 shows the department's organizational structure. The department chair consults with and is advised by advisory boards representing industry; undergraduate and graduate students; and faculty and staff. Our operations are broken down into the following business units: undergraduate program; graduate program; business office; and laboratory, instructional technology, and shop services. The administrative structure includes an associate chair for academic affairs; an associate chair for graduate studies and research, who also serves as the director of graduate education; a program coordinator 2 who has overall responsibility for supervising office staff and managing the department's financial matters; a systems support specialist 4 who has overall responsibility for supervising the technical staff and manages the department's physical plant and information technology; and the faculty who meet the department's educational, research, and professional service missions.

The department's staff is structured to improve operations and provide needed capability for expanded services and initiatives. Our Advising Center has three full-time academic advisors to improve the delivery of advising services to our students. To meet our internal and external communication needs, we have a half-time equivalent communication specialist. We receive full-time equivalent support from the university's foundation for development purposes and major gift production. Additionally, two program assistants, one for the undergraduate program and one for the graduate program, better manage and develop those important programs.

The Advising Center receives faculty support through a liaison team that provides career counseling to students; delivers guest lectures to ENGR 101 and ME 202 sections and coordinates external speakers; advises extracurricular student groups; evaluates course transfer requests; and provides lab tours and information for students interested in graduate school. Our advising model is a hybrid in which academic advisors and faculty work together to meet the needs of our students.

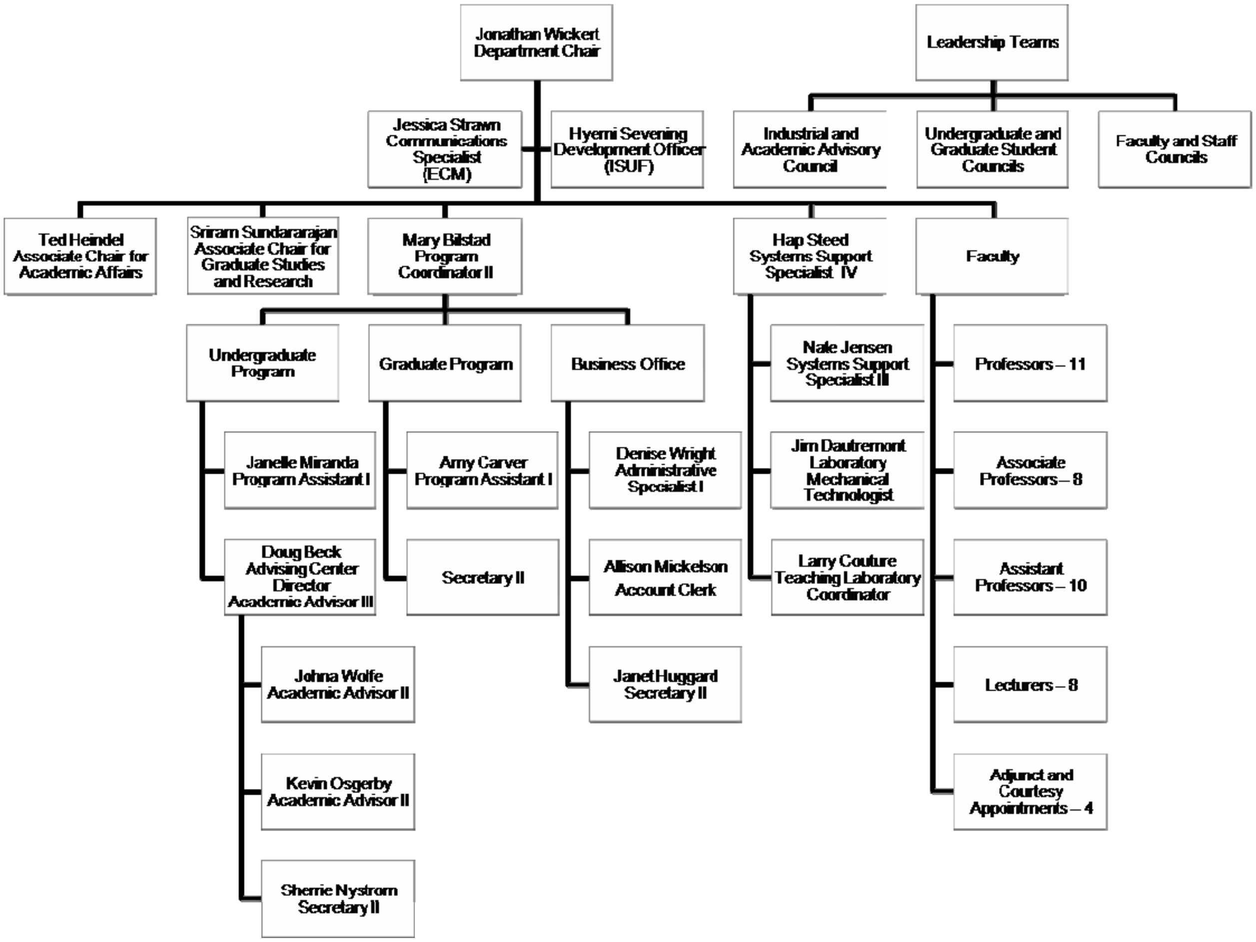

Figure 9.1: Organization chart for the Department of Mechanical Engineering.

