BOARD OF HIGHER EDUCATION

REQUEST FOR COMMITTEE AND BOARD ACTION

COMMITTEE: Academic Affairs **NO**.: AAC 12-04

COMMITTEE DATE: October 11, 2011

BOARD DATE: October 18, 2011

APPLICATION OF THE UNIVERSITY OF MASSACHUSETTS DARTMOUTH TO AWARD THE DOCTOR OF PHILOSOPHY IN ENGINEERING AND APPLIED SCIENCE AND THE MASTER OF SCIENCE IN ENGINEERING AND APPLIED SCIENCE

MOVED: The Board of Higher Education hereby approves the application of the **University of Massachusetts Dartmouth** to award the **Doctor of Philosophy in Engineering and Applied Science** and the **Master of Science in Engineering and Applied Science.**

Upon graduating the first class of this program, the University shall submit to the Board a status report addressing its success in reaching program goals as stated in this report and in the areas of enrollment, curriculum, faculty, resources, and program effectiveness.

Authority: Massachusetts General Laws Chapter 15A, Section 9(b)

Contact: Dr. Francesca Purcell, Associate Commissioner for Academic and P-16 Policy

BOARD OF HIGHER EDUCATION

October 2011

University of Massachusetts Dartmouth

Doctor of Philosophy in Engineering and Applied Science

Master of Science in Engineering and Applied Science

INTENT AND MISSION

The University of Massachusetts Dartmouth (UMD) filed an expedited application to offer a graduate program leading to the Doctor of Philosophy in Engineering and Applied Science and the Master of Science in Engineering and Applied Science. The aim of the proposed Ph.D. is to prepare qualified scientist/engineers who will carry out research in governmental and national labs, research foundations, and companies; become entrepreneurs to found R&D companies; work for state and local organizations to help society adapt to the rapid changes brought about by new engineering and technology; and to teach and research in higher education programs. Students will take courses across several disciplines and work with fellow students from various technical backgrounds. The proposed program will offer four options for students to pursue: applied mechanics and materials, computer science and information systems, industrial and systems engineering, and computational science. The options were designed around faculty strengths rather than around departments and involve over forty tenured and tenure-track faculty from multiple departments and colleges. The proposed master's degree will be offered en route to the completion of the doctoral program - direct admission into the master's program will not be permitted.

The production of more Ph.D. graduates is aligned with the goals of the University Strategic Plan which focuses both on increasing graduate enrollment and increasing the research profile of the campus to achieve Carnegie Doctoral status. Currently UMD offers three doctoral programs in technical areas: Biomedical Engineering and Biotechnology, Electrical Engineering and Marine Science. The proposed degree will enable research-active faculty from multiple colleges and departments to participate. It will also foster cross-disciplinary pedagogical and scholarly collaborations.

The proposed program will build upon the strengths of UMD's existing master's programs in the College of Engineering which collectively produce over forty graduates per year. Sponsored research funding has reached a total of $7.5M with annual expenditures of $2.3M. Research funding has reached a level where it could support an additional 25+ doctoral students. At present the 100+ eligible UMD graduates all go to other graduate programs or to industry and many end their education sooner than would be optimal in terms of their future career prospects. An enhanced research program will generate more undergraduate research opportunities and this will increase the number of students interested in staying on to gain a research degree. Many of the educational opportunities that are proposed to foster STEM students entail undergraduate research opportunities.

The final proposal was approved by the University Board of Trustees on May 25, 2011. In accordance with Board of Higher Education guidelines for the expedited review of new programs, a letter of intent for the proposed program was distributed to all public colleges and

University presidents and chancellors. No comments in response were received.

NEED AND DEMAND

The U.S. Department of Labor's 10-year employment projections in the table below show significant growth in EAS disciplines (Occupational Outlook Handbook, 2010-2011).

