SELF STUDY REPORT

FOR

THE UNIVERSITY OF WASHINGTON ACADEMIC PROGRAM REVIEW

OF

THE DEPARTMENT OF MECHANICAL ENGINEERING
COLLEGE OF ENGINEERING
SEATTLE CAMPUS

DEGREES OFFERED

- **BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING**
- **MASTER OF SCIENCE IN MECHANICAL ENGINEERING**
- **MASTER OF SCIENCE IN ENGINEERING**
- **DOCTOR OF PHILOSOPHY**

YEAR OF LAST REVIEW: 2007

PER G. REINHALL
PROFESSOR AND CHAIR
DEPARTMENT OF MECHANICAL ENGINEERING

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PROFESSOR AND ASSOCIATE CHAIR
SELF-STUDY COORDINATOR
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MARCH 28, 2017

EXECUTIVE SUMMARY

The goal of this summary is to highlight the principal points coming out of our self-study. We have organized this introduction into what we feel are our unique strengths, our weaknesses, and the opportunities available to us. These form the basis of our plans for moving the department forward.

Our department is configured as what many would view as a traditional ME program offering BSME, MSME, and PhD degrees. We are made up of a core of 34 tenured/tenure-track faculty members, along with approximately 6 research faculty and two special appointments involving members of the Applied Physics Laboratory.

Strengths. Our research expenditures have grown from ~$7M/yr during the recession to ~$13M/yr in the last year. This corresponds to $382K/yr per tenure line, a productivity similar to the best ME departments in the country. One major factor influencing this is the hiring of around 6 new faculty in the last three years, all of whom have been very productive in generating grant income. A second factor has been a significant growth in research activities in health/ medicine/ medical devises. The UW medical establishment, and the Seattle medical infrastructure in general provide significant opportunities for collaboration that are matched by few places in the country. A third factor is the success of several large research centers, *e.g.,* the National Marine Renewable Energy Center, and the Boeing Advanced Research Center (BARC).

Our undergraduate program continues to be in very high demand. The last 6 years have seen a doubling in requests for seats in our program. Unfortunately, we have only been able to grow capacity a little during this time. We could clearly upsize the undergraduate program without compromising the quality of the admitted students, and in doing so be of substantial additional service to the state.

Our PhD program has also grown, going from ~10 graduates a year in 2006 to around 20 now. The graduates are going on to excellent jobs in industry, with a large fraction going into academia.

The department is financially strong, principally due to the conversion of our MS program to a fee-basis six years ago. MS enrollments have grown substantially, chiefly because many BSME holders view the MSME as a valuable added credential. This growth has been reflected in enhanced revenues from our fee-based program.

The department has consistently ranked at the top of units within the university in generating patents and patent disclosures. The activity has resulted in many startup enterprises that have attracted external funding, with a large fraction having entered the marketplace.

The department has been successful in developing a model for sustainable industry collaboration. The Boeing Advanced Research Center (BARC) provides space on campus as a permanent work station for Boeing engineers who focus primarily on manufacturing robotic assembly and big data problems. They involve both faculty and students in the project work.

Finally, the department has done well in terms of developing a diverse faculty, and this has paid off in improving diversity within both the graduate and undergraduate populations. Enhancing diversity continues to be an important part of all faculty searches, graduate student recruiting, and scholarship/ fellowship donor solicitations. We have recently instituted a Diversity and Outreach Committee that has been active in sending students and staff to meetings and in raising diversity fellowship funds.

Weaknesses. Our physical plant is small relative to the size of our research and educational activities. This is one reason we have research labs spread over nine buildings on and off campus. In addition, our home building opened in 1958, and as such it lacks much of the infrastructure needed to support modern research (*e.g.,* fume hoods). Thus, space and quality of space are challenges.

The size of the department in terms of faculty membership is roughly half that of ME departments at comparable departments in flagship public universities in similar sized states. Impact (and ranking) depends on both quality and quantity. We feel our quality is excellent, but our smaller size reduces our external impact, and this can be reflected in national rankings. It also affects our ability to expand the number of undergraduate seats to meet the demand noted above.

Finally, support staff levels are low relative to the number of faculty, students, and the amount of research expenditures. This can lead to faculty performing tasks that could be done by skilled staff, and also lead to delay in important long-term facility projects.

Opportunities. In the last 10 years only one faculty member retired. Over the next 10 years, we project around 13 retirements, with many of these in the next 5 years. This, coupled with the potential for additional instructional funding to meet undergraduate demand, gives us the opportunity to substantially expand the faculty. This in turn allows us the opportunity to plan strategically for the future. In other words, we have the rare flexibility of remaking our department.

As mentioned above, the department is in relatively good financial shape. Strategically spending resources on staff and infrastructure is both an opportunity and a challenge.

Several campus-wide collaborative initiatives provide us the opportunity to interact with other researchers and share state-of-the-art facilities. Particular examples include the new NanoES Initiative, the MolE Initiative (both have new buildings), and the new Nanofabrication Lab in Fluke Hall. This gives us an advantage in terms of faculty recruiting and competing for research funds.

The large undergraduate demand may allow us to negotiate for resources to increase undergraduate throughput.

All these factors have converged to make this a critical time to strategically plan for the future of the department.

Self-Study Report for the Academic Program Review of the Department of Mechanical Engineering

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Part A
Background Information for the Review Committee

Section 1: Overview of Organization

Mission & Organizational Structure

Our formal mission statement reads:

> *"Our mission is to advance the well-being of society through excellence in teaching, research and service that exploits the rapidly changing technical diversity of mechanical engineering. We achieve this within a collaborative environment that stimulates faculty, staff and students to reach their highest potential through life-long learning."*

An important point underlying our mission statement is a recognition that mechanical engineering is one of the broadest of the engineering disciplines, whose work includes energy, materials, manufacturing, controls/ dynamics/ robotics, and engineering aspects of medicine/ health care. The impact resulting from our research should reflect this broad diversity. More importantly, the people trained by our teaching should possess an excellent skill set, but also a capability to think quantitatively and critically about new challenges. This commitment to new knowledge and to teaching forms the core of our beliefs.

The department offers four degrees:

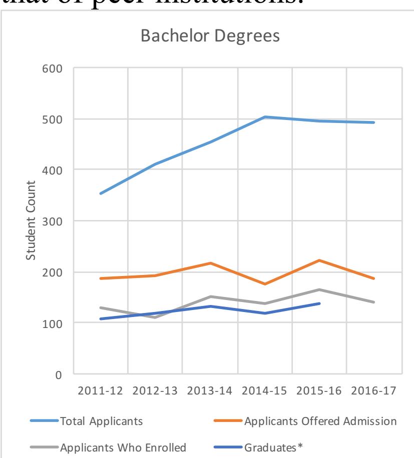
- *Bachelor of Science in Mechanical Engineering*: A four year ABET-accredited undergraduate program. Two formal options exist within this degree program, leading to an annotation on transcripts:
    1. Mechatronics option
    2. Nanoscience and Molecular Engineering option (joint with Bioengineering, Chemical Engineering, Electrical Engineering, and Materials Science and Engineering)

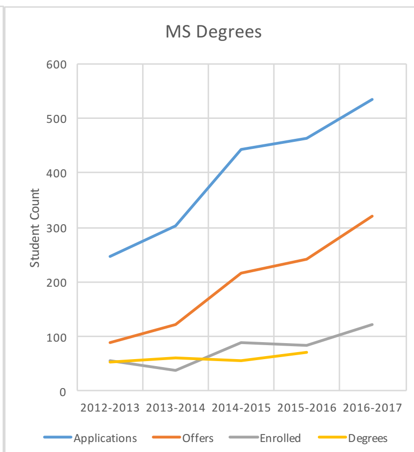
- *Master of Science in Mechanical Engineering*: This degree is offered in both a thesis format, a coursework only format, and an intermediate coursework plus project format. In keeping with the custom within the discipline, this degree is reserved for those who also have the skills associated with the BSME degree.

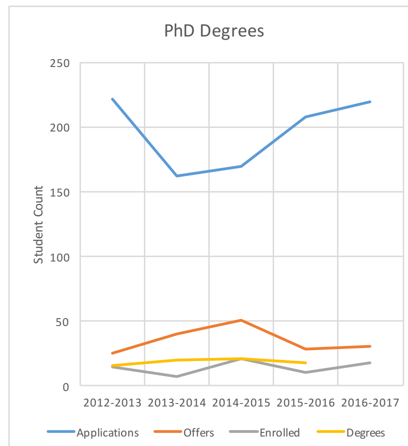
- *Master of Science in Engineering*: This degree is awarded to those who complete the MSME degree requirements, but who do not have the equivalent of a BSME (*e.g.,* a student with an undergraduate degree in physics).