9.3 Establish benchmarking guidelines

As shown in Figure 9.2, we have the sixth largest program in terms of undergraduate enrollment when compared to our aspirant institutions. Other programs from this list having larger undergraduate enrollments are Georgia Tech, Ohio State, Purdue, Texas A&M, and the University of Texas—Austin. Nationally, our program continually ranks in the top 10 in terms of the number BS graduates.

Figure 9.3 shows that our undergraduate enrollment fell in the early 1990s, grew in the late 1990s, and stabilized in recent years. As shown in Figure 9.4, our graduate enrollment follows a similar trend. Although our faculty count has declined somewhat in recent years (Figure 9.5), we continue to deliver high-quality education to our students with reasonable teaching expectations of our tenured and tenure-stream faculty. Our typical teaching load is three courses per year. As shown in Table 9.1, this expectation is consistent with that of many other programs. The department manages its sizable enrollment by:

- Providing full-time advisors for our students, so faculty are empowered to focus on research and teaching excellence.
- Partnering with other departments that teach some of our core courses such as materials, mechanics of materials, statics, and dynamics.

- Examining our class size and number of sections to accommodate the large number of students. For example, the average class size for the required mechanical engineering courses (ME 231, 324, 325, 332, 335, 370, 421, 436, and 415) was 36 students in fall 2007 and 44 students in spring 2008. Although those class sizes are larger than 20 years ago, so is the national educational landscape, and our class sizes remain modest, and in some cases they are smaller than those in some other programs (Table 9.1).

The college has a goal through the Cluster Hire Initiative to reduce the student-to-faculty ratio from 21.9 to 18.8. Based on 2007 ASEE data, which accounts for all faculty typically focused on undergraduate instruction,[25] mechanical engineering currently employs 29 full-time equivalent (FTE) tenured or tenure-stream faculty and 6.7 FTE nontenure-stream faculty (lecturers). With our current FTE undergraduate enrollment of 925 students, we have an undergraduate student-to-faculty ratio of 25.9. However, this number is not the most accurate depiction of our ratio. Aside from orientation courses, we do not teach freshmen students, and as a result, the size of the freshmen class does not demonstrably influence our educational program. Further, we have chosen to use lecturers, in addition to professors, to deliver high-quality education. Our lecturers typically teach twice as many classes as professors, making their contribution to our student-faculty ratio twice that of the professoriate.

Our declared major-faculty ratio is higher than that of any other college department. When we include undergraduate and graduate students in student enrollment and all faculty in the faculty count, our student-to-faculty ratio over the past 10 years increased from 22.3 in 1998 to a high of 35.6 in 2004. The latest (2007) numbers show we are currently at 29.9 students per faculty member. Compared to the entire university,[26] this student-to-faculty ratio is nearly 1.7 times the Iowa State average of 17.8 students per faculty member.

To more accurately reflect our operations, we have calculated our ratio using alternative values. Because lecturers teach twice as many classes as tenure-stream faculty, we define a total instructional FTE (TIFTE) faculty complement, which considerably lowers our student-to-faculty ratio. We also include only sophomores, juniors, and seniors in the total student count because our faculty members do not teach freshman courses. Taking these factors into consideration, our student-to-instructional faculty ratio is a reasonable 19.8. Table 9.2 summarizes these data for 2007.

Table 9.3 shows that in terms of total student-credit-hours per total-faculty-count (including tenure-stream faculty and lecturers), our department is consistently above the college average, and in recent years, near the Iowa State average. For the past three years, our total student-credit-hours per total-faculty-count has been the second highest in the college with aerospace engineering having the highest count.

We also compared ourselves to programs outside of Iowa State. Our department teaches approximately 8% more student credit hours than our peers that are part of an ASME benchmark group, which includes very high research-active public universities as determined by the Carnegie Foundation (Table 9.4). Because we handle much of our teaching load through lecturers, our annual number of credit hours taught per tenure-stream faculty is 16, which is lower than the 17 for the ASME benchmark group.