Occupation	%Δ
Computer and information scientists research	+24
Operations research analysts	+22
Computer software engineers	+21
Environmental scientists and specialists, including health	+28
Computer and information systems managers	+17
Industrial engineers	+14
Environmental engineers	+31

Additionally, the job climate for technical Ph.D.s. was analyzed in the National Science Board's *Science and Engineering Report 2010* whose most recent data indicate that employment growth in science and engineering was twice as great as that for the rest of the U.S. workforce and that unemployment of people holding doctorates in science and engineering showed improvement "from already good conditions" to 1.3%. The Massachusetts Office of Labor and Workforce Development is projecting that technological demands are going to increase demand for increasingly educated workers over the next five years and that consulting (management, scientific and technical), computer systems design and scientific research and development are going to generate more than 45,000 new jobs in Massachusetts by 2016 (*Commonwealth of Massachusetts Employment Projections 2006-2016)*.

The proposed program is also consistent with the recognized need to conduct interdisciplinary research to address pressing societal needs. Interdisciplinary research is a mode of research by teams or individuals that integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines or bodies of specialized knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or area of research practice (*Facilitating Interdisciplinary Research*, Committee on Facilitating Interdisciplinary Research, Committee on Science, Engineering and Public Policy, National Academy of Sciences, National Academy of Engineering, and Institute of Medicine of the National Academies, National Academies Press, Washington, D.C., 2004.) The collective assembly of faculty expertise in computational/information/physical/engineering science will enable pursuit of interdisciplinary research topics/priorities that have been identified by many government agencies as critical for growth (*The National Academics Keck Futures Initiative: Complex Systems*, National Academy of Sciences, 2009; *Investing in America's Future: Strategic Plan FY2006 – 2011*, National Science Foundation, 2006; *Assessing the Impacts of Changes in the Information Technology R&D Ecosystem: Retaining Leadership in an Increasingly Global Environment*, National Research Council, 2009; *Integrated Computational Materials Engineering: A transformational discipline for improved competiveness and national security*, National Research Council, 2008; *Defense Modeling, Simulation, and Analysis: Meeting the Challenge*, National Research Council, 2006; and *America's Energy Future: Technology and Transformation*, National Research Council, 2009).

According to UMD, there are no equivalent interdisciplinary programs in the UMass system, but enrollment has almost doubled since 2000 in the doctoral engineering programs at UMass Lowell. Similarly, enrollment in the existing doctoral programs at UMass Dartmouth has more than doubled over the last three years, with particularly strong growth in the three existing science and engineering programs in which enrollment went from 43 in 2008 to a current enrollment of 90 in Fall 2010.

Interdisciplinary engineering doctoral programs exist within the region at Brown University, Harvard University, and Northeastern University. UMD believes it will serve a different student population than the Ivy League Institutions and that Northeastern's program is significantly different from UMD's proposed program.

ACADEMIC AND RELATED MATTERS

This proposed program is interdisciplinary and will offer the following four options: Computational Science and Engineering, Applied Mechanics and Materials, Computer Science and Information Systems, and Industrial and Systems Engineering. Students will indicate their option choice during the application process and be admitted after the evaluation and approval by both a sub-committee for each option and by the program admission committee. Common core courses will have to be taken by all students in the program regardless of their options as well as a common student seminar series. These will serve as the unifying mechanisms to ensure ample interactions among faculty and students in the complete program. Within each option, the structure of degree requirements are also interdisciplinary.

Curriculum (Attachment A)

The proposed degree will require a minimum of 66 semester credit hours beyond the bachelor's degree. Of the 66 credits a minimum of 36 semester credit hours must be course work and a maximum of 30 credit hours may be allotted to doctoral research. Further, the following distribution of course credit is required:

- 6-credit hours of graduate-level mathematics or numerical analysis common to all options;
- 12-credit hours of core courses in the discipline with a B+ average (3.25 GPA) including one on experimental or computational techniques;
- 6-credit hours in a minor area in another field of science or engineering;
- 1-credit Ethics; and
- 2-credits of doctoral seminar.

