



Institution: **Oregon State University**

College/School: **College of Engineering/  
School of Mechanical, Industrial, and Manufacturing  
Engineering**

Department: **NA**

Program: **Master of Science (MS),  
Master of Engineering (MEng), and  
Doctor of Philosophy (PhD) in  
Robotics**

OSU CPS Tracking # 87438

<https://secure.oregonstate.edu/ap/cps/proposals/view/87438>

## 1. Program Description

a. *Proposed Classification of Instructional Programs (CIP) number: 14.4201*

**CIP #: 14.4201**

**Title:** Mechatronics, Robotics and Automation Engineering

**Definition:** A program that prepares individuals to apply mathematical and scientific principles to the design, development and operational evaluation of computer controlled electro-mechanical systems and products with embedded electronics, sensors, and actuators; and which includes, but is not limited to, automata, robots and automation systems. Includes instruction in mechanical engineering, electronic and electrical engineering, computer and software engineering, and control engineering.

*Source:* US Department of Education, National Center for Educational Statistics, CIP 2010 ed.

- b. *Brief overview (1-2 paragraphs) of the proposed program, including its disciplinary foundations and connections; program objectives; programmatic focus; degree, certificate, minor, and concentrations offered.*

The field of robotics has grown tremendously in the last decade as new research has demonstrated its relevance and impact to fields as diverse as manufacturing, planetary exploration, medicine, healthcare, military, and consumer products. We have reached a turning point where this technology is moving from the purview of a handful of specialists (Mars rovers) to the general public (robotic car, household robots, elderly care, and unmanned search and rescue).



This picture shows six magazine covers from the last year alone, dedicated to robots. What's remarkable here is not that there are so many covers for robotics but that only one of them is dedicated to a traditional robotics concept (robots for space exploration). The other covers show the intent of robots to penetrate every day life, from music to the workplace, while also introducing new societal issues such as dialogs with robots, and the social implication of humans interacting with robots.

A graduate program in Robotics is needed to complement the existing MEng, MS, PhD programs in Mechanical Engineering, and Electrical Engineering and Computer Science. Currently, students interested in Robotics must choose one of these disciplines and take courses from the other disciplines to complete their degree program. Though this approach has been acceptable up to now, it does not capture

the truly multi-disciplinary nature of robotics.

The proposed degrees will provide an integrated program that will embrace the multi-disciplinary nature of robotics. The program will be directed towards advanced studies related to robotics and include core areas of concentration from each of the disciplines: actuation, locomotion, manipulation, dynamics, control (Mechanical Engineering); sensors, vision, motors (Electrical Engineering); artificial intelligence, human robot interactions (Computer Science).

The academic home of the new degrees will be the School of Mechanical, Industrial and Manufacturing Engineering (MIME) at Oregon State University (OSU). Other programs on campus will be able to offer graduate minors in Robotics.

### **PhD, MS, MENG in Robotics (CIP # 14.4201)**

- CPS #: **87438**
- Degree Types:
  - Master of Science (MS)**
  - Master of Engineering (MEng)**
  - Doctor of Philosophy (PhD)**
- Program Type: **Graduate**
- Academic Home: **School of Mechanical, Industrial, Manufacturing Engineering**
- Areas of Concentration:
  - **Legged locomotion**
  - **Mobile Robots**
  - **Multi-robot coordination**
  - **Autonomous Robots**
  - **Manipulation**
  - **Assistive Robots**
  - **Human Robot Interaction**
- Graduate Minor: **Robotics**
- Course Designator: **ROB, ME, CS, ECE**
- Credit hours: MS/MEng = **45** (minimum); PhD = **108** (minimum)
- Delivery Mode and Location: **On-Campus/OSU-Main**
- Admission Requirements: **BS; 3.0 GPA; GRE; Transcripts; Letters of Recommendation (3); Personal Statement**
- Enrollment Limitations: **None**
- Accreditation: **None**
- Proposed Effective Date: **Fall Term 2014**

- c. *Course of study – proposed curriculum, including course numbers, titles, and credit hours.*

Students enrolled in the PhD degree will complete a total of 108 graduate credits, including at least 45 credits of graduate, non-blanket numbered coursework and at least 36 credits of dissertation. Students enrolled in the MS degree will complete a total of 45 graduate credits. The MS thesis option will require at least 30 credits of graduate level coursework and 12 thesis credits. The remaining credits can come from coursework or seminar credits. The MS project option will require 39 hours of coursework and 6 project credits. Students enrolled in the MEng degree will complete a total of 45 graduate credits.

Unless otherwise specified, students will conform to the rules and regulations (e.g., qualifying exam timing, structure) of the academic home (MIME).

Courses listed below in **bold** will use the new ROB designator. Others will be cross-listed as appropriate.

The coursework for all degrees in Robotics (including minors) will consist of at least 15 credits of core courses, selected from the following list:

***ENGR 521: Applied Robotics (4)***

*ME 531: Linear Multivariable Control Systems I (4)*

*ME 532: Linear Multivariable Control Systems II (4)*

*ME 533: Nonlinear Dynamic Analysis (4)*

***ME 536: Actuator Dynamics (4)***

*ME 537: Learning-Based Control (4)*

***ME 538: Autonomous Agents and Multi-agent Systems (4)***

*Cat II proposal in planning/progress (Have been/will be offered as ME 539: Selected Topics)*

***ME 551: Biomechanisms (4)*** (Taught as ME 539 in Winter 2013)

***ME 554: Geometric Mechanics (4)*** (Taught as ME 539 in Spring 2013)

***ME 557: Programming Mobile Robots (4)*** (Taught as ME 539 in Fall 2012)

***ME 558: Intelligent Mobile Robotics (4)*** (Taught as ME 539 in Winter 2014)

*CS 515: Algorithms and Data Structures (4)*

*CS 531: Artificial Intelligence (4)*

*CS 532: Advanced Artificial Intelligence (4)*

*CS 533: Intelligent Agents and Decision Making (4)*

*CS 534: Machine Learning (4)*

*CS 536: Probabilistic Graphical Models (4)*

*CS 556: Computer Vision (4)*

*ECE 550: Linear Systems (4)*

For a PhD, MS or MEng in Robotics, the remaining course credits can come from either courses in this list or other courses relevant to the program of study as approved by the students' thesis committee. The completion of 15 credits from this list will satisfy the minor requirements in Robotics.

*d. Manner in which the program will be delivered, including program location (if offered outside of the main campus), course scheduling, and the use of technology (for both on-campus and off-campus delivery).*

The program will be delivered on-campus through classroom and laboratory formats. There are no plans for off-campus delivery at present.

*e. Ways in which the program will seek to assure quality, access, and diversity.*

The program will continue to recruit students nationally and internationally. Currently, about 60-70 students apply to the Mechanical Engineering program with the intent to specialize in Robotics. About half the applications are from international students and currently only a small fraction is from women.

Underrepresented students will be encouraged to apply for admission in all recruiting materials and all efforts are made to provide financial aid to all qualified underrepresented students. In particular, we intend to emphasize the applications of robotics to health care (prosthetics, exoskeletons, rehab, elderly assistance) as well as humanitarian engineering (disaster recovery, minesweeping), which are topics that have been shown to have broader appeal to underrepresented groups.