- *Doctor of Philosophy*: The terminal degree focusing on the most advanced coursework and a research apprenticeship.

Enrollment Patterns: Our undergraduate program continues to experience increased demand. The figure below shows the number of applicants to our program, the number of offers we have made, the number of students who actually enrolled, and the BSME degrees granted, all listed by entry year. Our undergraduate program is subject to one of the highest demands of all majors on the Seattle campus, and we are currently turning away a large number of fully qualified applicants. This increasing student demand reflects both the emphasis on STEM that the students receive from high school and college advisors, as well as the recognition that the breadth of mechanical engineering training is a huge asset as a starting point for one's career. We could clearly grow the undergraduate program without compromising the quality of the admitted students, and in doing so be of substantial additional service to the state. Our primary constraints are the size of the faculty and infrastructure limitations. Both of these issues are addressed later in this report. Our current per capita rate of degree production is around 4.25 BSME/tenure line faculty-year, which is slightly above the College of Engineering average and that of peer institutions.







The demand for the MS degree has also increased substantially in the last several years. New BSME graduates are often recognizing that the MS degree provides "value added", and that the MSME and MSE degrees are attractive to employers. Unlike the BSME degree, we have additional capacity within the MS program, so we have been actively encouraging additional enrollment. As will be discussed later, revenue from the growing MS program is an important source of income for the department.

Our PhD program has also grown, going from ~10 graduates a year in 2006 to around 20 now. The graduates are going on to excellent jobs in industry, with a large fraction going into academia. Our PhD production rate of ~0.75 degrees/tenure track faculty-year is near that of our peer institutions.

Staffing and Governance: Our faculty organization chart is provided in Appendix A. The faculty are broadly divided into three technical interest groups (Energy & Fluids, Materials & Manufacturing, Systems & Dynamics). These groups act primarily to coordinate (1) teaching schedules, and (2) graduate recruiting. Research collaborations are increasingly interdisciplinary, and the interest group structure has become of much less importance in organizing our research activities.

We view our tradition of shared governance, collegiality, and respect as one of our major strengths. Due to the large size of our voting faculty (around 40 members, including tenure line and research faculty), a significant amount of our governance work is done in five standing committees (Undergraduate Education, Graduate Education, Faculty Affairs, Research and Resources, Diversity and Outreach). These committees deal with developing initiatives and legislation, and they also deal with rules, regulations, policy, and waivers/appeals. For example, Graduate Education is the place where recommendations regarding changes in graduate degree requirements are initially discussed before eventually being presented to the faculty. It is also the place where individual petitions for waivers in policy are decided. The committees include staff membership as appropriate (*e.g.,* members from the advising office are part of the Graduate Education and Undergraduate Education Committees). Major initiatives that fall outside these areas are handled by special committees, *e.g.*, strategic planning, ABET coordination, faculty search. The faculty meetings are then devoted primarily to communication by the administrators and committee chairs, and to debate on major legislation. Staff members have been important contributors to the faculty meetings, with the exception of rare executive sessions. Faculty meetings are public meetings under the state open meeting law.

The department uses a fairly lean and open administrative structure to provide responsiveness and flexibility for change. The faculty administrators consist of the Chair, Per Reinhall, the Associate Chair for Research and Infrastructure, Nate Sniadecki, and the Associate Chair for Academics, John Kramlich. The overall staff structure is also shown in Appendix A. The Department Administrator, Jen McEwen, reports to the Chair, and is responsible for general staffing issues and specifically supervises the fiscal staff. The Associate Chair for Academics supervises the advising staff, consisting of both the undergraduate and graduate advising offices. The academic staff is supported by faculty committees that deal with admissions, and with scholarship and fellowship awards. The Associate Chair for Research and Infrastructure supervises the facilities, shop personnel, and the assignment of research space.

The department has 34 tenure line faculty, two Applied Physics Lab personnel who have permanent faculty appointments, and 6 research faculty. Comparison with peer institutions (flagship public universities of similar size in states of similar size) suggests that our tenure line faculty count is small, and based on these comparisons it should be closer to 50. This is reflected in our inability to accommodate the BSME degree demand noted above. It is also likely reflected somewhat in our ranking in various polls, where the impact the polls seek to measure will be a function of both quality and quantity. Our plans for addressing this appear later in this report.

Our staffing levels are also low relative to peer departments of the same size, especially in the advising and fiscal areas. We have been addressing this issue with new hires as our financial situation has improved, but it must remain an area of emphasis for us, as discussed later in this report.

The department makes use of three external constituencies in obtaining input:

1. *Industrial Advisory Board*: This is a group of 22 representatives from industry that meet once every six months to primarily advise on new initiatives. The membership is shown in the appendix.

2. *MEGA*: *The Mechanical Engineering Graduate Student Association*: This is a very active group of student leaders who meet monthly with the Chair, again primarily on new initiatives.
3. *ASME/Student Project Groups*. The leadership of ASME and the various student project teams meet periodically with the Chair to provide input primarily into issues affecting undergraduate students.

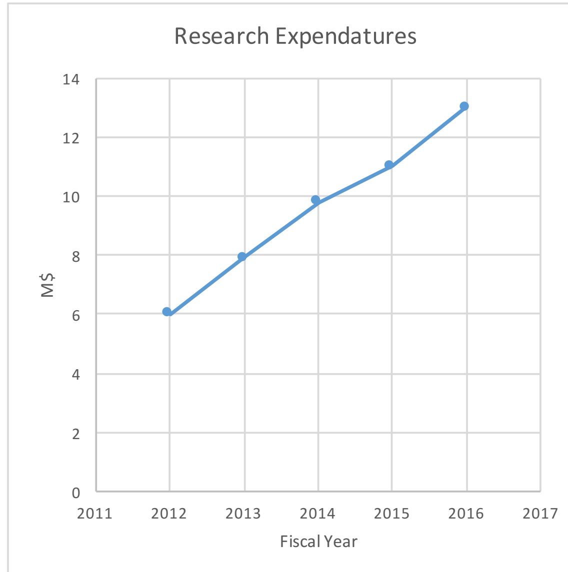
Budget & Resources: The table shown below provides an overview of our department's financial state.

Revenue Source	2011	2012	2013	2014	2015	2016
GOF/LFA	$5,252,414	$6,019,201	$4,833,612	$6,968,650	$5,403,197	$6,880,509
Self Sustaining	$299,969	$799,714	$1,289,148	$1,327,857	$1,469,022	$1,585,632
ICR Return	$440,172	$379,289	$342,671	$357,385	$442,663	$542,003
Total Revenue	$5,992,555	$7,198,204	$6,465,431	$8,653,892	$7,314,882	$9,008,144
Expenses	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Faculty	$3,082,504	$3,357,729	$3,177,160	$3,547,486	$3,537,563	$3,876,254
Staff	$608,402	$583,329	$591,684	$783,857	$870,815	$912,213
Grad Student TA	$291,391	$350,852	$385,667	$448,839	$440,786	$511,767
Retirement & Benefits	$945,415	$1,225,182	$1,163,859	$1,316,462	$1,266,773	$1,413,569
Total Expense	$4,927,712	$5,517,092	$5,318,370	$6,096,644	$6,115,937	$6,713,803
Surplus	$1,064,843	$1,681,112	$1,147,061	$2,557,248	$1,198,945	$2,294,341
Additional Revenue	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Gifts, Fellowships, other	$803,211	$865,589	$1,051,449	$1,243,942	$1,160,143	$1,010,312

The funding for the core of the department is provided by three principal sources:
1. *General Operating Fund (GOF/LFA):* These are funds provided by the university from state appropriations and tuition to fund the general educational mission of the department.
2. *Self-Sustaining*: These funds are revenue from fee-based degree programs that are not supported by the state. These originate from our two MS degrees.
3. *Indirect Cost Recovery Return (ICR Return):* A portion of grant and contract indirect cost is returned to the department to defray the costs of administrating and housing research grants/ contracts.

The principal use of these funds is to provide salary for tenured/ tenure-track faculty, for departmental staff, and for graduate student TAs. Expenses for RAs, the grant portion of tenure-line faculty salaries, and the salaries of research faculty are not shown as expenses above since they are derived from grand and contract revenues. Additional resources include gifts and fellowship income, which are collected and dispersed independently.

