The University of Michigan
College of Engineering
Curriculum Committee

Agenda
January 23, 2007
1:30-3:00 p.m.
GM Room
Room 2210 Lurie Engineering Center

1. Approval of Minutes from January 9, 2007 Meeting
2. Project Based Learning (Practicum Proposal) – Pete Washabaugh

University of Michigan
College of Engineering
Curriculum Committee Meeting
Tuesday January 9, 2007
1:30-3:00 p.m.
Lurie Engineering Center GM Room
Minutes

Richard Robertson called the meeting to order at 1:40 p.m.

Members Present: R. Robertson, L. Bernal, J. Barker, G. Herrin, A. Hunt, D. Karr K. Kearfott, M. Keyserling, C. Lastoskie, M. Moghaddam, J. Pan, J. Shi, R. Rogers, M. Solomon, T. Teorey

Members Absent: P. Mazumder, S. Pang, K.Patel, R. Sulewski

Guests: Peter Nagourney (for R. Sulewski), Cinda Sue Davis, Cindy Finelli, Elijah Kannatey-Asibui, Maurice Telesford

Motion to approve the minutes of the last meeting

The minutes of the last meeting were approved

The Diversity and Outreach Committee Presentation

Cindy Finelli gave a presentation regarding the Diversity and Outreach Committee. There were several members of this Committee present and they handed out some information at this meeting.

They presented several topics including: Diversity in the Curriculum.
There was a discussion regarding the best ways to implement this.

Course Approval Forms

These Courses Were Tabled

ME 320 *Modification – Changing Prerequisites from: ME 235 and ME 240* ***to: MATH 215, ME 235 and ME 240****.*

ME 450 *Modification – Changing Credit Restrictions from: ME 495 is not to be elected concurrently. Not open to graduate students.* ***to: May not be taken concurrently with ME 495. Not open to graduate students.***

ME 495 *Modification – Changing Prerequisites from: ME 360, ME 395; preceded or accompanied by ME 350* ***to: ME 360, ME 395, P/A ME 335 and ME 350****; Changing Credit Restrictions from: Recommend ME495 not be elected concurrently. Not open to graduate students* ***to: May not elect ME 450 concurrently. Not open to graduate students.***

Richard Robertson called for a motion to approve the following courses. This was moved and seconded.

<u>These Courses Were Approved</u>

ME 539	Modification – Changing Title from: Heat Transfer in Porous Media ***to: Heat Transfer in Physics;*** Changing Description; Changing Prerequisites from: ME 335 or equivalent ***to: ME 235, 335***.
ME 574	New Course
ME 580	New Course

<u>Adjournment:</u> Motion to adjourn was made and seconded
<u>Motion carried (approved)</u>

Next Meeting January 23, 2007
GM Room – Fourth Floor LEC

Practicum in a Multi-Disciplinary World:
A Proposal for an Interdisciplinary Practicum Concentration Initiative

September 11, 2006

Oversight Counsel (Partial Membership)
Brian Gilchrist (Lead Overall Effort, EECS, AOSS)
Cynthia Finelli (Center for Research in Learning and Teaching),
Daryl Weinert (CoE)

Engineering in Service (Partial Membership)
David Chesney (EECS)
Steve Skerlos (ME)

Space Exploration Initiative
Brian Gilchrist (EECS, AOSS)
Nilton Renno (Co-Lead Space Exploration, AOSS),
Aaron Ridley (AOSS),
Chris Ruf (EECS, AOSS),
Pete Washabaugh (Co-Lead Space Exploration, AERO),
Thomas H. Zurbuchen (AOSS, AERO),

Point of Contact:
Brian Gilchrist, 3303 EECS, 3-4417, brian.gilchrist@umich.edu

Participating **Institutions (as of Sept 2006):** CoE: College of Engineering, AERO: Aerospace Engineering, AOSS: Atmospheric, Oceanic and Space Sciences, EECS: Electrical Engineering and Computer Science, ME: Mechanical Engineering (More anticipated)

Summary –

The real world offers tremendous challenges and numerous opportunities for our students when they leave the University of Michigan. Many of these challenges are intrinsically multi-disciplinary and require work across the boundaries of traditional educational programs. The College of Engineering is initiating new efforts to find ways to expand and improve experience-based opportunities for students to help prepare them for this multi-disciplinary world. This proposal is an important part of this effort. It is also part of a larger vision spanning across the University engaging a broader spectrum of students, faculty, and academic units. We intend to make the Fall of 2006 an important period to seek out a broad range of collaborations within the University.

Many of us have experienced the successes of students from a variety of backgrounds brought together to undertake significant projects that are interdisciplinary by nature. Examples of such projects include the design and fabrication of a solar car to race for thousands of miles across North America and Australia, small spacecraft, an aid to alleviate a physical impairment, tools and resources for non-profit organizations. These and other activities engage students in significant multi-semester technical and organizational efforts that create tremendously valuable experiences that send them out in the world both wiser and better leaders at levels not possible by "book learning" alone. Other important benefits to many of these projects are that (1) students, with appropriate guidelines, can largely manage much of a project's day-to-day activities and, (2) mentorship of newer students by more senior students (including graduate students) follows the spirit of a "see one, do one, teach one" teaching model representing a huge - often overlooked - resource for students and their institutions. However, in most of these efforts, there has been little trackable curricular outcome for the students (e.g., it does not appear on their transcript) and the efforts have been largely uncoordinated. Moreover, these efforts are often inhibited by administrative boundaries between schools and departments as well as narrow curriculum. *This proposal seeks to tap in to the inherent strengths of interdisciplinary practicum experiences and address the deficiencies by developing an over-arching interdisciplinary practicum concentration (IPC), equivalent to a minor, that with appropriate customization will be available for the broadest set of students possible and will promote collaborations between faculty, departments, and colleges/schools across the University.*

We intend to make IPC the basis of a broad initiative that is *significant* and *available to a wide-range of students*. It will be developed in a way that enables, over time, numerous interdisciplinary practicum opportunities covering a wide-range of activities such as student competitions, society driven projects, collaborations with industry, research and development driven. The IPC will therefore be developed to allow flexibility and will focus on essential core requirements that we deem common aspects of "real world" problems. Like a minor in the College of LSA or a concentration in the College of Engineering, it will "ride on top" or enhance and not compete with existing undergraduate degree programs. Further, the IPC will provide a common vision that can be coherently and broadly communicated to our students, faculty, and sponsors.

From the outset we intend to develop the overall initiative with sustainability in mind. There is already an existing core of faculty participating in similar activities. Every indication we have is that industry will be highly supportive and be motivated for philanthropic, student recruiting, and practical reasons. Strong alumni support is also expected. As a concentration or minor, additional student credit hours will be generated.

For hands-on experiences we intend to start with two practicum pilot-projects followed by others in the second and third years to "prime the pump" of our initiative. One already involves faculty from several departments and the other we expect will engage students and faculty from multiple colleges/schools. We will start with an ongoing "Space Exploration" initiative already attracting students from numerous departments in engineering and the sciences. These projects address innovative solutions to problems arising from the exploration of the Earth, other planets and beyond from space platforms. Last year, over 200 students and nearly a dozen faculty from several departments were involved in several significant multidisciplinary projects. Some of these activities were part of formal courses while many involved student run projects. We have already worked for years to develop the existing opportunities for the students (some students have been involved both as undergrads and graduate students). The major challenge for the Space Exploration Problems initiative thus is in the integration and development of a sustainable curricular component within the framework of the IPC.

Our second pilot project is intended to build upon several initiatives creating student opportunities in a "Service Learning" initiative requiring technology and/or organizational solutions. Some on-going activities within engineering include ProCEED-Program for Community Engagement in Engineering Design and BLUELab-Better Living Using Engineering Laboratory (formerly Engineers Without Borders). Our goal will be to involve these and other initiatives in to a broader sustainable program that can be assisted by the IPC initiative focus. We believe that especially this kind of interdisciplinary practicum experience can benefit from drawing in students from across the University as indicated by the endorsement from the Ginsberg Center for Community Service and Learning.

Justification

Consider the following examples of students engaging in extra-curricular experiences with huge impact on their academic development:

- After being engaged starting as a freshman in the multi-disciplinary development of Michigan's first-ever student-built satellite, Icarus, for a NASA mission, one of our students found herself developing mission contingency plans for a NASA manager as a junior. As a senior, she developed a new spacecraft and mission design for NASA-JPL during a summer internship showing skills beyond her academic level. Even in a period of budget cuts, it was not surprising to learn that she was a "strategic hire" for JPL.
- For sixteen years now, students in Michigan's solar car team have undertaken the substantial effort of the development, finance, logistics, and racing of a solar car across thousands of miles in North America and Australia. They have earned 4 national championships out of 8 races; more than Bo Schembechler! Solar car student "alumni" have taken lead responsibility for training the next generation of solar car student racers showing one paradigm for sustainability.
- Based largely on an initial ENG 100 freshman class project conceiving a real-time UM bus-tracking system, the MAGIC Bus student project is nearing its initial deployment of a complete prototype GPS tracking system for UM's Transportation Services.
- Michigian students investigate and develop water purification systems for rural homes in the third world.
- Students designed a mobile transfer system for a local wheel chair bound resident.
- Recently, a major California company invested hundreds of thousands of dollars for a team of interdisciplinary students to develop an innovative commercial space imaging system of the Earth's surface (the GoBlueImager). The students are now developing critical sub-system to demonstrate the viability of their concept.

