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I. Executive Summary

Mechanical Engineering is an engineering discipline that is at the center of solving many of humanity's grand challenges. Mechanical engineers are involved in exploring new sources of renewable energy, improving energy efficiency of mechanical systems, developing new tools for medical diagnostics and treatments, and devising ways to create a cleaner and healthier environment. Society has a growing need for highly trained and well-educated engineers who are able to contribute to the solution of the grand engineering challenges.

For decades, the Department of Mechanical Engineering at the University of Minnesota has been among the most highly ranked mechanical engineering departments in the nation, providing students with a first class mechanical engineering education at the bachelor’s, master’s and doctoral level. It has contributed to the solution of societal problems through its world-class research and promoted science and engineering through its service to the state, the nation, and the professional community.

This strategic plan concludes with a set of actions that are aimed at further enhancing an already highly productive and widely recognized department. Five task forces, involving fifty-three individuals, took a strategic look at three research focus areas as well as the Department’s graduate and undergraduate programs. Task forces broadly represented all stakeholders in the Department, including students, faculty, staff, local and national industry, and alumni. This strategic plan is the result of the recommendations of these task forces.
Overview of the Department

A. Mission, Values and Vision

1. Mission Statement

The Department of Mechanical Engineering at the University of Minnesota offers

- undergraduate and graduate education of the highest quality in mechanical engineering,
- conducts significant basic and applied research in selected areas, and
- provides professional service to the appropriate constituencies of Minnesota’s land grant university.

2. Values

The Department of Mechanical Engineering at the University of Minnesota places high value on:

- Research at the highest level of quality and integrity.
- Holistic education of undergraduate and graduate students at the highest level.
- Support of industry in Minnesota and the nation.
- Service to our profession and the University.
- Engagement in public affairs.
- Atmosphere of respect and collegiality among faculty, students and staff.
- International awareness and leadership.

3. Vision

The Department’s vision is to

*become the best mechanical engineering department in the country in our areas of emphasis.*

These areas of emphasis are selected topics within:

- Energy and Transportation Research,
- Biomechanical Engineering and Human Health,
- Environmental Engineering,

as well as

- Graduate Education, and
- Undergraduate Education.
B. Department Faculty

The Department of Mechanical Engineering has 36 mechanical engineering faculty, among those three are on phased retirement. The Department also serves as tenure home to seven faculty who are associated with two independent programs: Industrial and Systems Engineering and History of Science, Technology, and Medicine.

The Mechanical Engineering faculty have achieved a high level of professional distinction. Of the Department’s eight members of the National Academy of Engineering, three are currently active (Profs. Goldstein, Ramalingam, and Sparrow), two are faculty emeriti (Profs. Liu and Pfender), and three are deceased (Profs. Eckert, Jordan and Whitby). One of the Department’s faculty is a Guggenheim Fellow (Prof. McMurry). Seventeen of the 36 faculty members are Fellows of at least one professional society, including the American Society of Mechanical Engineers.

The quality of the research and teaching of the Department of Mechanical Engineering has been recognized within the University through University-wide and college-wide awards. The title of Regents Professor is held by one current (Prof. Goldstein) and two former ME faculty (Profs. Eckert and Liu). Three faculty members are Distinguished McKnight University Professors (Profs. Bischof, Kortshagen, and Pui). Six faculty won the Horace T. Morse-University of Minnesota Alumni Association Teaching award (Profs. Chase, Durfee, Erdman, Strykowski, Sparrow, and Starr).

C. Students

The Department consistently attracts undergraduate and graduate students of the highest caliber. The Department annually graduates around 180 bachelors in Mechanical Engineering, 40 Masters of Science in Mechanical Engineering, and about 16 Ph.D.s. With 180 B.S. degrees, Mechanical Engineering has the largest undergraduate program within the college, the Institute of Technology, which graduates about 950 B.S. total with its eighteen undergraduate programs. Undergraduate students are admitted into the college and are of excellent quality. The average high school rank of all students enrolled is in the ninety-first percentile of their high school class and the average ACT score is 29.6 (in 2009) out of a maximum of 36.

For its graduate program, the Department receives about 400 applications each year and admits around 130 students, of whom 60 chose to enroll. The average GRE score of the enrolled students is: 528/757/4.3 (verbal/quantitative/analytical). The Department’s graduate students are highly competitive for national fellowships. In 2009, two students won NSF graduate fellowships, and one student won a National Defense Science and Engineering Graduate fellowship. Around ten students each year win University-wide fellowships.
D. Alumni

The Department has a large and committed group of alumni. The Department is aware of just over 11,000 living alumni. Over 655 alumni have founded one or more companies and made major contributions to the economic development of the state of Minnesota and the nation.

ME alumni are strongly committed to the Department. In the 2008/09 fiscal year alone over $2,670,000 in individual gifts were made in support of the department's students and faculty. This included cash gifts of $1,935,693, with over $130,000 to the ME Discretionary fund, and also includes $85,000 in matched scholarship endowment funds (held at the college level), which will go toward ME students. A new endowed chair was created by Ron (ME 1972) and Janet Christenson for research in renewable energy. Professor Jane Davidson was appointed the Department’s inaugural holder of this chair. Alumni also shared that they have made $650,000 in planned gifts from their estate that will come to the department from their estates.

In support of the new building, which opened in 2002, during a five-year campaign, a key group of alumni was closely involved in raising $9M for the building, which had a total cost of $22M.

In Fall 2009, a group of ME alumni founded the ME Alumni Network. This group is intended to serve as a venue for ME alumni to connect with each other and to engage alumni in sustaining and building teaching and research excellence in the Department.

E. Benchmarking with Peer Departments

In 2009, the Department’s graduate program was ranked 15th nationwide among 167 ME graduate programs according to US News and World Report. The last ranking performed by the National Research Council in 1995 ranked the Department’s graduate program 8th in the country.

Big 10 Plus ME Departments with 2009 US News and World Report Rankings

- **Big 10:**
  - Michigan State (40)
  - Northwestern (11)
  - Ohio State (22)
  - Penn State (17)
  - Purdue (8)
  - U. Illinois UC (6)
  - U. Iowa (48)
  - U. Michigan (5)
  - U. Minnesota (15)
  - U. Wisconsin (15)

- **Plus:**
  - Carnegie Mellon (11)
  - Cornell (9)
  - Georgia Tech (6)
  - MIT (1)
  - Stanford (2)
  - UC Berkeley (3)
  - UT Austin (11)

For more objective measures, the Department participates in annual meetings of the Big Ten Plus Department Heads. The Big Ten Plus group of ME departments includes **13 of the top 15 ME departments** according to the US News and World Report ranking.
Within this peer group, the Department ranks:

- **5th in terms of citations per faculty**: Department faculty received 104 citations per faculty in 2008, compared to a Big Ten Plus median of 87.$^{1}$

- **6th in ME degrees awarded per faculty**: In 2008, the Department awarded 6.2 BS, MS, and PhD degrees, compared to a Big Ten Plus median of 5.7.$^{2}$

- **7th in research expenditures per faculty**: In 2008, research expenditures per faculty were ~$442k, compared to a Big Ten Plus median of ~$384k.$^{2}$

- **11th in publications per faculty**: Department faculty published 3.0 papers per faculty, compared to the Big Ten Plus median of 3.2.$^{1}$

- **13th in terms of ME faculty size**: The Department has 36 ME faculty compared to a Big Ten Plus median of 42.$^{2}$

- **16th with respect change of faculty size between 2003-08**: The Department’s ME faculty size shrank by 1.5 faculty FTE, compared to a Big Ten Plus average growth of 3.3.$^{2}$

It is obvious that the Department ranks highly among Big-Ten Plus departments on measures of faculty quality and productivity. However, the Department is among the smaller ME departments in the Big-Ten Plus, and one of only five Big-Ten Plus departments that has seen a reduction of its faculty size between 2003 and 2008.

Within the group of seven engineering departments within the college Institute of Technology, the Department ranks:$^{3}$

- **1st in total research expenditures**

- **1st in research expenditures per faculty**

- **1st in terms of bachelor’s degrees awarded**

- **3rd in terms of degrees awarded per faculty**

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$^{1}$ ISI Science Citation Index  
$^{2}$ 2008 Big Ten Plus survey  
$^{3}$ 2008 ASEE department profiles
II. Strategic Planning Process

During the Fall semester 2008 and Spring semester 2009, several faculty meetings were held around the future direction and organization of the Department. Topics of the discussion were the departmental mission, vision, and values, as well as the definition of focus areas. Faculty input was sought in faculty meetings and through anonymous surveys among faculty.

At the beginning of Spring 2009, five task forces in the research areas of Energy and Transportation, Human Health, and Environmental research and the educational areas of Undergraduate and Graduate education were established. Task force members were volunteers who were assigned according to their interests. In assembling task forces, great care was taken to have a broad representation of all relevant stakeholder groups.

Task forces were given the following charge:

- Take a strategic view of your respective task force area to identify key issues/big challenges/important trends facing Mechanical Engineering.
- Objectively analyze the Department’s strengths/weaknesses/opportunities/threats (SWOT) in your respective task force area to ensure that thorough internal and external perspectives guide our strategic analysis.
- Identify key areas of intellectual pursuit in the task force area for the Department of Mechanical Engineering at the University of Minnesota.
- Develop strategic objectives that will advance these key areas of intellectual pursuit in the ME Department.
- Propose actions/initiatives/efforts/projects to most effectively achieve distinguished performance within the key areas of intellectual pursuit.

After an initial kick-off meeting, the Department held two research symposia to inform task force members and the interested public about its research activities. Educational programs were also highlighted during these symposia, as well as on ME Day. After about six months of deliberations, the task forces reported their findings on October 9, 2009. Detailed reports of the task forces are attached in Appendix C-F.
Section IV summarizes the main Departmental areas of strengths identified by the task forces. Section V presents recommendations to enhance these strengths, take advantage of opportunities, and mitigate weaknesses and threats. Section VI presents an Action Plan to implement task force recommendations.

Table 1: Timeline of Strategic Plan Development

- February 27, 2009: Kick-off event
- March 11, 2009: Research symposium I
- April 1, 2009: Research symposium II
- April 22, 2009: ME Day (focus on education)
- March-September, 2009: Task forces meetings
- October, 2009: Presentation of Task force recommendations
- Oct.-Nov. 2009: Comment phase
- December, 2009: Completion of strategic plan
III. Areas of Departmental Strength

Each of the task forces was asked to perform an analysis of the Department’s strengths, weaknesses, opportunities and threats in their respective areas. The detailed results of these analyses can be found in the task force reports in the appendices. The following presents a brief listing of areas of particular strengths in the Department that are of critical importance for its strategic direction:

A. Compact and Efficient Fluid Power

The Department headquarters the NSF Engineering Research Center on Compact and Efficient Fluid Power. Department faculty provide leadership to a multi-university group of investigators from institutions including Georgia Tech., University of Illinois-Urbana Champaign, Purdue University, Milwaukee School of Engineering, North Carolina A&T State University, and Vanderbilt University. Among the exciting research projects of the Center are enhancing the fuel efficiency of passenger cars through hybrid hydraulic technology and improving functionalities of biomechanical devices through application of fluid power.

Professor Perry Li and a graduate student examine the hybrid hydraulic vehicle in the lab.
B. Intelligent Transportation Systems

In the area of intelligent transportation, Department faculty focus on new technologies that enhance the safety and efficiency of transportation systems. Technologies developed by the Intelligent Transportation group allow bus drivers to drive on narrow highway shoulders with high speed in poor visibility conditions, allow snow plows to be on the road in virtual white out conditions, and enhance vehicle safety by alarming drivers of fatigue and unsafe teen driving behaviors.

The Intelligent Vehicles Laboratory developed the smart bus, with virtual displays.

C. Solar Energy Research

The Department features solar energy research of unusual breadth for any mechanical engineering department. Faculty are involved in various aspects of low temperature and high temperature solar thermal energy utilization and in the production of fuels using solar energy. Other faculty specialize in the area of solar photovoltaic energy generation utilizing nanomaterials-based third generation solar cells.

Graduate students in the Solar Energy Laboratory.
D. Biomedical Device Design

The Department headquarters the University of Minnesota Medical Devices Center. The Center connects University researchers with the more than 500 medical devices companies in the Twin Cities area. The Center fosters a highly interdisciplinary environment that connects engineers with clinicians in efforts to develop new tools for medical diagnostics and treatment. Its flagship medical devices design fellows program is only the second program of this kind in the country, after Stanford University.

E. Environmental Research

The Department’s Particle Technology Laboratory has been one of the world-leading the environmental aerosol research labs for the past five decades. The laboratory’s efforts range from the development of new instruments for the size and chemical analysis of aerosolized nanoparticles, to understanding the formation of pollutant particulates in the atmosphere, to investigating particulate emissions from commercial kitchens, to exploring and reducing particulate emissions from internal combustion engines.

Professor Chris Hogan develops new aerosol measurement instruments.
In addition to the areas, which are directly aligned with the Department’s focus areas, the Department has significant strengths in the fundamental research areas of mechanical engineering. Strength in these fundamental areas is essential for success in the Department’s focus areas. The fundamental areas are:

F. **Heat Transfer, Fluid Flow, and Plasma Engineering**

Heat transfer and thermal sciences have been a traditional strength of the Department of Mechanical Engineering dating back to the arrival of Professor Ernst G. Eckert in Minnesota in 1951. With four members of the National Academy of Engineering (Profs. Eckert, Goldstein, Pfender and Sparrow), this area continues to play a major role in the Department. While initially having been focused on heat transfer in thermal mechanical systems, the heat transfer efforts in the Department may now be among the broadest at any University in the US and possibly the world. Research areas range from heat transfer in mechanical and combustion systems, to heat transfer in biological systems, to heat transfer at ultra-high temperatures, when matter transitions into the plasma state, sometimes called the 4th state of matter. Studies in these nontraditional areas are conducted in major centers, including the Center for Biotransport, and the High Temperature and Plasma Laboratory, which is the most widely recognized plasma laboratory in any mechanical engineering department in the country.

![Professor Steven Girshick with graduate students in the High Temperature Plasma Laboratory.](image)

G. **Design, Manufacturing and Controls**

Design, manufacturing and controls are core areas of mechanical engineering. In the controls area in the Department, analytical research includes control of nonlinear systems, passivity, observer design, stochastic estimation, signal processing and repetitive control. Faculty work on a large number of sponsored projects involving real world applications of control systems, including applications in vehicle control, engines, power-
train systems, fluid power systems, sensing and control of color printers, paper manufacturing processes, robotics and human assist machines. Major areas of interest in design are in computer aided engineering, solid mechanics, mechanics of materials, and mechanism design.

Students work on a wide range of projects during their senior year and present them at the Senior Design Show.
IV. Summary of Task Force Recommendations

Each of the five task forces was asked to define strategic objectives to be achieved in their respective areas. The following presents a summary of the strategic objectives. Details for individual areas can be found in the appendices.

A. Strategic objectives in research areas:

R1. Develop Department-wide centers of excellence in focus areas.
   a. Foster closer integration of Departmental activities in these areas.
   b. Leverage college-/university-wide strengths/initiatives to enhance Departmental activities.
   c. Coordinate efforts to attract larger center-like entities to campus (such as ERCs).
   d. Hire faculty in key areas to enhance strengths in areas of strategic importance.

R2. Increase visibility of focus areas.
   a. Web presence.
   b. Professional Societies.
   c. Feature student role models (graduates with successful careers on the web).

R3. Build undergraduate/graduate/continuing education curriculum in focus areas that matches strengths in research areas. Coordinate efforts with other departments to avoid duplication of effort.

R4. Increase industry/Department partnership in focus areas.

R5. Expand development efforts for endowed professorships and for improved research laboratory infrastructure.

R6. Improve administrative support for securing and managing grants and contracts.
**B. Recommendations for Graduate Education:**

G1. Improve recruiting of graduate students.

   a. Pre-recruiting: improved web site that features educational and graduate research opportunities, include faculty in recruiting process.
   b. Recruiting: Recruiting weekend and availability of financial support.