At least 10 courses at the 500-600 level must be full-credit graduate courses with clear technical, scientific, or mathematical focus. Twelve of the required 36 credit hours of coursework will be at the 600-level or above. More course work may be required by a particular option or by an individual supervisory committee.

Course requirements for the proposed Ph.D. will be governed by two general principles. First, students will take courses to reach the level of competence in their chosen option needed to do high-quality research. Second, although depth of knowledge in the option is essential, breadth of knowledge in related areas is just as important for interdisciplinary research. The detailed program of study for each student will worked out in consultation with the student's faculty advisor and supervisory committee.

Additional non-course work requirements are:

- Successful passing of a Qualifying Examination upon completion of coursework;
- Approval of a dissertation proposal submitted and presented by the candidate;
- Passing a Comprehensive Examination on research preparedness; and
- Approval and successful defense of the dissertation in an oral examination conducted as specified by university procedures.

Up to 24 semester credit hours of advanced standing may be granted to doctoral students who have an earned Master's degree in a related field from another institution. For students who earn their master's degrees at UMD, up to 30 semester credit hours of advanced standing may be granted for course work with a grade of 3.00 or above; although most students who earn a Master's will only be eligible for 24 credits hours of advanced standing because they will not have taken more than 24 credit hours of course work.

Dissertation committees will include at least four members from at least two different academic departments at UMD. External members of faculty standing may also be included, but a majority of the committee members must be full time faculty at UMD. All dissertation committees must be approved by the AACC prior to the dissertation proposal.

The major work toward the degree is the conduct of independent research in science or engineering and the preparation and defense of a doctoral dissertation. The doctoral candidate will defend his/her written dissertation before the doctoral dissertation committee, the university, and the outside community. The specific format of the defense is usually decided by the committee chair, but a typical format consists of the Ph.D. candidate first presenting an overview of the thesis research; then answering specific questions asked by the committee members.

Students are expected to be engaged in full-time study and complete their degree within six years. Students must be in residence at the UMD campus for at least two consecutive semesters of full time study. In addition to specifying minimum scholastic standards for coursework, each option will establish standards for satisfactory progress to degree completion. Each option will establish a process for monitoring and reporting the progress of each student in the program.

All graduate Ph.D. students are required to attend research seminars. In addition, each graduate student will present his/her research in a public seminar at least once during their graduate student career.

The College of Engineering Industrial Advisory Board will serve as the external advisory board for the program. The advisory board will evaluate job placement data for graduates and provide guidance in the development or modification of options to meet the needs of industry.

The master's degree is an option for students in the Ph.D. program. Requirements for the master's degree are completion of 33 credits of course work and passing a capstone exam. The completed coursework must include all of the coursework for one of the EAS doctoral options, excluding ethics and any courses, such as doctoral seminar, that can be taken only after the student has passed his/her dissertation proposal defense. A cumulative GPA of 3.0 or greater in all courses taken towards the degree is required for degree conferral.

Admission

Admission to the proposed program will follow general UMD regulations. Most students entering the program will have a Master of Science degree from a traditional engineering or science department at UMD or elsewhere. Exceptionally qualified candidates may be accepted with a Bachelor of Science degree. Admissions criteria for the Ph.D. program include GRE scores, undergraduate and graduate GPA and a TOEFL score (if required). Significant weight will also be placed on reference letters, the applicant's statement of purpose, and professional experience. Generally, an undergraduate GPA ≥ 3.00 (on a scale of 4.00) is required or a graduate GPA ≥ 3.25. Applicants whose native language is not English should have a minimum paper-based TOEFL score of 550, a computer based TOEFL of 213 or an internet based TOEFL of 79.

No direct admission to the master's program will be allowed.

Enrollment

UMD put forth the following enrollment projections:

	# of Students Year 1	**# of Students Year 2**	**# of Students Year 3**	**# of Students Year 4***
New Full Time	12	12	12	14
Continuing Full Time	0	12	22	30
New Part Time	0	0	0	0
Continuing Part Time	0	0	0	0
Totals	12	24	34	44

RESOURCES

Faculty

The proposed program will not require the hiring of any additional faculty and a major portion of the instructional cost for this program will be supported using UMD's existing instructional budget. According to UMD, the incremental cost increases associated with this program will be modest.