Industry seek out students with real-world experiences because they have generally achieved a level of wisdom beyond their academic level in terms of raw experience, have a better idea what they want to do, generally have a stronger intuitive understanding of their book-learned knowledge, plus many other advantages. However, students, for the most part, have had to acquire these experiences as extra-curricular activities with little or no academic credit even though it has been a very important part of their overall academic training. The students that have participated in complete development cycles of these projects have demonstrated industriousness and nimble thought; and graduate with a broad-base of experience, knowledge and wisdom. These outcomes are exactly what we try to obtain by means of our regular curricula, but have difficulty in achieving. The purpose of this practicum is to promote and enhance these academic developments.

We believe industry will be very supportive of our efforts to create the IPC and student practicum experiences. Daryl Weinert, Director of Corporate Relations for the College of Engineering writes in an attached letter that "The proposed practicum concentration would enable the College to better organize its existing student project activities, but more importantly it would provide a structure to enable multi-disciplinary project activities. It would also enhance our ability to pursue corporate and alumni support to make these efforts sustainable."

Most faculty can immediately see the benefits. However, concerns for excessive time involvement is often one reason given for not directly participating in these activities. This is an understandable concern that must be addressed for any effort to be sustainable. However, consider one of our student managed projects – the Student Space Systems Fabrication Laboratory (S3FL). Last year there were approximately 140 students involved in S3FL addressing several projects with just 2 faculty advisors. The reason that so many students could be "handled" was because the students took so much responsibility to self-organize. Further, juniors, seniors, and grad students have taken the initiative to mentor sophomores and freshman entering S3FL in the spirit of a "see one, do one, teach one" teaching model. Our own students are an un-tapped resource.

We believe the IPC and a wide range of student practicum experiences can provide significant experience to our students and a simple message that can be communicated to students, faculty, and potential sponsors.

Detailed Description of Program

Program Elements

Our program plan can be summarized as follows:

- We propose to implement an over-arching interdisciplinary practicum concentration (IPC) that, with variations, would be appropriate for students from numerous UM colleges/schools in this initiative.[1] Undertaking a substantial interdisciplinary experience would be at the core of the concentration requirements. As such, faculty and students from multiple academic units would be associated with any multi-disciplinary project.
- We will establish and operate a counsel of faculty and staff that will guide the overall initiative and will oversee
    - a practicum concentration/minor sub-team to develop the details and work with various academic units to adapt the practicum, and monitors its implementation
    - an "outreach" sub-team focusing on developing broader collaborations among university units and creation of an infrastructure to promote new practicum opportunities, and
    - a sustainability sub-team to develop and implement a process for attracting outside support and developing a viable internal cost structure
- We will establish of several pilot-projects involving faculty from different disciplines that provide a path for meeting the practicum concentration (in engineering or equivalent in other colleges/schools). We are proposing two initial pilot-projects with the intention to implement at least a third in the second or third year of the program that builds on the experiences of the first two. Our first two projects are planned to be: (1) a "Space Exploration Problems" initiative, and (2) a "Community Service and Society Needs" initiative.

The Practicum Concentration

We envision some key features of the IPC to include:

1. The practicum concentration will meet certain top-level academic outcomes requiring a minimum of 12 credit hours spread between hands-on efforts and a limited number of special or existing courses and seminar activities;
2. A student completing the concentration requirements would have it noted in their transcript (for example in Engineering: B.S. in [Name your Program] with Practicum);
3. The practicum concentration is intended be designed to be independent of the various existing degree programs and their requirements. However, like other concentrations it needs to be approved by each program and may involve specialization. For example students will be able to use free-electives hours and some programs might allow certain aspects of the practicum to count for some required courses. Therefore, a student in a specific program for the College of Engineering might satisfy the IPC with a total number of credit hours less than 128 + 12.

The IPC *curricular elements* will be scaled to fit within a minimum of 12 credit hours. We are proposing the College of Engineering practicum could consist of 4 distinct elements. These include an introductory system level experience, courses involving diverse product realization, activities in mentoring/advising/leadership, and a capstone multi-term design-build-test project. The outcomes of each of the elements is discussed below:

1. Introductory System Experience: The intent here is to expose students to an entire system. This may necessarily involve a design-build-test component. An example of this type of activity would be Eng 100-700 (an introduction to space systems engineering, culminating in the flying of Martian scaled blimps) or Eng 100-800 (designing, building and operating a simple computer). An introductory experience would also need to be offered to for transfer students and students not in the College of Engineering.

2. Product Realization: The purpose of this element is to enhance a student's experience with the fabrication of a breadth of components. Many programs emphasize the application of scientific principles. This would

[1] This could be a realized as a minor in some colleges/schools and some could even opt to integrate the practicum more closely within an existing program. Here, we will discuss the proposal in the terms of a *concentration* in the College of Engineering with the understanding that customization would almost certainly be needed in various colleges/schools. For example in the College of Literature Science and Arts, this would likely fit the template of a *minor*.

provide a foundation to realize a design. For example, a Computer Engineering student might be required to take a course that might include the design and fabrication involving both hardware and software (e.g. EECS 373) and perhaps another course that builds mechanical components (e.g. ME 250).

3. Mentoring, Advising, Leadership: The goal here is to have a student involved in the mentorship/advising/leadership of their younger peers in the spirit of a "see one, do one, teach one" educational philosophy. One way to enhance a student's own education is to involve them in such duties. Further, it helps promote the early and significant engagement of younger students in to a team.

4. Capstone multi-term DBT project: The practicum would culminate in a substantial design-build-test project. Here, we apply DBT in its broadest definition. In the College of Engineering, this activity is distinguished from typical program capstone or major design experiences by the DBT requirement, the multi-term span, and the involvement of several layers of teamwork and management.

One path for a student to satisfy this template would be to maintain a consistent theme. For instance for the Space Exploration Initiative, a first year student might first take the sequence ENG 100 (Sect-700), EECS 215, ME 250, lead a microgravity flight (NASA C-9) team and be a member of a one or two year satellite project. Some of these activities might occur in parallel. However, one of the reasons to map out a template is to allow a student some flexibility. A student might take an alternate introductory course, learn about different fabrication techniques, lead a team involved in community service and still be a member of the satellite project culminating in a Space Exploration practicum. For example, the precise project that is covered in the introductory experience does not drive the end project - the purpose of the first outcome is to give a student an appreciation of an overall system and some techniques to manage them. A reason to map out a curricular template is to allow students flexibility in mixing their experiences as their own personal and career goals evolve.

Schedule

We currently plan to organize this initiative in four phases.

Phase 0, **Fall 2006:** It will focus on initial development of the IPC, to establish stronger ties between schools and colleges, to identify an operational counsel made up of faculty, staff, and students. This counsel will manage the overall IPC initiative, and develop the pilot projects.

Phase 1, from Winter to Summer 2007: It will focus on formalizing the IPC, initiating the operational counsel, communicating the initiative among faculty plus potential sponsors, starting the pilot projects, and identifying a third pilot project.

Phase 2, from Fall 2007 to Summer 2008: The IPC will be fully implemented during this phase. The students will work on the first two pilot projects, and the third project will be developed. The guidelines for developing new projects will be established.

Phase 3, from Fall 2008 to Summer 2009: We will study the feedbacks from students, faculty and industry partners and revise the curriculum, project selection guidelines, and mentorship program. MLTT support of the first two pilot projects will be ramped down in this year to allow measurement of sustainability.

Space Exploration Problems Pilot-Project

This project is intended to capture the curricular merit and promote the system engineering of vehicles and scientific payloads. A detailed description is given of this pilot-project in *Appendix A*. This project already has elements of a multi-disciplinary, real-world practicum with over 200 students and nearly a dozen faculty involved from several departments last year. However, the curricular connection is limited, unfocussed, and most student projects were largely uncoordinated. As a pilot-project, it will be possible to focus on integrating on-going student practicum projects to the new IPC. Further, we hope to expand collaborations between not only engineering fields but also at least basic science disciplines.

Service Learning Pilot-Project

This project is intended to promote solutions to contemporary societal problems. A detailed description is given of this pilot-project in *Appendix B*. Although there are already several activities on-going (e.g. BLUElab, ProCEED), there is a need to better coordinate these activities. And, it appears this pilot-project would be "a natural" in terms of drawing together an especially diverse group from across the campus building on going efforts such as is part of the Ginsberg Center for Community Service and Learning.

Multi-Disciplinary elements of Program

The capstone-level projects that are acceptable to the practicum will inherently be solving a top-down-level problem. These problems start with customer requirements and needs, and the solution strategies are subsequently derived. Solving system-wide problems inherently involve collaborations across typical academic disciplines. Very rarely can the system drivers be identified apriori. The current pilot projects span most of the College of Engineering, but, we would like to expand on ideas where this initiative might promote expanded collaboration.