The program will be reviewed by the Graduate School five years after initial approval, and every 10 years thereafter, in a manner consistent with the Guidelines for the Review of Graduate Programs published by the OSU Graduate Council.

*f. Anticipated fall term headcount and FTE enrollment over each of the next five years.*

The number of graduate students in the Mechanical Engineering Program who specialize in Robotics is 20-30, with about half of them being in the PhD program. Both sets of numbers will rise as recent faculty hires (four robotics hires in the last two years, doubling the size of the MIME robotics group) establish and grow their research labs.

*g. Expected degrees/certificates produced over the next five years.*

MS program: 5-8 per year

MEng program: 1-3 per year

PhD program: 2-3 per year

Over the first five years, we expect to graduate at least 10 PhD students and 30 MS/MEng students.

*h. Characteristics of students to be served (resident/nonresident/international; traditional/nontraditional; full-time/part-time; etc.)*

The students to be served are primarily expected to be full-time, traditional students. The program has traditionally had a small number of part-time students who are working in the Corvallis area. We expect that the student population will be about 50% US and 50% international.

*i. Adequacy and quality of faculty delivering the program.*

The Mechanical Engineering program presently has eight faculty directly engaged in research in robotics. These eight faculty teach all the ENGR/ME graduate courses listed in 1.c. All faculty have active research programs and advise graduate students in robotics. In addition, there are at least eight faculty in the School of Electrical Engineering and Computer Science who teach the CS and ECE courses listed in 1.c, and also have active research programs relevant to robotics.

Five of the faculty listed below (1.j) accounted for about \$4 Million in expenditures in 2012, making them one of the most active groups within the College of Engineering. In addition, the faculty hold (or have recently held) critical positions in international conferences and editorial boards of international journals. The combined expertise of the sixteen faculty members (listed below) will allow the delivery of a unique and high quality robotics program.

*j. Faculty resources – full-time, part-time, adjunct.*

The faculty members currently in the School of Mechanical, Industrial and Manufacturing Engineering with an emphasis in robotics are:

**Ravi Balasubramanian**, Assistant Professor, MIME. PhD from Carnegie Mellon University. Robotic manipulation, robotic hands.

**Belinda Batten**, Professor, MIME. PhD from Clemson. Optimal Control, Unmanned aerial vehicles, marine energy.

**Cindy Grimm**, Research Associate Professor, MIME. PhD from Brown University. Computer graphics, human-computer interactions.

**Ross Hatton**, Assistant Professor, MIME. PhD from Carnegie Mellon University. Geometric mechanics, locomotion, snake robots.

**Geoff Hollinger**, Assistant Professor, MIME. PhD from Carnegie Mellon University. Field robotics, marine robotics, and motion planning.

**Jonathan Hurst**, Assistant Professor, MIME. PhD from Carnegie Mellon University. Legged robots, passive dynamics

**Bill Smart**, Associate Professor, MIME. PhD from Brown University. Software architectures for robotics, mobile robots, human robot interactions.

**Kagan Tumer**, Professor, MIME. PhD from The University of Texas. Autonomous robots, multi-robot coordination, multiagent learning.

In addition, the following faculty in the School of Electrical Engineering and Computer Science teach courses or are active in research in topics directly related to Robotics:

**Glencora Borradaile**, Assistant Professor, EECS. PhD from Brown University. Algorithms, computational geometry, planar graph algorithms

**Tom Dietterich**, Professor, EECS. PhD from Stanford University. Machine learning, intelligent systems.

**Alan Fern**, Associate Professor, EECS. PhD from Purdue University. Artificial intelligence, automated planning/control

**Xiaoli Fern**, Associate Professor, EECS. PhD from Purdue University. Machine learning, data mining.

**Raviv Raich**, Associate Professor, EECS. PhD from Georgia Institute of Technology. Adaptive sensing/sampling, manifold learning.

**Prasad Tadepalli**, Professor, EECS. PhD from Rutgers University. Artificial intelligence, machine learning, automated planning.

**Sinisa Todorovic**, Assistant Professor, EECS. PhD from University of Florida. Computer vision, object recognition, video object segmentation.

**Weng-Keen Wong**, Associate Professor, EECS. PhD from Carnegie Mellon University. Machine learning, anomaly detection, human-in-the-loop learning.

*k. Other staff.*

Support staff (at least 0.5 FTE), funded by the School of MIME and/or the College of Engineering, will provide administrative support. Also, the program will partner with the School of Mechanical, Industrial and Manufacturing Engineering administration to accomplish necessary organizational functions such as curriculum delivery, recruitment and admission.

*l. Facilities, library, and other resources.*

Computer, teaching and research laboratories and faculty offices are presently located in Rogers, Covell, Graf, and Dearborn Halls as well as the Kelley Engineering Center. Computer services are provided through the College of Engineering and include access to graduate-level software packages for analysis and design. Graduate students are provided offices in Rogers, Covell, and Graf Halls as well as Kelley Engineering Center.

Library evaluation revealed that the current support was “marginally adequate” to support this program. Subscriptions to the journals listed in the library study will enhance the program. The additions of the “*International Journal of Robotics Research*” and “*Robotics and Autonomous Systems*” will be particularly useful.

*m. Anticipated start date.*

Fall Term 2014, or as soon as approval of this proposal.

## **2. Relationship to Mission and Goals**

*a. Manner in which the proposed program supports the institution’s mission and goals for access; student learning; research, and/or scholarly work; and service.*

The Robotics degrees will support OSU’s mission and goals through education, research and service by providing graduates with expertise in the design, control, programming and operation of robots. These degrees will provide access for national and international students as well as OSU’s Mechanical Engineering, Manufacturing Engineering, Industrial Engineering, Electrical and Computer Engineering, and Computer Science students.

Robotics is a truly multi-disciplinary field that directly supports OSU’s commitment to a wide variety of fields that is impossible to capture within the confines of a traditional degree. Here is a list of disciplines that are relevant to robotics (grouped by the primary “home” of the relevant topics in the current degree structure):

- Traditional Core Robotics Fields:
  - Mechanical Engineering (actuators, locomotion, exoskeletons,

- prosthetics)
  - Electrical Engineering (Sensors, vision, motors)
  - Computer Science (artificial intelligence, human robot interactions)
- Fields that Directly Support or Benefit from Robotics:
  - Alternative Energy (robotic diagnostic/maintenance for wave energy buoys)
  - Biomedical Engineering (artificial muscles)
  - Medical Care Delivery (robotic surgery)
  - Healthcare (long term care for the elderly)
  - Oceanography (underwater communication, robots for sensing, repair)
  - Civil Engineering (traffic studies and impact of robotic cars on roadways)
  - Biology (mammal/insect/bird studies for locomotion)
  - Anthropology (use robots to animate/estimate locomotion of extinct species)
  - Exercise Science (gait studies for walking robots)
  - Nuclear Engineering (robots for maintenance, safety in harsh environments)
  - Game Theory (incentives for robots)

Currently, we address most of the topics in the first bullet by having students interested in Robotics pursue ME, ECE or CS degrees. This approach works to a point, but does not allow OSU to showcase the unique strengths of Robotics (the multi-disciplinary nature of the field) and does not provide an internationally visible platform to attract and retain the best students in the field. In addition, it does not allow the flexibility to naturally include topics in the second bullet in the students' programs of study, nor does it provide a path forward to address the challenges of the future. The creation of the Robotics degree will allow OSU to address the current needs and implications of the growing intersection of robotics and everyday life, while also positioning the University in a way to allow us to frame future questions within this program.