G2. Evaluate Mission and Strategic Direction of Graduate Program.

   a. Clearly define the mission of the graduate program.
   b. Revaluate balance and roles of MS and PhD program.
   c. Revaluate match between graduate preparation and industry needs.

G3. Increase Departmental financial support for graduate students.

**C. Recommendations for Undergraduate Education:**

U1. Improve the student experience, thereby growing the attractiveness and reputation of the undergraduate program.

U2. Graduate students who are highly attractive as new hires, thereby placing them in the best jobs on a national scale.

U3. Improve the diversity of the student population.

Undergraduate student during research experience.
V. Action Plan

The following action plan addresses actions to achieve the strategic objectives defined above. Different groups within the Department will be charged with the implementation of these actions. Each of the actions lists in parentheses which of the strategic objectives are addressed:

1) **Develop Department-wide collaborative initiatives in departmental key areas (R1, R3, R4).**

   Internal working groups will be charged with developing a vision for research in key areas, identifying opportunities to leverage strengths at the college and university level, identifying center-like funding opportunities, and developing proposals for future faculty hires. Working groups will prepare proposals for new courses to educate students in their area. Working groups will also be charged with developing enhanced collaboration with industry.

   The Department research committee will be charged with defining an appropriate set of working groups and identifying coordinators for these groups. Faculty will be free to join these working groups based on their research interests.

2) **Direct faculty hires to build new strengths in areas of strategic importance and to protect areas of existing strengths, as relevant to the Department’s mission (R1, R3, R4).**

   Areas identified by the research task forces as being essential to build new areas of strength/protect existing strengths are:
   a. Biotransport, biomechanics, biomedical devices,
   b. Renewable energy,
   c. Power and propulsion, and
   d. Indoor environment and particle technology.

   New faculty are expected to be outstanding researchers and teachers, with a strong foundation in fundamental mechanical engineering disciplines. Hence hires may occur in the fundamental mechanical engineering research areas, if the candidates have a clear vision as to how their research will promote one or more of the Departmental emphasis areas.
3) **Improve Departmental visibility (R2, G1, G3).**

A committee will be formed and charged with improving the presentation of Departmental research and graduate education through website content and printed media. The committee will also propose measures that will increase the Department’s visibility within professional societies.

4) **Enhance development efforts to increase faculty support, graduate student support as well as research and teaching infrastructure (R5, R6, G3).**

Continue and enhance efforts that will lead to greater stakeholder investment into the Department. These efforts will include communicating the importance of a strong mechanical engineering program to the college, solidifying industrial and alumni support, and enhancing engagement of all stakeholders in the success of the Department. Development efforts should focus on:

- Endowed Professorships to support faculty,
- Fellowship endowments to support graduate students,
- Scholarship endowments for undergraduate student financial support,
- Improvements of research and teaching infrastructure.

5) **Evaluate Strategic Direction of Graduate Program (G2, R1)**

The newly formed Departmental Graduate Education committee will be charged with evaluating the direction of the Graduate Education program. This evaluation will include redefining the roles of the M.S. and the Ph.D. programs, making recommendations with respect to Departmental resources allocations to both parts of the graduate program, reviewing the graduate course curriculum, and reevaluating credit requirements for graduate students.

6) **Implement recommendations of Undergraduate Education Task Force (U1-U3).**

The Undergraduate Education Task Force provided a set of five concrete action items to achieve the strategic objectives U1-U3. The action items include recommendations to:

Enhance the “work readiness” of ME students:

1. Offer a design experience every year.
2. Extend senior design to a two semester course.
3. Encourage students to participate in student-driven design projects (e.g. solar car, solar house, Engineers Without Borders, ASME Student Design Contest, ...).
Enhance the student experience through improved faculty and alumni interactions:

4. Utilize alumni or industry presenters in seminars or lectures.
5. Establish a “Professional Development Day” to increase interactions between students, advisers and employers (students can talk with faculty, industry reps, grad students, International Programs reps, etc.).

The newly formed Department Undergraduate Education Committee will be charged with devising routes to implementing these recommendations.

Students in the class “Introduction to Mechanical Engineering.”
Appendix A

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Appendix B

Undergraduate Education
Task Force Report
Executive Summary

The Task Force on Undergraduate Education constitutes one of five task forces formed to set future directions for the Mechanical Engineering Department at the University of Minnesota in February 2009. Their mission was to identify strategic objectives that will have the greatest impact on the Department’s future success in educating undergraduates, then to develop recommendations to achieve those objectives. The 18 member Task Force included alumni and friends who have worked in industry, faculty, students and representatives from supporting programs.

The strategic objectives identified are:

1. To improve the student experience, thereby growing the attractiveness and reputation of the undergraduate program.
2. To graduate students who are highly attractive as new hires, thereby placing them in the best jobs on a national scale.
3. To improve the diversity of the student population.

The Tier One recommendations, defined as having significant impact while also requiring little effort to implement, are:

1. Include a design project during every year of the undergraduate experience.
2. Extend the Senior Design Project to a two semester course.
3. Encourage students to participate in design projects sponsored by a student group, such as an ASME Design Project.
4. Utilize alumni or industry presenters in seminars or lectures.
5. Establish a “Professional Development Day” to increase interactions between students, advisers, and employers.

Fourteen additional Tier Two and Tier Three recommendations for achieving the strategic objectives are also proposed, including some which would require long-term planning.

The Task Force followed a formal design process to develop these recommendations, including specification, concept generation, and concept selection phases. The specification took the form of a Strengths, Weaknesses, Opportunities and Threats (SWOT) Chart, which is included. Also included is a complete list of 81 concepts generated by the Task Force.
The Undergraduate Education Task Force was one of five task forces convened by University of Minnesota’s Mechanical Engineering Department Head Uwe Kortshagen in February 2009. Motivations for convening the task forces included: developing goals and priorities for the future of the Department, developing strategies to achieve these goals, promoting the Department, attracting future students, and developing communication with departmental stakeholders.

The specific charge to the Undergraduate Education Task Force was to identify strategic objectives that will have the greatest impact on the Department’s future success in educating undergraduates, then to develop recommendations to achieve those objectives.

The strategic objectives developed by the Task Force are stated in Section 2. Metrics for evaluating them are also suggested. Plans for achieving those objectives are summarized in Section 3. The process which was used to produce those findings is documented in Section 4.

The Task Force was composed of 18 members representing industry, Departmental faculty, students, and supporting programs. The composition of the Task Force membership is summarized in Table 1.

The term “work ready” is utilized in the following recommendations and their associated descriptions. Formally defining this phrase is stated as a recommendation unto itself (see Recommendation 9). Nevertheless, a working definition of “work ready” is proposed to enable using the term in the following discussions:

“Graduating students who are highly attractive as new hires and are able contribute immediately to the tasks of their first professional jobs as mechanical engineers”.

2 Strategic Objectives

The strategic objectives identified by the Task Force are:

1. To improve the student experience, thereby growing the attractiveness and reputation of the undergraduate program.

2. To graduate students who are highly attractive as new hires, thereby placing them in the best jobs on a national scale.

3. To improve the diversity of the student population.

\[1\] Three of the remaining task forces address research thrusts of energy & transportation, human health, and environment. The last addresses graduate education.
These objectives were distilled from a Strengths, Weaknesses, Opportunities and Threats (SWOT) chart created by the Task Force, which is included as Table 6.

The Task Force recommends that metrics be established and monitored to evaluate the effect of implementing the plans to achieve the strategic objectives. Metrics for each objective are suggested here.

**Improving the student experience:** The primary metric suggested for evaluating the quality of the student experience is student retention, or, equivalently, graduation rate. The Task Force also feels that the student-faculty ratio is an indicator of the potential quality of the student experience and should be improved. Another metric might be based on results from a standardized survey of current and former students.

**Graduating “work ready” students:** The fundamental metric for evaluating the attractiveness of the department’s graduates as new hires is the percentage of students that obtain jobs upon graduation. Success in placing students in co-operative work training assignments and internships may also be meaningful. Another metric might be based on survey results from students and their employers.

**Improving the diversity of the student population:** Currently, 11.8% of the undergraduate population is female. The Task Force encourages the Department to surpass the national average of 13%. Other measures for evaluating departmental diversity include ethnicity, disability, and age.

### 3 Summary of Findings

The Task Force has distilled its findings to 19 final recommendations. Those 19 finalists have been further categorized into three tiers (see Tables 2, 4 and 5). Their ranking by tiers is based on a combination of the merit of each recommendation toward achieving a strategic objective and the feasibility of implementing the recommendation; i.e., impact and ease of implementation. For example, the Tier 1 findings are considered to both have significant benefit and to be feasible for implementation in the near term.

While the Task Force sees benefit in all 19 recommendations, we recognize that administrative complications may encumber the implementation of some of those in Tier 3 (see Table 5). For example, Recommendation 18 suggests setting the length of mechanical engineering classes based on their topical content rather than the length of a semester. While this has pedagogical appeal, decoupling courses from the standard academic calendar would be challenging within the Institute of Technology. Nevertheless, these recommendations are included for consideration for longer-range planning.

A mapping between the strategic objectives and the recommendations is provided in Table 3. Most recommendations address multiple objectives. Note that all of the Tier 1 recommendations address the objective of improving the student experience, and that the largest number of recommendations are aimed at the objective of graduating “work ready” students.

The top three recommendations all concern design experiences. Design experiences are favored because they serve to integrate students’ knowledge from their courses, thereby helping to ensure “work ready” students upon graduation.

The task force does not minimize the importance of improving the diversity of the student population. Rather, the members felt that some of the recommendations that best addressed this objective would be better implemented at the level of the Institute of Technology (IT) rather than the Mechanical Engineering Department. For example, promoting mechanical engineering
1. Design project every year
   (a) Builds on prior years experiences
   (b) Introduces coming year’s coursework or professional practice
2. Extend Senior Design Project to a two semester course
3. Encourage students to participate in design projects sponsored by a student group, such as: ASME Student Design projects, Solar car, SAE, Engineers Without Borders, Solar House, etc.
4. Utilize alumni or industry presenters in seminars or lectures
   (a) Bi-weekly seminar course
   (b) Quest lectures in relevant courses
   (c) Lower division seminar to help students choose tech electives
5. Establish a “Professional Development Day” to increase interactions between students, advisers and employers. Classes are canceled. Students come in and have an opportunity to talk with:
   (a) Faculty about advising questions
   (b) Graduate students
   (c) Co-op companies
   (d) Reps from industry advisory board
   (e) International Programs representatives

Table 2: Tier 1 recommendations.

<table>
<thead>
<tr>
<th>Improving student experience:</th>
<th>1, 2, 3, 4, 5, 10, 11, 12, 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graduating “work ready” students:</td>
<td>1, 2, 4, 5, 6, 7, 8, 9, 10, 13, 14, 15, 18</td>
</tr>
<tr>
<td>Improving the diversity of the student population:</td>
<td>5, 11, 16, 17, 19</td>
</tr>
</tbody>
</table>

Table 3: Classification of recommendations by strategic objective.

at the high school level (recommendation 19) would require broad outreach, which requires IT-wide resources. Furthermore, such outreach would be most effective if it included promoting all departments within the Institute of Technology.

The following three sections provide detailed descriptions of each recommendation in each of the three tiers.

3.1 Comments on Tier 1 Recommendations

1. Design Project Every Year: The task force felt that participating in a design project every year is important to students staying connected with the practice of mechanical engineering. This experience may be particularly important during the first two years, when a student following the four year flowchart would typically only take one mechanical engineering class. The extent of the projects may vary significantly from year to year. For example, the freshman design experience might be limited to only a design experience at orientation (see Recommendation 11). In contrast, the senior experience would ideally continue through the entire academic year (see Recommendation 2).

An excellent design sophomore experience is already in place in the “Introduction to Engineering” class (ME 2011). The task force understands that many juniors participate in a
significant design experience in the Design & Manufacturing II class (ME 3222), but that others may not, depending on the instructor. We recommend ensuring that all juniors participate in a similar experience.

Some students participate in the co-operative work training program, internships or international experiences. These off-campus activities may include design experiences. Such experiential design activities are encouraged and would qualify for fulfilling the annual design recommendation.

2. Extend Senior Design to a two semester course: The task force expressed concern that students could not adequately experience the entire design cycle, from defining customer needs through completing a prototype, in the time frame of a single semester. We recognize that adding credits to the Mechanical Engineering Program is undesirable, as it may extend the graduation times of some students. Therefore, we suggest re-packaging the four credits of Senior Design into two two-credit semester courses that are taken in consecutive semesters. The first semester could include defining customer needs, writing product specifications, generating concepts, and selecting the most promising concept. The second semester could include detailed modeling, design, and prototyping.

Students in the co-operative work training program are likely to have difficulty taking Senior Design for two consecutive semesters, as it is likely to conflict with their work assignments. These students could be addressed by making a special one-semester version of Senior Design available to these students only. Note that students in this group are likely to have a greater familiarity with the design process.

3. Encourage students to participate in design projects sponsored by a student group: Several benefits could be realized from students participating in a student group design project. First, working on a student team would encourage social interaction in small groups, thereby achieving more of a “small college” atmosphere (see Recommendation 12). Second, the team design projects are likely to provide design experiences very close to industry design experiences, thereby aiding in producing “work-ready” students (see Recommendation 7). Third, projects such as those sponsored by “Engineers Without Borders” are likely to provide experiences with social as well as technical value.

An independent metric to measure the success of this recommendation would be to count the number of students who are members of each student group.

4. Utilize alumni or industry presenters in seminars or lectures. The formation of the Undergraduate Task Force brought to light that the Mechanical Engineering Department has a talented, knowledgeable and enthusiastic alumni base that is eager to contribute to the Department. This talent base could be utilized to provide seminars and guest lectures to mechanical engineering undergraduates. The effort could be made sustainable by identifying mechanical engineering faculty or staff who could schedule seminars and lectures on an ongoing basis.

5. Establish a “Professional Development Day”: This concept originated from a similar program that is currently being implemented at the University of Wisconsin. One day, or a portion of a day, per year could be dedicated to providing an open forum for students to talk with potential employers, faculty, and representatives of graduate and international programs. Students could thereby seek mentoring to meet their specific needs and interests despite the large enrollment in the department. Therefore, it provides a mechanism for providing one of the positive aspects of a “small-college” education (see Recommendation 12).
6. Develop a terminal “Plan C” M.S. program with an industry “work ready” focus. Would allow students who finish B.S. in 4 years to take additional coursework and participate in co-op or similar experimental program

7. Project “Work Ready” – Develop a curriculum track that allows you to claim (and prove) that your students are “work ready” when they graduate
   (a) Relevant to industry needs
   (b) Attractive to students
   (c) A way to differentiate UMN’s curriculum from that of competing schools

8. Expand ME 3222 design project to include a thorough & thoughtful manufacturing phase, mentored by local alumni & industry partners

9. If you want to produce “work ready” students you need to find out what it means to be “work ready”
   (a) What jobs will they hold (what percent are MEs, what percent are outside ME)?
   (b) What will they need to know?
   (c) To gain this knowledge, develop and conduct a survey of grads

10. Include “How Things Work” class or laboratory to make up for changes in background (students no longer work on their own cars)
   (a) Examples: bicycle transmission, toilet, lawn sprinkler, tractors, transmissions, air conditioner, excavator, power steering, IC engine, gas turbine
   (b) Tear things apart to reverse-engineer them
   (c) Could include basic dynamic modeling for all examples

11. First Year: Fun engineering project at orientation

Table 4: Tier 2 recommendations.

An independent metric to measure the success of this recommendation would be to count the number of participants per year, particularly those from industry.

3.2 Comments on Tier 2 Recommendations

6. Terminal “Plan C” M.S. Program: This recommendation most directly affects the Graduate Program, but the Undergraduate Task Force includes it on its list because the motivation for the degree arises from augmenting the undergraduate experience. The “Plan C” Master’s program is envisioned as providing outstanding depth to students intending to enter into the professional practice of engineering. The hallmark of the degree would be a requirement to acquire professional experience, such as a co-operative work training assignment or internship. The degree would also feature additional coursework to enable students to delve more deeply into engineering topics relevant to their professional development. Credits earned in a “Plan C” degree would not be allowed to transfer to a Ph.D. program, as its intent would be to foster practical experience rather than provide training for research.