Table 9.4 also shows that our MS and PhD production is lower than the ASME benchmark group. On the other hand, we also see that we exceed the ASME benchmark group in several areas, including sponsored research expenditures per tenure-stream faculty. Overall, Table 9.4 shows we excel in some categories and have opportunities for improvement in others, particularly our graduate program.

[25] http://www.asee.org/publications/profiles
[26] http://www.public.iastate.edu/~inst_res_info/FB08files/PDF%2008/FB08all.pdf

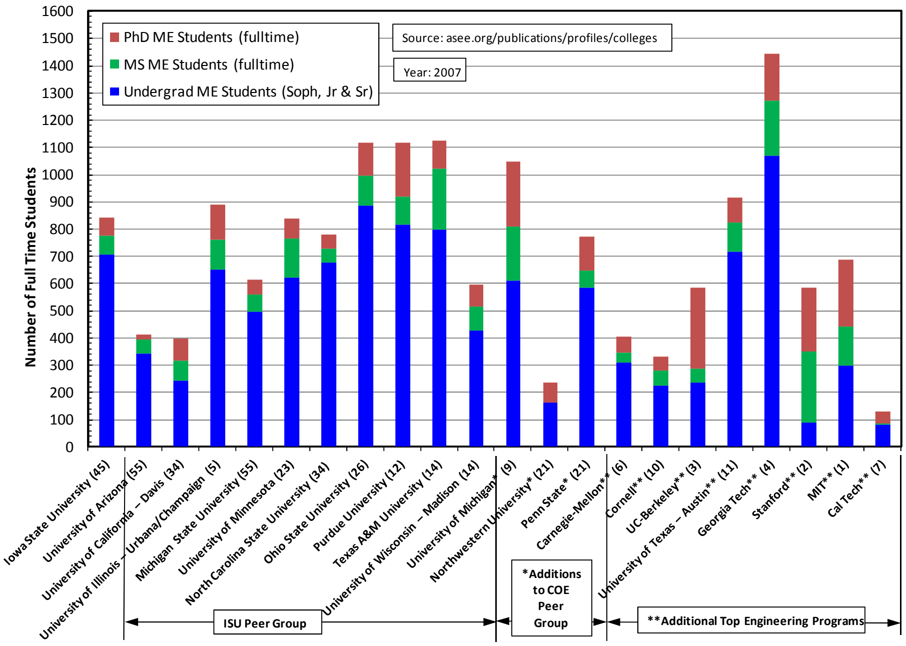

Figure 9.2: Total number of students in selected mechanical engineering departments. Undergraduate enrollment statistics here only include only sophomores through seniors because some departments do not include freshmen in their reported enrollments.

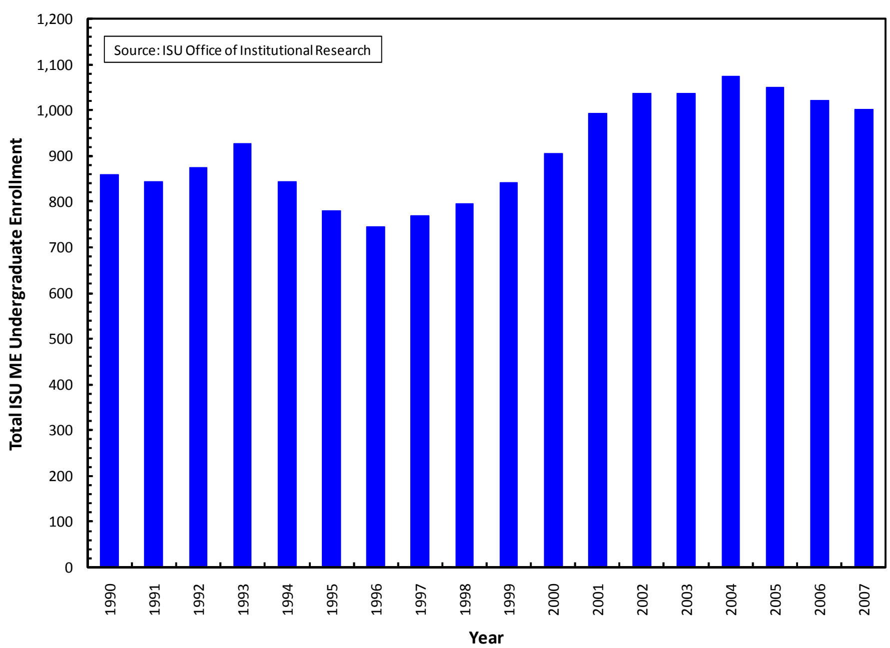

Figure 9.3: Mechanical engineering undergraduate trend.