In addition, OSU is the current home of ROS (Robot Operating System). ROS serves the worldwide robotics community by supporting the development of new software for robotics and has over 100,000 users. The proposed graduate degrees are a new step in increasing OSU's commitment to robotics, and cementing OSU's impact and visibility in this growing field.

*b. Connection of the proposed program to the institution's strategic priorities and signature areas of focus.*

The proposed Robotics degrees contribute to all three signature areas of distinction

in OSU's strategic plan: Advancing the Science of Sustainable Earth Ecosystems; Improving Human Health and Wellness; and Promoting Economic Growth and Social Progress. Broadly, the Robotics program will impact all three areas through new devices and new ways in which those devices and humans will interact:

- Robotics supports sustainable ecosystems by providing key technologies in different renewable energy devices. The contributions include advanced wave energy converters, and autonomous robots for maintenance of marine or wind energy devices. In addition, robotic monitoring devices for oceans and forests provide invaluable information about the health of our natural resources.
- Robotics supports human health and wellness through advances in robotic surgery, prosthetics, rehab technologies and exoskeleton research that are critical in improving the mobility of patients with disabilities. In addition, robots for assisting the elderly and disabled are becoming both more capable and more accepted, bringing the possibility of affordable in-house care for all who need it closer every day.
- Robotics supports economic growth by both opening new markets (new robots for exploration, education, hazardous environments) and by supporting established markets by improving the manufacturing processes (through automation and robotic manipulation of hazardous processes).

*c. Manner in which the proposed program contributes to Oregon University System goals for access; quality learning; knowledge creation and innovation; and economic and cultural support of Oregon and its communities.*

OSU and OUS strategic goals overlap in general and the addition of the Robotics graduate degrees will support both. A strong Robotics program that serves the manufacturing, healthcare and high tech industries industry in Oregon will provide significant economic benefits. (More supporting detail is provided in Section 4)

*d. Manner in which the program meets broad statewide needs and enhances the state's capacity to respond effectively to social, economic, and environmental challenges and opportunities.*

Robotics is a growing field, and the proliferation of robots into our everyday lives (from iRobot Roomba vacuum cleaner robot to robot lawn mowers to manufacturing robots to robotic cars to robotic assistants) is likely to be one of the key transformations of the 21<sup>st</sup> century. This technology will impact the economic and social structure of our society, and training our students in Robotics is key to ensure that Oregon reaps the benefits of this transformation.

Having graduates with advanced degrees in Robotics will ensure that Oregon trains and retains a workforce ideally suited to these challenges and will provide leadership, expertise and innovation to keep Oregon at the forefront of these advances.

### 3. Accreditation

- a. *Accrediting body or professional society that has established standards in the area in which the program lies, if applicable.*

There are no plans to accredit the graduate degrees in Robotics.

- b. *Ability of the program to meet professional accreditation standards. If the program does not or cannot meet those standards, the proposal should identify the area(s) in which it is deficient and indicate steps needed to qualify the program for accreditation and date by which it would be expected to be fully accredited.*

Not applicable.

- c. *If the proposed program is a graduate program in which the institution offers an undergraduate program, proposal should identify whether or not the undergraduate program is accredited and, if not, what would be required to qualify it for accreditation.*

Not applicable.

- d. *If accreditation is a goal, the proposal should identify the steps being taken to achieve accreditation. If the program is not seeking accreditation, the proposal should indicate why it is not.*

The Robotics program will need to satisfy standards applicable to all graduate programs at OSU, including undergoing a periodic review.

### 4. Need

- a. *Evidence of market demand.*

Robotics is growing field and there is an explosion of applications in manufacturing, medical, service and military applications. Many technology leaders (including Bill Gates) have likened the current growth of robotics to the growth of the internet in the 80s. Here are specific numbers taken from “A Roadmap for Robotics – 2013” a document that highlights the need for and growth of robotics in the US and the world (available at:

<http://robotics-vo.us/sites/default/files/2013%20Robotics%20Roadmap-rs.pdf> ),

for several key areas of robotics:

- **Manufacturing:** The sale of robotics for manufacturing grew by 44% in 2011. This is a remarkable figure considering that manufacturing accounts for 14% of US GDP, 11% of employment and a staggering 70% of exports.
- **Medical Robots:** The number of medical procedures performed by robots grew by 40% *annually* over the last few years. A study shows that use of robots can reduce complications in surgery by 80%.
- **Service Applications:** The annual growth in service robots is 30% (more than 6 million autonomous vacuum cleaners and 200,000 lawn movers have been sold worldwide).

In addition to these growth numbers, fields such as healthcare (over 11 million people with severe disabilities in the US who require personal assistants), space exploration (Spirit, Opportunity and Curiosity as well as earlier robots going back to Viking program in the 1970s) and defense (today, more than 50% of pilots entering the Air Force become operators of remotely piloted systems) are primed to become even larger markets for robotics.

Furthermore, there are multiple national programs to promote robotics. The National Science Foundation (NSF) started the *National Robotics Initiative* in 2012, one of the largest new initiatives in research. The Defense Advanced Research Projects Agency (DARPA) has continued to invest in robotics, including the autonomous Grand Challenge in 2006 to the current DARPA Robotics Challenge. The President's Advanced manufacturing Partnership also specifically calls for robots in manufacturing:

[http://www.whitehouse.gov/sites/default/files/microsites/ostp/amp\\_final\\_report\\_annex\\_1\\_technology\\_development\\_july\\_update.pdf](http://www.whitehouse.gov/sites/default/files/microsites/ostp/amp_final_report_annex_1_technology_development_july_update.pdf)

Finally, in addition to the economic drivers, there are significant pressures to educate and prepare researchers in this field. Only a handful of schools offer specific PhD programs in Robotics (Carnegie Mellon and Georgia Tech). As such, last year there were over 442 applicants to the CMU robotics program, of whom, 40 were admitted). Offering this degree will not only serve a great need in the United States, but also allow our graduates to be leaders and innovators in this field. (Our recent graduates in Mechanical Engineering with a robotics focus, for example, have gotten jobs at NASA and Meka Robotics, a leading robotics company.)

- b. *If the program's location is shared with another similar OUS program, proposal should provide externally validated evidence of need (e.g., surveys, focus groups, documented requests, occupational/employment statistics and forecasts).*

Not applicable.