7. Project “Work Ready”: The University of Minnesota’s location in the heart of a metropolitan area with a strong manufacturing base provides it with an advantage over many of its “Big 10” peer institutions. Project “Work Ready” is intended to exploit that advantage by graduating students who are especially well prepared to enter into the engineering workforce.
Such preparation would make our graduates particularly attractive to the firms who hire them, which would in turn attract strong students to enter the program. The “work ready” focus would also distinguish Minnesota’s program from several competing programs which have arisen in the region and the nation.

8. Expand ME 3222 design project to include a thorough manufacturing phase: This recommendation is inspired by a project piloted at Stanford University. Stanford has established a design project where development of a high quality prototype is required. Quality is achieved by partnering design teams with alumni mentors, who bring with them a broad manufacturing knowledge base.

One element of Recommendation 1 suggests ensuring that all Juniors participate in a substantive design experience in the “Design & Manufacturing II” class (ME 3222). This recommendation extends that element by providing alumni to mentor the building of the prototypes associated with that project. Alumni are enlisted to enable providing sufficient support for all members of each class. Nevertheless, the task force recognizes that University of Minnesota’s class sizes are substantially larger than Stanford’s, which introduces challenges to implementation.

9. Find out what it means to be “work ready”. The task force embraced preparation of “work ready” graduates as a goal, resulting most directly in Recommendations 6 and 7. While a working definition of “work ready” has been proposed in the Introduction, the task force recognizes that precisely defining “work ready” will best benefit the department’s graduates. The purpose of this recommendation is to establish that definition by identifying the career paths of the department’s graduates and researching the background which would have best prepared them on those paths. This knowledge could be acquired by surveying the alumni base.

10. Include “How Things Work” class or lab to make up for changes in background: The Task Force recognizes that the background of many students entering into mechanical engineering has changed over the last 50 years. Formerly, most students entering the program were attracted to it through prior experience with mechanical devices, such as maintaining their own automobiles. Today, the prevalence of “maintenance free” and disposable products, along with the rise of alternative activities such as video games and computers, has deterred many incoming students from obtaining hands-on experience with mechanical systems. As a result, many are no longer familiar with the composition and operating principles of common mechanical devices.

The task force recommends enhancing the undergraduate experience by providing opportunities for students to learn how a variety of common mechanical products are constructed. This would improve their ability to apply the theory learned in the core classes to real mechanical systems, which is perceived as a weakness in the current curriculum.

While the “How Things Work” experience could be packaged as a class, the task force recognizes the constraints on adding credit hours to graduation requirements. Therefore, the experience might alternatively be distributed as a series of laboratories in several classes. The examples presented in the laboratories could be utilized as applications case studies for associated lecture series.

The task force recognized that figuring out how a product works can provide an educational but entertaining team building experience. If properly designed, “How Things Work” experiences might contribute to establishing the feel of a small college within the mechanical engineering department (see Recommendation 12).
11. First Year: Fun engineering project at orientation: The task force feels that maintaining student enthusiasm about engineering throughout their four year tenure in the program is critical to improving student retention. The freshman year presents a particular challenge, since the students typically do not take any classes in the mechanical engineering department. However, all incoming students are required to go through orientation. Including an entertaining but relevant design experience as part of orientation may provide an effective way to address this challenge.

3.3 Comments on Tier 3 Recommendations

12. Treat ME like it is a small college: The intent of this recommendation is to improve the student experience by providing students with better connectedness to the department and their peers. Reaching every student on an individual basis in our graduating classes of approximately 200 per year is challenging. Nevertheless, we can likely make improvements with reasonable effort. For example, sub-dividing each class according to student interests might improve each student’s sense of community. Promoting social activities both before and after graduation may also improve departmental spirit.

13. Replace “acquisition of knowledge” learning model with “professional practice”: This recommendation is perceived as the most ambitious to implement, but it also has potential to bring the greatest recognition to the department. The lecture-based learning model would be superseded by a series of practice-based experiences, as is now done in medicine. The “Iron Range Engineering Program” offered through Minnesota State University at Mankato appears to be based on the professional practice model. Implementation is hindered by the large class size of approximately 200 students. The task force feels that maintaining ABET accreditation would be a requirement for making any changes to the teaching methodology.

14. Add faculty whose experience and focus is professional engineering: The Task Force recognizes that research is an essential element for tenure track faculty at the University of Minnesota. Linking research and education may be feasible through programs such as Research Experiences for Undergraduates. At a minimum, hiring a few highly qualified adjuncts, for whom research activity is not required, with significant industry experience may both improve the “work ready” qualifications of our graduates as well as improve the currently unattractive student/faculty ratio in the department. Supporting such initiatives by leveraging programs in NSF’s Department of Undergraduate Education should be explored.

15. Partner with an international school: International experiences improve the “work ready” appeal of graduates. However, the department has evaluated only a small number of classes from a limited number of international institutions. Therefore, transferring credits from international schools to the department is generally difficult. Establishing exchange programs with select schools, where courses would be pre-identified as appropriate substitutes for University of Minnesota required classes or technical electives, could expand participation of our students in international programs.

16. Actively market what it “means” to be an ME: While department enrollment appears to remain strong, this recommendation is intended to buck the national trend of declining engineering enrollments. The Task Force feels that incoming students may not be aware of the breadth of the field of mechanical engineering, and they may in particular be unaware of the many ways that mechanical engineers help people. Improving this awareness may lead to more of the top students choosing mechanical engineering as a career path. Additionally,
12. Treat ME like it is a small college
   (a) Break graduating classes into “Sections”
   (b) Make “The Class” special and inclusive
   (c) Promote socialization
   (d) Have ongoing reunions and so on

13. Replace “acquisition of knowledge” learning model with the “professional practice” model, as is done in medicine and law (ref: Sheppard, Sheri, “Educating Engineers: Designing for the Future of the Field”)

14. Add faculty whose experience and focus is professional engineering, to complement current focus on research
   (a) Use fact that current student to faculty ratio is so high to justify in part
   (b) Can tap into DUE funding from NSF and programs linked to community colleges, etc.

15. Partner with an international school
   (a) Undergraduate exchange program with pre-selected courses to guarantee credit equivalence
   (b) Establish remote design/manufacturing project

16. Actively market what it “means” to be an ME
   (a) Change perception of ME education to incorporate: “MEs help people”
   (b) Promote engineering career path - can lead to top management, etc.

17. Create joint majors: Mechanical Engineering & Bioengineering; Mechanical Engineering & Medicine; Mechanical Engineering & Business; Mechanical Engineering & Law; Mechanical Engineering & . . .

18. Disconnect the length of a course from the length of the semester. Copy medical school practice of course length as long as needed. Some 3 weeks; some 3 months.

19. Project “High Visibility”: Every student in every H.S. science class should know about the “cool” things that go on in the UMN ME Dept.
   (a) utilize upper division students
   (b) utilize graduate students
   (c) utilize alumni network (especially fresh graduates)
   (d) utilize competitions

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Table 5: Tier 3 recommendations.
mechanical engineering students are generally unaware of how many graduates eventually move into high level management career paths. The department may be able to utilize our alumni base and graduate students to assist with such outreach efforts.

17. **Create joint majors:** This recommendation was inspired by an initiative at Pennsylvania State University. In particular, a joint Bioengineering / Mechanical Engineering major was created at that institution. This was found to be popular with female students, providing an effective way for improving the generally poor female-to-male ratio of students in mechanical engineering. Other joint majors with Business, Law and Medicine might also attract high quality students, in addition to providing useful and unique career foundations.

18. **Disconnect the length of a course from the length of a semester:** This recommendation arises from the practice in medical school of designing class length based on content rather than semester calendars. While this recommendation has pedagogical appeal, rigid class scheduling constraints imposed by Classroom Management at the University of Minnesota may impede its implementation.

19. **Project “High Visibility”:** The goal of this recommendation is to reach out to high school students to ensure that they are aware of the many exciting experiences associated with a mechanical engineering career. As with Recommendation 16, the goal is to recruit more top high school students into the department. The Task Force suggests that this recommendation be forwarded to the Institute of Technology, as recruiting efforts would be equally beneficial to the other IT departments. Possibly professional staff or a coordinated volunteer effort could facilitate its implementation.

4 **Process**

The Task Force on Undergraduate Education followed a structured design process to develop their recommendations. The process began with a mission statement:

“Identify strategic objectives that will have the greatest impact on our future success in educating undergraduates, and develop plans to achieve those objectives.”

Specifications were then developed, an extensive list of concepts was generated, and the most promising concepts selected. The procedure is summarized below.

The task force felt that a Strengths, Weaknesses, Opportunities and Threats (SWOT) Chart would provide a reasonable way to document specifications for the unusual “product” of strategic objectives. The result is shown in Table 6. They were distilled to the three final objectives described in Section 2.

Once a SWOT chart was drafted, the task force members generated concepts both individually and as a group. Approximately 100 concepts were generated. They were distilled to eliminate or combine redundant concepts, yielding a refined list of 81. They were then categorized by topic. The resulting list is included as an Appendix.\(^2\)

The list was shortened to a set of preferred recommendations by multi-voting. Each Task Force member was asked to select their 7-10 favorite recommendations from the list. Their choices were then assigned weights of 1-10, with 1 being an individual’s lowest choice and 10 their highest. If an individual selected less than 10 concepts, the highest was still weighted at 10, and the lower

\(^2\)To ensure accuracy, the concepts are all stated close to their original form. Some have been intentionally modified between their original statement and the final form presented in Section 3.
The results of each participating member were then totaled. Any concept that received a combined weighting of 15 or more was advanced to a finalist list. This produced the set of 19 final recommendations.

Finally, task force members were asked to rate each final recommendation according to impact on students, impact on employers, and ease of implementation. The results showed little difference between impact on students and impact on employers, so each concept was ultimately ranked on “impact” versus “ease of implementation”. A scatter graph was generated from these results (see Fig. 1).

Concepts which ranked highly on both “impact” and “ease of implementation” were placed in the set of Tier 1 recommendations (see Table 2). In other words, these concepts were in the upper right of the scatter graph. Concepts in the lower left were placed in Tier 3 (see Table 5), while the remaining concepts were placed in Tier 2 (see Table 4).

Figure 1: Scatter graph of impact versus difficulty of implementation for all final recommendations.
<table>
<thead>
<tr>
<th>Strengths</th>
<th>Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>S–1 Opportunities for students to work in research labs</td>
<td>O–1 Hands on experience</td>
</tr>
<tr>
<td>S–2 Opportunity for four tech electives in undergraduate program</td>
<td>(to fill in for lack of background)</td>
</tr>
<tr>
<td>S–3 Laboratories are hardware-focused (rather than virtual labs)</td>
<td>O–2 Applications to real world problems</td>
</tr>
<tr>
<td>S–4 Department is in a large, comprehensive university with many opportunities and facilities</td>
<td>O–3 Team experiences</td>
</tr>
<tr>
<td>S–5 Strong graduate program yields research employment opportunities and keeps UG program up-to-date</td>
<td>O–4 Culture change: graduates must be “job ready” (define “work ready” metrics collaboratively with industrial partners)</td>
</tr>
<tr>
<td>S–6 Interdisciplinary opportunities</td>
<td>O–5 Managing &amp; working in a global engineering team</td>
</tr>
<tr>
<td>For example, potential partnership with Carlson School</td>
<td>O–6 Match student passions with curriculum</td>
</tr>
<tr>
<td>S–7 Co-op program</td>
<td>O–7 Local versus global context: What will still be done locally?</td>
</tr>
<tr>
<td>S–8 Industrial connections provide internship opportunities, connections for graduates, advisers for design projects, and program mentorship</td>
<td>O–8 Industry connections and locality</td>
</tr>
<tr>
<td>S–9 Locality of many excellent companies</td>
<td>O–9 Involve more undergraduates in research experiences</td>
</tr>
<tr>
<td>S–10 UG program in place to earn a Business minor (realistically requires 5th year)</td>
<td>O–10 Have students actually instrument an experiment (rather than using pre-existing set-up)</td>
</tr>
<tr>
<td>S–11 Availability of student design projects (Solar Vehicle, Formula SAE, Solar House)</td>
<td>O–11 Further exploit student-driven design projects (for example, provide course credit)</td>
</tr>
<tr>
<td>S–12 Breadth of faculty expertise: well-rounded Thermo, Design, Biomedical, Particle Tech, etc.</td>
<td>O–12 Further leverage ABET Continuous Improvement process</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Weaknesses</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>W–1 Constraints on Liberal Education requirements</td>
<td>T–1 Globalization; i.e., outsourcing of engineering</td>
</tr>
<tr>
<td>For example, difficult for ME’s to get credit for business classes</td>
<td>T–2 Push for 4-year graduation</td>
</tr>
<tr>
<td>W–2 Lack of background of high school graduates in mechanical devices</td>
<td>T–3 Tuition versus the competition</td>
</tr>
<tr>
<td>W–3 Fee for companies who participate in co-op program</td>
<td>T–4 Difficulty of staffing and funding student-driven design projects</td>
</tr>
<tr>
<td>W–4 “Status quo” of 4XXX versus 5XXX class offerings</td>
<td>T–5 Excessive dependence on research grants to fund department</td>
</tr>
<tr>
<td>W–5 Students who do not do co-ops may not be professionally ready (e.g., as a med student would be)</td>
<td>T–6 Requirements for accreditation discourage usage of “industry experienced instructors”</td>
</tr>
<tr>
<td>W–6 High student-faculty ratio relative to some peer schools at our tuition level</td>
<td></td>
</tr>
<tr>
<td>W–7 Cost of degree?</td>
<td></td>
</tr>
<tr>
<td>W–8 Competition with research related activities for professors’ time</td>
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</tr>
<tr>
<td>W–9 Partial dependence on state for funding</td>
<td></td>
</tr>
<tr>
<td>W–10 Interaction with State Government dictating some aspects of program design</td>
<td></td>
</tr>
<tr>
<td>W–11 Advising students in regards to logistics of the university and solutions to problems on an exception basis</td>
<td></td>
</tr>
</tbody>
</table>

Table 6: SWOT chart analysis of undergraduate educational program.
5 Conclusion

Section 2 presents a set of three fundamental objectives identified by the Task Force to improve the department’s success in educating undergraduates. Section 3 presents 19 recommendations for achieving those objectives. While the task force feels that all 19 recommendations would be beneficial, they have been tiered according to their combined impact and ease of implementation. Section 4 documents the process by which the objectives and recommendations were formed.

The Task Force emphasizes that the Department already has many fine programs in place which contribute to achieving the stated objectives. For example, the Cooperative Work Training Program provides an excellent method for educating “work ready” students (recommendation 7), and the “Introduction to Engineering” class provides an excellent Sophomore-year design experience (recommendation 1). The Task Force applauds these existing efforts; implementation of the new recommendations is intended to augment, rather than replace, them.

Appendix: Complete List of Concepts Suggested to Improve Undergraduate Education

Concepts have been categorized according to intent.