Recently, the University has redirected graduate resources to support Ph.D. students. Competitive stipends and fee waivers are available for teaching and research assistants and some fellowships are available for top students. It is anticipated that the TA allocations of the participating departments will be awarded to incoming Ph.D. students. Also, in some departments such as mathematics, which has a large number of introductory courses taught by part-time lecturers, those positions could be filled by doctoral candidates in mathematics.

Administration

Administrative oversight for the program will be provided by the Dean of Engineering. The advising/admissions/curriculum committee (AACC) will be comprised of one representative from each of the participating departments – appointed by the department chairperson and approved by the Dean. The AACC will nominate one member to serve as graduate program director (GPD), to be approved by the Dean.

Administrative support for program advancement and student services will be fulfilled by the Office of the Associate Dean for Research and Graduate Studies in the College of Engineering. Operating costs such as supplies, computers, telephones, photocopying, etc. will be covered by departmental budgets. Additional expenses associated with seminars, student activities, recruitment, and publicity are estimated at about $100 per student. Internal and external funding sources are already in place to support travel to conferences and research sponsors.

Facilities

The aggregate research space among the primary departments is 18,500 square feet, which with some reapportionment is adequate for the program. A primary need is for laboratory space renovation and office space for graduate students. The university has recently committed $11 million to laboratory renovation. Plans underway indicate this will provide new space for as many as 20 new investigators according to UMD. Much of this space has been specifically targeted to promote interdisciplinary research of the type supported by this proposal.

Library and Information Technology

According to UMD, the faculty participating in the proposal run large externally funded programs now using the current library, thereby demonstrating the adequacy of the resources; but in general the library collections need to be strengthened to better support graduate programs on campus. Plans are underway to increase library holdings as doctoral programs continue to grow and UMD is directing a significant portion of the increased fee revenue from this program toward the library.

BUDGET (Attachment B)

According to the University, most of the resources required to field and sustain the proposed program are already in place.

PROGRAM EFFECTIVENESS

Goal	Measurable Objective	Strategy for Achievement	Timetable
Achieve total enrollment of 40 full time students by Fall 2015	Number of enrolled students	Engage well funded faculty who support graduate students at the master's level and provide assistantship support for entering students to aid recruitment	2015
Generate an	Published Papers	Engage faculty with	

average of more than 2 quality journal publications based on dissertation work per graduate		excellent publication records and use fellowships to assist them in recruiting and supporting high quality students.	Continuous
Produce 5 graduates per year by Fall 2015	Graduation rates	Monitor student progress on an ongoing basis and reward faculty who demonstrate effectiveness in leading students to graduation with fellowship support for incoming students	2015
Increase external funding secured by participating units by more than 10% per year	Research Expenditures	Provide doctoral training opportunities to faculty who have proven records for securing external funds using only master's students.	continuous

EXTERNAL REVIEW AND INSTITUTIONAL RESPONSE

The proposed program was reviewed by Dr. Mehmet Toner, Helen Andrus Benedict Professor of Surgery, Harvard Medical School; and Dr. Chi-Wang Shu, Theodore B. Stowell University Professor of Applied Mathematics, Brown University. The committee members were impressed by the efforts the University has put in to this new Ph.D. Program, both in terms of planning facilities and lab spaces and in getting the relevant faculty members together to carefully design the details of the program. They were also impressed by the enthusiasm and support from participating faculty to this new program. The external reviewers cited congruity with institutional mission and strategic objectives; justification in terms of need, demand, access and benefits; innovative learning and research opportunities through interdisciplinary collaborations; strong institutional and faculty commitment; appropriate student/faculty/programmatic quality controls; and cost effectiveness and adequacy of resources to launch and sustain the program.