*c. Manner in which the program would serve the need for improved educational attainment in the region and state.*

There is great demand for Robotics in both Oregon and the Pacific Northwest. This need is growing with the recognition of robotics as either a key final product, or a key competitive advantage in many industries. Our graduates are well poised to fill positions in startup companies, large established companies, and governmental agencies. These Oregon companies include DW Fritz (hired recent graduate), Concept Systems, ESCO (has employees pursuing MS at OSU), Intel (hired recent graduate), and Korvis Automation (hired recent graduate).

*d. Manner in which the program would address the civic and cultural demands of citizenship.*

Graduate students with advanced degrees in Robotics will be well positioned to make decisions related to technology and shape our state and national policy in the coming decades. Because Robotics is a multidisciplinary topic, the students in the program will have different backgrounds (mechanical engineering, electrical engineering, physics, computer science, mathematics, ethics) and learn both to generate innovative solutions and to integrate diverse views before making decisions. In addition, some of the policies and decisions that impact our workforce (role of automation, job creation) will require leaders with a full grasp of the technical subtleties and the implications of those technologies. Graduates in Robotics will be important contributors to such debates as society grapples with such complex social issues.

## **5. Outcomes and Quality Assessment**

*a. Expected learning outcomes of the program.*

The learning outcomes of this program are the university graduate learning outcomes

For the PhD program, they are:

- 1- Produce and defend an original significant contribution to knowledge
- 2- Demonstrate mastery of subject material
- 3- Conduct scholarly or professional activities in an ethical manner.

For the Master's program, they are:

- 1- Conduct research or produce some other form of creative work
- 2- Demonstrate mastery of subject material
- 3- Conduct scholarly or professional activities in an ethical manner.

*b. Methods by which the learning outcomes will be assessed and used to improve curriculum and instruction.*

The graduate Doctoral and Master's program assessment plans, as well as the annual reporting (assessment and reflection on graduate Learning outcomes (GLOs) is presented in Appendix A.

The format and procedure for the PhD qualifying exam in Robotics is presented in Appendix B.

In addition, a Graduate Program Review (GPR) every 10 years will enable the program to reflect on and evaluate programmatic successes and failures, and potential improvements. Program reviews will identify strengths, weaknesses, aspirations, opportunities and need. The process includes the following main steps:

1. Prepare a **self-study**
2. Host a **review committee site visit**
3. Receive a **review committee report**
4. Respond to the review committee report and develop an **action plan** if the major is to be maintained, restructured or expanded; and implement an action plan
5. Perform a **third year assessment** in the 10 year cycle of the program on progress towards the action plan

The GPR self-study components and review include assessing and summarizing the following:

1. Inputs—the total resources (e.g. students; courses and curriculum; human and financial capital; infrastructure) supporting the program
2. Productivity—the level of program performance(e.g. degree completion, grant support, publications, scholarly outputs, creative activity, awards)
3. Outcomes and impacts—the quality of the outcomes (e.g. alumni employment or successes, degree of outreach and community engagement)

The action plan addresses each of the Review Panel's recommendations to improve program quality.

*c. Program performance indicators, including prospects for success of program graduates (employment or graduate school) and consideration of licensure, if appropriate.*

- Number of applicants, offers and acceptance rates
- Academic qualifications of applicants and accepted students
- Graduation rates

- Employment upon graduation
- Student satisfaction from exit interviews
- Survey information from employers

*d. Nature and level of research and/or scholarly work expected of program faculty; indicators of success in those areas.*

All faculty members who identify with the Robotics graduate program are active in research including funded projects. For the twelve of the sixteen faculty listed in Section 1 who have been at Oregon State University for more than two years, the present research funding is about \$5 million per year. We anticipate that number to exceed \$6 million per year as the new faculty continue building their research programs. The scholarly publication rate for these faculty combined is about 30 refereed journal articles per year. Performance parameters continually collected by the College of Engineering include:

- Scholarly publications
- Participation in professional meetings, conferences and workshops
- External funding for research
- Number and magnitude of proposals written
- Number of PhD/MS students supervised
- Participation in professional societies, committees, boards, and commissions

These indicators are evaluated each year in the faculty member's annual review.

## **6. Program Integration and Collaboration**

*a. Closely related programs in other OUS universities and Oregon private institutions.*

No program in Oregon overlaps with the proposed Robotics graduate degree program. The proposed interdisciplinary robotics program is unique.

*b. Ways in which the program complements other similar programs in other Oregon institutions and other related programs at this institution. Proposal should identify the potential for collaboration.*

There are engineering degrees at Portland State University, as well as Computer Science degrees at Portland State University and the University of Oregon that provide some of the topics in a Robotics program. They can be considered complementary. For example, the Intelligent Robotics Laboratory

(Prof. Marek Perkowski) in the Electrical and Computer Engineering Department at Portland State University would be a potential collaborator in this endeavor. In addition, this program would be complementary with research at the Oregon Health and Science University, particularly in Robotics in medicine. Finally, the proposed Robotics program will provide opportunities to undergraduates (for example at the Oregon Institute of Technology) who aim to pursue a graduate degree in Robotics in Oregon.

*c. If applicable, proposal should state why this program may not be collaborating with existing similar programs.*

Not applicable.

*d. Potential impacts on other programs in the areas of budget, enrollment, faculty workload, and facilities use.*

No impact on existing programs is expected.

## **7. Financial Sustainability** (attach the completed *Budget Outline*)

The budget outline and justification documents prepared by the College of Engineering business office are attached.

*a. Plans for the program that anticipates and provides for its long-term financial viability, addressing anticipated sources of funds, the ability to recruit and retain faculty, and plans for assuring adequate library support over the long term.*

The support of these graduate degrees is part of the College of Engineering's present budget and future strategic plan. No changes to present plans for financial viability, funding, and recruitment of faculty or library support are expected.

*b. Plans for development and maintenance of unique resources (buildings, laboratories, technology) necessary to offer a quality program in this field.*

The research programs associated with the proposed Robotics degree are currently located in Graf, Covell and Rogers Halls and are funded by MIME and the on-going research program, as well as located in the Kelley Engineering Center and funded by ongoing research in EECS. There are plans for the renovation of Graf Hall to host all robotics activity (research, education, student clubs), that would significantly enhance our current capabilities. These plans are enthusiastically supported by the leadership in the school of MIME and the COE, and fundraising efforts are ongoing. The

University Planning committee has provided support for the program and the redevelopment plan (see Liaison letter from Jean Duffett).

c. *Targeted student/faculty ratio (student FTE divided by faculty FTE).*

The target ratio is to have approximately 5 graduate students per faculty, leading to a total graduate enrollment of about 40 students.

d. *Resources to be devoted to student recruitment.*

Present resources for student recruitment include the costs of promoting the program including creating and distributing marketing material (~\$2,000), creating and maintaining an up-to-date webpage (~\$2,000), and organizing a recruiting event in Feb/Mar each year (~\$3,000). This will result in \$7,000 of recurring cost, as well as \$500 of start-up costs to cover “branding” material (posters, cards etc.).