Research grant expenditures are shown in the figure at the right. The large recent growth is due to both the high activity of recent hires, the success of the large research centers, and the fact that many of the faculty are positioned in fertile funding areas (*e.g.,* health/ medicine, renewable energy).



Like most units on campus, the GOF was impacted by state budget cuts during the recent recession. In response, we were the first engineering department to convert our two MS degrees from state supported to fee-based status. This conversion started in 2011, and involved self-administering these programs via a service contract with UW Professional and Continuing Education (now UW Continuum). The academics underlying these degrees did not change, only how they are fiscally administered. Although the Memoranda of Understanding underlying this transition is complex, the net result is that approximately 70% of each tuition dollar is returned to the department via two mechanisms: (1) faculty salary recharge that accounts for the portion of time faculty spend instructing these students, and (2) program net income. As indicated in the table above, this income has become an important contributor to the department's finances, allowing us to avoid the worst of the recession budget cuts. More importantly, it provides us with resources to fund initiatives. Our "Unit-Generated Questions" address thoughts on the use of these funds.

Our distance learning MS degree is also included in the fee-based programs. This program is around 30 years old, being one of the first such offerings in the country. It presently represents a relatively small fraction of the total fee-based activity. The program was recently recognized as one of the better values in the country in terms of academic productivity versus cost, so we are considering a national advertising initiative to take advantage of this recognition.

Our present strategies to improve the budget situation include the following:

- The principal opportunity to expand GOF resides in *proviso* agreements with the state, in which we agree to expanded undergraduate enrollment in return for specific increases in core funding. We developed a plan to increase undergraduate funding by targeted increases in core faculty, somewhat increased use of instructors, additional TAs, and the use of evening and weekend labs to overcome facility constraints.
- The MS program continues to have room for expansion with minimal added costs. Most of the current graduate classes have space for additional students. It has been somewhat surprising that the demand for the MS degree has increased in the last few years; in the past demand usually decreased as the employment market grew stronger. The demand of international students for this program has been strong and growing.
- The focus for increasing grant and contract income continues to be hiring faculty that create complements with our existing strengths, with the goal of reaching critical mass for truly national competitiveness in areas where such opportunities exist. Thus, we are

very concerned about where new faculty fit into our existing strengths and how they fit into long-term national funding priorities and opportunities.

- Interaction with industry provides another avenue for funding. The prime example is the Boeing Advanced Research Center (BARC), in which Boeing employees are housed within the ME building. They interact with UW faculty and employ graduate students on project work, at present primarily robotics associated with manufacturing operations (*e.g.,* robots for wing interiors that are too small for workers). Other industrial firms have shown considerable interest in this model, and negotiations are presently under way.

Academic Unit Diversity

As is the case for many engineering disciplines, attracting and retaining a faculty and student body who's ethnic and gender diversity reflects that of the general population remains an ongoing challenge, and this continues to be an important initiative area for the department.

Our present diversity statistics are summarized as follows:

Faculty:
- We have 6 female faculty out of a total count of 40 (5 tenured/tenure track and 1 research)
- We have 4 underrepresented minority (URM) faculty, one African American and three Hispanics.

Undergraduate Students:
- The female student percentage of the total undergraduate student body has increased from 17.8% in 2013-2014 to 24.5% in the present year.
- The URM percentage has increased from 5.4% in 2013 to 10.4% in the present year. This is primarily in African American and Hispanic students.

Graduate Students:
- The female student percentage of the total graduate student body 18.1% in the present year.
- The URM percentage is 3.9% in the present year.

As discussed below, there have been a number of initiatives that have assisted the diversification of our undergraduate student body noted above. We would like to highlight two that we feel have had a significant impact.

STARS: The Washington STate Academic Red Shirt program provides an opportunity for URM / disadvantaged students to take additional time in acquiring the preparation needed to undertake the engineering curriculum. A second, critical contribution of the program is to provide a home and a sense of community for the cohort. Focus groups have repeatedly shown that a major barrier to the success of URM students is the feeling of isolation in their first two years. For many, it is easier to just drop out. We feel this is the single most successful URM initiative every undertaken in UW engineering, and that is responsible for much of the recent increase in URM students within our department.

Increased Technological Diversity: In the last 10-15 years, the mechanical engineering discipline has expanded, and this expansion has opened technical topics that appeal to a broader cross-section of students. One example is the substantial increase of work in health and medicine, and another is the significant work in renewable energy. The broader pallet of technical choices has drawn a broader demographic of students. We feel this has had the most impact on gender diversity. A second, significant driver for gender diversity is the existence of excellent role models on the faculty.

The lessons learned from the success of these initiatives are that we need to (1) emphasize the technical diversity of our work, (2) create a home where all students feel welcome, and (3) provide financial support to ease the passage of students through our program. Our *Diversity Plan,* and our *Diversity/Outreach Committee* exist to make this happen. Our Diversity Plan can be downloaded by clicking the colored text. The principal points are as follows:

- Outreach to K-12. Lab tours and demonstrations that involve the students as participants, not observers.
- Assigning staff and faculty to ensure that URM applicants are tracked, reviewed, and considered for scholarship opportunities.
- The department has been aggressively pursuing fellowship opportunities for female and URM students, and in the last year has received both ARCS and GO-MAP awards to target recruiting on these students.
- The department has supported travel for URM student to attend and present at technical conferences.
- The department has been a leader in the new NSF-supported Access Engineering program, which supports and encourages individuals with disabilities to pursue careers in engineering and trains all engineers in principles of universal design. Prior research has indicated that integrating topics related to universal design into engineering curricula can not only encourage inclusive design, but also increases interest and retention of students from underrepresented groups in engineering.
- Our Diversity/ Outreach Committee was established in 2014, consisting of faculty representatives, academic advising staff, and two students.
- We note that faculty have received Presidential Fellowships to provide teaching release to develop their careers. All URM and female faculty who have gone through the tenure process have been successful. With respect to retention, in the last 25 years, we have not lost any URM faculty and only one female faculty (the latter involved a spousal hire elsewhere that was beyond our control).
- MEGA (the mechanical engineering graduate student association) has established a formal mentorship program to aid all new students, with a special sensitivity towards helping URM and female students through the first year.

SECTION II: TEACHING & LEARNING

Student Learning Goals and Outcomes

Bachelor of Science in Mechanical Engineering

In the Mechanical Engineering Department at the University of Washington we promote quality in our undergraduate curriculum through a culture of continuous evaluation and improvement. Our educational objectives reflect these values, and as such they have been endorsed by our stakeholders, including our external advisory board, our faculty, and our students. The following objectives, outcomes, and assessment statements, and results of assessment measures are summarized from our ABET accreditation documentation; the full self-study report can be accessed by clicking.

Goals/Program Educational Objectives

- Success in the Profession. Success for graduates in industry, research, and academic careers by virtue of skills and attributes learned in the Mechanical Engineering program, including:
    - Using fundamental science and analysis to solve engineering problems,
    - Successfully executing engineering designs
    - Performing effectively in design teams, in the use of management tools, and through effective oral, written and graphical communication.
- Contribution to society. Graduates should be critical thinkers in the tradition of the broad liberal arts education. They succeed in this goal by being able to:
    - Think critically, in the sense of broadly educated individuals (i.e., be informed evaluators/consumers of information),
    - Perform independent, informed analysis on issues inside and outside of technology, and
    - Continue lifelong learning.

Outcomes: Each student receiving a BSME degree from the program will demonstrate:

- Background in mathematics, science and engineering principles
- Ability to apply background knowledge to the formulation and solution of Mechanical Engineering problems
- Ability to design thermal and mechanical components to achieve a desired goal
- Ability to develop, conduct, and analyze experiments or tests that may aid in the design process
- Understanding of the necessary professional abilities of a practicing engineer including ethical conduct, teamwork in the pursuit of a goal and effective communication
- Ability to conduct computer based design and analysis in engineering applications
- Exposure to a general educational program that aids in the understanding of and increase the appreciation of the "non-technical" world
- Realization of the business environment in which engineering is practiced
- Awareness and necessity of continuing education, graduate study and other lifelong learning experiences

Assessment focuses on gathering data from stakeholders (students, employers) as well as self-examination by the faculty.