- As already noted – Collaboration with Ginsberg Center for Community Service and Learning
- Engagement with Business School Multi-disciplinary Action Project (MAP) first year MBA students
- Coordination with Urban Planning masters students community projects
- Coordination with the College of Engineering and Business School Tauber Manufacturring Institute (TMI)
- Connection with the Vice-President for Research's new initiatives in entrepreneurial culture

Establishing broader linkages and collaborations are important to the long-term viability of the practicum.

Target Enrollments

The simple answer for target enrollments is hundreds to ultimately even thousands across the university over the three to five year timeframe. An important point here is that this can be part of a single vision theme that can be effectively "sold" to a broad number of potential student and faculty participants as well as external sponsors and users.

For the next several years, we plan to measure our success in terms of participation by identifying interest (students requesting participation), the number of practicum of projects being planned, as well as the increase in the number of faculty and students actively involved. Moreover, we plan to track randomly selected students graduating with and without the practicum concentration and compare their job placement, satisfaction and success.

Team Teaching Model

Since the IPC must be interdisciplinary, the faculty involved must also be interdisciplinary. Faculty must collaborate in establishing project objectives and measuring results. Further, faculty may very well be involved with the end-user or sponsor for a project, thus learning for them selves the real-world issues of the projects. The proposed introductory level courses and capstone-level courses necessarily involve experts from a variety of areas, with a single instructor acting as the focal point. We have used this model to effectively teach courses like Eng 100-700, Eng 450, Aero 483 and Aero/AOSS 582 and 583. Given this experience we believe that it will translate to other courses.

Methods of Evaluation (student outcomes, teaching collaborations, and overall benefits of program)

Student Outcomes and Teaching Collaborations – Our experience has been that the best and easiest method to measure student outcomes and teaching collaborations through project progress reviews by faculty and industry technical experts. In these reviews, the students must defend the logic and design/development priority used. Whether the students "get it" is a quick way to learn if the educational approach is working.

The expectation is that the steering committee will coordinate several activities. The most important activity will be to sponsor an interaction to share best practices. For instance, the techniques and methodologies to effectively and efficiency teach first year design-build-test courses are under development. The course Eng 100-700 has been taught two times and the course is now incorporating a peer mentoring component to help upper level students connect with first-years. This is being done to both give the upper-level students valuable experience, but also in an attempt to make sure that no first-year students get lost as the course size is increased.

Similarly the methodologies and techniques used in the capstone projects are under constant development as we learn how to effectively integrate the student teams and interact with the sponsors. For example, last year we set-up the Aero/AOSS 583 students to perform two tasks with the Aero 483 students. One task was to have teams of students provide detailed training and problem solving sessions on specific simulation software. This led to the very desirable behavior of having close interaction of graduate and undergraduate students. It also naturally identified certain graduate students as expert resources. The second task was to have the 583 students act as reviewers for the 483 projects. This step was spectacular in that we had over 30 sets of eyes reviewing the student projects leading to an unprecedented level of professionalism in the class. Our intention is to continue this process of self-evaluation.

Overall Program Benefits – In the end, the primary measure comes from the feedback of graduated students and the project sponsors versus the cost and effort. For example, recently we had a student write about her time in our S3FL project: "*I learned so much from my time with you at S3FL, both technically and administratively. To this day I still **laud the experience** and the **high standards that the lab sets** to my colleagues here at GE. S3FL does an excellent job preparing students to be valuable engineers.*"

Sustainability Plan

We plan to start from the beginning to develop this initiative with sustainability in mind. For the practicum experience, sustainability requires:

- Student and faculty interest and participation
- Adequate financial and resource support
- An operational model that does not over burden the faculty time

We are quite certain that there will be generally broad student interest. Faculty interest is generally not the issue. Rather it is a question of participation that usually goes back to the question of time involvement. As in anything, one can spend more time. However, by requiring students to largely self-organize and by engaging in the "see one, do one, teach one" teaching model. Faculty time involvement can constrained depending on their interest.

External funds will be essential to keep any project going. College of Engineering Corporate Relations assessment (see endorsement by Daryl Weinert) is that an IPC will resonate well with industry. We also think it will present well with our alumni. We intend to have corporate relations represented on the IPC counsel.

One of the reasons to integrate these activities into the curriculum is to tie in with one of our most fundamental mission of education. There are processes in place to support courses of all types. The goal here is to make certain critical aspects of the practicum supported in a regular way by means of usual course offerings. For instance, once a lab is set-up to educate first year students, the funds to support the equipment will come from typical instructional laboratory equipments funds. Thus is it very important to involve a sufficient number of students in the labs to justify this continuing expense.

Proposed Budget

At this time, we have estimates for costs to establish and run the Counsel and support initial efforts for our first two pilot-projects. Financial support will come from at least three sources in the first three years: the MLTT initiative, the College of Engineering, and outside industry and donors. This list will likely grow as we move forward with planning. A summary of the oversight costs, as well as the yearly costs for the pilot projects are listed below.

Table 1: Proposed Budget for Counsel and General Operations:

Resource	Description	Year 1	Year 2	Year 3
Personnel • Fac. lead (5% AY, 1 summer month) • Staff – Program Coord (50%) • Staff – Sustainability (50%)	Run program over see Curricular Development Administer program Support Counsel, Coord Colleges/Schools Industry/External projects coordinator	$20K Cost-Share Cost-Share	$20K Cost-Share Cost-Share	$20K Cost-Share Cost-Share
Central Equipment Support	Laboratory equipment/supplies for all projects	$25k	$25k	
Office Space		Cost Share	Cost Share	Cost Share
Yearly Totals		$45K	$45K	$20K

The costs are heavily weighted toward the pilot projects. The purpose here is to develop curriculum and the place where it is being created is in the projects. Consequently the oversight costs are kept to a minimum.

Table 2: Proposed Budget for Space Exploration Pilot-Project:

Resource	Description	Year 1	Year 2	Year 3
Introductory Lab Refurbishment (e.g. 2243 FXB)	Removal and redeployment of existing experiments	Cost Share	0	0
Introductory Lab Equipment	10 lab stations to run 20 students per section for a variety of DBT lab projects	$25K	25k	0
Project Lab Refurbishment (e.g. 1225 SRB)	Room Partitioning and Heating, Vent. and elect. 5 lab stations	Cost Share	0	0
GSI/Student Support	Lab development and Prototyping Teaching prototyping	$50K	$50K	$50K
Staff Support	Lab development and Prototyping Initial lab supervision	$50K	$50K	$50K
Yearly Totals		$125K	$125K	$100K

Table 3: Proposed Budget for Service-Learning Pilot-Project:

Resource	Description	Year 1	Year 2	Year 3
Personnel • Fac. lead (33%, 33%, 25%) • Admin. Sup. (50%)	Run program Project Support	$45K $35K	$45K $35K	$34K $35K
Operating Funds	Initially $4K per team per year, with increasing numbers of teams each year. Will seek Government and/or Industry funding – to be used for materials/supplies, transportation to and from community partner client/user site…	$16K (4 teams)	$16K (8 teams)	$16K (16 teams)
Space	Need appropriate Course Meeting, Team Meeting and Lab space, possibly in the Student Project Building.	Cost Share	Cost Share	Cost Share
Yearly Totals		$96K	$96K	$85K
MLTT Total		$266k	$266k	$205k

There are distinct differences in the two approaches for each of the projects. This is due to the different nature of the projects. The space exploration initiative is heavily hardware dependent, and is consequently focused on the creation of lab space, and equipment acquisition and maintenance. It has costs that are front-loaded. The labs that are envisioned are system wide, but they have a technical focus. This is in contrast to the service-learning project that requires more and persistent organization. In addition the projects can be quite varied. Another difference is that the faculty associated with the space exploration initiative frequently, either get contacts for projects through their research activities or in some case sponsors approach them. These projects tend to involve at least a dozen students at a time. The Service-learning project is expected to involve more effort in obtaining projects. It is also likely that these projects will have smaller teams.

We recognize that these costs are significant. They are, however, our current best estimate. Negotiations regarding space and cost sharing with the Departments and the College of Engineering are on-going. The creation of a practicum in the curriculum is a very substantial effort and each unit is coming to grips with its value.

Appendices

A - Space Exploration Pilot-Project Details:

B - Service-Learning Pilot-Project Details:

Appendix A

Space Exploration Initiative

Systems Engineering by means of Design-Build-Test of Complex Flight Systems

<u>Introduction</u>

Why Space Exploration? The first space instrument that flew on-board Explorer 1, the first American satellite, led to the discovery of the Van Allen radiation belts in 1958. Since then, space exploration has taken us to the Moon, all other planets of the solar system and beyond. It has revealed an inspiring and unimaginable universe, a world that is connected to its roots; observations of the farthest boundaries of the universe tell the story of its first few minutes of formation.

Space exploration has been having a profound impact on our society. Indeed, it has fundamentally transformed our understanding of the world. Images of the Earth from space show that we live on a single and fragile planet (Figure 1). Therefore, the fates of all people on Earth are interconnected. Data taken from Earth orbiting spacecraft reveal disturbing changes in our planet's environment such as the Ozone hole, the melting of glaciers, and the rise in global temperature. These human induced changes jeopardize the future of our environment and the quality of life for generations to come.