Continuous Improvement

1. Establish metrics for UG Improvement
   (a) Recruiter satisfaction
   (b) Applicant acceptance rate
   (c) Grad survey
2. Send questionnaire about curriculum to graduating seniors then again later to see how opinions change over time
3. If you want to produce “work ready” students you need to find out what it means to be “work ready”
   (a) What jobs will they hold (what percent are MEs, what percent are outside ME)?
   (b) What will they need to know?
   (c) To gain this knowledge, have a survey of grads
4. Recruit alumni to sit in on classes and make suggestions for improvements

Curriculum

5. Focus on Fundamentals
   (a) Need students to be grounded in fundamentals
   (b) Need to provide this base efficiently in order to accommodate other programs and still be 4 years
   (c) What revolutions can make this possible?
6. Emphasize grades with hope of making “non-self-driven” students into better “self-motivated” individuals:
   In every elective course the instructor has to include - as part of the formal grade - a 2 sentence “strengths and weaknesses” summary
7. Final exam at graduation that covers all 4 years of education: “Exit Exam” or passing the FE exam
8. Require a strong, rigorous biology course
9. Develop a terminal “plan C” M.S. program with an industry “work ready” focus.
   Would allow students who finish B.M.E. in 4 years to take additional coursework and participate in
   co-op or similar experimental program

10. Set up a 1-credit course involving real world practice
    (a) Can be waived by credit from “work experience”
    (b) Reward may be letter grade improvement in related course

11. Replace “acquisition of knowledge” learning model with the “professional practice” teaching model,
    as is done in medicine and law (ref: Sheppard, Sheri, “Educating Engineers: Designing for the Future
    of the Field”)

12. Base 3xxx classes on real world examples:
    e.g. base ME 3281 frequency response example on designing a low pass filter to remove noise from an
    accelerometer signal

13. Hands-on training integrated into course laboratories
    (a) Enhance labs of existing courses? (Does not have to be a new course)
    (b) New lab course / content

14. Require inclusion of a micro, nano, bio, EE or computer science tech elective

15. Require hands on professional experience: daily interaction with practicing engineers & scientists
    (a) Cooperative work training: Recruit more coop participants (subsidize $650 fee?)
    (b) Internship
    (c) Tech Aide
    (d) UROP
    (e) Courses or travel abroad

16. Coop program becomes an “advanced” program

17. Implement freshmen course revolved around CAD and machining work
    (a) Make ME 2011 CAD projects more difficult
    (b) Allows for FEA teaching in ME 2011

18. Eliminate some unnecessary “Themes” for undergraduates and fill with design and analysis based
    courses. These courses could also be filled with tech electives.

19. Design more labs to be “Independent” in that students will have to design their own experiments to
    solve a certain problem

20. Project “Work Ready” – Develop a curriculum track that allows you to claim (and prove) that your
    students are “work ready” when they graduate
    (a) Relevant to industry needs
    (b) Attractive to students
    (c) Different from competing schools

21. Institute a biological systems based lab elective
    (or cross-list a bioengineering lab)

22. Position “green” and global / social engagement angle / leadership

23. Implement more emphasis on good technical writing
    (a) More/Different lab reports for juniors and seniors
Grad based on both results and quality with which they were delivered

24. Encourage use of more presentations or technical speeches to professors for students
   (a) Have students give two or more technical presentations per academic year
   (b) Make students comfortable with giving presentations to groups of engineers/peers

Globalization

25. Have students participate in an “Engineers Without Borders” Project

26. Partner with an international school
   (a) Undergraduate exchange program with pre-selected courses to guarantee credit equivalence
   (b) Establish remote design/manufacturing project

27. Establish “Excellence in Global Engineering” class which includes local advantages:
   Identify engineering areas that are the most difficult to outsource and focus on those areas

28. Intent: Internationalization
   Suggestion: Investigate low-tech communications options as a way of linking U students to others in
design projects. Initially invest little to see the value of even trying to do this.
   (a) Low bandwidth video
   (b) E-mail chat
   Low-tech, low-cost also opens up dealing with less-funded institutions.

29. Add international cooperative work training option (possibly partnering with IASTB)

Inter-Departmental Partnerships

30. Business, Entrepreneurship and Management integrated into curriculum
   (a) Intentional course opportunities in collaboration with Carlson
   (b) Business / Entrepreneurship / Management components in existing courses;
   e.g., in a MEMS course, invent a device (this is a design component) & provide business justifi-
cation

31. Create joint majors
   (a) Mechanical Engineering & Bioengineering
   (Penn State experience: this attracts female students to the ME program.)
   (b) Engineering & Medicine
   (c) Engineering & Business
   (d) Engineering & Law
   (e) Engineering & . . .

Liberal Education

32. Extend the ethics credit requirement to undergraduate students

33. Expand liberal arts classes: art, psychology, languages, communications, writing, and creative writing
Marketing

34. Increase department visibility and influence in undergraduate education by organizing an engineering education conference
   (a) Possible theme: 3-year degree plus professional degree, based on European model
   (b) Possible theme: Address some ABET requirement

35. Make our technical teaching assets available:
    Promote our gadgets, engine lab, and so on

36. Expand association (ASME, SME) to promote understanding of engineering

Practical Engineering

37. Include “How Things Work” class or laboratory to make up for changes in background (students no longer work on their own cars)
   (a) Examples: bicycle transmission, toilet, lawn sprinkler, tractors, transmissions, air conditioner, excavator, power steering, IC engine, gas turbine
   (b) Tear things apart to reverse-engineer them
   (c) Could include basic dynamic modeling for all examples

38. “How Things Are Made” workshop

39. Have 1st and 2nd year ME students attend a seminar series on the “way things work”. Could be a required, no credit class

40. Expand ME 3222 design project to include a thorough & thoughtful manufacturing phase, mentored by local alumni & industry partners (Stanford model)

41. Design project every year
   (a) Builds on prior years experiences
   (b) Introduces coming years coursework or professional practice

42. Thinking outside the box
   (a) 1 credit on creativity
   (b) 1 credit innovation at the converge (e.g. Joel Barker, a local author, famous for Paradigm shift)
   (c) Don’t tell the Chinese what we’re doing. Let them continue with tunnel vision.

43. Extend Senior Design Project to a two semester course

44. Require students to join some student group with design project
   (a) ASME
   (b) Solar car
   (c) SAE
   (d) Engineers Without Borders
   (e) etc.

45. Use industry to identify student-driven design projects, then get industry support for staffing and funding

46. Required mentor review of projects
   (Integrated in course work)

47. First Year: Fun engineering project at orientation

48. Create a sense of design leadership (passion):
    “I want to be great at designing, building (fill-in-the-blank) product or industry”
Recruitment

49. Project “High Visibility”: Every student in every H.S. science class should know about the “cool” things that go on in the UMN ME Dept.
   (a) maybe utilize upper division students
   (b) maybe utilize graduate students
   (c) maybe utilize alumni network (especially fresh graduates)
   (d) maybe utilize competitions

50. Increase diversity: recruit minorities and women

51. Strongly promote the value of co-op program and internships to prospective students

52. Tailored career course for students interested in mechanical engineering

53. Actively market what it “means” to be an ME
   (a) Change perception of ME education to incorporate: “MEs help people”
   (b) Promote engineering career path - can lead to top management, etc...

54. Recruit students with real world experiences
   (a) Tours
   (b) Informational Interviews
   (c) Internships
   (d) E/Web access to industry

Resources

55. Replace the old ME building

56. Increase commitment to undergraduate education:
   Establish an Endowed Teaching Professorship, including responsibilities for developing colleagues teaching skills; developing teaching resources; and publicizing department activities related to teaching. (I know there are University programs for skill development, but this is aimed at local department development)

57. Drop fee for companies who participate in the co-op program

58. Find out how U of Texas has very good reputation, lower tuition, and lower student-faculty ratio that U of M, then figure out how to do that here

59. Add faculty whose experience and focus is professional engineering, to complement current focus on research
   (a) Use fact that current student to faculty ratio is so high to justify in part
   (b) Can tap into DUE $ from NSF and programs linked to community colleges, etc.

Scheduling

60. Change to 5 year program:
   Provides more flexible opportunities for co-op program participation and non-engineering courses (business, economics, philosophy, etc.)

61. Go back to quarter system so students get more courses

62. Provide extensive evening classes for students who are working
63. Disconnect the length of a course from the length of the semester. Copy medical school practice of course length as long as needed. Some 3 weeks; some 3 months.

64. Single class concept: One class at a time (2-3 weeks each)

65. Pre-package course progression
   (a) KISS
   (b) Include scheduling

**Student Support**

66. Involve undergrad students in student associations (e.g. ASME) combined with other local “Engineer Schools” (programs)
   (a) Objectives—increase communication
   (b) Possible outcome - steal good ideas/programs from outer schools (e.g. FAB-LAB at Century College, and MIT product - World wide)

67. Utilize alumni or industry presenters in seminars or lectures
   (a) Bi-weekly seminar course
   (b) Quest lectures in relevant courses
   (c) Lower division seminar to help students choose tech electives

68. Start required student advising program among undergrads
   (a) Juniors advise Freshmen
   (b) Seniors advise Sophomores
   (c) Professors advise Juniors and Seniors

69. Have a big brother program between grad students and undergrads

70. Industry mentor program
   (a) All interested students are paired with an industry mentor as part of an advisory program
   (b) Could be done as part of an alumni support network
   (c) Could collaborate on an industrial project: Resembles internship but much shorter in duration

71. Treat ME like it is a small college
   (a) Break graduating classes into “Sections”
   (b) Make “The Class” special and inclusive
   (c) Promote socialization
   (d) Have ongoing reunions and so on

72. Encourage students to form “book club” like interest groups but on technical interests. Mentors could be leaders.

73. Create a website or web forum that enables sharing information between undergraduates and alumni resources who are willing to address specific problems

74. Enlist seniors to perform TA duty in a sophomore or junior level class:
    Develop leadership skills, salesmanship and demonstrate mastery of subject matter

75. Find ways to use technology to provide learning and progress toward graduation during all hours of the day and days of the week

76. Project “Passion Capture”:
    How do you identify and then tap into the passion of students?
(a) 1 on 1 advising?
(b) Hands-on opportunities?

Be **intentional** to identify and tap into passions.
(Take-away from this and other cards: expand note of advising...)

77. The ME “me” (as in “wii”):
Have students define and update their ME “me” throughout their career at the U of M as a way to reflect on who they are and where they are headed.

(a) Advising tool
(b) Self reflection / assessment tool

78. Establish a “Professional Development Day”. Classes are canceled. Students come in and have opportunity to talk with:

(a) Faculty about advising questions
(b) Graduate students
(c) Co-op companies
(d) Reps from industry advisory board
(e) International Programs representatives

(U Wisconsin initiative)

79. Student Life: Engineering Commons with coffee shop, wireless, power

80. Encourage (incent?) committing early to ME.
Shift advising focus from scheduling & “discernment” to diagnosing at-risk students and guiding to success

81. Organize informal dinners where alumni and current undergraduates can network
Appendix C

Graduate Education
Task Force Report
Final report for Graduate Student Task Force

Allison Hubel, Task force chair
Frank Kulacki
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H. Young Chung
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30Aug2009
A. State of the Graduate Program:
The first phase of the taskforces' work involved understanding the current state of the graduate program. The Director of Graduate Studies assembled information on the current enrollment and historical data for the program in the last 10 years and this information is summarized below. The cohort for this data is the group of students admitted in a given year. For example, fifty-six students were admitted to the MS program in 2006. To date, thirty-seven of those students have completed their degrees, twelve students have discontinued and eight students are still actively pursuing their degrees.

Master of Science in Mechanical Engineering
Current active enrollment: 144 (down from 166 in 2008/2009 year)
Time to degree completion: ~3 years
Recent historical data (1999 to present)

Doctoral Program
Current active enrollment: 122 (up from 113 in 2008/2009 year)
Recent historical data (1999 to present)
Cost for a graduate student: Between $38,000 and $42,000/year depending upon the nature of the student’s appointment over the summer. This cost includes salary, fringe benefits (health insurance) and tuition benefit. This estimate does not include overhead costs (when overhead is included the cost is between $57,000 and $63,000/year). Our students are supported at the current time on a mixture of research assistantship (RA), teaching assistantship (TA), fellowships and tuition payments from employers or their own funds. The cost for a graduate student exceeds that of post-doctoral associates and provides a significant financial burden for faculty.

Tuition dollars generated by graduate students: all graduate students pay tuition either indirectly through their appointment (RA, TA, etc) or through direct payments of tuition. All of these funds go to the college level (Institute of Technology). None of these funds flow back to the department directly. Thus, the department receives no benefit from increasing enrollment in the graduate program. This policy is different from undergraduate tuition dollars; a portion of those funds flow directly backs to the department.

B. Issues discussed by the Taskforce
B.1 Benefits to stakeholders
We discussed the relative benefits of the different graduate degrees to the various stakeholders: faculty, college/unit, and community. It is clear from the assessment that the doctorate of philosophy (PhD) program provides the greatest benefit to all the stakeholders (faculty, department, college, community). It was also clear that the ‘community’ values the MS program. In the context of this report, the term ‘community’ really represents local industry. Most local industries will hire principally students from our program with either a bachelors of science (BS) or a MS degree. Industry also hires PhDs but less than MS or BS level graduates.

<table>
<thead>
<tr>
<th>Degree</th>
<th>Faculty</th>
<th>College/Unit</th>
<th>Community</th>
</tr>
</thead>
<tbody>
<tr>
<td>PhD</td>
<td>Research output Training future faculty</td>
<td>Rankings Tuition income Enrollment</td>
<td>Faculty for other ME degree granting programs Industry New businesses</td>
</tr>
<tr>
<td>MS Plan A</td>
<td>Research output Move up to PhD</td>
<td>Tuition income Enrollment</td>
<td>Industry New businesses</td>
</tr>
<tr>
<td>MS Plan B</td>
<td></td>
<td>Tuition income Enrollment</td>
<td>Industry</td>
</tr>
</tbody>
</table>

B.2: Pre-recruiting
The process of attracting high quality applications to the program is defined in this report as pre-recruiting. Once an applicant has applied to the program, the success of the program at getting the student to accept admission and enroll in the school is defined as recruiting. Total number of applicants to the program has been largely stable (~500) and our acceptance rate of departmental fellowship offers has been fairly stable as well (40%).

Recommendations: As resources (time and funding) are limited, efforts at improving pre-recruiting should be focused.

1. Website should be reorganized to include more easily accessible information on research in the department. The DGS has already started this process and the website will also be augmented by student profiles and other materials to communicate about life as a graduate student and research in the department.

2. Faculty should be encouraged to contact colleagues at relevant institutions to ask them to recommend our program to their high achieving students.

3. Faculty who speak at another institution should indicate in their talks that we are looking for good graduate students and offer to meet with students during their visit.
B.3: Recruiting
A survey of the students who attended the recruiting weekend in 2009 demonstrated:

1. Students applying to our department are also considering schools all over the country. Survey respondents indicated that they were applying to: Carnegie Mellon, University of Texas, Austin, Georgia Tech, Notre Dame, Washington University, St. Louis, University of Wisconsin, Purdue University, Stanford, University of Southern California, Massachusetts Institute of Technology, Berkeley, Cornell, University of Illinois at Urbana-Champaign.

2. The recruiting weekend was helpful to the students and they were impressed with the experience.

3. Students learned of the graduate program through the following methods (in order of importance):
   a. Research on the web (including our website and others)
   b. Referral from professors at their undergraduate institution (a close second)
   c. REU program

Recommendations
The recruiting weekend should be continued and is an effective recruiting tool. The information on the graduate student website should be augmented and re-organized. The Director of Graduate Studies (DGS) has already started this process and student profiles are being assembled. These profiles use the Slidemaker software to have students narrate their own experiences in graduate school and describe their typical schedule and a description of their research. The objective of these student profiles are to provide potential applicants with more information on both the graduate student experience and the type of projects that students are involved with in the department. The segment in the graduate student website describing the research areas in the department will also be revised and re-organized.

B.4: Admissions:
The taskforce did not express any concerns regarding the admissions process. However, there were concerns expressed about numbers of students admitted. The State of Minnesota does not directly fund graduate education. The department does not receive a portion of the tuition dollars paid by graduate students and budgets for Teaching Assistantships are diminishing. Therefore, the cost of the program really rests upon the departmental endowment and external research funding of departmental faculty. Currently, other engineering departments in the Institute of Technology are significantly curtailing admissions in their MS programs. These programs are diverting resources to maintain and support their PhD program.

Recommendation: It is the recommendation that:

1. The graduate program should be rebalanced. Currently, MS students outnumber PhD students and that ratio should be reversed.
2. MS students should be encouraged to finish in a timely fashion (reduce the time to degree completion to ~2 years).
3. The quality of the MS program should be elevated. We need to encourage and cultivate the admission of high quality MS students who could either go to industry or move up to the PhD program.
4. We need to communicate effectively with local industry the nature of graduate studies and its importance to the department, university and community.
5. Dwindling resources to support the graduate program is a serious issue and the department as a whole will need to discuss the implications for the MS and PhD program.
6. Financial support for the graduate program should be deepened. Specifically, Departmental Fellows should be supported for their first year of graduate school (Fall and Spring semesters). We should also support as many PhD students at the end of their career to ensure the completion of their degree.
B.5: Conduct of the Graduate Program
After discussing this topic, it became clear that there are several interwoven issues that concerned the taskforce: proper preparation of students for the qualifying examination, the total credit requirements in particular for PhD students (as it is currently much higher than most other engineering departments at the U of MN) and the curriculum currently available for students. It was clear that members of the taskforce considered that these issues needed to be dealt with in an integrated fashion (not separating one issue from others).