- Classroom assessment, various methods
- Course evaluation, with each of the outcomes listed mapped onto course offerings. This allows each course to be evaluated in terms of its ability to provide the outcome goals.
- Annual meetings of faculty involved in each course given to compare the courses offered with the specific educational outcomes mapped to that course; shortcomings are noted for correction in the future
- Exit surveys of seniors.
- Surveys of graduates one year and five years out regarding their impression of the educational process, the skills they acquired, and the relevance of skills to their careers
- Capstones projects, evaluated with a project rubric that allows external evaluation of capstone projects relative to the outcomes expected from the projects. This review is performed by an external jury.
- Selected capstone projects, evaluated via a national competition
- Student performance on Fundamentals of Engineering Exam (FE), a national exam that is the first step towards professional registration, affording the department the opportunity to compare UW graduates against those of other institutions on the basis of academic engineering fundamentals.
- Focus groups with students conducted by the Industrial Advisory Board on issues regarding department climate, curriculum, and student services. Suggestions from these groups are prioritized by (1) impact of the suggestion if implemented, and (2) "cost" to implement the suggestion. This is used to guide a prioritization of the suggestions for implementation (e.g., the department is more likely to implement a high impact, low cost change than a low impact, high cost suggestion).
- Industrial Advisory Board review of the curriculum, as well as suggested changes. Many of the department's students start their careers in the kinds of firms these members represent.

Recent changes to the curriculum that have resulted from these evaluation processes include the following:

- *Thermo/Fluids Course Realignment*. Make some of the more advanced topics in thermodynamics optional so students interested in other areas could diversify. Those interested in the advanced topics (exergy, psychometrics, reactions) would get exposure in a senior elective.
- *Establish Engineering Innovation in Medicine Path*. Biotechnology is a strong growth area in mechanical engineering, and our assessments indicate that students need more training here for both employment and to be ready to take advantage of opportunities in graduate school. To address this issue, the faculty instituted a biotechnology concentration. This involved creating some new courses, but also organizing existing courses inside and outside of our department to provide a coherent curriculum for those seeking training in this area. A year-long capstone sequences was developed to allows students to work with clinicians on engineering solutions to medical problems.
- *New Technical Concentrations*. Instructor Course Assessments for the capstone course, and Alumni Student Surveys have for many years reflected the substantial student interest in two of our senior-year concentrations: 1) Mechatronics, and 2) Nanoscience. The

Department formalized recognition of student achievements in these areas by offering two new degree options:
  - Bachelor of Science in Mechanical Engineering with an option in Mechatronics
  - Bachelor of Science in Mechanical Engineering with an option in Nanoscience and Molecular Engineering.
- *New Courses.* These were instituted to meet needs identified in during the assessment process.
  - ME 410: Nanodevice Design and Manufacture
  - ME 411: Biological Frameworks for Engineers
  - ME 461: Mechanics of Thin Films
  - ME 498/599: Boeing Manufacturing Process Course

Much more detail on these assessment processes and their outcomes are contained in our ABET accreditation self-study, which is available on request.

<u>Master of Science in Mechanical Engineering/ Master of Science in Engineering</u>

These two degrees have identical requirements and goals, differing only in that the MSME degree is taken to imply the presence of a technical background consistent with a BSME. Both these degrees are available as (1) thesis option, (2) coursework-only option, and (3) coursework plus project option. The latter focuses on group projects, some of which involve participation in senior capstone projects.

The goals are to acquire advanced technical preparation in fluid mechanics, thermodynamics, heat transfer, mechanics of materials, dynamics of mechanical systems, systems analysis, machine design, manufacturing, and design. The only mandatory curriculum requirements are for two courses in advanced engineering mathematics and a course in numerical methods. Otherwise, the students have broad latitude, within limits to fulfill the 42 quarter credit requirement from a combination of coursework, project work, or thesis credits.

Our principal assessment has been via graduate surveys, which have generally indicated excellent satisfaction with technical preparation, career mentoring provided by faculty, and preparation to work independently. Recent assessments have suggested two areas for improvement: (1) more involvement of the faculty/ department in finding employment, and (2) improved training in technical oral and written communication. In consultation with MEGA, the students have taken it upon themselves to organize a seminar in Winter quarters addressing the oral communication issue.

Both these degrees are also offered in a distance learning format.

<u>Doctor of Philosophy</u>

The PhD program in mechanical engineering was authorized in 1959, with the first degree awarded in 1963. The program has consistently focused on engineering science with the goal of preparing academic professionals, industrial and government researchers, and leaders in the profession. The program presently graduates around 20 students per year.

The principal goals of our PhD program are to:

1. Prepare individuals for careers in academia, for research in corporate and government settings, and for leadership in the profession.
2. Establish a community of faculty and PhD scholars whose goal is the creation and dissemination of new knowledge.

These goals are consistent with those of top research university programs across the country.

The standards we use to measure our achievement of these goals consist of *internal* quality measures that are applied to the students during their degree program, and *external* measures. The internal measures primarily involve the preparation for, and performance on the three degree exams: Qualifying, General, and Defense of Dissertation. The external measures consist of evaluating the success of our graduates in finding appropriate employment positions and their success in these positions.

Instructional Effectiveness

Our broad goal is to improve teaching effectiveness by evaluating the materials and techniques used in presenting a course, as well as a critical overview of the students' response to the teaching. This is coordinated by the department's *Committee for the Collegial Evaluation of Teaching Effectiveness*. The review of instruction is primarily based on the following four items:

1. Our independent review of the instructional materials used.
2. The students' perception of their learning experience. We take this from student evaluations (both written comments and the computer summary).
3. The faculty member's perception of the learning experience, as presented by their self-evaluation.
4. An evaluation of class activities derived from a a faculty member attending one or more class sessions.

Each faculty member is required to perform an Office of Educational Assessment survey of each class they teach. In addition, the policy adopted by the Mechanical Engineering Faculty require a peer evaluation of faculty in the various ranks according to the following schedule:

- Assistant Professor: Each year
- Associate Professor and Professor: Every third year

The goals of this process are (1) to provide the faculty member with collegial feedback on their teaching in a confidential way for their own use, and (2) to provide a peer evaluation of their teaching for use in performance and promotion reviews.

The general approach is to not attempt a direct outcome assessment, but rather to evaluate teaching/learning effectiveness so far as possible based on the methods/materials used, and the perception of the outcome from the point of view of both the teacher and the students.

The evaluation procedure involves the preparation of a detailed review of the materials submitted, an independent evaluation of student teaching ratings over the last several years, and an assessment of the faculty member's self evaluation.

Following the preliminary assessment, the faculty member meets with committee members to discuss the preliminary findings. The goal of this interview is to provide a frank informal environment for the exchange of thoughts between the committee and the faculty member. No record of this discussion is reported. For example, at this meeting the committee could raise observations or issues that it wishes to discuss, and the faculty member could clarify the rationale behind pedagogical approaches or innovations.

Following the interview, the committee prepares a report assessing the faculty member's teaching. The member has the opportunity to review the report and respond to it in writing before it becomes final. This then becomes part of the merit and promotion packages, and can be used by the chair in discussions of performance and improvement with the faculty member (*e.g.,* the required annual conferences). An example of a review is included in the appendix.

Some of the more notable outcomes from this review process include the following:

- Improved exchange of teaching ideas between instructors. Many instructors teach in isolation without having much understanding of approaches used by their colleagues. We have found that application of the findings of the assessment process described above via workshops can lead to change, improvement, and the adoption of best practices.
- One example has been the more extensive use of recorded lectures. While nobody has fully flipped a classroom in our department, some faculty teaching in the larger lecture classes have made extensive use of recorded lectures with enhanced student/ teacher contact in the released time (*i.e.,* flipped lite).
- Another example involves the use of PowerPoint for lectures. While this is popular with some faculty, others find that it often presents material too fast for processing/ understanding. Proper use appears to require careful planning and an ability to go slow and have patience. We have been able to mentor faculty who use this format.

Teaching and Mentoring Outside the Classroom

The department supports many learning activities outside of the classroom. Probably the most noteworthy are the capstone design projects. The department offers several projects, ranging from large, organized projects that run from year to year to small groups working on *ad hoc* projects. The major projects include:

- *SAE Car Project*. Students design and build a small race car that competes with entries from other schools in (1) a national event held on the West Coast each year, and (2) a competition in Germany. The competitive criteria include performance, efficiency (mileage), cost, manufacturability, and recyclability. This is our largest project involving multiple subteams that require both leadership and coordination.
- *EcoCAR III*. The project is funded by the Department of Energy, involving the conversion of a Camaro to an ultra-high mileage hybrid vehicle.