Our access to space allows solutions to human problems, in ways that could not be easily addressed otherwise. Today's long distance communications and efficient transport systems are possible because of space technologies. Space exploration problems are both complex and inspiring, and provide ample opportunity for students to apply what they learned in the classroom. These problems require complete system architecture and are therefore multidisciplinary, challenging, and require the use all skills that need to be developed during the Practicum Concentration that we are proposing.

Figure A-1: Image of the Earth from the Moon. This image is both not only about technology, but also about a new and integrated view of the world, enabled by space exploration.

We have been using space exploration projects to train students in hands on activities for more than five years, both in formal courses and in extra-curricular activities. One example of each is given next. We developed a Multidisciplinary Engineering Design (ENG 450) course in partnership with NASA's Jet Propulsion Laboratory (JPL) and one of us has been teaching it since January 2004. ENG 450 is a capstone design course in which teams of students from engineering and science departments work together on space exploration projects. Industry experts mentor the student teams and come to the University of Michigan to give guest lectures and meet with the students. JPL and the aerospace industry have been actively participating of ENG 450, not only because it trains the students in practical problems, but also because it gives them the opportunity to observe the students and recruit them. They have been hiring a large fraction of the students that take the course.

NASA and various corporations have been funding ENG 450 projects because they benefit from creative solutions to some of their real problems. For example, the Phoenix thruster experiment started with a team on students in January 2005 and is now an official part of the validation plan of NASA's 2007 mission to Mars. Currently, NASA is supporting a graduate student working on this project, and Lockheed Martin (the main contractor for this mission to Mars) is proving additional support for hardware fabrication, equipment, and staff salary. The winter 2006 ENG 450 course included joint projects with the Jet Propulsion Laboratory, the Aerospace Corporation, The Astrobiology Institute, Cameron Balloons, Advanced Technology Center, and Lockheed Martin Space Systems. This course is self-supported and extremely popular with students. Students have been signing in since May 2006, to take it in January 2007. ENG 450 is an example of a capstone activity of a Space Exploration Initiative version of the practicum.

There are comparable activities that we also seek make part of the practicum as elective classes. The Student Space System Fabrication Laboratory (S3FL) is a student-led organization dedicated to providing students with practical space systems design and fabrication experiences. S3FL students lead the design, analysis, test, fabrication, integration and operation of new payloads for flight vehicles and spacecraft. They work on projects ranging from small payloads for stratospheric balloons and aircraft, to large-scale efforts such as Get Away Special (GAS) payloads for NASA's Space shuttle missions. One of these payloads was the VOrtex Ring Transit EXperiment (VORTEX), which studied the influence of vortex rings traversing the boundary of two dissimilar fluids in zero gravity. More recently the students designed, built and fabricated an end-mass for the NASA ProSeds mission. This payload was called ICARUS and was a tethered satellite complete with complete power, computer, navigation and telemetry system. This past year there were over 120 students from across the College involved in S3FL managed projects. Many of these projects are also self-sustaining. The current project to fabricate a tethered satellite testbed is being funded by the US Air Force nano-satellite program.

Example Space Exploration Projects

Various space exploration projects led by some of us have involved a large number of students in a multidisciplinary environment, consistent with the Practicum requirements outlined above. These projects, and their impact on research and educational goals, are briefly described below. They are intended to be examples of activities that will be further developed into a capstone level projects of the practicum curriculum.

ENG 450 Mars Balloon: A novel balloon for the exploration of Mars, and the upper atmosphere of the Earth other planets has been developed by faculty and students. This project involved a dozen students as part of a two-semester capstone multidisciplinary design sequence. The goal of the proposed Mars balloon mission is to study the cycle of organics on Mars, and their evolution during Mars' history. Lockheed Martin and NASA are now supporting the concept mission developed by us for refinements and

Figure A-2: ENG 450 Mars Balloon Tethered the development of a proposal for a real mission to Mars that will be led by the University of Michigan. Students from aerospace engineering, mechanical engineering, materials science, planetary sciences, and biomedical engineering were involved in this project. The innovative balloon inflation system that was developed for this project was prototyped and is shown in the image on the upper right. The proposed inflation system is a novel combination of a parachute and a balloon that allows large and thin envelops to be safely inflated during high-speed descent from orbit. Students get excited about working in challenging projects such as this one. More than 120 students already contacted us to try to work in it during the fall of 2006.

ENG 450 Phoenix Thruster Experiment: Engineers from JPL and Lockheed Martin were having difficulty simulating the effects of the Phoenix, NASA 2007 Mars Lander, on the surface of Mars during landing. In the winter of 2005 a team of students designed, fabricated and tested a laboratory simulator of the effects of the thrusters on the surface. The results of their initial tests were very encouraging, so NASA and Lockheed Martin sent a team of engineer to inspect their simulator at the University of Michigan. In December of 2005 NASA decided to make this student project an official part of the validation and verification plan of the Mars mission. Now, we are building on this success and a new group of students will design, fabricate and test an experiment to study the effects of a comparable thruster of the Joint Striker Fighter on surfaces.

S3FL VORTEX: The S3FL has sponsored four large-scale projects since its inception. The first project, over a decade ago, was VORTEX. The VOrtex Ring Transit EXperiment (VORTEX) studied the dynamics of vortex rings traversing the boundary of two dissimilar fluids in zero gravity. This experiment consisted of flight qualified structures, computers and data systems. During the flight a small chamber was repeatedly filled with a set of dissimilar fluids and an annular vortex generator set up a ring vortex in one fluid with an initial velocity toward the other. The motion was recorded using backlight illumination and a series of small video cameras. The experiment flew twice as a Get Away Special (GAS) payload on the NASA space shuttle. This project was student initiated and led. Alumni of S3FL have had remarkable impact. These students have gone on to be strategic or recruited hires at NASA, the DOD and by our peer institutions.

Figure A-3: S3FL VORTEX

Fast Imaging Plasma Spectrometer (FIPS): The FIPS instrument has been funded by NASA and is currently on the way to the planet Mercury, where it will provide the first measurements of Mercury’s environment, composition and dynamics. FIPS was designed and built at the University of Michigan, by faculty, a dozen professional staff, and students. FIPS involved three graduate students

Figure A-4: FIPS Flight Instrument

and forty undergraduate students of various departments such as electrical engineering, mechanical engineering, aerospace engineering, and planetary physics. All students were actively involved in the instrument development, and often performed important tasks independently. The primary objective of FIPS was basic research, but such projects have benefited tremendously from student involvement. It is conceivable that students could indeed develop instruments for space flight, such as recently demonstrated by the University of Colorado, where an entire sensor was designed and built by students for the New Horizons spacecraft currently en route to Pluto.

GoBlue Imager Project: Earth imaging is revolutionizing the use and distribution of geographically relevant data. Initiated by a small startup company, keyhole.com, Earth imaging data are used to zoom in and out of a given location and therefore understand the geographical relation of any two locations on Earth. These applications are quickly changing how geographically relevant information is distributed and searched. Initial commercial applications include Earth Google, Teraserver, Microsoft. and others. Disciplines addressed in this study are wide-ranging, but involve: space science, metrology, aerospace engineering, optics, data systems, communications systems, and many more.

This was a student project that involved two graduate classes (Aero/AOSS 582, 583) and one undergraduate class (Aero 483). The goal of this project was to develop a satellite to provide global images of Earth with 1 m of resolution. The project involved a total of 30 Masters students, 60 Undergrads, during three classes and summer projects that provided real-life hardware experiences for all students involved

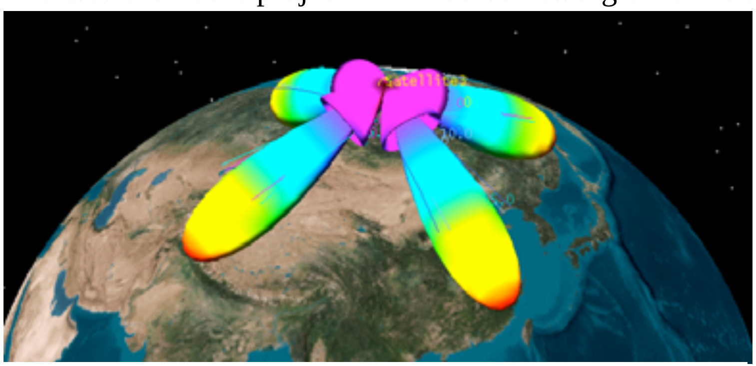

Figure A-5: Antenna Simulation of the GoBlue Imager

Magic Bus: Space technology also affects the University of Michigan bus system, as proven by the Magic Bus project that has recently become operational. Approximately 50 upper division undergraduate students, one faculty, and one professional staff worked on the Magic Bus project. Furthermore, over 200 incoming freshmen were actively involved in the project through their classes, developing, evaluating, and refining the project. The major disciplines involved were electrical engineering, computer science, mechanical and thermal engineering, industrial operations and atmospheric science. All U-M buses are now tracked using GPS receivers that provide their exact location, speed and heading. These locations, as well as auxiliary data, are transmitted through a telecommunications network, to a central database server. The raw data and the predicted time-of-arrival for every bus stop are provided via web sites such as http://mbus.pts.umich.edu/ and instant messenger

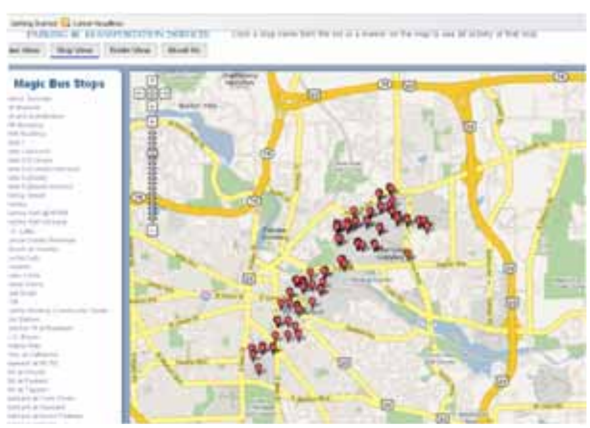

Figure A-6: Magic Bus web page

"bots" for the U-M Transportation Services administration and the general public.