- 8. External Review** (if the proposed program is a graduate level program, follow the guidelines provided in *External Review of new Graduate Level Academic Programs* in addition to completing all of the above information)

The proposed external reviewers for this program include:

**Howie Choset**

Professor, Robotics Institute  
Carnegie Mellon University  
choset@ri.cmu.edu

<http://www.cs.cmu.edu/~choset/>

**Gaurav S. Sukhatme**

Professor and Chairman  
Department of Computer  
Science  
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**Robert D. Howe**

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## Appendix A: Outcomes and Quality Assessment

Graduate Doctoral Program Assessment Plan			
<b>Process</b>			
How does your unit reflect on the assessment data gathered and who is involved? How do the results of your assessment efforts relate to strategic planning and overall program review?			
The data will be collected by the graduate advisor. The results of the assessment will be used to determine course offerings (content and frequency) in future years.			
What data are archived? Where, how and for what duration?			
Student theses (10 years) Student preliminary examination records (10 years) Student qualifying examination records (10 years) Student program of studies (10 years) Student yearly assessment by advisor and robotics faculty (5 years)			
Program Outcomes, Measures and Benchmarks or Milestones			
List the university and program level student learning outcomes (GLO).	Produce and defend an original significant contribution to knowledge	Demonstrate mastery of subject material	Conduct scholarly or professional activities in an ethical manner
What year will you report on this outcome? (Every university GLO must be assessed annually and others at least once every five years.)	yearly	yearly	yearly
List the measures/methods /instruments to be used to assess the outcome. Identify measures, methods, and/or instruments as being direct (D) or indirect (I). (At least one of these must be direct measures.)	36 credits of thesis credits (D)	42 credits of coursework (D)	Online Ethics workshop (D)
What benchmarks/milestones will you use to determine if the outcome has been satisfactorily met by the students? <sup>z</sup>	Preliminary Exam Dissertation defense Presentation to seminar	Cumulative GPA above 3.0 Presentation to seminar	Dissertation defense
<sup>z</sup> Examples include courses, workshops, program of study, internship/externship, research proposal, presentations of research or project results, project or thesis defense, final report or thesis. This is not an exhaustive list of possibilities.			
<sup>y</sup> Programs especially with options will likely have specific learning outcomes (competencies, goals, etc.). State those and how they are being assessed.			

## Graduate Master's Program Assessment Plan

### Process

How does your unit reflect on the assessment data gathered and who is involved? How do the results of your assessment efforts relate to strategic planning and overall program review?

The data will be collected by the graduate advisor. The results of the assessment will be used to determine course offerings (content and frequency) in future years.

What data are archived? Where, how and for what duration?

Student program of studies (10 years)

Student theses (10 years)

Student yearly assessment by advisor and robotics faculty (5 years)

### Program Outcomes, Measures and Benchmarks or Milestones

List the university and program level student learning outcomes (GLO).	Conduct research or produce some other form of creative work	Demonstrate mastery of subject material	Conduct scholarly or professional activities in an ethical manner
What year will you report on this outcome? (Every university GLO must be assessed annually and others at least once every five years.)	yearly	yearly	yearly
List the measures/methods /instruments to be used to assess the outcome. Identify measures, methods, and/or instruments as being direct (D) or indirect (I). (At least one of these must be direct measures.)	MS: 12 credits of thesis credits (D) or 6 credits of project credits (D) MENG: one course with creative project (eligible class list available)	30 credits of coursework (D)	Online Ethics workshop (D)
What benchmarks/milestones will you use to determine if the outcome has been satisfactorily met by the students? <sup>z</sup>	Master's Defense Presentation to seminar	Cumulative GPA above 3.0 Presentation to seminar	Thesis defense

<sup>z</sup>Examples include courses, workshops, program of study, internship/externship, research proposal, presentations of research or project results, project or thesis defense, final report or thesis. This is not an exhaustive list of possibilities.

<sup>y</sup>Programs especially with options will likely have specific learning outcomes (competencies, goals, etc.). State those and how they are being assessed.

**Graduate Doctoral Program Annual Reporting --- Assessment and Reflection on Graduate Learning Outcomes (GLO)**

<b>List the university and program level graduate learning outcomes (GLO).</b>	<b>Produce and defend an original significant contribution to knowledge</b>	<b>Demonstrate mastery of subject material</b>	<b>Conduct scholarly or professional activities in an ethical manner</b>
Is this GLO new or revised since the last year you reported on it? (write no, new, or revised)			
What do the data show about student learning or success relative to the outcomes you are reporting on this year?			
Describe any course---level changes related to this outcome that will result /have resulted from assessment activities in this reporting year. Include timelines.			
Describe any program/degree level (e.g. curricular, outcomes, goals, objectives) changes related to this outcome that have resulted/will result from GLO assessment activities in this reporting year and/or from other impetuses (e.g. feedback from accreditors).			
How did your program reflect on the data you are reporting and who was involved? Were there any challenges or concerns? How are the results of your assessment efforts related to strategic planning and overall program review?			
<b>Plans</b>			
Describe the program's assessment plans for the upcoming year.			
<b>Attachments---</b> Please share any relevant attachments related to the items/results you are reporting in this report.			

Graduate Master's Program Annual Reporting -- Assessment and Reflection on Graduate Learning Outcomes (GLO)			
List the university and program level graduate learning outcomes (GLO).	Conduct research or produce some other form of creative work	Demonstrate mastery of subject material	Conduct scholarly or professional activities in an ethical manner
Is this GLO new or revised since the last year you reported on it? (write no, new, or revised)			
What do the data show about student learning or success relative to the outcomes you are reporting on this year?			
Describe any course---level changes related to this outcome that will result /have resulted from assessment activities in this reporting year. Include timelines.			
Describe any program/degree level (e.g. curricular, outcomes, goals, objectives) changes related to this outcome that have resulted/will result from GLO assessment activities in this reporting year and/or from other impetuses (e.g. feedback from accreditors).			
How did your program reflect on the data you are reporting and who was involved? Were there any challenges or concerns? How are the results of your assessment efforts related to strategic planning and overall program review?			
<b>Plans</b>			
Describe the program's assessment plans for the upcoming year.			
<b>Attachments---</b> Please share any relevant attachments related to the items/results you are reporting in this report.			

## Appendix B: PhD Qualifying Examination in Robotics

The purpose of the PhD qualifying exam is to assess students' research skills (their ability to analyze, interpret, and communicate fundamental scientific, mathematical, and engineering concepts) for the purpose of determining their aptitude for the PhD program. The examination also includes a diagnostic function to highlight potential weaknesses in the students' background that can be addressed through additional coursework or independent study.

### Exam Format

The qualifying examination for Robotics consists of three components:

1. A written research paper on a topic selected by the committee. This will generally consist of literature review with a discussion highlighting the interesting research directions in that topic. The committee will specify the format and length of the paper, which will be due one week prior to the scheduled oral examination.
2. A 30 minute oral presentation on the topic of the research paper.
3. A 30 minute questioning session on topics presented in the research paper, as well as topics identified by the committee as a result of evaluating the research paper. These topics will be communicated to the students at least three days prior to the oral examination.