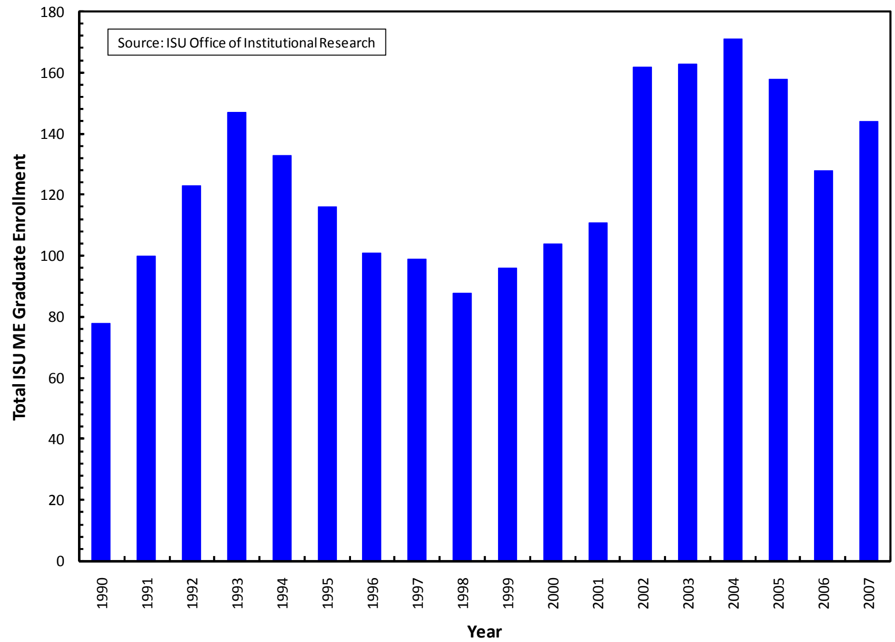

Figure 9.4: Mechanical engineering graduate enrollment trend.

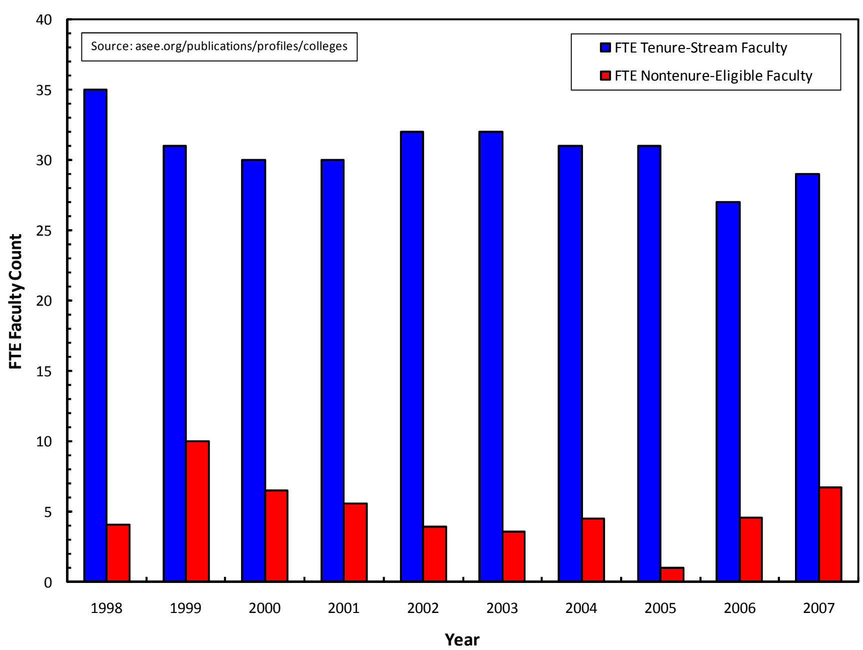

Figure 9.5: Mechanical engineering tenure-stream and lecturers trend.

Table 9.1: Typical instructional policies at various institutions. These data were acquired by querying individual ME colleagues at the represented institutions.