The reviewers suggested that UMD enhance the common student seminar series which will be attended by all students in the program; in the future, combine the Comprehensive Examination with the Qualifying Examination to move students to a research focus in a more expeditious manner; provide resources for students to purchase research articles; and institute surveys of program graduates.

The planning committee endorsed the concept of enhancing the student seminar series to reinforce the interdisciplinary aspect of the program and incorporate a professional socialization experience. The two-credit hour required doctoral seminar will extend beyond a research colloquium and will be designed to foster a community of scholars in which faculty and graduate students share and discover the methods of interdisciplinary research. Since the early graduates of the program will greatly determine the reputation of the program and its ability to continue to attract quality students and faculty, the planning committee favors initially using the two-step qualifying/comprehensive exam process to assure high quality graduates. UMD will monitor student quality and progress on a yearly basis and make recommendations for changes

to the examination format. The planning committee will work with the UMass Dartmouth Library to provide enhanced research article access for qualified EAS doctoral students. Finally, the AACC will work with the UMass Dartmouth Center for Policy Analysis to design and administer an alumni and employer survey to assess how well the program is meeting its educational objectives. The results will be reviewed by the program faculty and External Advisory Board to determine if any programmatic changes should be adopted.

STAFF ANALYSIS AND RECOMMENDATION

Staff recommendation is for approval of the request of University of Massachusetts Dartmouth to award the Master of Science in Engineering and Applied Science and the Doctor of Philosophy in. Engineering and Applied Science

Upon graduating the first class for this program, the University shall submit to the Board a status report addressing its success in reaching program goals as stated in this report and in the areas of enrollment, curriculum, faculty resources, and program effectiveness.

ATTACHMENT A: Curriculum Outlines

Applied Mechanics & Materials Option

Engineering & Applied Science - Ph.D.
Applied Mechanics & Materials Option **CURRICULUM**

Core Courses Requirements	EAS 501 Advanced Mathematical Methods	EAS 502 Computational Methods	EAS 503 Continuum Mechanics	9 core course credits
Major options	Solid Mechanics: Analytical, Experimental and Numerical Solid Mechanics			15 credits
	Fluid Mechanics & Thermal sciences: Analytical, Experimental and Numerical Fluid Mechanics, Heat Transfer			
	Non-linear Dynamics: Advanced Dynamics, Non-linear vibrations, Dynamics and stability of engineering systems, Acoustics			
	Computational Materials Science: Multi-scale Simulations, Multi-phase flow			
	Composites: Biomaterials, Nanomaterials, Heterogeneous Materials, Mechanics of Composites, MEMS & Thins Films, Pavement Materials			
	Polymer Engineering: Fiber Engineering, Rheology, Thermodynamics, Kinetics of Polymers, Soft materials, Polymer chemistry			
Minor courses				6 credits
Thesis Proposal Preparation Project	Student must take this course after completion of Qualifying Exam. (Pass/Fail)			3 credits
Doctoral Seminar (1 credit/semester)	Seminar series (talks from student in the program, participating faculty and external speakers), Student must take this course in two semesters			2 credits
Ethics				1 credit
Qualifying Exam	Written & Oral			
Comprehensive Exam Dissertation Proposal	Written & Oral			
Independent Research or Study (up to 6 credits)/ Dissertation Credits	EAS 603 EAS 701			30 credits
Dissertation Defense				
PhD. degree awarded				66 credits (minimum)

Computational Science Option

Engineering & Applied Science - Ph.D.
Computational Science Option **CURRICULUM**

Core Courses Requirements	EAS 501 Advanced Mathematical Methods	EAS 502 Computational Methods	CSC 501 High Performance Scientific Computing	15 core course credits
	CSC 601 and CSC 602 Scientific Computation Research Seminar			
Major elective courses	Elective courses in physics and mathematics			9 credits
Free elective courses (minor)	Graduate level science, mathematics, and/or engineering courses			9 credits (incl. 6 as a minor)
Doctoral Seminar (1 credit/semester)	Seminar series (talks from student in the program, participating faculty and external speakers), Student must take this course in two semesters			2 credits
Ethics				1 credit
Qualifying Exam	Coursework GPA			
Comprehensive Exam Dissertation Proposal	Written & Oral determined by supervisory committee			
Independent Research or Study (up to 6 credits)/ Dissertation Credits	EAS 603 EAS 701			30 credits
Dissertation Defense				
Ph.D. degree awarded				66 credits (minimum)