The qualifying exam will be evaluated by the faculty in Robotics. At least four faculty members must be present at the examination.

### Exam Scheduling

The qualifying exam will be conducted in the first three weeks of Winter term every year. The timeline for taking the qualifying exam is as follows:

- **For students entering the program with an MS degree:** No later than their second year in graduate school.
- **For students entering the program with a BS degree:** No later than their third year in graduate school.

Students who fail to meet this deadline will not be allowed to continue in the PhD program.

Students who fail the qualifying examination will be allowed to re -take it **once** within 60 days.

Students who fail the qualifying examination a second time will not be allowed to continue in the PhD program and may be re-directed toward an MS or MEng degree, if appropriate.

# Budget Outline Form

## Estimated Costs and Sources of Funds for Proposed Program

Total new resources required to handle the increased workload, if any. If no new resources are required, the budgetary impact should be reported as zero.

Institution: Oregon State University

Indicate the year:  X  First   Second

Program:  MS, MEng, PhD in Robotics

Third   Fourth

Academic Year:  2014-15

***Prepare one page each of the first four years***

	Column A From Current Budgetary Unit	Column B Institutional Reallocation from Other Budgetary Unit	Column C From Special State Appropriation Request	Column D From Federal Funds and Other Grants	Column E From Fees, Sales and Other Income	Column F LINE ITEM TOTAL
<b>Personnel</b>						
Faculty (Include FTE)						
Graduate Assistants (Include FTE)						
Support Staff (Include FTE)	\$16,716 (0.5 FTE)					\$16,716
Fellowships/Scholarships						
OPE	\$5,809					\$5,809
Nonrecurring:						
<b>Personnel Subtotal</b>	<b>\$22,525</b>					<b>\$22,525</b>
<b>Other Resources</b>						
Library/Printed	\$6,196					\$6,196
Library/Electronic						
Supplies and Services	\$500					\$500
Equipment						
Other Expenses	\$7,000					\$7,000
<b>Other Resources Subtotal</b>	<b>\$13,696</b>					<b>\$13,696</b>
<b>Physical Facilities</b>						
Construction						
Major Renovation						
Other Expenses						
<b>Physical Facilities Subtotal</b>	<b>\$0</b>					<b>\$0</b>
<b>GRAND TOTAL</b>	<b>\$36,221</b>					<b>\$36,221</b>



# Budget Outline Form

## Estimated Costs and Sources of Funds for Proposed Program

Total new resources required to handle the increased workload, if any. If no new resources are required, the budgetary impact should be reported as zero.

Institution: Oregon State University

Indicate the year:         First         Second  
                                   X Third         Fourth

Program: MS, MEng, PhD in Robotics

Academic Year: 2016-17

**Prepare one page each of the first four years**

	Column A From Current Budgetary Unit	Column B Institutional Reallocation from Other Budgetary Unit	Column C From Special State Appropriation Request	Column D From Federal Funds and Other Grants	Column E From Fees, Sales and Other Income	Column F LINE ITEM TOTAL
<b>Personnel</b>						
Faculty (Include FTE)						
Graduate Assistants (Include FTE)						
Support Staff (Include FTE)	\$18,430 (0.5 FTE)					\$18,430
Fellowships/Scholarships						
OPE	\$6,497					\$6,497
Nonrecurring:						
<b>Personnel Subtotal</b>	\$24,927					\$24,927
<b>Other Resources</b>						
Library/Printed	\$6,573					\$6,573
Library/Electronic						
Supplies and Services						
Equipment						
Other Expenses	\$7,427					\$7,427
<b>Other Resources Subtotal</b>	\$38,927					\$38,927
<b>Physical Facilities</b>						
Construction						
Major Renovation						
Other Expenses						
<b>Physical Facilities Subtotal</b>	\$0					\$0
<b>GRAND TOTAL</b>	\$38,927					\$38,927

## Budget Outline Form

Estimated Costs and Sources of Funds for Proposed Program

Institution: Oregon State University

Program: MS, MEng, PhD in Robotics

Academic Year: 2017-18

Indicate the year:      First      Second  
     Third  Fourth

**Prepare one page each of the first four years**

	Column A	Column B	Column C	Column D	Column E	Column F
	From Current Budgetary Unit	Institutional Reallocation from Other Budgetary Unit	From Special State Appropriation Request	From Federal Funds and Other Grants	From Fees, Sales and Other Income	LINE ITEM TOTAL
<b>Personnel</b>						
Faculty (Include FTE)						
Graduate Assistants (Include FTE)						
Support Staff (Include FTE)	\$19,352 (0.5 FTE)					\$19,352
Fellowships/Scholarships						
OPE	\$6,870					\$6,870
Nonrecurring:						
<b>Personnel Subtotal</b>	\$26,222					\$26,222
<b>Other Resources</b>						
Library/Printed	\$6,770					\$6,770
Library/Electronic						
Supplies and Services						
Equipment						
Other Expenses	\$7,650					\$7,650
<b>Other Resources Subtotal</b>	\$14,420					\$14,420
<b>Physical Facilities</b>						
Construction						
Major Renovation						
Other Expenses						
<b>Physical Facilities Subtotal</b>	\$0					\$0
<b>GRAND TOTAL</b>	\$40,642					\$40,642

Total new resources required to handle the increased workload, if any. If no new resources are required, the budgetary impact should be reported as zero.

## Summary of Support Letters:

We received support from the Industry Advisory Board members, Pacific Northwest researchers as well as prominent Robotics program directors across the nation (including the Director of the robotics institute at Carnegie Mellon University). Enclosed are a few quotes from the support letters. (Full letters are attached.)

Matt Mason, Professor, Computer Science and Robotics, Director, Robotics Institute, Carnegie Mellon University:

*"I strongly support the creation of a new Robotics graduate program at Oregon State University."*

*"The faculty at OSU has a well-established international reputation, particularly on topics such as legged locomotion, manipulation, marine robotics, multi-robot coordination, artificial intelligence and software architectures for robots. With the strong research focus and the diverse course offerings, they are well positioned to deliver a top robotics program."*

Michael Gennert, Professor, Computer Science and Computer & Electrical Engineering Departments, Director, Robotics Engineering Program, Worcester Polytechnic University:

*"The proposed program addresses a critical need for multi-disciplinary engineers and scientists in robotics."*

*"... no single discipline provides the breadth necessary for robotics, making it increasingly important to offer programs such as yours."*

*"In industry, IEEE-US Today's Engineer reported that the robotics industry will create 1,000,000 jobs in the next 5 years."*

*"Not only does it have a core of well-established faculty members, the recent addition of extremely talented junior faculty members, some of whom I know personally as rising stars in the field, should enable OSU to become a top university for robotics research and education."*

*"... I enthusiastically support the program and commend you for your leadership in this effort. I wish you and your colleagues the very best of success."*

Christopher Allan (Associate Professor, University of Washington, Hand and microvascular surgery):

*“Given my experience with your team and the rapid changes in all fields of surgery, I strongly believe that a graduate-level program in robotics at Oregon State University could be of tremendous benefit to the region and the nation through collaborative biomedical engineering research projects.”*