University	Sem. or Qtr.	Typical Teaching Load	Buyouts	Notes
Iowa State	Sem.	3 courses/year	1 month salary for first course, 2.5 months salary for second, and 4.5 months salary for third	• Graders provided if requested for required courses • Lab coordinator is equivalent to a course
Brigham Young University	Sem.	3.2 courses/year		• Research-active faculty usually teach 3 courses, while faculty with less research teach 4
Carnegie Mellon	Sem.	2 courses/year	None	• One large undergraduate course (100+ students) and one elective or graduate course is typical teaching load • Required courses are typically 4 credits
Georgia Tech	Sem.	4 course/year	1.5 months salary; not encouraged	• Required courses get 4 hours/week of grader time for every 30 students • Typical required undergraduate course size is 60+ students
Minnesota	Sem.	2.5 courses/year	1.5 months salary	• Courses are typically 4 credits
North Carolina State	Sem.	3 courses/year		• Research-active faculty teach 3 courses, while faculty with no research teach 4–5 courses
Ohio State	Qtr.	1 course/qtr.		• Must pay 1 month salary to department to reduce teaching load; otherwise, teaching is 4–5 courses/year • Must teach 1 required undergraduate course per year
Penn State	Sem.	4 courses/year	25% salary	
Purdue	Sem.	2 courses/sem.	15% salary for 1 class; 30% salary for 2 classes	• Most faculty teach 3 courses/year
University of Illinois—Urbana-Champaign	Sem.	1 course/sem.	Not encouraged	
University of Wisconsin—Madison	Sem.	4 courses/year	1.2 months salary	• 5 or more externally funded graduate students reduces teaching load to 3 courses/year • Typically get a grader for every 40 students • Some undergraduate courses have 120+ students
University of California—Santa Barbara	Qtr.	1 course/qtr.	Not encouraged	
University of Massachusetts Amherst	Sem.	4 courses/year		
University of Washington	Qtr.	1 course/qtr.	1 month salary	• Undergraduate courses typically have 100+ students with TA and grader support
Utah State	Sem.	3–4 courses/year	1 month salary	• Large undergraduate required classes get 1 grader (20 hours/wk) • Typically teach at least 1 required undergraduate course per year
Virginia Tech	Sem.	3 courses/year for most research-active faculty	5% academic year buyout requires 1.125 month salary	• Teaching load is formula driven, based on number of MS and PhD students • Faculty with no students teach 6 courses/year

Table 9.2: Student enrollment, faculty count, and student-to-faculty ratio for 2007. FTE = full time equivalent. TTT = tenured and tenure-track. NTE = nontenure eligible. TFTE = total faculty = TTT + NTE. TIFTE = total instructional faculty equivalent = TTT + 2*NTE.

	Enrollment			Faculty Count				Student-to-Faculty Ratio				
	UG	Grad[a]	Total[b]	FTE TTT	FTE NTE	Total FTE	Total Instr. FTE[c]	UG TFTE	UG TIFTE	Grad TTT	Total TFTE	Total TIFTE
Iowa State	21,004[f]	4,664[f]	26,160[f]	1,187[f]	282[f]	1,469[f]	1751	14.3	12.0	3.9	17.8	14.9
College	4,600[f]	947[f]	5,547[f]	220[g]	33.9[g]	253.9[g]	287.8	18.1	16.0	4.3	21.9	19.3
ME[d]	925[g]	135[g]	1060[g]	29[g]	6.7[g]	35.7[g]	42.4	25.9	21.8	4.7	29.9	25.0
ME[e]	705[g]	135	840	29	6.7	35.7	42.4	19.7	16.6	4.7	22.5	19.8

[a] does not include Vet Med
[b] includes all students
[c] assumes NTE teach twice as many classes as TTT
[d] includes freshman through senior
[e] includes sophomore through senior because most freshman do not take courses taught by ME faculty
[f] data from ISU Fact Book 2007–2009, http://www.public.iastate.edu/~inst_res_info/
[g] data from ASEE, http://www.asee.org/publications/profiles/

Table 9.3: Student credit hours and faculty count from 2006–2007.[27]

	Student Credit Hours			Faculty Count				Student-to-Faculty Ratio				
	UG	Grad[a]	Total[b]	FTE TTT	FTE NTE	Total FTE	Total Instr. FTE[c]	UG TFTE	UG TIFTE	Grad TTT	Total TFTE	Total TIFTE
Iowa State	592,796	68,483	679,470	1,187[d]	282[d]	1,469[d]	1751	403	339	58	463	388
College	61,948	13,834	75,782	220[e]	33.9[e]	253.9[e]	287.8	244	215	69	298	263
ME	11,506	2,400	13,906	29[e]	6.7[e]	35.7[e]	42.4	322	271	83	390	328

[a] does not include Vet Med
[b] includes all student credit hours
[c] assumes NTE teach twice as many classes as TTT
[d] data from ISU Fact Book 2007–2008, http://www.public.iastate.edu/~inst_res_info/
[e] data from ASEE, http://www.asee.org/publications/profiles/

[27] ISU Fact Book 2007-2008, http://www.public.iastate.edu/~inst_res_info/.

Table 9.4: ASME Biennial benchmarking study for U.S. mechanical engineering departments during 2007–2008 academic year.