Figure A-7: Balloon camera image.

Atmospheric Research Balloon: A balloon for suborbital exploration was developed by a group of 11 undergraduate and 4 graduate students. The balloon project involved the development of a payload bus to communicate with its scientific payload and track it's position and heading. An image taken with the balloon-borne camera is displayed on the left. Disciplines involved include atmospheric science, space science, aerospace engineering, and electrical engineering.

These are examples of projects that we seek to integrated into the practicum concentration. These projects are substantial in scope, multidisciplinary, involve technology development, applications for every-day use, and have the potential to have commercial impacts beyond the classroom and educational environment.

MLTT Goals and its Impact on our Current Activities in Space Exploration

As indicated above, many space exploration projects already exist at varying degrees of formality. The closest to being a sustainable part of a practicum concentration is ENG 450. It is already packaged as a course and has been offered repeatedly. The other projects have comparable merit but their curricular connections are more tenuous or intermittent. MLTT will improve and expand these activities by focusing on three areas:

1) **Provide Curriculum**. The Practicum will formalize and provide a standardized way for students to demonstrate that they have worked with open-ended problems. This is the major goal of MLTT. It will also allow interactions between projects that have not been available thus far. This will involve formalizing the curricular underpinnings leading up to the capstone projects. It will also involve refining the capstone projects to capture their curricular content.

2) **Enhance Common Facilities**. The Practicum projects require a number of common areas, tools and instruments that are not currently present or generally available in our existing academic programs. The creation of introductory design-build-test courses, courses that cover specific fabrication technologies and test techniques, and the capstone projects all require space and equipment. Currently the practicum activities exist intermittently. The goal here is not completely solve these space and equipment issues but to enhance them so that the essential core of activities can be sustained, prototyped and substantiated.

3) **Enhance Staff Support**. It is clear from project descriptions above that there is a need for moderate staff support. Staff members would perform tasks that relate to development of design-build-test laboratory experiments, fabrication and testing experiments, and student safety and certification, Given their expertise in product realization, they would also be included in projects to support problem solving.

Curriculum Development

Our goal is to collect classes and projects into a coherent sequence that allow students to experience a set of realistic design-build-test-operate cycles, culminating in a capstone project. In certain cases it will be necessary to create new variants or classes or completely new projects. We envision classes and project activities starting at the first year and spanning though all levels. There will be a set of courses that are specific to a particular practicum initiative and those that can be common.

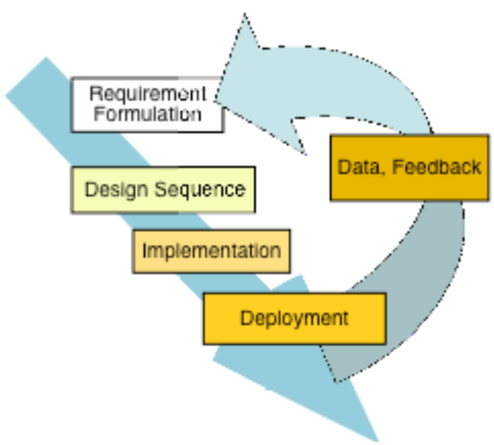

Figure A-8: Engineering design cycle enabled by Practicum projects. The completion of an entire cycle is a fundamental part of the "Practice"

For undergraduate students in the College of Engineering, there is a logical path that starts in one or both of the required first year classes (Eng 100 and 101). Preferably, but not a condition for future participation, is that the class be based on a design-build-test cycle. An Eng-100 offering consistent with that cycle is currently being prototyped by Aero faculty (Washabaugh) and are under discussion in NAME and AOSS. A variant of Eng 101 that incorporates the design-build-test of a computer is being offered by EECS faculty (Chen). By choosing a particular elective, these classes are examples of how a student could initiate a concentration in practice.

The Eng 100 variant is an intensive course that introduces first year students to an entire flight system. The course, Engineering 100-700, consists of four parallel and synergistically interwoven activities. These include lectures and activities on technical and engineering principles, technical communications, and teamwork; individual labs on instrumentation and fabrication techniques; and a sequence of team design-build-test projects. The final project involves the fabrication, testing and a competition of a lighter-than-air remote controlled vehicle that is designed for Martian operation but scaled to function in a terrestrial environment. The course is scheduled to have 6 contact hours per week over a 14- week term. Given its rigor and extensive time commitment, the course is unusually popular and has led to some desirable emergent behavior in subsequent

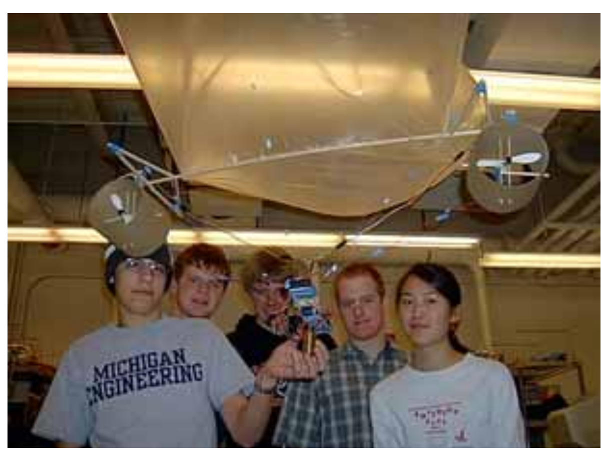

Figure A-9: Fall 2004 Eng 100-700 Class Team 5 Displaying their Blimp Design independent student projects. For example, the test facilities set-up for the first-year students have been used by S3FL students to diagnose their designs.

Our goal here is to find efficient variants and to institutionalize these first-year design-build-test offerings so that they can be offered regularly and would form a common entry point to the practicum. For instance, the existing blimp course is relatively expensive to offer. One large expense is due to the size of the blimps – they are difficult to store in a typical lab. Variants based upon a submersible (NAME) and another based upon a small balloon payload (AOSS) will be developed. The expectation is that both of these will have equivalent curricular merit, but have smaller footprints leading to better space utilization. Other courses need to be developed. For instance, another first year course could be modified as an entry point into the practicum. For example, Eng 101 covers introductory computer programming. It may be possible to offer a version that not only introduces programming but also introduces hardware. The students could program small mechanisms or robots with a variety of sensors. Another need is a sophomore level course primarily for transfer students (and first year students that didn't take a practicum version of Eng 100 or 101) as an entry point into the practicum.

To support these curricular step there is substantial development that needs to be accomplished. We are essentially inventing curricular material both in terms of the pedagogy and the physical hardware. Our proposed path is to follow in the footsteps of the Eng 100 blimp and computer courses. Here upper level students were given sample projects to first build and then dissect the flight hardware into a sequence of first-year student edible labs. The proposal here is to support these students at the rate of a 50% GSI over the term of 3 years. This would be ~ $50k per year. We would first seek to develop a submarine and then a balloon version of Eng 100. Later, a sophomore level course – likely based upon one of the Eng 100 variants – will be developed. Finally if time permits modification to Eng 101 in line with the practicum will be explored.

Space Practicum Facilities

The practicum and project classes in general have suffered from an incoherent approach within departments and within the College of Engineering. A majority of the facilities are dedicated to single projects and go through periods with little or no activity. During these periods, facilities degrade and become useless. Frequently projects get shuffled around between area and a tremendous amount of effort is expended simply collecting and maintaining sufficient equipment. Staff support is highly non-uniform and there is therefore a very high entry price for faculty attempting to use the facilities. There is also non-uniform process for use of these labs and there is concern about user safety. A coordinated facility will address all these disadvantages in a coherent approach with very limited investment needs.

There are some very immediate needs. For example one of the most important costs in offering a practicum version of Eng 100 is the size of the existing facility. We are borrowing the Aero graduate experimental methods lab which means that the course can only be offered when it doesn't interfere with the graduate program. Further, the current lab sections consist of 10 students. We need to double the size of the facility so that lab instructors can be more efficiently employed. The course will never have sufficient impact, or be financially viable or sustainable if it is limited to small lab sections. Similarly, all of the capstone projects have struggled to varying degrees with obtaining and then maintaining lab space. In some cases the projects were done on carts and shuffled between areas or utilized hallways. We propose to take a step toward solving some of these difficulties by two facility level up-grades.