*“In summary, I strongly support the development of a graduate-level robotics program at Oregon State University. I look forward to continued close and productive interactions with your excellent robotics faculty and students.”*

David Browning, MIME Industry Advisory Board member, Altman Browning and Company:

*“During my tenure on the IAB, I witnessed and encouraged amazing growth in the robotics group... The resulting research in mobility, recognition and decision making on a robotic level is inspiring and technically highly advanced.”*

*“With these factors in mind, I think it is essential for the OSU robotics program to include a graduate degree program.”*

Rick Williams, College of Engineering IAB member, Leidos Maritime Solutions:

*“This letter is written in strong support of the proposed new graduate degree program in Robotics that would result in Ph.D., M.S., and M.Eng degrees. “*

Kevin Lynch, Professor and Chair, Mechanical Engineering, Northwestern University:

*“The number of job opportunities and research funding in robotics are currently undergoing significant growth.”*

*“The faculty at Oregon State are well positioned and have sufficiently diverse research interests to offer a robust Robotics curriculum.”*



# Carnegie Mellon

5000 Forbes Ave., NSH 4303  
Pittsburgh, PA 15213  
Phone: (412) 268-8804  
Fax: (412) 268-6436  
[matt.mason@cs.cmu.edu](mailto:matt.mason@cs.cmu.edu)

October 10, 2013

Professor Kagan Tumer  
Oregon State University  
Mechanical Engineering Department  
204 Rogers Hall  
Corvallis, OR 97331-6001

Dear Professor Tumer,

I strongly support the creation of a new Robotics graduate program at Oregon State University. I have served as director of the Robotics Institute at Carnegie Mellon University since 2004, and served as chair of the Ph.D. program from 1995-2004. The Robotics Institute is the largest and oldest robotics graduate program in the world. We have seen very strong student demand for Robotics degrees, and consistent demand from industry and academia for Robotics graduates. I personally know many of the faculty at Oregon State who are initiating this graduate program, and I have confidence that they have the capability to build a strong program.

I have been closely involved with the robotics community for more than three decades. In that time, I have seen the community grow by orders of magnitude, and this growth continues to accelerate. The growth of robotics industries has also accelerated. The role of robotics in manufacturing, transportation, logistics and services is reaching such proportions that a National Robotics Initiative was launched by the Obama administration. Both local and national companies would benefit greatly from a strong robotics program at OSU.

The faculty at OSU has a well-established international reputation, particularly on topics such as legged locomotion, manipulation, marine robotics, multi-robot coordination, artificial intelligence and software architectures for robots. With the strong research focus and the diverse course offerings, they are well positioned to deliver a top robotics program.

I'm excited by Oregon State's trajectory and look forward to working together to take robotics to new heights.

Sincerely,

Matthew T. Mason  
Professor, Computer Science and Robotics  
Director, Robotics Institute  
Carnegie Mellon University

MTM:ejh



# WPI

Robotics Engineering Program  
Worcester, MA 01609-2280, U.S.A.  
508-831-5476, Fax 508-831-5776  
<http://robotics.wpi.edu/>

September 5, 2013

Prof. Kagan Tumer  
School of Mechanical, Industrial and Manufacturing Engineering  
College of Engineering  
Oregon State University  
Corvallis, OR 97331-6001

Re: Letter of Support for Proposed Graduate Degree Program in Robotics

Dear Prof. Tumer,

I am pleased to write this letter of support for the proposed M.Eng., M.S., and Ph.D. program in Robotics at Oregon State University.

I feel well-qualified to evaluate the proposed program, having led the faculty team at Worcester Polytechnic Institute that developed B.S., M.S., and Ph.D. degrees in Robotics Engineering and serving as Director of the Robotics Engineering program since 2007. A complete CV is available at <http://web.cs.wpi.edu/~michaelg/work/CV.pdf>.

The proposed program addresses a critical need for multi-disciplinary engineers and scientists in robotics. Traditionally, engineers in the robotics industry have degrees in one of the core disciplines of Computer Engineering, Computer Science, Electrical Engineering, or Mechanical Engineering. Yet no single discipline provides the breadth necessary for robotics, making it increasingly important to offer programs such as yours. Robotics is also a rapidly growing discipline. In academia, the robotics-worldwide email list (<http://duerer.usc.edu/pipermail/robotics-worldwide/>) distributes notices of faculty and research positions and conference announcements. For example, in a 6-day period 23-28 August 2013, robotics-worldwide listed approximately 20 positions available, mostly for Ph.D.s, and mention of over 10 conferences, workshops, and symposia in robotics. In industry, IEEE-USA Today's Engineer reported that the robotics industry will create 1,000,000 jobs in the next 5 years (<http://www.todaysengineer.org/2012/Feb/career-focus.asp>).

The OSU School of Mechanical, Industrial and Manufacturing Engineering has clearly positioned itself to offer a very strong graduate program in robotics. Not only does it have a core of well-established faculty members, the recent addition of several extremely talented junior faculty members, some of whom I know personally as rising stars in the field, should enable OSU to become a top university for robotics research and education. Tighter integration of EECS faculty into the program would further strengthen it. The curriculum appears sound and appropriate for the degrees proposed.

One expects graduates of the proposed program will be in high demand by industry and academia. I would welcome M.S. students into our Ph.D. program and would consider Ph.D. recipients and post-docs for positions at WPI.

In summary, I enthusiastically support the program and commend you for your leadership in this effort. I wish you and your colleagues the very best of success.

Sincerely,

A handwritten signature in black ink, reading "Michael A. Gennert". The signature is written in a cursive style with a long, sweeping horizontal line extending to the right from the end of the name.

Michael A. Gennert  
Professor, Computer Science and Computer & Electrical Engineering Departments  
Director, Robotics Engineering Program  
Worcester Polytechnic Institute

## Department of Orthopaedics and Sports Medicine

Box 359798  
325 Ninth Avenue  
Seattle, WA 98104-2499  
Phone 206.744.3466  
Fax 206.744.3227

September 10, 2013

[www.orthop.washington.edu](http://www.orthop.washington.edu)

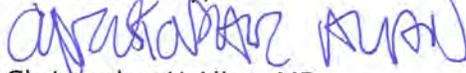
### To Whom It May Concern:

I am delighted to write this letter in support of the creation of a robotics graduate program at Oregon State University. I am a hand surgeon at Harborview Medical Center, one of busiest trauma centers in the country and a part of University of Washington (UW) Medicine, which has a strong robotic-assisted surgery program. My core research interests are in the area of hand reconstruction and regenerative medicine. I have been working closely over the last eighteen months with Dr. Ravi Balasubramanian of the OSU School of Mechanical, Industrial, and Manufacturing Engineering on a project that seeks to implant robotic mechanisms in the human hand to advance post-surgery hand function. As we progress in our work and I learn of the variety of surgical procedures conducted using robotic platforms both at UW Medicine and worldwide, it is becoming increasingly evident to me that robotics is poised to play a much greater role in the field of surgery in the coming years.