Benchmark Metric	Iowa State ME Department	ASME Benchmark Group[a]
Total student credit hours taught	13,731	12,828
Credit hours taught per tenured or tenure-stream faculty	16	17
BS degrees awarded	223	151
MS degrees awarded	31	40
PhD degrees awarded	9	15
Full professors	13	16
Associate professors	7	9
Assistant professors	9	8
Lecturers and instructors	6	2
Adjunct faculty	4	4
Faculty positions open	2	2.8
Faculty leaving during past year	1	1.5
Total external sponsored research expenditures per tenured or tenure-stream faculty	$387k	$185k
Research supported half-time graduate research assistants advised per tenured or tenure-stream faculty	2.6	1.9
Graduate students supported by other non-teaching means advised per tenured or tenure-stream faculty	0.03	0.4
Fraction of academic year salary required to buyout one course section	11%	14.8%
Academic year salary recovery through research grants and contracts per tenured or tenure-stream faculty	$2.9k	$6.9k
Endowed faculty positions for tenured or tenure-stream faculty	5	3.4
Fraction of overhead returned to faculty member	15%	9.1%
Graduate research stipend for 9 months	$14,575	$15,300
Half-time graduate teaching assistants supported per tenured or tenure-stream faculty	0.48	0.4
University supported staff	15	13

[a] Carnegie classification for very high research-activity public universities

9.4 Enhance the department's climate

In a cooperative environment, faculty members can effectively pursue professional goals, as well as the collective goals of the department and college. We are committed to maintaining a culture within the department that is dynamic, respectful, collegial, and collaborative. As individuals, we will naturally disagree about certain initiatives and policies, and we are committed to constructive criticism and open dialog to better the department, being sure to value and respect each person's opinion. Once a collective decision is made, we will support its implementation to the best of our individual abilities because the department can only be successful to the extent that faculty work as a team to achieve common goals.

There are enormous benefits of working in an enriched cultural and intellectual environment. We spend a great deal of time at work, and we should make others feel as though they have achieved something each day and enjoy companionship and social interactions. We want to be proud of what we do and motivated to do it better next time. We strive for a department culture in which people can see clear career development pathways, while receiving help and support along the way.

Esprit de Corps will be nurtured by setting special days, generally once each semester, where all faculty and staff members will be encouraged to wear departmental branded clothing and recent achievements will be recognized. Encouraging faculty and staff to use departmental presentation and poster templates, when appropriate, for presentations and displays will foster the common look and feel of the department. The templates will include the department's style template, the branding line "Knowledge. Innovation. Leadership." to articulate our values and the department's Web site URL. These actions will demonstrate the department's professionalism and purpose-driven mission.

9.5 Create informal opportunities for collaboration

Promoting opportunities for informal discussion, which are often the seeds for research and educational collaboration, can enhance our sense of community. Regular break times of 10:00–10:15 a.m. and 3:00–3:15 p.m. will be encouraged so faculty can run into one another more often and discuss their work in an informal setting. A common faculty and staff break room will facilitate these informal interactions. This shared space will include faculty and staff mailboxes, the photocopier, coffee maker, whiteboard, and a table and chairs. Likewise, we will establish a common study and break area, which can also serve as a meeting place for student groups and study sessions, to enhance undergraduate and graduate student satisfaction..

We also seek collaboration with other departments, centers, and institutes within the university. Some examples of further potential collaborative opportunities include:

- Developing research centers
- Drawing other departments and researchers into our strategic research programs
- Organizing on-campus conferences
- Co-teaching, or alternating teaching duties, of courses with other departments
- Sharing instructional laboratories between our courses and with other departments
- Co-advising groups that engage students in several departments

9.6 Share our message

As we share our message, we will emphasize our themes in research, graduate education, and undergraduate education, as well as our differentiation relative to peer institutions. By remaining on-message internally and externally, we can reinforce our identity and recognition and improve our external visibility. Faculty members have a unique position to be leaders in academe, professional societies, and society at large, and such visibility is valuable to magnify our impact and reinforce our brand in research and education.

We strive for open and transparent communication so all are aware of our policies, procedures, expectations, and accomplishments. Iowa State mechanical engineering brand recognition will be enhanced by a clear, consistent message that we as faculty, staff, and students articulate both internally and externally. We will share our consistent message through several avenues, including:

- Providing wall posters at key locations within the building that describe key facts (for example, student activities, research programs, mission, etc.)
- Displaying lab description posters outside all laboratories summarizing major facilities and research efforts within the respective lab
- Distributing print media (examples described below) to all departmental visitors, and leaving print media with others when we visit external locations
- Using departmental presentation templates and Iowa State mechanical engineering graphics, when appropriate, for faculty and student presentations
- Wearing Iowa State mechanical engineering branded clothing when business-casual attire is appropriate to advertise our association with the department

We will expand our print and electronic communication efforts, developing and regularly updating newsletters, brochures, handouts, and posters to highlight our research, teaching, and service activities. Our Web site will be redesigned to provide timely information, and we will use e-mail to promote our activities to the widest possible audience.

