Mechatronics Innovation Center Pre-Proposal Concept Paper

There are fundamental questions that must be answered by this concept paper:
1. What is innovation and what are the main obstacles to innovation?
2. What is mechatronics and how does mechatronics enhance innovation?
3. What is the Mechatronics Innovation Center and is the creation of this center by Marquette University desirable, feasible, and manageable?
4. How will the Mechatronics Innovation Center become financially viable and sustainable?

This pre-proposal concept paper addresses these questions and attempts to show how the Mechatronics Innovation Center at Marquette University will enable the Marquette College of Engineering, with its new engineering building, to become a national model for innovation and transformational engineering education.

What Is Innovation and What Are The Main Obstacles to Innovation?

The United States is in an innovation crisis fueled by a crisis in engineering education. The urgent problems society faces are multidisciplinary, complex, and ever changing. Engineers need to be able to adapt and apply technology that is human-centered, desirable, feasible, viable, sustainable, usable, and manageable. Innovation (figure right) is local – you don’t import it and you don’t export it! You create it! It is a way of thinking, communicating, and doing. Present-day engineering education is not adequately preparing young engineers for the challenge. Basic engineering skills have become commodities worldwide. To be competitive, U.S. engineers must provide high value by being immediate, innovative, integrative, conceptual, and multidisciplinary.

The 21st-century engineer is a critical-thinking, multidisciplinary problem solver and is effectively characterized as a $T^2$ engineer (figure right).

There are two main impediments to innovation in both engineering education and engineering practice: silos and comfort zones. First, the silo structure in both academia and industry does not enhance innovation. Silos promote narrowly-focused group-think, complacency, and mediocrity. Silos occur at all levels, e.g., within a department, among departments, among schools at a university, among divisions in a company. The silo mentality inhibits multidisciplinary collaboration and fails to recognize that collaboration enhances, not diminishes, all we do. Collaboration is not a zero-sum game; everyone wins! The silo problem starts with
administrators who are old-school managers rather than leaders, with no understanding of the real-world present or vision for the future. This view then propagates down through the ranks. Second, there is a failure of faculty and practicing engineers to get out of their comfort zones, become immersed in real-world problem solving, and respond to the challenges of both teaching and practicing multidisciplinary engineering problem solving in a discovery learning mode. Knowledge needs to be unbundled and rebundled in both engineering education and engineering practice to give it balance between theory and practice and relevance to the solution of the multidisciplinary problems society faces.

In addition, universities are pricing themselves out of existence. The current value of the education does not justify its cost. In particular, engineering schools must demonstrate excellence, value, and relevance, as well as innovative ways to collaborate with industry and technical community colleges. Leadership in outreach to the K-12 public schools is desperately needed to show how every student, not just STEM students, can be a part of the innovation revolution.

**What Is Mechatronics And How Does Mechatronics Enhance Innovation?**

Mechatronics (figure left below) is the *synergistic integration* of physical systems, electronics, controls, and computers through the design process, from the very start of the design process, thus enabling complex decision making. Integration is the key element in mechatronic design as complexity has been transferred from the mechanical domain to the electronic and computer software domains. Mechatronics is an evolutionary design development that demands horizontal integration among the various engineering disciplines as well as vertical integration between design and manufacturing. It is the best practice for synthesis by engineers driven by the needs of industry and human beings.

In a modern multidisciplinary engineering system (figure right below), performance, reliability, low cost, robustness, efficiency, and sustainability are absolutely essential. All components must be simultaneously integrated and optimized from the start of the design process. Two elements are essential in modern engineering practice: human-centered design and model-based design. Human-centered design requires interdisciplinary collaboration, an iterative process with frequent prototyping, and engagement with real people. Also, in evaluating concepts, a modeling-and-analysis approach must replace any design-build-and-test approach, but this modeling is multidisciplinary and crosses domain boundaries. Mechatronics is multidisciplinary system problem solving and is a vital element to the transformation of both engineering education and engineering practice to achieve innovation.
What is the Mechatronics Innovation Center?