Computer Science & Information Systems Option

Engineering & Applied Science - Ph.D.
Computer Science and Information Systems Option **CURRICULUM**

Core Courses Requirements	EAS 501 Advanced Mathematical Methods	EAS 502 Computational Methods	CIS 580 Paradigmatic Software Development	9 core course credits
Major core options	CIS 560 Theoretical Computer Science ECE 565 Computer Operating Systems	CIS 570 Advanced Computer Systems ECE 562 Advanced Computer Architecture		6 major course credits
Major elective courses	Four graduate level courses from CIS/DIS/MIS/CPE			12 credits
Minor courses	Two graduate level courses from a designated minor program			6 credits
Doctoral Seminar (1 credit/semester)	Seminar series (talks from student in the program, participating faculty and external speakers), Student must take this course in two semesters			2 credits
Ethics				1 credit
Qualifying Exam	Written exam *or* core course GPA			
Comprehensive Exam Dissertation Proposal				
Independent Research or Study (up to 6 credits)/ Dissertation Credits	EAS 603 EAS 701			30 credits
Dissertation Defense				
Ph.D. degree awarded				66 credits (minimum)

Industrial and Systems Engineering Option

Engineering & Applied Science - Ph.D.
Industrial and Systems Engineering Option **CURRICULUM**

Core Course Requirements	EAS 502 Computational Methods	MNE 539 Engineering Optimization	12 core course credits
	MNE 5xx Stochastic Processes	EAS 5xx Design of Experiments	
Major courses	Two graduate level courses from MNE (Group 1)		6 credits
	Two graduate level courses from CCB (Group 2)		6 credits
Minor courses	Two graduate level courses from a designated minor program		6 credits
Elective course	One free elective approved by supervisory committee		3 credits
Doctoral Seminar (1 credit/semester)	Seminar series (talks from student in the program, participating faculty and external speakers), Student must take this course in two semesters		2 credits
Ethics			1 credit
Qualifying Exam	Coursework GPA		
Comprehensive Exam Dissertation Proposal	Written & Oral		
Independent Research or Study (up to 6 credits)/ Dissertation Credits	EAS 603 EAS 701		30 credits
Dissertation Defense			
Ph.D. degree awarded			66 credits (minimum)

Attachment B: Budget

One Time/ Start Up Costs		***Annual Expenses***			
	Cost Categories	**Year 1**	**Year 2**	**Year 3**	**Year 4**
0	New Full Time Faculty *(Salary & Fringe)*	0	0	0	0
0	Estimated Instructional Cost Based on Faculty Time Course Delivery	$52,344	$100,326	$100,326	$109,050
0	Estimated Instructional Cost Based on Faculty Time Thesis/Dissertation Advising	0	$62724	$114,994	$156,810
0	Part Time/Adjunct Faculty *(Salary & Fringe)*	$4,000	$4,000	$4,000	$4,000
0	Staff	0	0	0	0
0	General Administrative Costs	0	0	0	0
0	Instructional Materials, Library Acquisitions	0	$25,000	$50,000	$100,000
0	Facilities/Space/Equipment	0	0	0	0
0	Field & Clinical Resources	0	0	0	0
0	Marketing	$10,000	$5,000	$5,000	$5,000
	Other (Specify) Assistantships	$120,000	$240,000	$320,000	$320,000
	TOTALS	$186,344	$437,050	$594,320	$694,860