Introductory Practicum Laboratory:
Since an Eng 100 introductory course has already been prototyped the path to take to make this effort sustainable is reasonably straightforward. The current lab consists of 5 lab stations and a general work area. A typical station is shown in figure 10. The need is to increase the number of stations to at least 10. Our proposal is to seek space to accomplish this expansion from the Aero Dept. Preliminary discussion have taken place to remove one of the 2 x 2 wind tunnels and combine is functionality with another. Along with other re-arrangements in scheduling this will free up a lab in FXB that could be used for this expansion. The proposed cost of equipping the area for with a computer workstation, portable instrumentation (power supplies, DMM, function generator, and oscilloscope), and prototyping area would be ~ $50k. The movement and re-integration of the 2 x 2 wind tunnel, and modification to the building infrastructure would be expected to be cost-shared.

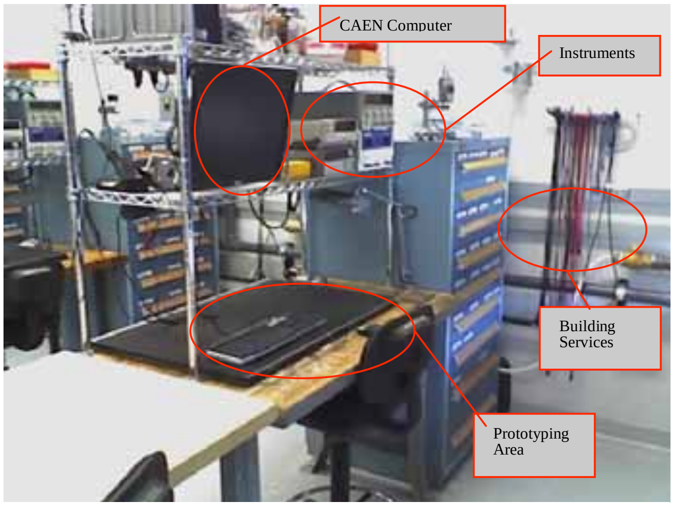

Figure A-10: Typical Eng 100 lab station (Aero Lab)

Multidisciplinary Design Facility (UM-IDF):
To address the needs of the capstone level projects we propose to integrate some existing facilities and construct a testing area in SRB. Figure 11 is a schematic of the UM-IDF and its user community. The UM-IDF falls into three distinct parts, each under the control of a given department, leading to three labs – IDF-AERO, IDF-AOSS, and IDF-EECS. IDF-AERO focuses on its strength of structure analysis and controls. IDF-AOSS focuses on testing, qualification, and system integration. IDF-EECS focuses on design and fabrication of boards and firmware. In principle, it is simple to think of enhancing this by adding more departments, as long as the complementary character is maintained and the interfaces between the different labs adhere to consistent standards.
The entry process for students into UM-IDF will be common for all students and involve a specific educational path to be outlined later. Departments will be responsible for maintaining and staffing these labs, though this is not anticipated to be a major cost due to the already existing resources which will be pooled for UM-IDF.

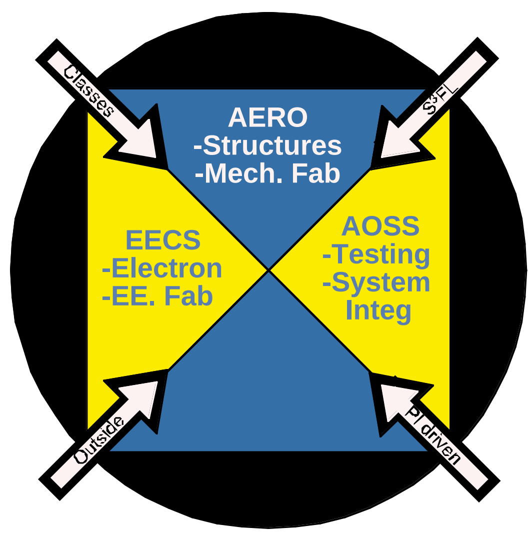

Figure A-11: The UM-IDF and its components. Even though individual labs, they adhere to a set of standards that allow seamless coordination between them.

There are currently facilities in the Aero and EECS department to address the fabrication of components. The difficulty is with the protocols to allow exterior students access and use the equipment. The hope is that by requiring an introductory course and perhaps a specialization course for the practicum there will be a formalism to train students across disciplines. The facilities in AOSS –Space Research Building (SRB) for testing and system integration are a different matter. The SRB is not student friendly. A space has been identified as a possible location for a student project lab. The proposal here is to assume that that AOSS and the College will cost share the infrastructural improvements (a wall addition, and card-reader installation) and support from MLTT will provide the base equipment to the lab. The base equipment is estimated at 5 lab stations or ~ $50k.

Staff-Support

Staff support is a critical element to achieve MLTT objectives. The support sought through this will address primarily the addition of facilities and the creation of new experiments in the curriculum. One the initial transient introductions have been satisfied, each area will be supported by the College and their respective Departments. We estimate that this cost will be in total ~ 50% staff member for a calendar year, accounting for ~$50k per year.

Funding and Budget

The main issues for this proposal are the start-up costs to take these prototype activities and make them sustainable. The costs described above account for $150k in initial costs to outfit two design-build-test areas. This assumes that other infrastructure will be cost-shared by Departments and the College of Engineering. In addition, there are three years of personnel costs to develop the hands-on activities. Each year this would account for ~$100k per year split between students and staff support. The current plan is to have the College and Departments pick up the costs of refurbishing the actual space. For the introductory lab in the FXB these costs are estimated to be less than $10k. The most pressing issue here is the movement and reintegration of a 2' x 2' wind tunnel. The refurbishment of the area in the Space Research Building ranges from $55k to $80k. The proposed space is actually a large lab that is being partitioned. The high estimate assumes that the heating, cooling and electrical services to the room will have to be re-worked.

Depending upon the level of support from the MLTT program, additional cost sharing may be sought from the College of Engineering. Or, we may need to live with a less than complete experiment. For example we would likely sacrifice a more permanent home for the introductory activities, thereby saving $100k up-front in order to sustain some of the capstone-activities. The rationale here is that the introductory experience can exist at least intermittently on a regular basis, while the capstone project space is a more pressing need.

After the initial start-up, capstone projects will still seek external sponsorship. A laboratory fee structure may be considered in the long run. This fee could be project or student paid, depending on the entry track of the student, and covers overall maintenance and staff support, as well as amortization of the facilities. In any case, after the three year period the expectation is that by coupling these activities with the curriculum, will allow the base infrastructure to be maintained through usual methods: Fundamentally, departments are responsible for the financing of their respective part of the UM-IDS facility. It should be expected that this will involve maintenance of the facilities and some limited staff support. Most departments already have staff support for teaching laboratories, and a consolidation of these labs is not expected to dramatically increase that cost.

Table A-1: Proposed Budget from MLTT

Resource	Description	Year 1	Year 2	Year 3
Introductory Lab Refurbishment (e.g. 2243 FXB)	Removal and redeployment of existing experiments	Cost Share	0	0
Introductory Lab Equipment	10 lab stations to run 20 students per section for a variety of DBT lab projects	$25K	$25K	0
Project Lab Refurbishment (e.g. 1225 SRB)	Room Partitioning and Heating, Vent. and elect. 5 lab stations	Cost Share	0	0
GSI/Student Support	Lab development and Prototyping Teaching prototyping	$50K	$50K	$50K
Staff Support	Lab development and Prototyping Initial lab supervision	$50K	$50K	$50K
Yearly Totals		$125K	$125K	$100K

Assessment

Determining if this is a successful effort ultimately will be determined by its impact on several fronts. Perhaps the most important metric will be national and international recognition of the results of the capstone projects. Another component will be the popularity in terms of the number of students involved in the practicum. Projects like Eng 450, GoBlue Imager, Magic Bus and the Student Space Systems Fabrication Lab are bursting at the seams with students trying to get involved. Hundreds of students, or the equivalent of a CoE Department (in terms of enrollment) are involved. Finally, since the practicum overlaps with the curriculum, we will have access to CRLT methodologies for course assessment. For example, the very first offering of Eng 100-700 involving the blimps had a course rating of 4.83 out of 5. This is at least partial evidence that students are eager for a practicum-like-effort.

Appendix B

Engineering in Society

Service-Learning in the College of Engineering that Connects Students across Michigan's Departments and Schools/Colleges

Introduction

Our second pilot project is intended to build upon several initiatives that foster student opportunities in service-learning. Service-learning is broadly defined as "a form of experiential education" in which students engage in activities that address human and community needs together with structured opportunities intentionally designed to promote student learning and development. Reflection and reciprocity are key concepts of service-learning.[1] As described in further detail later, this proposal describes a multi-discipline, vertically integrated (fresh, soph, jr, sr), multi-year approach to designing and implementing real projects with significant impact in our community into the engineering curriculum at Michigan. Within the College of Engineering we already have prototyped initiatives such as ProCEED-Program for Community Engagement in Engineering Design and BLUELab -Better Living Using Engineering (formerly Engineers Without Borders). Our goal will be to involve these and other initiatives in to a broader sustainable program that can be assisted by the IPC..

ProCEED

ProCEED aims to apply the engineering expertise of our students and faculty in efforts that will directly benefit members of the community. These can be projects that focus on just a few or many.