Recommendation:
Therefore, the committee strongly recommends that a special committee be convened to address the following issues:
• Identify one or two core curricula that the majority of the graduate students should pursue.
• Review the requirements for M.S. or Ph.D. degrees (including potentially a plan C Master’s degree).
• Align course structure to serve the qualifying examination.
• Assess curriculum and compare it to renowned peer institutions.
• Assess training in non-technical areas, such as communication skills, exposure to international experience, and ethical and social responsibilities.
Appendix D

Energy and Transportation Research Task Force Report
Energy and Transportation Task Force  
DEPARTMENT OF MECHANICAL ENGINEERING  
University of Minnesota  

Report  
October 7, 2009  

Charge  
The assignment given the Energy and Transportation Task Force charge was to:  

- objectively analyze the department’s strengths/weaknesses/opportunities/threats (SWOT) in the broad areas of energy and transportation,  
- identify key areas of intellectual pursuit in these areas within the Department,  
- develop strategic objectives that will advance the identified areas of intellectual pursuit, and  
- propose an action plan to pursue the strategic objectives.  

Membership  

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Summary of Findings  
The global economy is expected to grow by a factor of four over the next 40 years and as much as a factor of ten in developing countries. This growth will be accompanied by increased energy use and an urgent need for development of cleaner and renewable modes of power generation, more efficient energy conversion technologies, and expanded energy and transportation...
infrastructure. Mechanical engineers have a long history of achievements in the energy sector and today are deeply involved in new and evolving technologies that are affected by, and responsive to, a growing demand for energy and a mandate for reducing greenhouse gas emissions.

In addition, human safety in the transportation is of great concern. We have not seen any significant reduction in the 40,000 road fatalities that occur annually on American roads since the early 90’s. Whereas significant reductions were achieved until then through improved vehicle crashworthiness, the deployment of restraint systems, better road design, driver education and increased enforcement, we have reached a critical stage where major breakthroughs are in order. New methodologies are needed to provide better situation awareness to the driver through improved human-machine interfaces, and better sensing and driver assist systems so that crashes are avoided in the first place. Mechanical engineers can and should play a role in this vital field.

The Department of Mechanical Engineering faculty has enormous strengths in many of the engineering disciplines required for energy and transportation related research. In addition, more than half of the faculty members have active research programs in energy and transportation. Key areas of intellectual pursuit within the Department are fundamental and applied thermal sciences, applied science and engineering in renewable energy technologies, engine and combustion technologies, fluid power and controls, vehicle sensing and controls, driver feedback and behavioral psychology and other areas that contribute to transportation safety. An opportunity to build these areas to national and international preeminence exists across the Department’s academic missions of teaching, research and service. Given the compelling global energy issues and a generational opportunity for expanded funding for energy research, the task force provides the following five recommendations:

1. Develop Department-wide centers of excellence in energy and transportation by closer integration of Departmental activities, laboratories and centers in these areas
2. Establish a graduate curriculum and continuing education courses in emerging energy topics
3. Prioritize hiring of faculty in the areas of energy and transportation
4. Expand development efforts for endowed professorships and for improved laboratory infrastructure in energy and transportation
5. Improve administrative support for securing and managing grants and contracts in energy and transportation

**Background**

The Intergovernmental Panel on Climate Change (IPCC) estimates that by 2050, an 80% reduction in annual production of greenhouse gases (GHG) is needed for the planet to remain in the “cool zone” and avoid potentially catastrophic environmental consequences. The IPCC further recommends that by 2020, GHG levels should be no higher than those in 1990. Achieving this level would require roughly a 20% reduction in global GHG production from today’s levels. In order to achieve these goals, new technologies and systems that are both efficient and cost-effective are needed.

The wide variety of activities producing GHG means that it is unlikely that a “silver bullet” will be found that singlehandedly can reduce GHG by the required amounts. Instead, it is likely that substantial reductions will be needed in all sources of GHG. However, one thing is certain: the
US must lead the way in reducing GHG since we currently are second only to China in GHG emissions (see Figure 1). The GHG emissions in the U.S. are provided by sector in Figure 2.

Development of renewable energy technologies and improving combustion processes to reduce GHG emissions must be pursued as key elements of the global warming battle. The University possesses a strong core talent which can be supplemented with a few key additions and initiatives to position it as a premier center for alternate energy and transportation research and education.

![Figure 1: Countries producing the most GHG](source)

**SWOT Analysis**

The task force SWOT analysis was informed by faculty and staff responses to a questionnaire, its analysis of internal and external activities, and personal perspectives on energy and transportation. The results of the SWOT analysis are summarized below. The questionnaire and compilation of responses is included as an appendix to this report. The SWOT analysis provided the basis for the recommendations of the Task force.

**Strengths**

- **Diverse interests in energy and transportation among the faculty.** A self-summary of faculty activities in these areas is included in the appendix.
- **The faculty conducts leading edge energy and transportation research and has national and international visibility** in the areas of: (a) Intelligent vehicles and human interface (Intelligent Vehicles Laboratory and Human FIRST Program), (b) diesel and gasoline engine emission control, (c) solar energy, (d) basic and applied heat transfer, (e) plasma heat transfer and technology, and (f) particle science and technology.
- The NSF Engineering Research Center for Compact and Efficient Fluid Power (CCEFP) was established in June 2006 and includes seven participating universities and 55 industrial partners. It focuses on hydraulic and pneumatic technologies, including hydraulic hybrid vehicles and human scale power devices.

![Figure 2: Sources of GHG emissions in US](source)
• We have a strong history of external funding. Our faculty and centers have long-held relationships with federal and state funding agencies, including NSF, DOE, DARPA, NASA, US and MN Department of Transportation, and National Laboratories. The Intelligent Transportation Systems Institute (ITS Institute) has been congressionally designated and funded ($3 million/yr in 2008-9) by the USDOT as a National University Transportation Center since 1991. In addition to the congressionally designated funds, the ITS Institute brings in approximately $6 million annually.

• We have established industrial partnerships with particularly strong and broad interaction through the CCEFP, the ITS Institute, and the Center for Diesel Research (CDR).

• We have institutional support for renewable energy research through the Initiative for Renewable Energy and the Environment. Faculty collaborations extend across the University community within the Institute of Technology and also in the College of Biological Sciences; College of Food, Agricultural and Natural Resource Sciences; and College of Design.

• Supporting facilities are available for research. These facilities include the Department’s machine shop and computer support, the IT Characterization Facility, the Nano Fabrication Center, the Supercomputing Institute, and road test areas for ITS Institute.

• We have a strong and active base of alumni, many of whom are located nearby and have leadership positions in industry.

• On-going research in the Department has value to society and addresses needs for renewable energy technologies, clean and efficient energy, and vehicle and human safety.

Weaknesses

• There appears to be no clearly defined vision or strategic plan for the future of energy and transportation research within either the Department or the Institute of Technology. Within the department, synergistic activities are not well coordinated.

• There appears to be a lack of institutional support to go after larger programs and initiatives in energy and transportation.

• There are too few endowed professorships in energy and transportation.

• The Department needs to improve its outreach by communicating research and resulting publications on the internet and in other forums. The present curriculum does not adequately address emerging energy or transportation issues.

• Space allocation has not been adaptable to changing needs. Space needs identified include: (a) additional office space to increase number of researchers in ITS Institute; (b) laboratory space to work on vehicles and to garage them and the supporting equipment.

• Funds for equipment updates are insufficient.

• The administrative staff is overburdened and does not provide adequate support for grants management. This weakness is stressing faculty and forcing faculty members to either hire their own administrative staff or compete with each other for administrative support.

• The new accounting system at the University has been problematic. The faculty finds it very difficult and time consuming to manage and monitor funds. Tracking of funds in parallel with the University’s system seems to be needed.
• **Funding is often feat or famine.** There is no mechanism in place to sustain ourselves during the low funding periods. There is a need to assure long term viability of our labs.

**Opportunities**

• The **rich diversity and numbers of faculty members** active in energy, transportation and basic thermal sciences provides an opportunity for creation of new centers of excellence, pursuit of significant funding, industry partnerships and national visibility.

• The recent announcement of **four new faculty hires** offers an opportunity to build on existing strengths in engines and renewable energy.

• The **expanding government and industry interests** and funding levels for energy, particularly renewable energy and the transportation sector, is encouraging.

• There is **public support for “green” energy.**

**Threats**

• The **lack of University and IT initiatives** in energy/transportation

• The downturn in **the economy and budget cuts** (university-wide cuts lead to reductions in provided services, reductions in equipment matches and pay freezes which lead to non-competitive salaries)

• Strong **competition from other universities** that have established large, well funded, visible institutes or centers in alternative energy. Examples are: Stanford University Precourt Institute of Energy, University of California Energy Institute, University of Michigan Phoenix Energy Institute, University of Michigan Transportation Center, Caltech Center for Sustainable Energy Research, Penn State University Institutes of Energy and the Environment, University of Wisconsin Energy Institute, MIT Energy Initiative and Laboratory for Energy and the Environment. In transportation our main competition comes from transportation research centers at UC Berkeley, University of Michigan, and at Virginia Tech.

• **Diminishing access to non-federal matching funds** required for all USDOT contracts and most DOE contracts. In general, the Departmental and University abilities to provide matching funds appear to be in jeopardy because of budget cuts.

• **Lack of a coordinated curriculum** in energy to attract top students

**Recommended Actions**

1. To address the lack of coordinated effort in the Department, the task force recommends an internal working group be given the charge to develop Department-wide collaborative initiative(s) in energy and transportation. The working group should produce a five year strategic plan for a center(s) of excellence in energy and transportation research within ME. It should address leadership, needed infrastructure, and synergies in energy and transportation that will build on outstanding but somewhat isolated existing efforts. The faculty assessment should seek external input and should continue beyond the task force to establish future hiring priorities.

2. A graduate curriculum should be developed in energy that combines fundamental and applied courses in ME and other related disciplines. It is anticipated that a graduate curriculum in
this area along with the availability of graduate fellowships will attract top students, provide greater visibility for our research programs, and be of service to the engineering community.

In addition, continuing education courses in emerging energy and transportation topics will serve as a mechanism for outreach to the broader engineering community.

This recommendation should be considered by the Department’s Graduate Committee.

3. The task force recommends multiple new hires in energy and transportation. The selection of new hires should consider potential for exceptional scholarship and contributions in areas identified as strengths of the department and/or emerging areas of applied science and engineering. Suggested broad areas based on input to the committee are propulsion and renewable energy.

**Propulsion** engineering combines the knowledge of engines, power transmission, alternative power, and control to improve efficiency and reduce emissions. The worldwide powertrain market is estimated to be $300 billion, more than any other manufacturing industry. Approximately 2% of this amount, $6 billion is spent on R&D. With developed relationships, it is reasonable to expect that 1% of the R&D budget, $60 million, would be spent by industry for external research at universities. The synergy of on-going research on the transportation technology, engines, fluid power and particle technology provides a unique opportunity to build our reputation in this area. Off-highway applications such as construction and agriculture are especially good fit for these research groups since these applications use fluid power transmission and diesel engines and the main emission challenge is particulates. With the addition of one more faculty, the Department would be positioned to attract external research funding from government and industry and take a leadership position in this area.

The highest priority is for a new position in combustion. A new faculty hire in this area will provide continuity of the work in the CDR, expertise in a fundamental discipline that is currently weak in the department, and synergy with the CCEFP, and, potentially, the ITS Institute. The CDR in partnership with the Particle Technology Laboratory has a long history of successful work on diesel and gasoline engine emission control. Recently the CDR has begun to explore other forms of combustion including low temperature combustion and hydrogen assisted combustion. However, the CDR is lead by a single faculty member. There is not critical mass to maintain quality over the long term or to support the infrastructure. Without a new hire, we are unlikely to hold on to our reputation and industrial contacts in this area.

**Renewable energy** represents a broad range of technologies including solar, wind, biomass, and hydropower. The strength of the Department is solar energy. The Department has three faculty members working in the area of solar thermal energy for heating and cooling buildings, thermochemical fuel production, concentrating solar power and one faculty member working in the area of solar electric (photovoltaic) materials development. Moreover the Department has a long and renowned history in solar thermal research; our students are very well placed in government, industry and national labs; there is an excellent pool of graduate students; we have ample opportunities for outreach to industry, and public service at the state and federal levels; and the University’s Initiative on Renewable Energy and the Environment provides internal support. Senior faculty members are actively involved in advising industry and government in this area.
Other departments and universities are actively recruiting both senior and junior level faculty in this area and have formed centers or institutes on renewable energy. A new faculty member in renewable energy would provide the critical mass needed to propel our solar program to national prominence. Areas of synergy with on-going activities include renewable fuels, thermochemical storage, and fundamental heat and mass transfer applied to high temperature processes.

4. In the recent past, development efforts at the departmental level have focused on scholarships and graduate fellowships. The task force recognizes the importance of this activity but feels that fund raising should target also the establishment of endowed professorships in the energy area and development of state-of-the art laboratories, particularly for updating the engines laboratory and developing additional space for the ITS Institute.

5. A responsive and trained administrative staff is needed if the department is to substantially grow its research program. Leadership of the department should seek creative ways, even with a reduced budget, to improve support for fiscal grants management.
Appendix E

Human Health Task Force Report
Strategic Plan in Human Health Area

General:
The committee feels that biomechanical engineering (human health) is a growth area within engineering as a whole and mechanical engineering in particular. This area is vital to the economy of the State of MN (esp. Medical Device sector). Continued support from the state will be necessary and important to maintaining the health of this area in MN and it’s competitiveness within the global healthcare industry. Thus, the committee proposes that the ME department should continue to invest in and grow this area of intellectual pursuit as outlined in general comments below and the research, teaching and service portions this document. One general approach should be to increase the visibility of this area in our department. This can be achieved by highlighting activities including: curriculum (teaching) in this area, research in this area, and the department output associated with this area (i.e. success stories and news in this area). The department should use the website to achieve this. The committee also proposes an increase in strategic leveraging in this area (i.e. new hires, grant initiatives etc.).

The committee believes there is a general need to increase the integration and leadership of activities related to this intellectual area on campus. The ME Department Head should consider interfacing with other heads and directors: (IEM, BME, EE, CEMS, ME etc.) and craft a more unified vision with Deans and higher administrative structures on campus for this area at UM. ME can then fit into this unified vision. In forming a departmental vision at the steering committee level, input from each committee through member(s) (in addition to their written input) should be solicited to best reflect and craft a vision moving forward.

Research:
The committee proposes an increase in commitment to this area of intellectual pursuit in the department. Based on committee discussions, a number of specific areas to focus on for growth and hires were suggested: cellular and molecular biomechanics, combinatorial biological and/or nano or MEMs devices and sensors, and surgical robotics. These are complementary to departmental areas of strength, IT initiatives (Medical Devices and Nano-Structured Applications) and growth within ASME at the national level and the field of biomechanics internationally.

The committee further proposes an increase in initiatives in the biomechanical engineering (human health) area that the ME department can interface with (center grants, industry partnership, etc.). Ideally, this should proceed from a centralized office / position and reflect a common vision (IEM, BME, EE, CEMS, ME etc.). We should work to be part of an ERC in medical devices if possible. We should also work to build larger initiatives using existing successful models and cultures: SAFL, NSF ERC Fluids, MRSEC, iPRIME etc. Finally, the committee strongly recommends an increase in industry partnerships in this area as we have a strong local environment that can support and leverage this effort.

Teaching:
The committee suggests that we can better organize and possibly augment curriculum in this area within the department. The department can have curriculum recommendations (emphasis areas biomechanics, biofluids, biotransport, design and cell and tissue which mirrors ASME Bioengineering Division Technical Committees) online such that recommended tracks are available to students. Various emphasis areas related to research focus should be identified.
Positive role models / success stories in each emphases area should be posted to the ME website. ME should track students in each area.