- *Human-Powered Submarine*. This project is similar in scale and execution to the car projects, with the result entering a national competition each year.
- *Mechatronics Project*. This two-course sequence involves the design and construction of mechatronics devices. These vary each year, but generally involve a robotics or controls application.
- *Engineering Innovation in Medicine.* This year-long sequence involves working with clinicians to identify problems to be addressed by projects.
- *Robotics.* Projects resulting from the activities of the student robotics club.
- *Hyperloop.* Participating in the competition sponsored by SpaceX to design components transport in partially-evacuated tubes using air cushions and linear induction motors.
- *Industry-Sponsored Projects*. A variety of local and west-coast industries sponsor capstone projects. These generally involve the design and production of a prototype. Approximately six to twelve projects are sponsored each year. We have recently begun charging $20K per project to provide resources for better projects/ prototypes.

Many faculty participate in a mentoring program that has been established to assist in the advising process. In the mentoring program, each student is given the opportunity to associate with a full-time faculty member. The intent is to give the student an opportunity to discuss career plans, to understand what and why mechanical engineers do what they do, and to provide a supportive personal relationship.

A strength of the program is the amount of exposure to hands-on learning. We are unique in having a large machine shop devoted just to students. This is used both for instruction in manufacturing and for capstone design work. The department employs two full-time instructors who devote their full time to maintaining the shop and instructing/ aiding the students. We are particularly proud of the state-of-the-art equipment in the shop, including computer controlled mills, 3D printers, a modern water-jet cutter, and a large state-of-the-art laser cutter. These have been made available primarily by gifts from our corporate sponsors and the student technology fee program.

Many students also work within research laboratories. Notable examples include the East Africa Cookstove Project, where undergraduates traveled to Kenya to observe prototype testing in the field, and BARC (Boeing Advanced Research Center) where the students help develop prototypes of industrial robotics systems for automatic assembly.

Section III: Scholarly Impact

Broad Impact of Research

Mechanical engineering is arguably the broadest of the engineering disciplines. As such, we house scholarly work in energy, fluid systems/aerodynamics, advanced manufacturing, robotics, prosthetics, and many other technical topics. In the following paragraphs, we will try to capture via examples the technological diversity of the department, our major accomplishments and success stories, and the people who have made this possible. Most importantly, we wish to finish by using this background to indicate where we envision going in the future.

The following is a non-exhaustive list of the major research centers within the department that are characterized by relatively large grants from multiple funding sources. This illustrates the areas we view as special strengths

- **Boeing Advanced Research Center** pairs full-time Boeing engineers whose duty stations are housed within the department with students and professors to develop solutions for Boeing projects in the areas of automation, robotics and aircraft assembly. (Reinhall, Ramulu, Garbini)
- **Clean Cookstove Lab** focuses on the testing, design and development of low-emissions, high-efficiency wood-burning cookstoves for the developing world. This effort is in partnership with a non-profit that operates a cookstove factory in Kenya, and has resulted the development, manufacture, and sale of a clean, practical cookstove. (Posner, Kramlich)
- **Clean Energy Institute** is working to accelerate the adoption of a clean energy future by advancing solar energy and electrical energy storage materials, devices and systems, as well as their integration with the grid. Three members of the ME faculty are involved in this interdepartmental institute (MacKenzie, Li, Cobb)
- **Engineering Innovation in Health** is a year-long program in which students partner with physicians and clinicians to design medical devices aimed toward lowering healthcare costs. Projects have included minimally-invasive single fiber endoscopes lung diagnosis, prosthetics for children with cerebral palsy to develop strength and walking skills during the formative years, and improved prosthetics for hernia patients. (Posner, Steele, Liu, Reinhall)
- **Human Ability and Innovation Lab** aims to empower human mobility through engineering and design by working closely with patients, clinicians and families. (Steele)
- **Human Photonics Lab** advances the frontier of optical technology in the areas of human performance, cancer detection and treatment. (Seibel, Liu)
- **Northwest National Marine Renewable Energy Center** facilitates the commercialization of marine energy technology, informs regulatory and policy decisions and works to close gaps in scientific understanding. (Polagye, Aliseda)
- **Joint Center of Excellence for Advanced Materials in Transport Aircraft Structures (AMTAS)** is an FAA-funded center focusing on the development and application of composite structures and materials to modern aircraft. (Tuttle)
- **Center for Intelligent Materials and Systems (CIMS)** aims to accelerate research and educational for the design of actuator materials, actuators and the bio-inspired design of intelligent materials and systems. (Taya)
- **Solheim Manufacturing Laboratories** addresses advanced problems in additive manufacturing, pushing the envelope on materials and metals that can be used in 3-D printing, as well as problems in advanced composite material machining and damage repair. (Ganter, Storti, Ramulu)

Due to these labs and the work of other investigators, the mechanical engineering research program has seen a strong growth in research expenditures over the last seven years and has now reached $13M/year for the present year. The research expenditure per tenured/tenure track faculty is now approximately $382k/year which is comparable to the highest ranked mechanical engineering departments in the country. As indicated by the list above, a large percentage of the faculty members are working in fertile research areas. This includes both senior faculty who are running large research enterprises, and junior faculty who are being very entrepreneurial.

Some of the major grants received in the last few years provide an overview of the types of research performed by our faculty and the diversity of funding sources.

- NAVY - $2,353,232 - Polagye - tidal energy
- NFL - $1,500,000 – Reinhall, Posner - football helmet
- Gates Foundation - $1,392,644 – Gao – Cryogenic tissue/organ preservation
- Boeing - $1,000,000 – Devasia, Garbini, Reinhall - BARC
- DOE - $900,000 – Posner, Kramlich - Cookstove
- NIH - $839,092 – Seibel - Optical Imaging
- Ricoh - $2,505,951 – Ganter, Storti – 3D printing
- NIH R01 - $1,400,000 – Steele – Neuromuscular Control in Cerebral Palsy
- NSF/NIH - $1,500,000 – Steele – Rehabilitation following Neurologic Injury
- NSF - $600,000 – Fabien – Research Experience for Teachers: Advanced Vehicles
- NIH R01 - $2,500,000 – Seibel – Fluorescence biomarker of in situ cancer detection
- DOD-DTRA - $1,500,000 – Novosselov, Kramlich, Reinhall, Mamishev – Supercritical detoxification of chemical warfare agents
- MURI - $1,200,000 – Aliseda – Liquid droplet control in sprays
- NSF - $2,000,000 – Boechler – Elastic Wave Propagation in Solid State Media
- DOE - $2,100,000 – Polagye – Instrumentation for the Study of Marine Energy Environmental Effects
- NSF – $1,500,000 – Taya – Nanorobotic Design Based on Magnetically-Active Helicies for Cancer Diagnosis and Treatment

We will very briefly summarize some of the major recognitions received by our faculty members

- 10 National Science Foundation Presidential, Young Investigator and Early Career Award recipients. In recent years, virtually every new faculty member has received an early career award.
- 3 National Academy of Engineering members
- 27 professional association fellows
- 3 UW Presidential Entrepreneurial Faculty Fellows
- 21 patents issued from 2015
- Ranked among most innovative UW departments in terms of patent disclosures, patents issued, and startups.
- 2 UW Faculty Innovator of the Year awards

Student Involvement

We routinely involve undergraduates in research, most notably via the NSF REU (Research Experiences for Undergraduates). We do not have a central list of these, although essentially every NSF grant has been involved. Other grants (*e.g.,* NASA, DOE) also provide mechanisms for this. The department has not institutionalized procedures for this. Instead, the individual faculty involved have taken the lead in recruiting students for such research. Almost every lab involves undergraduates.

Virtually every research grant involves graduate students. The number of presentations, publications, and awards are too numerous to list. Approximately 50 graduate students are employed as RAs on research grants at any one time. All graduate students are expected to serve as a TA at some point in their stay here, and we attempt to all any student who wishes to teach a class the opportunity to do so. Many of these opportunities are available in summer school.

Postdoctoral Fellows

We have at any given time around 15 postdoctoral fellows on staff. They work with the faculty and often have a role in mentoring graduate students. A small fraction have occasional teaching roles, depending on the needs of the department.