The Mechatronics Innovation Center is a place where education, government, and industry leaders can collaborate to address specific societal problems, develop broad new solutions, and create best practices that help re-shape U.S. industry and education as we know it today. It is a place where the main obstacles to innovation are removed. Silos and comfort zones do not exist. The center would be integrated into the new engineering building facilities. It would have its own problem-solving and design working-and-meeting space (1500 sq. ft.) in the new building for faculty, teachers, students, and industry collaborators. It would make use of the following facilities in the new engineering building:

- laboratory and prototyping facilities for industry-specific research and development activities
- education outreach facilities for K-12 schools, technical community colleges, collaborating universities, and industries to improve innovation education in all areas
- conferencing facilities for workshops, presentations, forums, video conferencing, and collaborations of any kind

The participants will be multidisciplinary (see figure below) and include:

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**Multidisciplinary System Design Team**

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- Marquette University College of Engineering faculty and students from all four engineering departments in collaboration with the faculty and students in the Colleges of Business Administration, Communication, Education, and Arts & Sciences
- Milwaukee City Government and Wisconsin State Government officials
- Local Technical Community College faculty and students
- Local K-12 Public and Private School teachers and students
- Local and Regional Industries, large and small, who would benefit from both joint and individual innovation activities

Activities will include (see supporting figure below):

- Industry engineering workforce enhancement through hands-on, integrated workshops (e.g., planned Automation Mechatronics two-day workshop in spring 2011) for local and regional industries. This activity would demonstrate value, relevance, and excellence and would lead to the identification of industry problems for faculty and student investigation and research, as well as in-house customized workshops for individual companies
- Periodic technology forums for center-member companies to discuss new technologies and challenges relevant across the industrial spectrum
- Industry-student multidisciplinary capstone design and course projects
- M.S. and Ph.D. faculty-supervised research activities

- K-12 Outreach Programs (see figure below) that bridge the gap between the K-12 teacher/student world and the world of real-world problem solving with the Mechatronics Innovation Center providing the Culture of Innovation K-12 ↔ Industry Bridge with Marquette graduate students acting as the guides and catalysts for change.
Administration of the M.Eng. in Mechatronics graduate program (see figure below), a transformational approach to graduate engineering education with one-credit integrated modules that have a balance between theory and industry best practices. These modules would support the graduate program, undergraduate courses in all departments, industry workshops, and industry engineering self-study.
How Will The Mechatronics Innovation Center Become Financially Viable and Sustainable?

- In the steady state, companies would be members of the center for an annual fee. This fee could vary between $25K and $50K, depending on the services provided by the center. Additional work, e.g., research, specific problem-solving, and customized training, would be handled on a case-by-case basis. An annual income of $500K would be the target amount.
  - Potential Charter Companies ($50K)
    - Rockwell Automation
    - P&G
    - Briggs & Stratton
    - GE Health Care
    - Bucyrus
    - Price Engineering
    - Harley-Davidson
    - Mercury Marine
    - Johnson Controls
- The income would be used to pay the center staff (one M.S.-level mechatronics engineer with industry experience, one electro-mechanical technical support person, and one center administrative assistant), as well as the center director (faculty member), participating faculty, and student involvement. It is important to note that faculty will be engaged in solving real-world problems, not just academic / theoretical problems.
- Wisconsin state funding and Milwaukee city funding would be highly desirable, as the center would promote innovation and job creation. Annual funding ($100K) would be the target amount.
- Once problems are solved for the industrial customers, the funding described above can be used to leverage federal (e.g., NSF, DOE) funding for more fundamental research.
- Periodic written and video publication / presentation (e.g., twice a year) of both a R&D and an educational nature would be implemented. Web site activities would also be implemented.
- University support is highly desirable in the form of tuition / overhead reduction and technical staff salary support.
- Intellectual Property policy needs to make working with center highly desirable, not an obstacle.