**Service:**
The committee suggests that UM ME faculty participate more in local and national meetings, societies and with industry in the Human Health area. The three major societies in biomedical engineering in the US are: ASME (Bioengineering Division), Biomedical Engineering Society (BMES), and the Engineering in Medicine and Biology Society (EMBS). The committee suggests an increase in ME faculty partnerships with local industry (consulting, student projects etc.). This requires bridge building and networking with local companies that should be organized by the department or a larger initiative (leadership) on campus (perhaps Institute for Engineering in Medicine – IEM, see above).

In conclusion, the committee feels that by implementing the above ideas, the UM ME Department can continue to be competitive and even leaders in the biomechanical engineering (human health) area. By focusing on our strengths in medical devices (esp. MEMS and nanotechnology), biotransport and biomechanics, UM ME will continue to provide both new knowledge and excellent trained students for the community (local and beyond) in this increasingly important area.
UM ME Department Human Health (Biomechanical Engineering)

SWOT Analysis:

**Strengths:** (Internal attributes of Dept. that are helpful to achieving the objective)

Strengths of faculty
- Citation index. We are in the top 5 on this basis.
- Research area strengths:
  - Medical Devices, Biotransport (Thermal Therapies and Biopreservation)
  - Nano-Enabled Flexible MEMS for Biomedical Applications
  - Sensors and actuators
  - Particle Science (quantum dots, biomedical nanoparticles, bioactive materials, gene gun …)
- Research strengths outside of Medical Devices and Biotransport (collaborations)

Strengths of students
- Students are good, but need to attract better to stay competitive.
- Use DMD Fellowship to attract best students.
- MDC Fellows are a strength, but need to find ways to fund in future.

University Strengths: initiatives / centers etc.
- Current IT initiatives:
  - Medical Device Center (Director: Art Erdman – ME)
  - (EX) IT had support to hire 6 new faculty in Medical Devices.
  - This has been delayed due to budget crisis.
  - We need to decide emphasis areas for new ME hires.
  - Human Health could be one, but in what specific areas?
  - Center for Nanostructured Applications (Director: Steve Campbell – EE)
  - iPRIME and other interdisciplinary initiatives (MRSEC)

- IT and AHC initiatives:
  - Institute for Engineering in Medicine (Director: Jeff McCullough)
  - New Translational buildings may house Human Health faculty in future.

Medical School.
A strong Medical School and Academic Health Center:
- [http://www.ahc.umn.edu/about/home.html](http://www.ahc.umn.edu/about/home.html)
- [http://www.med.umn.edu/about/home.html](http://www.med.umn.edu/about/home.html)

Concentrations of excellence in cancer, cardiovascular and neural health:
- Lillihei Institute (Cardiovasc.) - [http://www.med.umn.edu/lhi/](http://www.med.umn.edu/lhi/)
- Neuroscience and Neuroengineering:
  - [http://www.neuroscience.umn.edu/](http://www.neuroscience.umn.edu/)
  - [http://www.cne.umn.edu/](http://www.cne.umn.edu/)

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Strong departmental and institutional infrastructure
Review Departments – One of the most comprehensive Universities in world
Engineering, Medicine, Law, Business, Vet School, Liberal Arts, etc.
One reason for the “Top 3 Public University Quote” (U. Florida Study).
Centers and Institutes: For complete UM listing see:
http://www.business.umn.edu/test/cip/
University Enterprises Laboratories (Connecting UM to Industry)
http://www.uelmn.org
State and industry support
Early stage biology and biotechnology collaborative research center
Reduced rate for start ups

Statewide Strengths:
Industry
One of the largest concentrations of medical device companies in the world:
https://www.lifesciencealley.org/members/member_list.aspx
Support from (local) industry
Interest and participation in Medical Device Center
Interest and participation in DMD conference through MDC (Art Erdman) Individual
research agreements between industry and faculty are common.
Design projects for ME and BME from local industry
Coop projects and UG internships available
Local industry hires a great deal of our graduates.
Will check if tracking is underway with John Gardner.
Life Science Alley
MN Bio
Potential Growth in BioPharma (Destination 2025 – Steve Burell – Rochester)

Mayo Clinic

Weaknesses: (Internal attributes of Dept. that are prohibitive of achieving the objective)

Unclear vision for activity and growth in this area.
Lack of web visibility.
No clearly articulated message for this area on website
Unclear connection to other BME entities on campus.
BME department and IEM in particular.
Limited funding from federal sources
Limited cross talk/ collaboration between research areas in department:
EX: biotransport and medical devices.
Lack of faculty expertise in Human Health area (number of faculty)
Lack of visibility / connection of our Human Health (BME faculty) at major ASME or
BME or other Biomedical Engineering Research forums / meetings.
Meetings: ASME Summer Bioengineering and BMES for example. We are not
tapped into “star” groups from these meetings. We are not hiring “star” students from these meetings. If we hire from other pools, we need to carefully decide what community these hires represent.

Lack of student interest

- We are not competitive for students with top ME departments
- Best students in I.T. are now going to BME and CEMS on campus
- Need Fellowships to attract best/better students

Ratio of female to male faculty and students.

- ME is traditionally low.

Support from (local) industry

- Could possibly increase outreach and visibility of department to local companies
- MEAC – members from Medical Device Companies?
- Could have more industry – faculty partnerships.

Support from University

- We are under a hiring freeze.
- Infrastructure challenges
- We have administrative support challenges within the department currently. Mostly this is due to staff and budget issues.

Ranking Issues:

- # of Ph.D.s graduates
- Funding per faculty
- Total research expenditures
- Small faculty size (Ranking improves with faculty size).

Opportunities: (external conditions that are helpful to achieving the objective)

Future funding trends

- Device industry will likely evolve beyond existing medical device definitions and focus. Examples include Biopharma emphasis in Bioscience 2025 Current companies interface well with MDC for design (see study on web: http://biobusinessalliance.org/destination)
- Device characterization and testing is an opportunity as well
- EX: DOD Airworthiness Standards

Start ups

- SBIR and STTR funding
- UEL for startups

Lack of competition UMN is in a strong regional position.

- In comparison to East and West Coast, MN has few competitors.
Female to male ratio of faculty and students in BME is higher, thus Human Health is an area that may encourage a more positive ratio in ME in future.

Larger impact if Human Health coordinated on campus: BME, ME, EE, CEMS and IEM need to get on the same page.

Create industry advisory panel to ME (with possible overlap to EE, IEM, CEMS and BME) in medical device area.

New emerging area Nanobiotechnology.
   The particle technology background at UMN is world class. This could transition into something powerful if it can be more focused on biological and biomedical applications. It represents both a biotransport and a medical device area while simultaneously growing an existing strength in particle technology. Exs. David Pui filtration and gene gun work, Girshick and Bischof nanoparticle work, Hubel and Kortshagen quantum dot work, Hogan new hire, etc.

Possible growth areas from news where our faculty could contribute:
   Nanotoxicology
   Multi-scale modeling
   Stem cell research
   Non-invasive surgery
   e.g. non-invasive heart valve surgery (Edwards LifeScience)
   Minimally-invasive therapies
   Regenerative medicine
   Sports biomechanics
   Marine biotechnology
   Telerehab/Therapeutic Technology/Rehabilitation work

Human Health faculty
   Interested medical school faculty
   [Comment: part of this is distinction between ME and BME]
   Combined degrees for graduate students

**Threats:** (external conditions that are harmful to achieving the objective)

Expectation of declining funding
   Funding will need to come from a variety of sources in future.
   Endowments and local leveraging are expected to be important.
   Increasing emphasis on training grants (to get students paid for) is already a goal within ME department.

Overwhelming competition
BME departments (including our own) have strong basic science faculty. These faculty are well funded through NIH NIBIB and some through NSF. ME based biomedical engineers can have a tough time competing against BME faculty for this funding.

Declining emphasis of Biomedicine in state?
Area of Intellectual Pursuits: Human Health (Biomechanical Engineering)

(Brainstorming): Research, Teaching, Service activities

Research. (Taken from http://www.me.umn.edu/mission.shtml)
Research is an integral part of graduate education. While our research program should be broad in scope it cannot cover all aspects of mechanical and industrial engineering. Rather, we should select research foci based on such factors as faculty members' capabilities and interests, long-range importance to mechanical and industrial engineering, leadership potential within the department, the ability to provide supporting facilities, potential for enriching the undergraduate curriculum, and relevance to regional needs. Furthermore, these focus areas should be chosen with regard to the obligation to obtain adequate, stable financial support and be confined to a size and scope within the means of available resources. We encourage collaboration among faculty and programs that crosses disciplinary and departmental boundaries. Our research programs should be in the forefront of their respective areas and we should regularly measure their productivity in terms of technological impact and the quality and originality of publications, patents, and graduate degrees granted. It is expected that our graduates will be among the teachers and technological leaders of the future.

Basic and Applied Research (traditional support for faculty research programs)
Funding for this area is supplied through NSF, NIH, DOD, DOE and DARPA. There are also numerous foundations that support this work (Coulter, Hughes, Gates, etc.). In addition, more translational applications may fare well with SBIR and STTR funding mechanisms and industry partnerships.

Industry Research / Partnerships (likely to be increasingly important if federal funding continues to decline).

  - Contract and Licensing Negotiations:
    Reduced indirect costs. Particularly important in medical device and biomedical engineering industry. Need timely, helpful and knowledgeable people in the negotiations to keep a contract and/or licensing agreement moving.
  - Access to Ideas:
    Lots of local company interest, but not enough access to ideas to leverage and invest. Doug Johnson – Venture Center (OTC). James Woodman (Office of Business Relations – Assistant Director Univ. Wide).
  - Start Ups:
    Stimulate / give incentives to inventors (Professors) to create companies.
    Translation of research to I.P. and royalty (to Start Up or Licensing Company)
    Phase out 5%, 3% to 1% at end of patent.
    Licensing fees. Exclusive licensing. More up front or more on royalty.

Endowment Funding (This will be increasingly important in the future as federal funding declines)

Need to effectively raise money to support faculty research and student funding, especially fellowships, in the future.
Research Area:

Existing Areas of Strength:

(1) Medical Devices. Medical Device Center and affiliated ME faculty.  
http://www.mdc.umn.edu/

(2) Biotransport (Thermal Therapies and Biopreservation)  
http://www.me.umn.edu/research/areas.shtml#biotransport

(3) Evolving areas:
   Nano-Enabled Flexible MEMS for Biomedical Applications
   Sensors and actuators
   Nanotoxicology
   Particle Science and Bionanotechnology
   (quantum dots, biomedical nanoparticles, bioactive materials, gene gun…)
   Bionanotechnology is a potential growth area in state. See Destination 2025 brochure (http://biobusinessalliance.org/destination)

Other Possible Areas to consider (**These require further discussion and prioritization** _COULD LINK UNDER ABOVE STRENGTH /EXISTING AREAS 1 - 3)_

(1) Health Informatics (NAE Grand Challenge)
   Software system design for user-friendly health care history system
   Wireless integrated monitoring systems including sensor design. Home monitoring provides info to health care provider.
   Sensors for chemical and biological weapons.

(2) Organ replacement /repair (e.g Doris Taylor work)
   Extra –cellular matrices/scaffolds for tissue rebuilding with stem cells  Stereo-Lithography, other methods

(3) Medical instrumentation development
   cell sorting by flow cytometry
   can particle technology expertise be applied?

(4) Can David Pui “Gene Gun” be leveraged further for genetic engineering?

(5) Reverse Engineer the Brain (NAE)
   Can we use wi-fi equipped nanobots.
   Measure neural activity and transmit info out of body
   Actively stimulate nervous system to study interactions and pathways.

(6) Engineer Better Medicines (NAE).
   Combinatorial chemistry robotics
   Equipment for DNA sequencing and high-throughput screening

(7) Other:
   Aerosols - drug delivery (Tim Weideman)
   Cell Processing – Allison Hubel and St. Paul PACT center.
   Quality systems. Quality control.
      Infection control.
      Surgical suite systems control.
   Safety from mistakes (get the surgical target right).
   Medical records control.
Teaching. (Taken from: http://www.me.umn.edu/mission.shtml)
In teaching we seek to encourage our students to discover their individual talents, inspire them to
work up to their potential, and prepare them for lifelong learning and successful lifetime careers.
Our undergraduate education shall provide for study in the basic sciences, the liberal arts, and
engineering analysis and design in accordance with national standards and be innovative in
content and approach. In particular, our undergraduate program should benefit by enrichment
from our research activities and ties to industry and our maintaining a strong co-op program with
its opportunities for actual engineering experience. Our graduate program should combine
innovative research with a coherent plan of study and provide opportunities for full- or part-time
students seeking masters and doctoral degrees. We recognize that because of our urban setting
and size, some students may find it difficult to develop the satisfying, personal attachments to
our department and university that come more easily at smaller, more intimate institutions.
Accordingly, we must be conscious of the needs to create a departmental atmosphere that
overcomes these handicaps and build on the benefits that accrue from our rich surroundings.

Classroom teaching (See: http://www.me.umn.edu/education/courses.shtml)
Need to list / develop curriculum paths in Human Health related to the research areas.
Need to list successful outcomes of students. Need curriculum plan for G and UG students in
this area.

Need more classes with Bio and Health content in this area UG and G.
   ME 5666 – Modern Thermodynamics – Bio, Nano
   ME 8381 – Bioheat and Mass Transfer
   ME 4054 – Senior Design Projects
   ME 8221/8222 – New Product Design

Need more labs in this area (some content in the following).
   ME 4131 – Thermal Environmental Engineering Laboratory
   ME 4331 (now has a DSC section – need more biological content)

See BME courses:
   http://www1.umn.edu/bme/html/Our_department.html

Short Courses:
   IEM has a whole list of short courses in this area to expose students to:
   http://www.iem.umn.edu/education/short_courses.html

Meetings / Conferences on campus:
   DMD – www.dmd.umn.edu (Design of Medical Devices conference)
   IEM Symposia – www.iem.umn.edu
   EMBC (this fall) - http://www.embc09.org/

Service. (Taken from http://www.me.umn.edu/mission.shtml)
Our service obligations include participating in university self-governance, providing leadership
for professional organizations, and giving professional advice and counsel at the local, state,
national, and international levels. In addition, we have the responsibility, in a state-supported
land grant institution, to serve as a creative font and information resource for the citizens,
government, and industry of the state of Minnesota.

Increase perception and visibility – spell out mission and vision for this area.
Web visibility (especially important for UG and G students)
Also important for company contacts.

Student (UG) visibility.
- Dean of UG studies (Paul Strykowski).
- Outreach - minority kids + High School Project “lead the way” (Ken 3M).
- IEM and BME did a treatment of "what is a biomedical engineer."
- We could post this to our website (link).
- High school visits.

Faculty visibility.
- Have our faculty go to specific ASME and/or BMES meetings for visibility.
- Have particle technology (bionanotechnology focus) present at these meetings.

Industry visibility - relationships.
- Doug Johnson – Venture Center –
  http://www.research.umn.edu/techcomm/about.htm
- Can help with stronger industry contacts
- DMD
- Life Science Alley
Appendix F

Environmental Research Task Force Report
Preface. For more than a century mechanical engineers have worked to control indoor environments and protect the outdoor environment from manmade pollution. This work is largely based on the training that mechanical engineers receive in fundamental topics such as fluid mechanics, heat and mass transfer, design, CFD, and instrumentation. Our Department’s education and research programs have played prominent roles in such work, and a significant fraction of our graduates are employed as environmental engineers in the HVAC or other industries. Our doctoral graduates lead environmental engineering research programs in research laboratories, industry and academic institutions worldwide.

Mankind is facing many daunting environmental challenges. These include mitigating the magnitude and effects of global warming, maintaining safe and adequate supplies of food and water, producing clean energy in sufficient quantities to maintain a high quality of life, managing and recycling waste, and maintaining healthy living conditions in the built environment. Many of these challenges are being exacerbated by rising demands due to population growth and global development. Mechanical engineers will play a central role in solving problems associated with these challenges. The focus of our Task Force has been to identify particular environmental engineering teaching and research areas that should be strategically addressed by our Department.