Program Graduates

A number of PhD graduates are in academia, teaching at the University of Colorado, University of Minnesota, University of Massachusetts, University of Maryland, University of West Virginia, Seattle University, University of Portland, Washington State University, St. Martin's College, Embry-Riddle Aeronautical University, and the Stanford Center for Turbulence Research. Another group works in the national laboratories. Including Sandia, Lawrence Livermore, Los Alamos, and Argonne. Many of our BSME and MSME graduates have gone into industry, with a large number rising to senior management positions (*e.g., Pat Shanahan*: currently Sr. Vice President of Supply Chain & Operations, Boeing; Chair of the Board of Regents for the UW; just recently named Deputy Secretary of Defense; *Sally Jewell:* formerly COE of REI, and then Secretary of the Interior under Obama).

How have Advanced/ Changes in Funding/ New Technology Changed our Scholarship?

This is summarized in Section IV

On-Campus Collaborations

Almost all of the faculty collaborate outside of the department. Some of the principal collaborations involve:

- Medical School, Harborview, Children's Hospital, VA Hospital. Faculty members involved in orthopedics, prosthetics, advanced diagnostics, cardiology (both fluid flow and heart dynamics), and injury prevention have extensive collaborations with medical personnel. One of our advantages is the proximity to world-class medical resources.
- Clean Energy Institute
- Institute for Molecular Engineering
- The AMTAS Center is joint between ME and Aeronautics and Astronautics
- 3D printing, joint between ME, Aeronautics and Astronautics, and Computer Science and Engineering
- NSF Neurobiology between ME, Electrical Engineering, and Bioengineering

- NanoES, between ME, Bioengineering, and Chemical Engineering
- BARC, between ME, Aeronautics and Astronautics, and Computer Science and Engineering
- National Marine Renewable Energy Center, between ME, the Applied Physics Laboratory, Civil and Environmental Engineering, and Oceanography.

Mentoring of Junior Faculty

Each new faculty member selects three senior faculty members as advocates whose roles are (1) to act as primary mentors, and (2) to represent the faculty member during merit review and promotion decisions. The advocates often act as internal reviewers for proposals generated by the junior faculty member, although this task is often shared by others. The advocates help advise the new faculty member on expectations and approaches for career development. Some of the issues that are typically considered include:

- Review of the results of teaching evaluations: Suggesting changes in approach.
- Advice on the balance between conference papers and journal publication.
- Encourage volunteering for proposal panel reviews to learn approaches for writing winning proposals.
- Advice on appropriate internal and external service expectations.
- Advice concerning networking on campus, and the availability of institutional support at college and university levels.
- Junior faculty members are encouraged to perform seminar tours to gain visibility for themselves and their work
- In addition, the Chair makes use of the annual conference as outlined in the code.

Each junior faculty member meets twice a year with the chair. The Promotion Advisory Committee represents an additional formal channel for providing feedback to junior faculty, for helping them prepare their paperwork for promotion, and for making promotion recommendations to the department.

SECTION IV: FUTURE DIRECTIONS

The content of this section largely covers the same material as Part B, so we will present a summary here.

An overall goal is to increase the recognition and impact of the department, something that is often quantified by rankings. Our general strategy is to focus on areas where we are strong, and where we have existing advantages. Appropriate hires can synergize with existing faculty, resulting in a leveraged benefit that substantially exceeds the resources required for the hire.

Our resource allocation strategy focuses on reaching critical mass to enable impact and success in specific areas where we have an advantage. These advantages (which we term "unfair advantages") include the existence of skills within the faculty, the existence of collaborative groups within and outside the department, connections with industry that provides collaborative opportunities of mutual benefit, and the existence of relationships with funding agencies. The opportunities raised by these unfair advantages are an important factor in resource allocation and faculty hiring. This does not mean we abandon any of the important sub-disciplines within mechanical engineering since these are critical to providing complete instruction. We have, however, recognized that the path to impact and recognition lies in ensuring that the areas capable of achieving critical mass and moving to the next level require priority for resources.

The research topics listed below then represent our areas of strength/ critical mass that define our unique contributions and point the direction for future growth.

Automation (e.g., BARC)
Unfair Advantage: Proximity to Boeing
Subareas: Robotics, Controls, Advanced Materials, Automation, Health & Safety, Machine Learning, Big Data, Nonlinear Dynamics, Applied Mathematics

Health Innovation
Unfair Advantage: Proximity to the UW School of Medicine, World class infrastructure in Seattle
Subareas: Biodesign, Imaging, Biomechanics, Robotics, Prosthetics, Manufacturing, Sensing, Nanotechnology, Microfluidics,

Manufacturing
Unfair Advantage: Boeing, Aerospace industry
Subareas: Additive Manufacturing, Advanced Materials, Digital Manufacturing, Nanotechnology, Computing, Big data, Machine Learning

Energy (Alternative and Clean)
Unfair Advantage: Clean Energy Institute, NanoES, Northwest National Marine Renewable Energy Center
Subareas: Nanotechnology, Additive Manufacturing, Structures, Fluids, Ocean Engineering, Environment, Electrochemistry, Structures, Acoustics, Machine Learning, Transport Phenomena, Heat Transfer, Materials

Advanced Vehicles (PARC)
Unfair Advantage: Proximity to PACCAR
Subareas: Advanced Vehicles, Diagnostics/Prognostics, Reacting Flows, CFD, Robotics, Sensors, Actuators, Computing, Nanotechnology

A second area where we see growth is in increasing undergraduate enrollment. The demonstrated demand for seats in our program must be carried to Olympia and used to justify *proviso* funding. We previously developed a plan for accommodating increased undergraduate growth via a combination of tenure track positions, lecturer positions (or Professors of Practice), increased numbers of TAs, and use of lab space in the evenings and Saturdays. Thus, we are in an excellent position to negotiate directly for increased enrollment versus cost.

We plan to continue expanded our MS program and expand the audience for our distance learning MS cohort. Both initiatives will increase program revenue at little increase in cost.

Department of Mechanical Engineering
Part B – Unit Defined Questions

Summary of the Department

Summarizing from Part A, the main points guiding our path forward are:

- Strong demand for our undergraduate major. We could easily accommodate twice as many students as at present without significantly decreasing the academic quality of the students we graduate.
- Departmental funding is strong, primarily due to our own conversion of the MS degrees to a self-supporting basis
- Extramural research funding is strong, primarily due to (1) several active research centers that are highly productive, and (2) very productive junior faculty who are working in fertile funding areas.
- Strong research productivity, as defined both by scholarly output and by commercialization of research results.
- Our student and faculty diversity have improved, especially with respect to gender for faculty and students, and underrepresented minorities for the undergraduates. Success here creates role models, which leads to future success, so we must continue with those strategies that have demonstrated success (*e.g.,* the STARS program).
- Our physical plant is subpar, both based on raw size and on suitability for modern research, *e.g.,* fume hoods.
- A relatively large number of faculty retirements are anticipated over the next 10 years, which provide an opportunity to change the technical, ethnic, and gender makeup of the faculty.

Unit Defined Questions

Question 1: How to grow the faculty? This involves strategic decisions on hires/year, hiring towards strengths, hiring to bring research groups to critical mass, and hiring to ensure all the principal disciplines within ME are represented. In other words, a critical point is whether to hire towards existing strengths or hire toward technical diversity.

Our hiring plan addresses two main objectives:

1) We want to serve our constituency better by (1) enlarging the accessibility of our educational programs and (2) increasing the reach and impact of our research enterprise.
2) We want to increase our national prominence, with the goal of becoming one of the top Mechanical Engineering Departments in the country.

To accomplish these two objectives, we must expand the size of the department.

Whenever possible we would like to do cluster hires with other departments. For example the department has been working with the Aeronautics and Astronautics department in the area of additive manufacturing and advanced composite materials. It would therefore make sense to coordinate the hiring in this area with the Aeronautics and Astronautics department to reach a critical mass for this research group that spans both departments. Similarly, we would like to coordinate cluster hiring in the area of health with the Bioengineering and Electrical Engineering Departments, and machine learning and controls with Computer Science and Engineering. Every search should be done in coordination with another engineering department. Joint hires will, however, only be pursued when it clearly makes sense for recruitment and retention purposes

A goal that meets both teaching and research requirements is to grow the department to approximately 50 tenure line faculty. The hires will be at the assistant professor level, with some hires at the early associate professor level if the opportunity to bring aboard a superstar arises. We will make an extraordinary effort to diversify the faculty by actively recruiting women and URM during every search. To help in this effort we now have a very active Diversity & Outreach committee that has been charged with the task of recruiting and retaining women and URMs.

We estimate that 13 faculty members will retire within ten years. The estimated retirement time table is:

- In 1 - 3 years: 8 faculty
- In 3 – 5 years: 4 faculty
- In 5 -10 years: 1 faculty

We therefore need to hire three faculty members per year over the next five years just to obtain a slight increase from 33 faculty to 36. The hiring of three faculty members per year will not result in a significant increase in the size of the department until the projected retirement wave is over five years from now.