Examples of ProCEED projects include the a project to facilitate insulin dosing for the sight impaired. This is a device that can be programmed to draw up insulin into syringes from a variety of different manufacturers, according to specific patient's dosing requirements.

Figure B-1:Fall 2000 ProCEED Project, Insulin Dosing for the Sight Impaired

Figure B-2: Fall 1999 ProCEED Project: Mobile Transfer Device to Aid the Wheelchair-Bound

A number of projects have targeted those with physical disabilities. For instance, a reconfigurable wheelchair was developed for growing children to alleviate the a need for a persistent purchase. Similarly , a mobile transfer device to aid the wheelchair-bound was constructed. This device was for a person confined to a wheelchair. An action as simple as transferring from the wheelchair to a bed can be impossible without some assistance. For this reason, there is a need for a device that would allow a disabled individual to make this transfer on his or her own. Working closely with the customer who is in need of such a device, the student design team developed an innovative design that will uniquely fill this need. The device is mounted on casters for mobility within the living environment and docks with the wheelchair. It has a boom, which can swivel and carries a sling for transferring patient to and from wheelchair to bed. An electric motor powered by the wheelchair battery drives a winch, which is attached to the sling via ropes and pulleys.

BLUELab

These projects seek to have a more global impact. Students involved in BLUE have coordinated a seminar series for the past three year. They have also engaged applying their beliefs and skills. For example, a current project is a comparative assessment of point-of-use water purification systems for reducing infant mortality in developing countries. BLUElab has been working with Rancho al Medio, a community in the Dominican Republic with no access to clean drinking water. The Dominican Water Project was initiated in January 2005 to determine the most appropriate point-of-use water treatment technology for rural households in developing countries. The objective has been to help this community develop a method to provide clean water that is effective, regionally viable, sustainable, and inexpensive. In the process, the participating students have learned about the social impact their work can have on others. The collaboration with Rancho al Medio has been multidisciplinary and allowed engineers to work side-by-side with public health and medical students. Many of the students that have participated have been Hispanic or women, suggesting that this type of project will foster diversity in engineering education. Finally, and perhaps most importantly, the project has exposed engineering students to challenges they had previous not encountered in their textbooks or internships.

Figure B-3: BLUE Project: Assessment of Point-of-Use Water Purification Systems for Reducing Infant Mortality in Developing Countries; Students working in the Dominican Republic

Three water purification systems were developed based on existing designs, a dual bucket gravity flow system with both a cloth and activated carbon filter; a two bucket colloidal silver coated ceramic filter; and a two liter plastic soda bottle sterilization system (SODIS) [3]. Each system was easy to assemble, durable, and inexpensive. Prototypes were built in the US to determine the most effective technology under controlled conditions. In Rancho al Medio, a baseline health survey was performed of the participating families to determine the prevalence of water-borne illnesses in the families. The quality of each family's water was benchmarked using a series of indicators including E. coli plate counts. A prototype of the dual bucket and the SODIS systems were distributed to 30 households, for a total of 60 participating families. The ceramic filter was not distributed because of difficulty manufacturing units inexpensively near the community. After a twelve-month trial period, the houses were surveyed a second time to identify if there was a significant improvement in family health as a result of using the system. Data was also gathered about ease of use of the systems, durability, and effectiveness at purifying water under field conditions.

Figure B-4. Conceptual illustration of the AWARE@home system. Electronic accumulators and wireless transmitters connect to existing metering technologies (gas, electric, water). A USB-compatible receiver is utilized, along with a device to monitor & transmit electricity consumption of single appliances "plugged in to the wall".

Another BLUE lab project is "AWARE@home". AWARE@home is a simple-to-use technology for Americans to monitor their own utility consumption patterns. It empowers consumers to save money, conserve resources, and get more in-touch with their "environmental footprint" in both the short-term and the long-term. In the long term, the tool stands to serve the Nation well as a catalyst for positive change in infrastructure, markets, and government-citizen interaction. By reducing U.S. household consumption of natural gas, water, and electricity, AWARE@home will help to shift the environmental focus and discussion from developing new infrastructure (putting solutions well off into the future) to much more inexpensively improving the existing infrastructure and consumption patterns today.

The AWARE@home prototype system, developed through EPA P^3 funding, provides computer users the ability to view their own utility usage (natural gas, electricity, and oil) and expenditures with the click of a button. Since consumers are generally too busy to actively keep track of usage, the system has a simple interface that only asks the user to input the rates he or she pays for utilities and how much he or she is willing to spend on utilities each month. When this amount is to be exceeded in a given month (say, two weeks into the billing cycle) the system either sends an email or triggers a pop-up window. With no effort at all, except for a simple 5 minute up-front installation, the user is given information regarding excess consumption on which he or she can choose to act. As we have proven in this project, the AWARE@home concept is compatible with today's metering technology, and existing meter designs can be modified with minimal overhead to be compatible with in-home networks (e.g., wireless 802.11b standard). This serves as a natural compliment to already on-going efforts by utility providers to retrofit utility meters with the capability to contact the service provider with consumption information (e.g., using cell phone and modem technology distinct from that utilized in the AWARE@home system). The full AWARE@home system is conceptualized in Figure 4. The project won the 2005 EPA P^3 Sustainable Design Award and is continuing with participation from DTE Energy. A fully functional prototype is installed and working on the house of Professor Skerlos.

We are also looking to draw concepts from the Engineering Projects In Community Service (EPICS) program initiated at Purdue University (e.g. http://epics.ecn.purdue.edu/). We believe that especially a service-learning driven interdisciplinary practicum experience can benefit from drawing in students from across the University. We seek collaborations, for example, with the Ginsberg Center for Community Service and Learning. The current projects would form the foundation for this broader effort. The pilot project describe below would make the existing activities sustainable, allow for broader participation and greater impact.

Strategic Service-Learning Goals

- Develop a experientially-rich curriculum that is consistent with the academic objectives of the University and associated colleges/schools;
- Implement projects with high societal and environmental value that can motivate and draw a broad-spectrum of students;
- Improve recruitment and retention of engineering students; particularly females and under-represented minorities.

Implementation Plan for The University of Michigan

What follows is a summary of a 6-year plan for implementing a Service Learning model at The University of Michigan. The greatest level of detail is provided for the 1st year.

Year 1 (06-07AY): Build Infrastructure
- Benchmark nationwide models for Service-Learning in Engineering
- Determine CoE Logistics – establish resource availability and needs and develop funding
- Build Corporate/Gov't Sponsorships
- Establish Community Partnerships – consult CoE faculty and the Ginsberg Center for existing partnerships, expertise and guidance
- Design service-learning curriculum to address specific needs of multi-disciplinary, vertically integrated, long-term design model in CoE and seek Curriculum Committee Approval
- Solicit support of departments for course credit as technical elective (minimum)
- Recruit students for 07-08AY 'Class' and Faculty Team Leaders
- Develop model of faculty participation in program (i.e., faculty stipend, course credit, etc…)
- Explore potential for Certification on transcript for students completing service-learning sequence
- Design Community Partner Agreement Form to clarify expectations of both Community Partner and CoE in writing through mutual agreement
- Establish evaluation and assessment activities (indicators of success) to assure that data to perform rigorous assessment is collected at appropriate intervals and is useful in evaluation of impact and potential for scaling (seek assistance of CRLT and assessment expertise within University).

Years 2 & 3 (07-09AY): Pilot

- Collect evaluation and assessment data
- Recruit Freshmen and Juniors for subsequent academic year
- Administrate Program – maintain open dialogues with community partners and sponsors to assure satisfaction with program
- Perform initial evaluation and assessment of program effectiveness and impact – enhance curriculum for subsequent year to reflect results of evaluation

<u>Summer 09: Evaluate Scale & Implementation</u>

- Careful evaluation of program and decision of scaling and implementation based upon 3-year pilot. Answer questions, such as:
    - Investigate and perhaps follow EPICS (Purdue) Curriculum model?
    - Scale to multiple departments in Engineering College?
    - Scale to outside Engineering College?
    - Unique 'spin' for UM?

<u>Years 4-6 (09-12AY): Scaled Implementation (or not) based upon Pilot and Evaluation</u>

- Full implementation of program

<u>Detailed Implementation Plan for Year 1 at The University of Michigan</u>

The following offers greater detail for Year 1 (Build Infrastructure) of implementing Service Learning at UM. First, we must become better educated about the current implementation of Service Learning. To do so, we will become educated re/ EPICS, as it currently exists by traveling to Purdue to the 'heart' of program. I will also attend the National Service Learning Conference in Washington DC in May06. From the knowledge gathered, we will determine how/where Purdue program fits into a UM model. Alternative (other than EPICS) Service Learning models will be evaluated for potential implementation at UM.

Second, we will determine the logistics of Service Learning in the UM College of Engineering. Part of logistics is determining both resource and funding needs. Resource needs include personnel and lab space. Funding needs will be determined. Government and corporate funding will be pursued through the Corporate Relations Office.