We have several opportunities for improving communication through print media:

- Our *Points of Pride* handout will provide a summary profile of the department.
- Our newsletter, *Dimensions*, will highlight faculty, student, staff, and alumni accomplishments and be published in the fall and spring.
- A research and graduate studies brochure will describe our research program areas and opportunities to prospective students.
- We will develop posters to highlight student activities, including classroom and laboratory instruction; experiential learning; and extracurricular activities. These posters will be mounted on the walls near student classrooms, the advising center, the graduate student programs area, and the main office.
- Faculty will be encouraged to develop collage-type posters that showcase their scholarly activities and mount these posters near their laboratories.

Our efforts to improve our electronic communication will include:

- Updating our Web site to include dynamic content, such as video clips of student activities and examples of research projects and discoveries.
- Encouraging students to develop their own video clips highlighting why they chose Iowa State to complete their mechanical engineering degree, or explain why they feel that mechanical engineering is an exciting major. Selected clips may also be posted on YouTube and other public venues to enhance the department's name recognition.
- Soliciting video clips of alumni in work-related activities to highlight the many opportunities available to our graduates.
- Sending a periodic e-mail blast entitled *InCYde Mechanical Engineering* to faculty, staff, students, and alumni to provide them with the latest news from our department.
- Placing flat panel displays near the advising center and the department main office to provide a list of daily announcements, seminars, and recent accomplishments.
- Exploring text messaging capabilities to provide up-to-date information to our students.

The print and electronic communication activities must be timely and up-to-date for them to be successful. This effort will be the responsibility of the department's communication specialist.

Several advisory councils will foster communication between the faculty, staff, students, and the department chair.

- The Undergraduate Student Leadership Council comprises leaders of various student groups including ASME, Pi Tau Sigma, SAE, and others, and provides input on undergraduate program matters. The Graduate Student Leadership Council comprises MS and PhD students as recommended by the Director of Graduate Education, and also represents a cross-section of the graduate student body. This group will provide input and feedback relating to the graduate program.

- The Faculty Leadership Team is a forum for discussion between the chair and the department's faculty leadership team on policy and new initiatives. This team comprises the chair, associate chair for academic affairs, the director of graduate education, and two faculty-at-large.
- The Staff Leadership Team is a forum for discussion on matters of importance to staff. The membership of this council will include the chair, the administrative specialist overseeing the department's budget and staff, the administrative specialist for the department chair, manager of technical services, the coordinator of the advising center, the graduate program assistant, and the undergraduate program assistant.
- The Industrial and Academic Advisory Council comprises representatives from industry and academia, and acts as a liaison between our educational programs and society. This council provides an outside perspective to the department to help maintain educational relevance, helps identify long-term needs and goals, offers perspective on our strategic plan, and provides guidance and support of advancement activities.

9.7 Utilize space efficiently

Mechanical engineering is located primarily in Black Engineering, a building we share with industrial and manufacturing systems engineering. The department maintains approximately 52,000 net accessible square feet (nasf) of physical space in the Black Engineering Building, as well as in Hoover Hall and the Nuclear Engineering Laboratory. We recognize that, like our financial resources, our physical space is an important and valuable asset that must be well managed. Just as educational and research programs change with time, our space needs change with time, and it is important to periodically review space needs and adjust allocations accordingly.

Historically, we have split the second and third floors with the industrial and manufacturing systems engineering department. Although this format served the departments well in the past, it now creates significant fragmentation and restricts cooperative interactions. Sufficient space quality and quantity is important in establishing the department's functionality and sense of pride. Proximity of faculty within a department is an essential factor in sparking hallway conversations and collaborations and creating common identity, which are important factors for younger colleagues establishing their careers. The conference rooms, seminar areas, and other office areas have not been upgraded significantly since the building's construction.

Faculty members need the physical space necessary to carry out their research programs and to be impactful in their research endeavors. While the department has an obligation to provide laboratory space for faculty research programs, faculty have a responsibility to recognize that space is not allocated permanently, or to programs and projects that are no longer active when other projects requiring space exist. The chair, in consultation with faculty and the faculty leadership team, will allocate research laboratory space. We will periodically review space needs and utilization, while noting that it is not beneficial to frequently modify space. We recognize that, based on the activity of research programs, some laboratories will grow and some will shrink, some will be renovated and others will not, all of which depends on needs, extramural funding of programs, and funds available for renovations. Equipment that is no longer used will be stored in the university's warehouse and returned to a laboratory as new opportunities for it arise.