To increase the size of the department, of course, requires additional office space, lab space and resources. This is addressed under Question 3 below.

The resources for hiring would come from retirements, masters program income and an increase in GOF associated with *proviso* funds. The real challenge is in funding startup packages. The department will soon generate $2M/year in income from our masters program so part of the startup packages will come from savings from this program. In the case of cluster and joint hires, we will work with the Provost Office and industry to raise the necessary funds.

Our short term hiring plan focuses on specific hires over the next three years. This will be done by pursuing cluster hires with other departments to the highest extent possible. Specifically, we propose to recruit faculty in the following areas (cluster and joint hires with outer departments are indicated within parenthesis):

- This year: Manufacturing, Health, Computing
- 2017 - 18: Fluids (AA, BioE), Robotics (AA, CSE), Machine learning (eScience, EE), Materials (MSE, CEI)
- 2018 - 19: Robotics (CSE, EE), Fluids (BioE, AA), Health (BioE), Materials (MSE)

- 2019 – 20: Health (BioE), Dynamics, Manufacturing (AA, MSE, CEI)

The resources would mainly come from retirements and an increase in GOF.

In conclusion, we feel a number of important factors have converged make this the time to significantly expand the department. The huge demand for seats in both our undergraduate and graduate programs requires that we increase our capacity to deliver education. Our research focus areas have shown large growth in funding and productivity in recent years. This is largely due to the excellence of our new hires, leadership from senior faculty, and also the fact that our research areas are well positioned relative to the priorities of funding agencies. Carefully considered growth can lead to achieving critical mass for excellence and impact in each of these areas. Finally, program impact and recognition go hand-in-hand with the size of the department. This, by itself, is not a sufficient reason to grow the department. Instead, we strongly feel that the best justification for growth is that new hires will leverage our existing strengths. The benefit of increased size then comes as a bonus.

Question 2: How to best spend our available resources? There is always a competition between items such as new faculty startups, funding new research initiatives, infrastructure improvements, and staffing. What is the best strategic balance for our particular situation?

We view the prioritization of our use of resources has having four principal parts:

1. *Funding of the expansion of the faculty.* In general, the funding of salaries for new faculty hires is not the greatest challenge. Faculty hires are expected to be funded from retirements (where the higher salary of the retirees can be turned into a larger number of faculty lines), proviso funds from the state to increase enrollment, and funds from the MS program. Flexibility for opportunity hires outside of the normal cycle is provided by mortgaging against future retirements.

   A greater challenge is funding startup packages, which recently have ranged from $600K to $1.2M for experimentalists (considerably less for modelers). This generally needs to be provided out of MS program funds.

2. *Funding for expansion of the staff.* Since 2011, the department has grown substantially in terms of faculty (33→40 tenure line plus research), students (491→680) and research expenditures ($7M/yr → $13M/yr). Until 2015 there was essentially no increase in staff. Benchmarking studies both by us, and by Aeronautics and Astronautics (as part of their staffing planning) indicate that we have roughly half the staff of other departments of similar size in terms of students, faculty, and research activity. This leads to (1) faculty taking on jobs usually performed by staff, (2) overworked staff, and (3) missed opportunities to be proactive. Examples of the latter include developing a modern, professional website, something we did in the last year via the part-time hire of a communication specialist and a web specialist.

3. *Upgrading of research space.* To date, we have generally solved problems on an *ad hoc* basis. This has worked because we have a collegial culture in the department, which

promotes shared solutions to space issues. As examples, Phil Malte gave up his space in Room G4 to a new faculty (Nick Boechler) as the space was an excellent fit for Nick's planned work. Malte was then accommodated in shared space within the Energy/Combustion Lab. In another case, Joe Garbini released a third of his lab space to junior faculty as his large research project reduced in scope. As a final example, BARC moved into underutilized space that was refurbished with funds from the MS program. Other examples include Reinhall giving space to Fuller, Kramlich giving space to Novosselov, and Sniadecki giving space to Liu and Boechler. *The key point is that the collegial environment that exists here catalyzes these kind of exchanges, and is an important asset is not captured by a spreadsheet.* In general, the move has been towards sharing space among multiple investigators, and this has had the highest priority for receiving departmental funds for improvements.

4. *Student project support.* The various capstone projects have become an important part of both the undergraduate and MS programs. Employers are very enthusiastic about the hires they take from these projects. The projects do require substantial lab space and financial support. Most of the projects are very entrepreneurial about raising funds, and some have government grant support (*e.g.,* EcoCAR II). Nonetheless, providing appropriate space is a resource prioritization issue.

Our general prioritization is to focus resources where they will provide the largest external impact. This emphasizes new faculty and startup packages, especially those that generate new shared capabilities and infrastructure improvements. We will cautiously add staff to fill the greatest needs first. In the last year, we added two academic advisors, which while it does not relieve the entire shortage, it does provide a workable environment. Our new administrator, Jen McEwen, is realigning the staff, and as a result of her needs evaluation has hired (1) a payroll person, (2) a grants coordinator, and (3) two lab personnel.

Question 3: How to proceed with building space? Issues here include opportunities for a new main building, renovation of the current building, and joining other units for shared space. This interfaces with the aspirations of donors that we are working with.

To a considerable degree, the space issue is driven by external factors that are beyond our direct control (*e.g.,* donors). Thus, we need to focus on defining the various options and how we will respond to the evolution of opportunities.

As mentioned above, the principal challenge for our department is (1) a lack of raw square footage, and (2) lack of modern lab space. The current approach is to make use of space on and off campus, with the result that our operations are spread over nine locations at present. The potential solutions range from refurbishing the Mechanical Engineering Building to creating brand new space. These options include:

- Refurbishing the Mechanical Engineering Building: This would include moving classroom services out of the 2nd floor and converting this to lab space. The fact that this is the top floor would ease the cost of adding modern fume handling equipment. The building was originally built to handle the addition of a 3rd floor over the 2nd floor, so this could be added. At the same time, Industrial and Systems Engineering could be moved out of the G floor. Finally, the architect hired by the College of Engineering indicated that covering the alleyway between the building and the annex could create a very interesting high-bay space for student projects at a relatively low cost. The building would need to be retrofitted with a modern HVAC system. Beyond funding, challenges include the reluctance of classroom services to vacate the 2nd floor given the classroom shortage on campus, and finding improved space for Industrial and Systems Engineering.

- Construct a new building for educational purposes (classrooms, capstone design projects, space for corporate projects similar to BARC). We would then refurbish the Mechanical Engineering Building for research. This option depends on donor participation, with additional funding from bonds secured by income from the MS program.
- Adopt an approach similar to the previous point, but build a joint structure with other engineering departments (*e.g.,* Civil and Environmental Engineering, Materials Science and Engineering).

This is an ongoing effort whose timetable depends on the availability of resources (e.g., donors and other funding opportunities). Our approach is to have our options developed to the point that we can respond to opportunities as they ripen.

Department of Mechanical Engineering
Part C – Appendices

Appendix A: Organization Chart

The following two pages show (1) the faculty organization chart, and (2) the staff/ faculty organization chart.