We have identified the indoor environment as an appropriate and promising research focus for a faculty hire. Space heating and cooling accounts for about 40% of our energy consumption, and efforts to improve efficiency will likely have adverse effects on indoor air quality. Furthermore, research on the indoor.
environment has been neglected relative to atmospheric research and, historically, work in this area has fallen within the domain of mechanical engineering practice. Because humans spend such a large fraction of their time indoors, we think it likely that more attention will be paid to the indoor environment in the future. We have identified several possible research areas pertinent to the indoor environment that address intellectual frontiers and that would be good fits to our Department. These include the protection of humans from adverse health effects of biological particles (e.g., viruses, bacteria, molds, fungi, pollens) and unanticipated impacts of “green buildings” on indoor air quality (e.g., chemical or biological decontamination). Filtration is another possible research focus with applications to the indoor environment as well as to many other engineering applications. Filtration of liquids is an especially poorly understood process that requires a more fundamental understanding. Research on these topics might include the development of new instruments, a historical strength of our program, and could include collaborations with the colleges of Architecture, Biological Sciences, Medicine, or Public Health, all of which are conveniently located nearby. A faculty member working in this area would enable us to continue our educational programs, our connection to the HVAC industry, and our research leadership in an area of significant societal importance.

In summary, our Task Force has concluded that environmental engineering will continue to be important for mechanical engineering teaching and research programs in the future, and that our Department should continue its historically strong presence in this area. Furthermore, given the age distribution of our environmental faculty, we feel it is important that we hire a new faculty member soon to ensure continuity. We have identified several topics that we feel involve seminal research questions that could be successfully addressed by a faculty member in our Department. Appendix C includes the draft of a position description that describes our vision for a faculty member in the environmental area.

**SWOT Analysis for Environmental Division.**

Our Task force met several times to carry out a SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis for our environmental engineering teaching and research programs. An abbreviated summary of that analysis is given below. We focused on “opportunities,” since they will determine the department’s strategic decisions regarding faculty hires and future teaching and research initiatives. However, the opportunities that we defined were constrained by strengths, weaknesses and threats that we identified. Appendix A includes a more detailed discussion of our thinking behind some of these opportunities. At our final meeting we prioritized the opportunities that we’d identified earlier. The result of those prioritizations are given in Appendix B. There was a remarkable consensus among task force members regarding opportunities that should be given top priority by the Department.

1. **Strengths**
- aerosol measurements short course
- aerosol instrumentation
  > successful technology licensing
- aerosol fundamentals
- availability of senior faculty mentors
- Architecture school-close proximity to ME department.
- biology strength at UMN (collaboration)
- HVAC: Long record of leadership and teaching at local and national levels
- multidisciplinary collaborations
- nanotechnology lab for MEMS fabrication
- nanoparticles and nucleation
- partnerships with industry
  > aerosol science (microcontamination; filtration; instrumentation)
  > HVAC
- research interactions with community (governmental and private orgs)
- spinoffs
  > TSI
  > MSP
  > Nanocopoeia
- successful alumni
  > Professors in U.S., Asia
  > Industry leaders
  > Research laboratory leaders
- successful record of funded research programs
- worldwide network of collaboration in aerosol science

2. Weaknesses

- faculty demographics (young faculty required to continue work in this area)
- narrow outlook (environmental concerns extend beyond aerosols)
- no DARPA funding
- no strong University connections to funding opportunities in Washington
- no success with large center proposals
- small ME faculty size: maintaining a “critical mass” of faculty in this area

3. Opportunities (See Appendix for more detail)

- Aerosol MEMS Instrumentation
  > Distributed measurements with multiple inexpensive instruments
  > Potential major growth area
- Atmospheric Aerosols
  > ME Skills: Instrumentation, Thermal Sciences
  > Partners: University Atmospheric Science program and IONE
- biological particles
  > indoor air quality (molds, spores)
  > airborne transmission of disease
- Homeland Security
  - Deactivation
  - Instrumentation for real-time measurements

- Environmental Health and Safety
  - Nanotoxicity
  - Inexpensive, effective instrumentation

- Filtration
  - $30 Billion Industry
  - Gases: Airborne Molecular Contaminants (AMC)
  - Liquids: Fundamental work on liquid filtration is needed

- Gas Phase Nucleation
  - Occurs in semiconductor processing, materials synthesis, atmosphere, etc.
  - Processes important to aerosol systems not described by existing theories
  - Includes pioneering work at the interface between molecules, clusters, nanoparticles
  - Challenges include measurement and theory
  - Geoengineering to mitigate climate change

4. Threats

- Competitors at other academic and national laboratories
  - Atmospheric science
  - Homeland security
- Intellectual Property: patents, publications, etc.
  - Conflicting interests of University/Industry partners
- Picked much “low hanging fruit” on aerosol physics (measurement & behavior)
Appendix A

Opportunities

**Biological Particles:** Environmental exposure to particles of biological origin has enormous implications for the protection of public health. Disease can be spread by the inhalation of gas-borne viruses and bacteria, terrorists can use aerosols as vehicles to distribute deadly biological agents, and pollens, molds and fungi cause allergic suffering in both the indoor and outdoor environments. Although tremendous progress on real-time chemical analysis of aerosols has been made over the past 15 years, our ability to identify biological particles is primitive by comparison. Therefore, the study of biological particles is an area with tremendous promise for significant future breakthroughs. Seminal topics include:

*Instrumentation.* Real time methods for identifying types and concentrations of airborne viruses, bacteria, molds, fungi, pollen, etc. and the viability of viruses, bacteria and fungi. Better generation methods also need to be developed that provide continuous aerosols with known particle size and viability for laboratory testing and sampler calibration. A recent review on the state-of-the-art for sampling airborne viruses is given by Verreykt and coworkers \(\{, 2008 \#23389\}.

*Airborne transmission of disease.* Possible research focus areas include pandemic prevention, protection of hospital patients from the spread of disease including hospital acquired infections, protection of the public from exposure to biological particles in aircraft and other enclosed spaces.

*Deactivation.* Methods to render biological particles innocuous including physical stress, the effects of environmental parameters such as temperature, humidity and UV radiation, and other novel approaches including various wavelengths of electromagnetic radiation and chemical inactivation. This information is also useful when designing sampling systems to minimize losses.

Research on biological particles in an important intellectual frontier that would build from our existing strengths in aerosol science and the indoor environment.

A useful overview reference on the state of the art for virus particles, the category of particles receiving the most attention in recent years, is the review paper by Verreault, Moineau and Duchaine.

**Concerns:** Although this is clearly an intellectual frontier, a number of talented groups see it as an opportunity. Homeland security initiatives, for example, have led to significant research investments. If we were to hire a faculty member in this area we would need to be convinced that s/he had a niche that was likely unique. As an interdisciplinary area, we either need to develop biological expertise ourselves or to partner with others with the knowledge, equipment and facilities to perform cutting edge research in this area.
Filtration. The filtration industry is a $30 billion enterprise. Filters are used to remove particles from both gases and liquids. The filtration of particles from gases is relatively well understood. However, the filtration of airborne molecular contaminants (AMC) is an area of current interest to the industry that is not well understood. Also, a better fundamental understanding of the removal of particles from liquids is also needed. A recent article that describes nanoparticle filtration is {Kim, 2007 #20429}. Examples of challenges include:

*Instrumentation.* Methods for measuring airborne molecular contaminants at trace levels, methods to distinguish between molecules, molecular clusters, and nanoparticles in the ~500-5000 amu range; methods for measuring physical size distributions and chemical composition of liquid borne particles.

*Fundamentals.* Interactions of AMC with surfaces; transport processes of liquid borne particles, including double layer effects, etc.

A useful overview reference on the state of the art for particles filtration is under preparation.

Concerns: There may be an incorrect perception in the engineering community that filtration is a mature topic. This is not true as topics such as AMC and Liquid-borne Nanoparticle Filtration have not been investigated and involve many scientific fundamentals to be explored. Some “marketing” strategies may need to be addressed in promoting this field.

Gas Phase Nucleation. Nucleation leads to the formation of contaminant particles in semiconductor processing reactors, useful particles in aerosol synthesis reactors, and atmospheric particles that ultimately affect the earth’s radiation balance. While classical nucleation theory (CNT) was first developed nearly a century ago, this simple theory is not applicable to the types of processes that often occur in systems of interest to engineers. For example, CNT assumes that nucleation involves the condensation of supersaturated vapors. In systems of practical importance, however, nucleation is often a multicomponent process that involves the formation of stable molecular clusters by chemical bonding. The development of engineering models for many types of aerosol systems of practical importance will require an improved understanding of the types of nucleation processes that are responsible for particle production. Progress on this topic will optimally include multidisciplinary teams with expertise in computational chemistry and chemical kinetics, reaction engineering, instrumentation. A mechanical engineer with expertise and interests in a specific application area could lead such an activity. Examples of intellectual frontiers include:

*Instrumentation.* Methods to detect molecular species involved with nucleation, concentrations and composition of molecular clusters formed by nucleation, concentrations and sizes of nanoparticles formed by nucleation, etc. Many fundamental questions remain. The interactions of ions with molecular clusters is composition-dependent, and cannot be predicted by assuming that charging rates are determined by diffusion-limited mass transfer, as it typically done for larger aerosol particles. Nanoparticles are often detected by vapor condensation, but for
nanoparticles the tendency of a vapor to condense will depend both on the vapor and particle composition. Those effects are not understood. Also, while clusters will most likely be measured by mass spectrometry, the relationship between such chemical measurements mass and aerosol measurements, which are based on mobility classification, light scattering, diffusional separation, or vapor condensation, is not understood. This is a tremendously exciting area. An overview reference on the state-of-the-art for measurements pertinent to studying the mechanisms of atmospheric particle nucleation and growth is the article by McMurry et al. {, 2009 #23388}.

**Diverse Application Areas.** There is a need to develop experimentally-verified models for nucleation in application areas that include material synthesis reactors, plasma reactors, semiconductor processing reactors, the atmosphere, etc. A faculty member who is interested in becoming the authority in one of these areas could make significant and lasting contributions to knowledge.

**Modeling.** This is an area that needs new approaches to modeling. The work of Steve Girshick and coworkers (especially Mark Swihart) on the nucleation from silane in semiconductor processing reactors {Girshick, 2000 #9346} is an example of a fruitful new modeling approach. McMurry and coworkers developed the particle beam mass spectrometer {Ziemann, 1995 #4497} to carry out experimental studies of particle formation by nucleation in semiconductor processing reactors. Using this instrument, excellent progress was made in reconciling measurement and models {Nijhawan, 2003 #15038}. This work illustrates the promise for future work in this area.

A concern about hiring a young faculty member to work in this area is that nucleation largely remains a hard and unsolved problem. Recent progress on multiple fronts, however, shows that it is not intractable. The key is to focus on problems of practical importance to aerosol systems.

**Environmental Health and Safety.** The protection of workers and the public from adverse exposure to aerosols is a topic of current interest. A recent issue of particular interest in this area is the potential adverse health effects of nanoparticles {Maynard, 2006 #20267; Oberdorster, 2005 #18784; Oberdörster, 2005 #18384; Donaldson, 2000 #11790}. It should be noted that the field addresses both the adverse and beneficial effects of airborne nanoparticles, i.e., nanotoxicology and nanopharmaceutics. Minnesota has a niche in this broad field. For example, two of the top five cited papers on EHS published in the Journal of Nanoparticle Research in 2007-08 were coauthored by David Pui. The first paper addressed the efficiency of filters in removing airborne nanoparticles (Kim et al., JNR 9:117-125, 2007) The second paper addressed the rationale and principle of a surface area monitoring instrument (Fissan et al., JNR 9:53-59, 2007).

Research frontiers in this area include:

**Instrumentation.** Cost effective instruments that can accurately evaluate human exposures to nanoparticles. The ideal instrument system would monitor the spatial, temporal and chemical composition of nanoparticles as they are
transmitted from source to the human receptor. Also may also be important to develop instruments that can distinguish between compact (spherical) particles and, for example, nanowires, which may be more hazardous due to their shape. There is also a need in developing compact personal monitor to assess worker exposures, e.g., using MEMS technology.

Concerns: The EHS field is very broad, ranging from material science to aquatic biology. We need to identify a niche in Minnesota, such as Aerosol and Instrumentation, to attract potential hires and funds.

**Aerosol MEMS Instrumentation.** Aerosol instruments are typically large and expensive. For example, instruments that measure aerosol size distributions cost tens of thousands of dollars, weigh tens of kg and require about one kW of electrical power. In practice, several such instruments are operated in parallel to obtain the suite of measurements that is needed. There is a need for less costly and smaller instruments that can carry out measurements that are distributed over time and space. Ideally, such instruments would provide information on particle size, concentration and composition, as originally visualized by Friedlander {Friedlander, 1970 #192;Friedlander, 1971 #185}. Opportunities include:

Instrumentation. Very small instruments to characterize particles in the micrometer and nanometer size ranges. Success in this area would require a knowledge of MEMS design, sensors, and principles of aerosol transport and behavior. The availability of such instruments would revolutionize environmental monitoring, and would lead to significant technology transfer.

**Atmospheric Aerosols.** Atmospheric aerosols have been an important research focus for more than a century, and faculty in our department have been world leaders in this area for much of that time. There is a growing community of atmospheric scientists at the University of Minnesota, and collaborative relationships with them would likely evolve. There is an established community of atmospheric scientists, and it would not be difficult to identify and attract outstanding faculty candidates in this area. With their backgrounds in the thermal sciences (fluid mechanics, heat and mass transfer, thermodynamics, etc.) and instrumentation, mechanical engineers have the quantitative skills required to do innovative research that would likely not be done in other departments where such work is done (atmospheric sciences, geophysics, etc.) Recent reviews on atmospheric aerosol measurements are given by {McMurry, 2000 #8370}{McMurry, 2004 #17289}. Research frontiers include:

Instrumentation. Distributed instrumentation, clusters and nanoparticles; less costly instrumentation, etc.

Concerns: There are several reasons to be cautious about hiring a faculty member whose primary interest is atmospheric aerosols. First, this is now a relatively mature discipline, and there are quite a few young people working on it. It is not as much of a “research frontier” as it was several decades ago. Thus, there will be stiff competition for limited resources. Also, many other universities have built atmospheric science programs that include faculty whose skills cover a broad
spectrum, ranging from atmospheric chemistry, to meteorology, to modeling, to aerosols. Therefore, those programs have created communities of faculty who can work together to prepare multi-investigator proposals and carry out large, integrated field programs. It is possible that a faculty member at the University of Minnesota would be at a disadvantage, given the change in this “landscape.”

**Summary Comments**

There are synergies among the topics discussed. All topics are related to airborne particles and instrumentation, which are the strength of the Minnesota group. Further, the topic of Biological Particles can overlap with EHS and Filtration topics. The topic of AMC can overlap with Nucleation, Filtration, and EHS (as allergen). Perhaps these interrelationships will excite new faculty hires once they see both the scientific and application themes in them.
Appendix B.

Prioritizing Opportunities.

At our May 6, 2009, meeting, task force members discussed and prioritized opportunities. The results of our voting are given in the following two tables. Rather than focusing on broad environmental challenges, we narrowed opportunities down to topics that are significant, yet account for issues that we identified in strengths, weaknesses and threats analysis.

We began this meeting by prioritizing opportunities that we’d identified in our earlier meetings. Following a discussion, we made changes to descriptions of opportunities and voted again. The results of those votes are given in the tables below.