9.8 Review financial model

When considering our financial model, we must recognize that mechanical engineering departments across the country face the same challenges and pressures that we do. In fact, we have many advantages that other programs do not share, and as such, we are very well positioned for the future. For example, we have:

- Endowment support enabled by the vision of Henry Black and Pete Hilstrom
- Year-to-year carry-over budget ability
- A Resource Management Model based on an incentive structure
- Flexibility in the university's financial structure
- A large alumni base
- Supportive industrial partners

We recognize the importance of a hybrid private-public institution model for our operations, and we see that extramural funding to the department will become an increasingly important aspect of our financial future. Endowed scholars, professorships, and chairs; discretionary seed funding for faculty initiatives; startup packages for new faculty; new student diversity programs; student and faculty recruiting activities; physical space renovation; and matching funds for proposals are some examples of functions that will become increasingly dependent on extramural support. Proposals to state and federal agencies will be important sources of funding for our various new educational programs; scholarships and fellowships; course and curriculum development; laboratory renovation; and instrumentation acquisition. Everyone—faculty, staff, and students—has an important role to play in our financial future.

We see our financial future as one of opportunity. We have a number of comparative advantages over other departments within our university and over mechanical engineering departments at other universities nationwide. Our department boasts more than 7,500 living alumni; corporations eagerly recruit our students and seek engagement with us; and our research programs are visible, directed at important national needs and thriving. Through a concerted effort to advance the department, and by working with our communications and development staff, we seek to leverage these advantages to support our new initiatives and advance the department's missions at all levels.

9.9 Track our progress

We will track our progress in developing our community using quantitative and qualitative measures, including:

- Annual and major gifts to the department
- Feedback from our advisory councils
- Sense of community among the faculty, staff, and students

10 SUMMARY

Based on indicators outlined in reports by NSF, NAE, and ASME on the future of engineering education and research, we envision that mechanical engineering will continue to be a highly sought-after discipline, and that it will evolve into a combination of core disciplinary knowledge and a broad systems-level perspective. Our department will be a destination of choice for

Our department will be a destination of choice for students, faculty, and staff.

students, faculty, and staff. The roadmap outlined in this document will help us achieve this goal by focusing on the following five priorities:

1. **Extend our pillars of research excellence.** The department's research portfolio encompasses programs in biological and nanoscale sciences; clean energy technologies; complex fluid systems; design and manufacturing innovation; and simulation and visualization. Our hiring and investments will be strategically driven to support mature and develop emerging research areas.
2. **Strengthen our graduate program.** We strive to enhance the quality and impact of our doctoral degree program, which is the backbone of our research enterprise. Through recruiting targeted students; investing in fellowship and teaching assistantships; and making programmatic changes, we will increase the quality and productivity of the PhD degree to compete more effectively and better position our research programs for extramural funding and graduate student placement. We will also offer a coursework-only MS option to better serve distance education students, working professionals, alumni, and corporate partners.
3. **Enrich our undergraduate program.** Enrollment in mechanical engineering programs grew significantly both for the department and nationally from 1994–2004, but that trend has recently flattened. Healthy enrollment is welcome recognition of the important role mechanical engineering plays in our society and of our department being a destination of choice. The key challenge facing the undergraduate program is managing our enrollment level while maintaining our heritage of leadership and innovation in education. We will review our program and update our curriculum to ensure it remains fresh and relevant. We will continue to introduce our students to globalization and societal and technological trends; enrich the program with innovative ways of delivering engineering education through technology and pedagogical research; increase the participation of women and traditionally underrepresented minorities in the program; and increase students' quality of life and satisfaction at graduation.

4. **Develop our people.** We are committed to the principle of lifelong learning not only for students, but also for faculty and staff. We will provide both informal and structured mentoring opportunities to support our untenured faculty as they develop successful academic careers. Tenured faculty members will aspire to become widely recognized leaders in their chosen dimension of scholarship. Staff members will pursue opportunities for training and learning new skills to reach their career advancement goals.
5. **Build our community.** We are committed to maintaining and enhancing a culture within the department that is constructive, collegial, prideful, and collaborative. We will organize ourselves and our physical space in a manner that looks to the future and meets our aspirations. We will communicate our goals and accomplishments to our constituents and provide opportunities for our alumni and corporate partners to work with us to attain our shared vision.

The success of our department and the success of Iowa State are closely coupled. Our future is one of opportunity and great potential. We are members of a departmental community that is rich in heritage, and we are strong today because of the hard work and vision of those who came before us. We will build on that foundation to strengthen our research, graduate education program, and undergraduate education program.