Given my experiences with your team and the rapid changes in all fields of surgery, I strongly believe that a graduate-level program in robotics at Oregon State University could be of tremendous benefit to the region and the nation through collaborative biomedical engineering research projects. It is notable that your institution has brought together a group of faculty who provide skills across a broad range of research topics, including human-robot interaction, robotic manipulation, highly dexterous robots, graphics and visualization, and automatic learning. I have every expectation that this group will be able to build and grow a thriving robotics graduate program.

In summary, I strongly support the development of a graduate-level robotics program at Oregon State University. I look forward to continued close and productive interactions with your excellent robotics faculty and students. Please let me know if I can answer any questions.

Yours sincerely,



Christopher H Allan, MD  
Associate Professor  
University of Washington  
Hand and Microvascular Surgery  
Harborview Medical Center

#### TEAM PHYSICIANS TO THE UNIVERSITY OF WASHINGTON HUSKIES

Jens R. Chapman, M.D., *(Chairman)*

#### ORTHOPAEDIC FACULTY

Foot & Ankle Surgery,  
Amputee Care  
Stephen K. Benirschke, M.D.  
Michael E. Brage, M.D.  
Sigvard T. Hansen, Jr., M.D., Emeritus  
Bruce J. Sangeorzan, M.D.  
Douglas G. Smith, M.D.

#### Fracture Care & Traumatology

David Barei, M.D., FRCS(C)  
Daphne M. Beigessner, M.D.  
Carlo Bellabarba, M.D.  
Jens R. Chapman, M.D.  
Robert P. Dunbar, M.D.  
Reza Firoozabadi, M.D., M.A.  
M. Bradford Henley, M.D., M.B.A.

James C. Krieg, M.D.  
Sean E. Nork, M.D.  
Bruce J. Sangeorzan, M.D.  
Douglas G. Smith, M.D.  
Lisa A. Taitzman, M.D., M.P.H.  
Hand & Upper Extremity  
Christopher H. Allan, M.D.  
Douglas P. Hanel, M.D.

#### Outreach Program

Sean E. Nork, M.D.  
Research Faculty  
Steven D. Bain, Ph.D.  
Edith M. Gardiner, Ph.D.  
Ted S. Gross, Ph.D.  
Ronald Y. Kwon, Ph.D.  
Sundar Srinivasan, Ph.D.  
Allan F. Tencer, Ph.D.

#### Spine Surgery

Carlo Bellabarba, M.D.  
Richard J. Bransford, M.D.  
Jens R. Chapman, M.D.

September 5, 2013

To Whom It May Concern,

I am writing this letter of recommendation in support of the Department of Mechanical, Industrial, and Manufacturing Engineering (MIME) for a graduate degree program in robotics. I am a graduate of the MIME department, a practicing licensed professional mechanical engineer, a business owner, and an active alumnus of OSU.

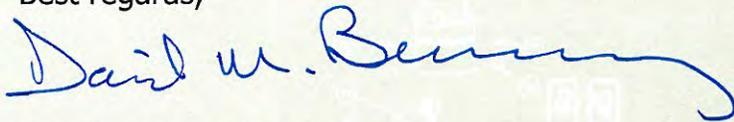
As an active alumnus I have served on the MIME Industry Advisory Board (IAB) for several years, just completing my last term on that board. During my tenure on the IAB I witnessed and encouraged amazing growth in the robotics group. The department has made a major commitment to the program, bringing in highly qualified research professors and greatly expanding the robotics lab. The resulting research in mobility, recognition, and decision making on a robotic level is inspiring and technically highly advanced.

As an engineer and business owner I oversee a group of engineers commercializing new technologies originating research laboratories. The research area of robotics is full of new technologically innovative opportunities and a potential driver for technology jobs in an emerging field of applied physics.

With these factors in mind I think it is essential for the OSU robotics program to include a graduate degree program.

Please feel free to contact me directly if you wish to discuss this further.

Best regards,



David M. Browning, P.E.

18000 S Shiloh Lane  
Oregon City, OR 97405

Dr. Sandra Woods  
Dean of Engineering  
College of Engineering  
Covell Hall 101  
Oregon State University  
Corvallis, OR 97331-2409

October 9, 2013

Dear Dean Woods.

This letter is written in strong support of the proposed new graduate degree program in Robotics that would result in Ph.D., M.S., and M.Eng degrees (CPS Tracking #: 87438).

The Robotics Program proposal is compelling. The industrial need is strong. Many of the companies at the core of Oregon's industrial base already employ a range of automation and robotics. Industry needs qualified applicants resulting in a demand for graduates. Additionally, the industrial workplace realities provide a practical input into the academic program, provides opportunities for interns and undergraduate and graduate projects.

Demand can also be found in the emerging wave energy industry and our nationally-recognized ocean observation program at OSU where underwater robotic systems are employed. Looking to aviation, land and surface sectors as well, the Pacific Northwest region hosts several companies that produce autonomous air vehicles, autonomous land vehicles and autonomous surface vessels.

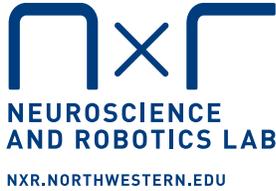
The School of Mechanical, Industrial and Manufacturing Engineering (MIME) is an ideal home for this new program and is well suited to integrate societal needs, student needs, and industry needs into the program.

Sincerely,



Rick Williams, Captain, US Navy (Ret)  
Member, OSU College of Engineering Advisory Board  
Director, Columbia Region  
Leidos Maritime Solutions

cc: Dr. Kagan Tumer



NORTHWESTERN  
UNIVERSITY

Kevin M. Lynch  
Professor and Chair  
Department of Mechanical Engineering  
Northwestern University  
2145 Sheridan Rd.  
Evanston, IL 60208

kmlynch@northwestern.edu  
nxr.northwestern.edu/people/kevin-lynch  
TEL (847) 467-5451  
FAX (847) 491-3915

September 9, 2013

Dear Sir/Madam,

I am writing in support of the proposed MS, MEng, and PhD programs in Robotics at Oregon State University. The number of job opportunities and research funding in robotics are currently undergoing significant growth. In response to this, Northwestern University is also currently starting up an MS Program in Robotics, accepting first students for Fall 2014. Programs such as the Northwestern program and the proposed Oregon State programs will find a good number of interested applicants, and graduates will have plenty of opportunities. The faculty at Oregon State are well positioned and have sufficiently diverse research interests to offer a robust Robotics curriculum.

I am Professor and Chair of the Department of Mechanical Engineering at Northwestern. I am a member of the Executive Committee of the IEEE Robotics and Automation Society, General Chair of the 2014 International Conference on Intelligent Robots and Systems (IROS 2014), Senior Editor of the IEEE Transactions on Automation Science and Engineering, former Senior Editor of the IEEE Transactions on Robotics, and an IEEE Fellow.

Sincerely,

A handwritten signature in black ink that reads 'Kevin M. Lynch'. The signature is written in a cursive style with a large, prominent 'K' and 'L'.

Kevin M. Lynch  
Professor and Chair, Mechanical Engineering