Mechatronic System Design

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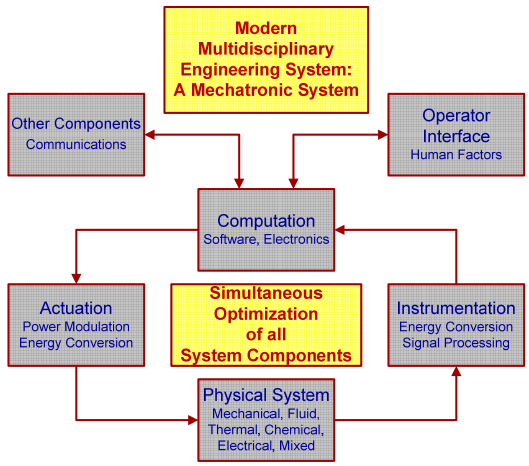
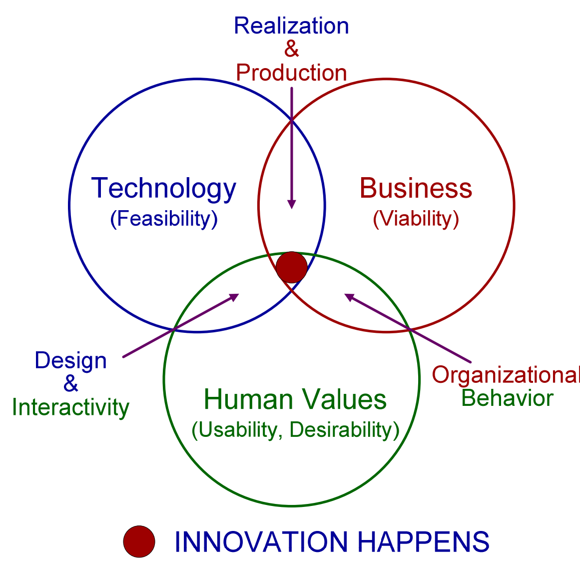
The word *mechatronics* originated in Japan around 1970 to describe the integration of mechanical and electronic components in consumer products. Today it has come to mean multidisciplinary systems engineering and it has never been more important.



Engineers today face daunting challenges. Their engineering problems are getting harder, broader, and deeper. They are multidisciplinary and require a multidisciplinary engineering systems approach to solve them. Multidisciplinary engineering systems, in addition to the physical system with its sensors and actuators, have as integral parts electronics, computers, and controls. These are enabling, and often hidden, technologies which foster innovation. Performance, reliability, low cost, robustness, energy efficiency, and sustainability are absolutely essential.

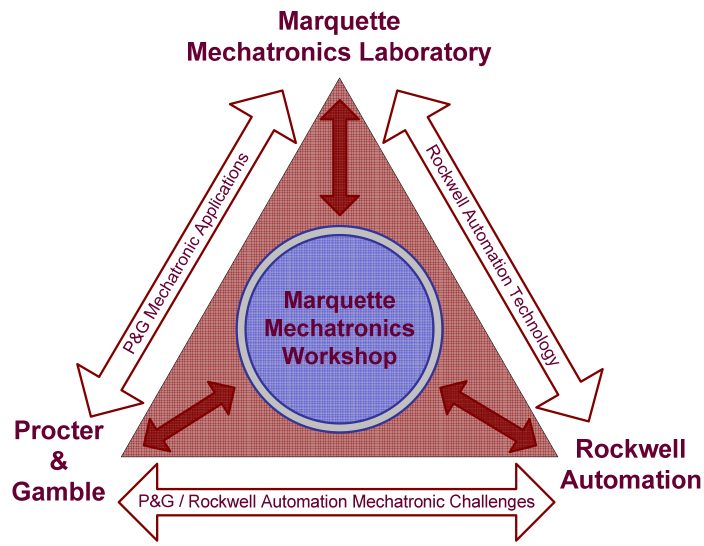


Basic engineering skills have become commodities worldwide. Other countries have a competitive advantage in low-cost manufacturing and services, with excellent engineers available at one-fifth of the cost of a U.S. engineer. To be competitive, U.S. engineers must provide high value by being immediate, innovative, integrative, conceptual, and multidisciplinary.

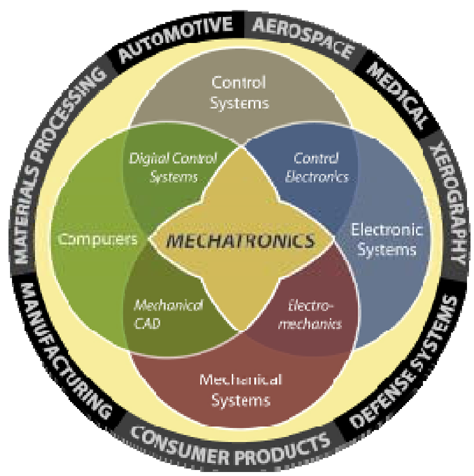
It is generally agreed that engineers must have depth in a specific engineering discipline, as well as multidisciplinary engineering breadth, with a balance between theory and practice. In addition, they must have breadth in business and human values. Innovation happens at the intersection of technology, business, and human values.

Engineering educators face daunting challenges. The preparation of new engineers is inadequate for the challenge. Sometimes, it seems that memorization has replaced understanding. Students focus on facts, tests, and grades and fail to understand concepts and processes. They are unable to integrate knowledge, processes, techniques, and tools, both hardware and software, to solve an engineering problem. Indeed, one of the great failures in engineering education has been the inability of graduating students to integrate all they have learned – science, mathematics, engineering fundamentals – in the solution of a real-world engineering problem.

What is the best way to educate students to become practicing engineers? Only through industrial interaction – knowing the types of problems engineers face, the concepts, processes, and tools they use to solve those problems, and the personal and professional attributes essential to be an engineer leader – not a follower – but an independent-thinking leader in our technological society – can we develop engineering curricula to transform our students. An example of this type of interaction is the Mechatronics Workshop that took place in August 2008 at Marquette University which brought together leading P&G and Rockwell Automation engineers to address urgent mechatronic needs. It was viewed by all as a huge success.



So what is mechatronics? Mechatronics is the synergistic integration of physical systems, sensors, actuators, 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.



Mechatronic system design deals with the integrated and optimal design of a physical system, including sensors, actuators, electronic components, and the embedded digital control system. The integration is respect to both hardware components and information processing, both on-line and off-line. 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. Every controlled physical system is not a mechatronic system, as controls can be just an add-on in a sequential design process. A real mechatronics approach requires that an optimal choice be made with respect to the realization of the design specifications in the different domains. Mechatronic system design requires simultaneous optimization of the system as a whole – no after-thought add-ons allowed.

Real-world multidisciplinary engineering problems, i.e., mechatronic system design problems, present enormous challenges to both academia and industry. Engineering education is in crisis, both at the university and professionally. A radical change in the status quo is needed. Nothing less than dramatic changes will do.

About the Author: Kevin Craig has spent 18 years teaching and performing research in mechatronic system design at Rensselaer Polytechnic Institute. At RPI, he developed the Mechatronics Program, which included an extensive teaching and research laboratory and several senior-undergraduate and graduate-level courses, and graduated 37 M.S. students and 20 Ph.D. students. He has conducted hands-on, integrated, customized, mechatronics workshops for practicing engineers at Xerox, Procter & Gamble, Pitney Bowes, Dana, Fiat, Plug Power Fuel Cells, NASA Kennedy Space Center, U.S. Army ARDEC, Siemens, Rockwell Automation, and for the ASME Professional Development Program.