One Time/Start-Up Support		***Annual Income***			
	Revenue Sources	**Year 1**	**Year 2**	**Year 3**	**Year 4**
0	Grants (10% per year Increased Indirect Cost Generation for PIs in program after year 1)	0	$50,000	$105,000	170,000
0	Tuition All students on RA/TA waiver	0	0	0	0
0	Fees (adding 10 externally funded students per year)	$52,000	$105,000	$160,000	$250,000
0	Departmental				
0	Reallocated Funds	$82,000	$136,448	$148,896	$54,350
0	Existing Instructional Budget that	$52,344	$145,602	$180,424	$220,510

	will support the EAS program				
	TOTALS	$186,344	$437,050	$594,320	$690,498

UMD's Budget Narrative:

We are implementing the EAS Ph.D. using a resource model similar to that used when we implemented the Biomedical Engineering and Biotechnology Ph.D. program (BMEBT) on the UMass Dartmouth Campus. The program builds on master's programs that house large numbers of externally funded researchers who are already supporting Research Assistants (RAs). Simply giving funded researchers the opportunity to train doctoral students enabled the BMEBT program to grow. The BMEBT program was successfully implemented with no new resources. More than 95% of students in that program have been supported on external funds and it is now the second largest doctoral program on campus with 26 full time doctoral students.

Similarly the EAS program can be implemented at minimal cost because it is being built on a large number of research intensive master's programs that are poised for expansion to doctoral status. As mentioned earlier, the research expenditures of the participating units currently exceeds $2.3 million per year. These units already offer graduate courses and the faculty supervise large numbers of graduate students. Making it possible for the best of those students to stay for doctoral training will actually reduce the advising burden on many of the faculty rather than increase it, since master's students often require more intense supervision than their more mature doctoral counterparts.

Most of the resources required to field and sustain the proposed EAS-Ph.D. program are already in place. Departments may realize additional revenue from anticipated increased enrollment, grants and administrative savings. Also, the program aims to be course section neutral (or possibly an instructional cost savings) by consolidating courses, especially in mathematics, to serve multiple disciplines.

The budget model includes estimates for the instructional cost of delivering all courses and advising to doctoral students in the EAS PhD as a proportion of faculty time.

The existing instructional budget that will support this program is also estimated in the budget model. Most of the required courses are already being offered in support of existing master's programs and many of the participating faculty already advise graduate students which makes the addition of new graduate advisees cost neutral . A significant portion of the instructional cost for the EAS PhD, therefore, will be supported by the existing instructional budget rather than by incremental cost increases associated with starting a new program. The existing instructional budget that supports the program increases as more students enter the program to fill vacant seats in existing graduate courses and receive advising from faculty whose graduate research groups are not at capacity.

The proposed budget includes university support for students in the program. This support will be available to entering students and as a mechanism to support a teacher training option for students who choose to pursue that.

The budget includes an investment in the library that grows as program enrollment increases.

The chair of the AACC will be given a course release, so coverage by a part-time lecturer is included for that ($4,000).

Marketing for the program will be covered out of the existing graduate studies marketing budget as part of the re-allocated funds.

New revenues come from university fees, which are paid for Research Assistants (RAs) by external grants at UMass Dartmouth; and by the increases in the indirect cost generation of researchers in the program. In the last fiscal year the participating faculty generated more than $500,000 in indirect costs. The budget assumes a 10% increase in indirect cost generation per year, starting in year 2.

Enrollment projections assume that students will be successfully recruited to fill all funded RA positions, as has been the case in our other doctoral programs. The projected number of available RA positions is based on continued growth in external funding at a rate equal to that experienced over the last three years by the participating departments. This is a conservative estimate given the additional opportunities for funding and research that implementation of this doctoral program will create.

Summary

This program will not require the hiring of any additional faculty and a major portion of the instructional cost for this program will be supported using UMass Dartmouth's existing instructional budget. The incremental cost increases associated with this program are modest. In years one, two and three the program will require investment through re-allocation that starts at $80,000 in year one and increases to about $150,000 in year three, but this investment is projected to decrease substantially in year 4 to just over $50,000. The program is projected to become revenue generating at steady state. Once again it is worth noting that the BMEBT program, which was built on the same model of relying heavily on existing instructional costs, has become a revenue generating program.