### First Vote (low numbers correspond to high priority):

<table>
<thead>
<tr>
<th>Topic</th>
<th>MF</th>
<th>DP</th>
<th>TK</th>
<th>CHL</th>
<th>LB</th>
<th>PS</th>
<th>PHM</th>
<th>Total</th>
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<td>Aerosol MEMS Instrumentation</td>
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<td>4</td>
<td>8</td>
<td>8</td>
<td>7</td>
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<tr>
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<td>6</td>
<td>9</td>
<td>7</td>
<td>7</td>
<td>9</td>
<td>9</td>
<td>4</td>
<td>51</td>
</tr>
<tr>
<td>Biological Particles</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>16</td>
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<td>NP Environmental Health and Safety</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>1</td>
<td>9</td>
<td>34</td>
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<tr>
<td>Filtration G&amp;L</td>
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<td>10</td>
<td>9</td>
<td>10</td>
<td>6</td>
<td>7</td>
<td>52</td>
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<tr>
<td>Geoengineering</td>
<td>7</td>
<td>6</td>
<td>9</td>
<td>10</td>
<td>8</td>
<td>10</td>
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<tr>
<td>IAQ-HVAC</td>
<td>10</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>6</td>
<td>3</td>
<td>2</td>
<td>28</td>
</tr>
<tr>
<td>Global Warming</td>
<td>8</td>
<td>7</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>34</td>
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<tr>
<td>Atmospheric Emissions</td>
<td>9</td>
<td>10</td>
<td>4</td>
<td>6</td>
<td>3</td>
<td>7</td>
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### Second Vote (listed by priority):

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<th>LB</th>
<th>PS</th>
<th>PHM</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological Particles-viruses, bacteria, fungi; maybe pollens</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>12</td>
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<tr>
<td>Filtration G&amp;L (barrier, water, VOC)</td>
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<td>2</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>21</td>
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<tr>
<td>IAQ-HVAC/Chemical Buildings (Chem, bio decon)</td>
<td>8</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>6</td>
<td>2</td>
<td>26</td>
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<tr>
<td>Global warming-C sequestration, etc.</td>
<td>7</td>
<td>5</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>4</td>
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<tr>
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<td>6</td>
<td>5</td>
<td>9</td>
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NOTE: We met with Ben Liu on 5/18/09, and he indicated that he agrees with this prioritization.
Appendix C.

Position Description.

The Department of Mechanical Engineering seeks a faculty member for a tenure track appointment as assistant professor with a research focus on the indoor environment. Appointment at the Associate Professor level will be considered for exceptionally well-qualified individuals. A strong fundamental background in the thermal sciences is required. Possible research topics include aerosol particles of biological origin, instrumentation, filtration, indoor air quality, etc. The successful candidate would be expected to develop a well funded and highly visible research program, and to provide leadership in our undergraduate and graduate education programs in thermal environmental engineering, HVAC systems, instrumentation and measurement, etc.
Appendix G

Task Force Recommendation
Presentation from October 9, 2009
Agenda

• Welcome and Overview (Kortshagen)
• Task Force Reports
  – Human Health (Bischof)
  – Environment (McMurry)
  – Energy and Transportation (Davidson)
  – Graduate Education (Hubel)
  – Undergraduate Education (Chase)
• Questions & Answers
Charge to Task Forces

- Take a strategic view of your respective task force area to identify key issues/big challenges/important trends facing Mechanical Engineering.
- Objectively analyze the dept.’s strengths/weaknesses/opportunities/threats (SWOT) in your respective task force area to ensure that thorough internal and external perspectives guide our strategic analysis.
- Identify key areas of intellectual pursuit in the task force area for the Department of Mechanical Engineering at the University of Minnesota.
- Develop strategic objectives that will advance these key areas of intellectual pursuit in the ME Department.
- Propose actions/initiatives/efforts/projects to most effectively achieve distinguished performance within the key areas of intellectual pursuit.

Overview

Preliminary Timeline

- Feb. 27: Kick-off event
- March 11: Research symposium I
- April 1: Research symposium II
- April 22: ME day (focus on education)
- March-Sept: Task forces meet
- Oct. ‘09: Presentation of Task force recommendations
- Oct.-Nov. ‘09: Comment phase
- Dec. ‘09: Completion of strategic plan

Overview
Human Health


SWOT

• Strengths
  Academic strength of Faculty and Students in this area in Dept. Commitment of University, Community, State in area.

• Weaknesses
  Lack of vision in area
  Lack of visibility in area: no clear web presence
  Less student interest than some other IT departments

• Opportunities
  Local Medical Device Industry
  Lack of academic competition locally
  Evolving areas: Nanobiotechnology where UM has strengths.

• Threats
  Declining funding
  Competition from other departments (faculty / students)
  Uncertainty of importance of biomedicine in MN in future.

Human Health
Areas of Intellectual Pursuit

• **Research**
  Basic Research - Biotransport, Biomechanics
  Applied - ex. BioMEMS, Medical Device Center, Device Development
  Funding (gov’t, industry, endowment, public, private, etc.)

• **Teaching**
  Some courses with bio and health content
  Some labs with bio content or short courses
  More courses and labs possible - also cross listing.

• **Service**
  Mission to train students in this area
  Student visibility (success stories)
  Faculty visibility (explain our impact)
  Industry visibility / relationships

*Human Health*

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**Strategic Objectives**

**General:**
Increase visibility of area by highlighting activity in department (web + glossy brochures)
Craft joint / unified IT wide vision for area with IEM, BME, EE, CEMS, ME etc. Need administrative leadership in ME and beyond on this.

**Research:**
Increase commitment to growth in specific areas resonating with departmental and IT wide strengths and initiatives. A non exhaustive list includes: cellular and molecular biomechanics, combinatorial biological and/or nano or MEMs devices and sensors, and surgical robotics.
Work within general vision (established with higher administration) to build larger initiatives such as ERC in area based on previous successful models (ERCs, MRSEC, iPRIME, SAFL etc.).

*Human Health*
Strategic Objectives

Teaching
Better organize and augment curriculum in this area - use cross listing with BME, EE and other departments if necessary.
Consider conforming curriculum to ASME BED tracks: biomechanics, biofluids, biotransport, cell and tissue, design and rehab
Find positive student role models (from our program) to illustrate careers in each area.

Service
Increase faculty and student participation in main meetings in this area: ASME Summer Bioengineering, Biomedical Engineering Society (BMES), IEEE Engineering in Medicine and Biology Society (EBBS)
Increase department / industry partnerships in this area (see larger vision / leadership to tap into for this)

Human Health

Action Plan for Distinction

1. Build larger vision (ME + IT and beyond) for human health - biomedical engineering on campus (involve all players).
2. Create web visibility in area in department
3. Hire faculty in ME in area (i.e. see earlier emphasis list)
4. Create larger entities in area on campus (i.e. ERC)
5. Build / create new courses / labs as needed in area.
6. Organize and clearly present courses for ME students in ME and other departments (cross list) on subject
7. Post role models (graduates with successful careers in area) to web.
8. Increase activity of faculty and students in ASME BED, BMES and/or EMBC
9. Increase industry / department partnerships in area.
10. Post successes to web

Human Health
For more than a century mechanical engineers have worked to control indoor environments and protect the outdoor environment from manmade pollution. This work is largely based on the training that mechanical engineers receive in fundamental topics such as fluid mechanics, heat and mass transfer, design, CFD, and instrumentation.

For decades our Department has provided international leadership in environmental research. *We should continue to play a leadership role in finding solutions to environmental problems.*
Key Areas of Intellectual Pursuit

- **Aerosol Science (Particle Technology):**
  - Instrumentation
  - Fundamentals: transport & deposition, nucleation, physical/chemical properties
  - Applications to filtration, semiconductor manufacturing, health, atmosphere, pollution control

- **HVAC:**
  - Energy efficiency & fire safety
  - Biological particles & health safety

Strengths & Weaknesses

**Strengths:**
Nationally & internationally recognized programs
Industry ties (short courses, research consortia, technology transfer)
University facilities: architecture, health sciences, Nanotech lab, CHARFAC, MSI, etc
Multidisciplinary approach: thermal sciences, chemistry, aerobiology, health sciences
Successful alumni: International leaders in academia, industry, laboratories
Public engagement: ASHRAE, EPA, MPCA, etc.
Senior faculty who can attract & mentor outstanding young colleagues

**Weaknesses:**
Demographics: Additional young faculty are needed
Narrow outlook: Primary focus is on aerosols
Opportunities & Threats

Opportunities (Listed in ranked order, highest priority first):

• Biological Particles
• Filtration of Gases & Liquids
• Indoor Air Quality & HVAC/Green Buildings
• Nanoparticle Health & Safety
• MEMS Instrumentation for Particles

Threats:

• Competing programs at other Universities: Atmospheric research, Homeland Security
• Intellectual property: Conflicting interests of university & industry collaborators
• Aerosol physics: Emerging into a mature discipline

Proposed Actions/Initiatives/Efforts/Projects

Seek a new faculty colleague with a strong fundamental background in the thermal sciences whose research interests combine indoor environment and particle technology.

– Merges traditional departmental strengths
– Continues our strong education & outreach programs in HVAC & PTL
– Focuses on a traditional ME topic (HVAC)
– Is an intellectual frontier with applications that will grow in importance
  • Energy efficiency (green buildings), homeland security, pandemics, hospital safety
– Addresses a seminal research area:
  • Real-time measurement of bio. particles (e.g., viruses, bacteria, molds, fungi, pollens)
  • Sources, viability, transport, deactivation of biological particles
**Energy and Transportation**

E. Aydil, M. Barnes, R. Campbell, R. Christenson, **J. Davidson**, M. Donath, J. Hallberg, T. Hebrink, H. Martin, T. Simon, Z. Sun, S. Uppal

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### SWOT Analysis

<table>
<thead>
<tr>
<th><strong>Helpful to achieving Objective</strong></th>
<th><strong>Harmful to achieving Objective</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strengths</strong></td>
<td><strong>Weaknesses</strong></td>
</tr>
<tr>
<td>• Diverse faculty interests</td>
<td>• Lack of University/IT/Department initiatives</td>
</tr>
<tr>
<td>• Leading edge research in select areas: CCEFP, ITSI, Thermal Sci., Solar, Engines/Particle emissions</td>
<td>• Lack of curriculum on emerging energy issues</td>
</tr>
<tr>
<td>• IREE/IonE</td>
<td>• Inadequate support for grants management</td>
</tr>
<tr>
<td>• Industrial partnerships</td>
<td></td>
</tr>
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</table>

<table>
<thead>
<tr>
<th><strong>Opportunities</strong></th>
<th><strong>Threats</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Compelling global energy issues</td>
<td>• Other Universities</td>
</tr>
<tr>
<td>• Generational opportunity for expanded funding &amp; collaboration with industry</td>
<td>• Downturn in economy</td>
</tr>
<tr>
<td></td>
<td>• Availability of non federal matching funds</td>
</tr>
</tbody>
</table>

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**Internal Origin**

**External Origin**
Recommendations

• Develop Department-wide centers of excellence in energy and transportation by closer integration of Departmental activities, laboratories and centers in these areas
• Prioritize hiring of faculty in the areas of energy and transportation
• Establish graduate curriculum and continuing education courses in emerging energy topics
• Expand development efforts for endowed professorships and for improved laboratory infrastructure in energy and transportation
• Improve administrative support for securing and managing grants and contracts in energy and transportation

Energy & Transportation

Actions

• Charge an internal working group to develop Department-wide collaborative initiative(s) in energy and transportation
  – 5 year strategic plan to address
    • Leadership
    • Infrastructure
    • Synergies in energy and transportation
    • Seek external input
    • Future hiring priorities

Energy & Transportation
Actions

• Multiple new hires in energy and transportation
  – Consider potential for exceptional scholarship and contributions in areas identified as strengths of the department and/or emerging areas of applied science and engineering.
  – Suggested broad areas propulsion and renewable energy.

Energy & Transportation

Actions

• Curriculum
  – Develop multi-disciplinary graduate curriculum in energy
  – Develop continuing education courses in emerging areas for the broader engineering community.

• Fundraising
  – Endowed professorships
  – Laboratory infrastructure

Energy & Transportation
Graduate Education

E. Egan, J. Heberlein, A. Hubel, F. Kulacki, S. Nyquist, K. Stelson, H. Young Chung

State of the Graduate Program

Master of Science in Mechanical Engineering
Current enrollment: 144

Doctor of Philosophy in Mechanical Engineering
Current enrollment: 122

Graduate Education
State of the program, Cont

• Strengths:
  – Nationally recognized programs (fluid power, nanotechnology, particle technology, medical devices, etc.)
  – Applicants apply to all the major graduate programs

• Weaknesses
  – Declining rankings
  – Small faculty size

• Opportunities
  – Improve communications and outreach
  – Reduce time to graduation

Graduate Education

State of the program, cont.

• Threats
  – Cost of a student
    • $57,000-63,000/year (when paid with external funds)
    • Rate of cost increases has far outstripped inflation
  – No direct support of graduate program from college
  – Declining support for MS program from Central administration
  – 10% departmental budget cut in 2012

Graduate Education
Recommendations

- Prerecruiting
  - Improve website
  - Outreach to faculty from other departments
- Recruiting
  - Continue support for recruiting weekend
- Conduct of the program
  - Rebalance MS/PhD program
  - Encourage timely completion of degrees
  - Communicate importance of graduate programs to local industry

Recommendations, cont

- Preparations for financial retrenchment
- Increase departmental support for PhD students from first semester to first academic year
- Assemble a working committee to address
  - Curriculum (core, course offerings)
  - Degree requirements
Our graduate program strengthens….

Undergraduate Education

### Undergraduate Education

#### SWOT Chart (Excerpts)

**Strengths**
- Locality of many excellent companies
- Positioning in a large, comprehensive university
- Co-op program

**Weaknesses**
- High student-faculty ratio
- Lack of background of high school graduates in mechanical devices
- Outreach & marketing to high school students

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**Opportunities**
- Applications to real-world problems
- Student-driven design projects
- Leverage ABET Continuous Improvement process

**Threats**
- Globalization; i.e., outsourcing of engineering
- Difficulty of staffing and funding student-driven design projects
- Push for 4-year graduation

---

### UG Ed Strategic Objectives

1. **To improve the student experience, thereby growing the attractiveness and reputation of the undergraduate program**  
   *Metrics: Student retention, graduation rate, student-faculty ratio, survey data*

2. **To graduate students who are highly attractive as new hires, thereby placing them in the best jobs on a national scale**  
   *Metrics: Job placement upon graduation, co-op placement, internships, survey data*

3. **To improve the diversity of the student population**  
   *Metrics: % female, ethnicity, disability, age*
Recommendations

- 81 unique concepts generated
- Reduced to 19 final recommendations
- Organized into 3 tiers (5-6-8) based on impact combined with ease of implementation

Undergraduate Education

Five Tier 1 Recommendations

1. Design project every year
2. Extend Senior Design to a two semester course
3. Encourage students to participate in student-driven design projects (e.g. solar car, solar house, Engineers Without Borders, ASME Student Design Contest, …)
4. Utilize alumni or industry presenters in seminars or lectures
5. Establish a “Professional Development Day” to increase interactions between students, advisers and employers (students can talk with faculty, industry reps, grad students, International Programs reps, etc.)

Undergraduate Education
Example: UG Diversity

19. Project “High Visibility”: Every student in every high school science class should know about the “cool” things that go on in the UMN ME Department

Comment: the Task Force feels that this should be implemented at the level of the Institute of Technology because it affects all departments

Undergraduate Education

Questions or Comments?
Appendix H

Department Benchmarking Data
Big 10 Plus ME Departments with 2009 US News and World Report Rankings

- Big 10:
  - Michigan State (40)
  - Northwestern (11)
  - Ohio State (22)
  - Penn State (17)
  - Purdue (8)
  - U. Illinois UC (6)
  - U. Iowa (48)
  - U. Michigan (5)
  - U. Minnesota (15)
  - U. Wisconsin (15)

- Plus:
  - Carnegie Mellon (11)
  - Cornell (9)
  - Georgia Tech (6)
  - MIT (1)
  - Stanford (2)
  - UC Berkeley (3)
  - UT Austin (11)

Faculty FTE: 2008

Source: Big 10+ survey
Faculty FTE Change: 2003-2008

ME Degrees Awarded per Faculty

Source: Big 10+ survey
Research Expenditures per Faculty

Source: Big 10+ survey

Publications per Faculty

Source: ISI Science Citation Index
Research Expenditures per Faculty

Source: ASEE

Degrees Awarded per Faculty

Source: ASEE