Department of Mechanical Engineering

FACULTY ORGANIZATION – AY 2016-2017

Associate Chair for Research and Infrastructure
Nate Sniadecki

Chair
Per G. Reinhall

Associate Chair for Academics
John C. Kramlich

Department Council
Per Reinhall, *Chair*
A. Aliseda
J. Wang
I-Y Shen

Promotion Advisory Committee
J. Garbini
M. Ramulu
J. Kramlich
J. Riley (Ex Officio)

INTEREST GROUPS

ENERGY & FLUIDS
A. Aliseda, *Coord.* (17)
G. Canton
A.F. Emery
D. Gao
J.C. Kramlich
D. MacKenzie
P.C. Malte
A. Mescher
I.V. Novosselov
B.L. Polagye
J. D. Posner
J. J. Riley

MECH. OF MATERIALS & MFG.
J. Wang, *Coord.* (17)
A. Banerjee
N. Boechler
R.P. Ching
J. Chung
C. Cobb
S. Kim
V. Kumar
J. Li
R. Mamidala
N.J. Sniadecki
M. Taya
M. E. Tuttle

SYSTEMS, DYNAMICS & DESIGN
I-Y Shen, *Coord.* (16)
M.R. Bailey
M. Berg
S. Brunton
J.S. Cooper
P.H. Dahl
S. Devasia
B.C. Fabien
S. Fuller
M.A. Ganter
J.L. Garbini
J. T. C. Liu
P.G. Reinhall
E.J. Seibel
K. Steele
D.W. Storti
W.C. Wang

STANDING COMMITTEES

R & R
M. Tuttle (17), Chair
J. T. C. Liu (17)
B. Polagye (18)
N. Sniadecki (Ex Officio)
Jen McEwen (Ex Officio)

FACULTY AFFAIRS
J. Riley (18), Chair
M. Taya (17)
S.Shen (19)

UG EDUCATION
A. Aliseda (17), Chair
J. Cooper (17)
N. Boechler (18)
J. Kramlich, (Ex Officio)
L. Girardeau, (Ex Officio)

GRAD EDUCATION
J. Chung (17), Chair
D. Gao (17)
M. Berg (17)
V. Kumar (Ex Officio)
W. Kisalang (Ex Officio)

Diversity/Outreach
N. Sniadecki (19), Chair
K. Steele (17)
K. Gayle (16)
B. Polagye (18))

Dept. of Mechanical Engineering AY 2016-2017

Promotion Advisory Committee (PAC): J. Kramlich, R. Mamidala, J. Garbini
CoE Council: I. Shen(2016-2019)
CoE Council on Educational Policy: M. Ganter (2015-2018)
CoE Council on Promotion & Tenure: M. Taya (2014-2017)

- **Chair** — P. Reinhall
  - Advancement (Dean's Office) — S. Brennan
  - Asst. to the Chair — Tricia Beigh
  - **Assoc. Chair for Academics** — J. Kramlich
    - Undergraduate Program
      - UG Admissions Committee — Reinhall (Chair), Polagye, Garbini, Chung, Girardeau
      - UG Scholarship Committee — Reinhall (Chair), Ganter, Cooper, Chung, Girardeau
      - Undergraduate Advisor — L. Girardeau, K. Burdette
    - Graduate Program Coord. — V. Kumar
      - Graduate Advisor — W. Kisalang
        - Program Manager — K. Gayle
  - **Faculty Standing Committees**
    - Graduate Education — J. Chung, Chair
    - Faculty Affairs — J. Riley, Chair
    - Research & Resources — M. Tuttle, Chair
    - Undergraduate Ed. — A. Aliseda, Chair
  - **Department Council** — A. Aliseda, J. Wang, I. Shen
    - Energy & Fluids Group — A. Aliseda, Coord..
    - Mechanics of Materials & Manufacturing Group — J. Wang, Coord.
    - Systems, Dynamics & Design Group — I. Shen, Coord.
  - **Assoc. Chair for Research and Infrastructure** — N. Sniadecki
    - Computer Support — N. Paradis
    - ILF/Instructional Shops — E. McQuaide, R. Rocamora
    - Lab Engineering — W. Kuykendall
    - Lab Engineering — M. Hickner
  - **Administrator** — J. McEwen
    - Grants Manager — H. Llamado
    - Fiscal Specialist — Vacant
    - Fiscal Specialist — N. Moses
    - Fiscal Specialist — H. Valdez
    - Work Study

Updated March 2017

Appendix B: Budget Summary

The budget summary was provided in the table on Page 4 of the text.

Appendix C
Information about Faculty

The following two pages provide a roster of the faculty. Clicking on any of the names will retrieve the CV for that individual.

Name	Rank	Appointment Type	Affiliations
Cooper, Joyce	Professor	Tenured	Adjunct, Civil & Environmental
Dahl, Peter	Professor	APL-WOT	Principal, Applied Physics Lab
Devasia, Santosh	Professor	Tenured	
Emery, Ashley	Professor	Tenured	Adjunct, Architecture and ISE
Fabien, Brian	Professor	Tenured	
Ganter, Mark	Professor	Tenured	
Gao, Dayong	Professor	Tenured	
Garbini, Joseph	Professor	Tenured	
Kramlich, John	Professor	Tenured	
Kumar, Vipin	Professor	Tenured	
Li, Jiangyu	Professor	Tenured	
Malte, Philip	Professor	Tenured	
Mamidala, Ramulu	Professor	Tenured	Adjunct, MSE and ISE
Reinhall, Per	Professor	Tenured	
Riley, James	Professor	Tenured	Adjunct, Applied Math and A&A
Seibel, Eric	Professor	Research	
Shen, Steve	Professor	Tenured	
Storti, Duane	Professor	Tenured	Adjunct, Applied Math
Taya, Minoru	Professor	Tenured	Adjunct, MSE, EE, Oral Dentistry
Tuttle, Mark	Professor	Tenured	Adjunct, ISE
Aliseda, Alberto	Associate Professor	Tenured	
Berg, Martin	Associate Professor	Tenured	
Ching, Randy	Associate Professor	Research	
Chung, Jaeyun	Associate Professor	Tenured	
Cobb, Corrie	Associate Professor	Tenure-Track	
Liu, Jonathan	Associate Professor	Tenured	
Mescher, Ann	Associate Professor	Tenured	
Polagye, Brian	Associate Professor	Tenured	Affiliate Investigator, APL
Posner, Jonathan	Associate Professor	Tenured	Joint, ChE; Adjunct, Family Medicine
Sniadecki, Nate	Associate Professor	Tenured	Adjunct, Bioengineering
Wang, Junlan	Associate Professor	Tenured	
Wang, Weichih	Associate Professor	Research	
Bailey, Michael	Assistant Professor	APL-WOT	Principal, Applied Physics Lab

Banerjee, Ashis	Assistant Professor	Tenure-Track	Joint, ISE
Boechler, Nick	Assistant Professor	Tenure-Track	
Brunton, Steve	Assistant Professor	Tenure-Track	Adjunct, Applied Math
Canton,Gador	Assistant Professor	Research	
Fuller,Sawyer	Assistant Professor	Tenure-Track	
Novosselov, Igor	Assistant Professor	Research	
Steele, Katherine	Assistant Professor	Tenure-Track	Adjunct, HDCE

Appendix D: Membership in the Industrial Advisory Board

- **David Barr**, Director, Boeing Programs, Hexcel
- **Jon Bishay**, Bardy Diagnostics
- **Anders Brown**, ’92 BS, ’94 MS, President, Radius, Inc.
- **Steve Chisholm**, ’86 BS, The Boeing Company
- **Stanley Gent**, President and CEO, Seattle Steam Company
- **Carl Hergart**, Director of Advanced Powertrain, PACCAR
- **Peter W. Janicki**, ’89 MS, President and CEO, Janicki Industries, Inc.
- **Michael C. Kintner-Meyer**, ’94 PhD, Energy-Environment Directorate, Pacific Northwest National Laboratory
- **Paul Leonard**, Principal, Leonard Consulting, LLC
- **Tom Loutzenheiser**, ’83 BS, Executive Vice President of Business Development, PRECO Electronics
- **Jill McCallum**, President, Pacific Rim Aerospace Corporation • **Hamid Mortazavi**, ’82 MS, ’89 PhD, Research Specialist, SEMS Corporate Research Lab
- **Ron Prosser**, ’70 BS, Chairman and CEO, Green Charge Networks
- **James M. Reichman**, PACCAR, Inc. (retired)
- **Donald Sandoval**, ’91 MS, ’95 PhD, Senior Research Physicist, Los Alamos National Laboratory
- **Robert K. Schneider**, ’71 BS, ’73 MS, ’76 MBA, President, D. Hittle & Associates, Inc.
- **K. Michael Sekins**, ’81 PhD, Director of Applications, Innovations Department, Ultrasound Division Siemens Medical Solutions USA, Inc.
- **Fred Silverstein**, ’72 MD, UW Clinical Professor of Medicine, Gastroenterology, and General Partner, Frazier & Co. (retired)
- **John T. Slattery**, Vice Dean for Research and Graduate Education, UW School of Medicine
- **Tim Stearns**, ’90 BA, Senior Energy Policy Specialist, State Energy Office, Washington State Dept. of Commerce
- **Al Stephan**, ’82 BS, CEO, Stratos Biosystems LLC
- **Tina Toburen**, ’92 BS, ’94 MS, T2E3 – Energy Efficiency Enterprises
- **Gil Wootten**, ’89 BS, Accenture

Appendix E: Links to Resources

ABET Self-Study highlighting undergraduate studies, assessment techniques, and assessment results.

UW Mechanical Engineering Diversity Plan