Overall the establishment of this program at this time represents a very small investment out of the University's annual budget of more than $200M because the major expense of hiring and supporting faculty qualified to deliver such a program has already been made.

a) Faculty resources

The university is already committed to increasing research capacity through strategic hiring in key research areas. No new faculty lines, over and above those positions already planned, are required for the addition of this program because plans to hire faculty into research clusters, many of which will be supported by this program, are already underway and will go forward whether or not this program is implemented. Furthermore, the opportunity for Ph.D. research will facilitate hiring qualified faculty to fill current vacancies.

The creation of this program will make the existing faculty and those who are newly hired more productive.

We have included estimates for the cost of instruction for the delivery of all courses and advising to the students in the program.

The estimated cost for instruction was calculated using the following model:

Model for Instructional Cost

The average salary for the faculty engaged in the program is $89,000 per year and the fringe rate is 34.92%.

The standard workload for faculty in this program is 40% Teaching and Advising, 40% Research and Scholarship and 20% Service.

A full teaching load for faculty in this program is two 3 credit courses and advising for three graduate students per semester.

The average section size for graduate courses in Science and Engineering is approximately 11 students (based on Fall 2010 enrollments).

Students will require research advising, as reflected in the teaching load, starting in their second year and will need advising for four full years on average.

The instructional cost, therefore, for offering one 3 credit course to one student is 0.4*(Salary + Fringe)*0.166*(1/11) = $727, where 0.4 represents the 40% of time dedicated by the faculty to teaching, 0.166 represents the fraction of a full year teaching load that one course represents (1/6) and 1/11 represents the fraction of the cost for teaching the course that is attributable to a single student in a class of 11 students.

The instructional cost for providing dissertation/thesis advising to a student for a full year is 0.4*(Salary + Fringe)*0.33*(0.33) = $5227. Some faculty advise more than three graduate students per year, but three is typical.

Full time students take 9 credits of courses per semester until they complete their coursework requirement. Two of the options require 12 classroom based courses and two of the options require 11 classroom based courses. The model, therefore, assumes 11.5 courses per student in total: 3 in each of the first three semesters and 2.5 in the fourth semester. Students will not usually take all their courses so efficiently, since most will choose to pursue research activities while taking lighter loads for some of the early semesters, but this model will capture the total cost correctly.

Given the expected enrollment of 12 students in the first year, the expected instructional cost for the first semester is 12(students)*3 (courses per student)*$727 (cost per course per student) = $26,172.

The cost for dissertation and thesis advising is zero for the first semester.

In the second year we project 12 new students and 12 returning students. In Fall of the second year we have 24(students)*3(courses per semester)*$727 = $52,344 for course instruction in the Fall, plus 12(students in second year) * $2614 (cost for thesis/dissertation advising for one semester) = $31,368, etc.

Estimated Existing Instructional Budget

Students in this program will be filling seats in many classes that are already offered in support of master's programs and many advisors in this program will shift their thesis advising from master's students only, to master's and doctoral students without affecting their teaching loads. Much of the instructional cost, therefore, already exists as instructional cost in the current

UMass Dartmouth budget. The amount of existing instructional budget that will be used in support of the EAS program is included in the budget template as well. Overall the existing instructional budget support increases over time as growing EAS enrollment fills more and more seats in existing classes. The model assumes that two new courses, representing an incremental budget increase, will be needed in year two, and this will increase to four additional courses in year 3. In year 4, the current advising capacity of the faculty will be exceeded, and student advising will represent another incremental cost increase. The incremental increase in instructional cost is represented in the budget by the gap between the program's instructional cost and the support the program receives from the existing instructional budget. As new courses and increased research advising become necessary to support the program, this gap widens.

b) Infrastructure

The university has already committed $11 million to laboratory renovation. Plans underway indicate this will provide new space for as many as 20 new investigators. Much of this space has been specifically targeted to promote interdisciplinary research of the type supported by this proposal.