Departments with potential interest will be solicited to determine the appeal of the proposed program. As mentioned, likely departments include Electrical Engineering and Computer Science, Mechanical Engineering, Industrial and Operations Engineering, Chemical Engineering, Naval Architechture and Marine Engineering, and Civil Engineering. Additionally, departments and colleges outside of CoE will be solicited, such as the School of Information.

Next, existing community partnerships will be strengthened, and possible additional partnerships will be established. As mentioned, strong relationships already exist with the following not-for-profit organizations:

- Engineers without Borders
- Engineers for a sustainable world
- Ann Arbor, Ypsilanti, and Brighton Public Schools
- Ann Arbor Hands-On Museums
- Livingston Area Services Agency
- Ann Arbor Center for Independent Living
- Washtenaw County Head Start Program
- HAVEN Women's Shelter
- Growing Hope
- Power, Inc.
- as well as several international aid organizations.

Proposed projects from the various community and environmental organizations will be thoroughly evaluated to find high-value, high likelihood of success projects for initial work. A *Design Community Partner Agreement Form* will be written to clarify expectations of both the Community Partner and the CoE.

We will develop a curriculum to create an overlay of practicum learning on top of engineering departmental degree requirements. There are several means to proceed on this front and significant amount of faculty time in the first year will be utilized for developing these degree requirements.

Finally, we will recruit 07-08AY 'Class' of students for the program. Over years 2 and 3 of the pilot, we will fill the pipeline with students from each class (freshman through senior). During year 2, freshman and juniors will be the target student group. During year 3, the original class (from year 2) will be sophomores and seniors, and so again the target student group will be freshman and juniors. This will 'fill the pipeline' by the beginning of year three with representatives of each class.

The initial group of students will be chosen carefully. Representatives from the Service Learning program will visit appropriate courses at UM. There is the potential of mailings to incoming Freshman. Following the ENG490 model, advertising space may be purchased on the UM Bus System. Ideally, we will establish four to eight teams, each comprised of approximately two to four students from each class. That is, team size will be eight to sixteen students.

Additionally, Faculty Team Leaders will be solicited. Faculty Team Leaders are needed to supervise and mentor each of the student team projects. The model of compensation for faculty involvement (stipend, course credit) will be clearly defined.

Finally, evaluation and assessment activities (indicators of success) will be defined to assure that data is collected at appropriate intervals and is useful in evaluation of impact and potential for scaling (may seek assistance of CRLT and assessment expertise within University).

Appendix B

Budget and Resources

The budget and resources needed to implement an Engineering in Society program definitely need a tremendous amount of organization up front to initiate and maintain contacts with prospective sponsors. The budget reflects an up-front cost to support a faculty or staff member to oversee this program. However, once the program has been initiated, the necessary time commitment should be reduced. It also includes support for a staff member throughout the program. The budget also reflects some of the costs associated with each of the projects. The expectation is that the teams themselves will help raise additional funds from sponsors to cover additional costs.

Table B-1 Budget and Resource needs for Service Learning Pilot from MLTT

Resource	Description	Year 1	Year 2	Year 3
Personnel • Fac. lead (33%, 33%, 25%) • Admin. Sup. (50%)	Run program Project support	$45K $35K	$45K $35K	$34K $35K
Operating Funds	Initially $4K per team per year, with increasing numbers of teams each year. Will seek Government and/or Industry funding – to be used for materials/supplies, transportation to and from community partner client/user site…	$16K (4 teams)	$16K (8 teams)	$16K (16 teams)
Space	Need appropriate Course Meeting, Team Meeting and Lab space, possibly in the Student Project Building.	Cost Share	Cost Share	Cost Share
Yearly Totals		$96K	$96K	$85K

The space needs to support these projects are relatively ambiguous because the projects can be virtually anything. Projects may be tiny in size or may require substantial area. Some projects are intended to be offsite. Currently these projects are primarily supported in the curriculum by means of ME 450 projects. The Mechanical Engineering Department supports these projects primarily by using the ME 250 and 350 Computer Aided Design and Computer Aided Manufacturing labs. This relationship will continue into the near future. However as this project grows, additional space will be need. In may be possible to share lab space with the Space Exploration Initiative Practicum. Currently there are faculty from ME, NAME and EECS involved in the service learning type projects like ProCEED and BLUE. One of the issues will be to grow the faculty participation along with the number of teams.

Summary

This proposal is an executive summary for Service Learning at the University of Michigan. A six-year plan for implementation of Service Learning at UM is given. The plan includes a three-year pilot, evaluation of the pilot, and full-scale implementation. More detail is offered for the pilot, than for the full-scale implementation. The timing is ideal to implement a Service Learning component into the College of Engineering.

References

[1] Jacoby, B., and Associates, etc. (1996). *Service-Learning in Higher Education: Concepts and Practices*. San Francisco, CA: Jossey-Bass.

[2] Howard, J., (2001) Service-Learning Course Design Workbook, Michigan Journal of community Service Learning Companion Volume, OCSL Press, the University of Michigan.

Endorsements

- Margaret Dewar, Faculty Director, Ginsberg Center for Community Service and Learning

Date: Sun, 10 Sep 2006 22:08:13 -0400
From: "Dewar, Margaret" <medewar@umich.edu>
To: Brian Gilchrist <gilchrst@eecs.umich.edu>
Cc: "Skerlos, Steven" <skerlos@umich.edu>,
"Howard, Jeffrey" <jphoward@umich.edu>,
"Chesney, David" <chesneyd@umich.edu>
Subject: RE: Possible Collaboration with a Multidisciplinary Learning and Team
Teaching Inititative (fwd)

We at the Ginsberg Center are very interested in how we can help make such efforts succeed.
In TCAUP, I would be happy to help you connect with the right people in Architecture to help bring undergrads into an interdisciplinary practicum especially in community-based projects. In Urban and Regional Planning we don't have undergraduates, but we have community-based projects integrated into the curriculum for master's students. Maybe we can figure out how to use our connections with community-based organizations to generate possible projects for engineering students.

Margaret Dewar
Professor of Urban & Regional Planning
Faculty Director, Ginsberg Center for
Community Service & Learning

- Daryl Weinert, Director of Corporate Relations, College of Engineering
See attached letter.

- David Munson, Dean, College of Engineering
See Attached letter.

UNIVERSITY OF MICHIGAN
COLLEGE OF ENGINEERING
CORPORATE AND GOVERNMENT RELATIONS

143 CHRYSLER CENTER
2121 BONISTEEL BLVD.
ANN ARBOR, MI 48109-2092
734 647-7080 FAX 734 647-7075
www.engin.umich.edu/relations/corporate

August 30, 2006

Brian Gilchrist, Interim Chair
Electrical Engineering and Computer Science
3303A EECS Building
1301 Beal Avenue
Ann Arbor, MI 48109-2122

Dear Brian,

I am responding to your inquiry regarding the Multidisciplinary Learning and Team Teaching (MLTT) proposal you are organizing. You had asked me about the climate for this kind of educational enhancement among our corporate constituents.

Based upon my seven years of experience in working with corporations on behalf of the University, I wholeheartedly endorse this effort to encourage greater interdisciplinary collaboration and practical engagement for our students. Our corporate visitors continually mention these needs and would welcome such an enhancement to the U-M programs.

The proposed practicum concentration would enable the College to better organize its existing student project activities, but, more importantly it would provide a structure to enable new multidisciplinary project activities. It would also enhance our ability to pursue corporate and alumni support to make these efforts sustainable.

The proposed activities would put Michigan at the forefront of engineering education. By combining a sound theoretical foundation with the skills to apply engineering concepts in practical situations, our students would enter the engineering profession ready to make a difference.

I stand ready to help in any way to implement and expand this program.

Sincerely,

Daryl C. Weinert
Director, Corporate Relations

DAVID C. MUNSON, JR.
ROBERT J. VLASIC DEAN OF ENGINEERING
PROFESSOR OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE
UNIVERSITY OF MICHIGAN
COLLEGE OF ENGINEERING
ROBERT H. LURIE ENGINEERING CENTER
1221 BEAL AVENUE
ANN ARBOR, MICHIGAN 48109-2102
734 647-7010 FAX 734 647-7009
munson@umich.edu
http://www.engin.umich.edu/admin/dean/

September 11, 2006

Brian Gilchrist, Interim Chair
Electrical Engineering and Computer Science
University of Michigan
3303A EECS Building
1301 Beal Avenue
Ann Arbor, MI 48109-2122

Dear Brian,

The College of Engineering has a strong interest in expanding opportunities for students in "real-world" activities that are multi-disciplinary in nature and require students to work across boundaries. Beginning this fall, the College is undertaking planning on several fronts to both improve and expand such opportunities. The "Practicum in a Multi-Disciplinary World" proposal has the potential to play an important part in such efforts and I am pleased to endorse its vision. The College is available to work with faculty this academic year to begin integrating your ideas into the College's efforts.

I also endorse the idea we discussed that this initiative should span the University, engaging students, faculty, and academic units from outside of engineering. I encourage you to move forward with reaching out to other groups within the University this fall.

I anticipate that there will be College (cost-sharing) support for these efforts, including faculty and staff support and assistance in coordinating space for pilot projects. The College already is planning for project space in the Space Research Building this fall. Further details will be worked out over the next couple of months.

Sincerely,

Dave

David C. Munson, Jr.

DCM/mas