Mechatronics:
Getting Your Act Together

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Mechatronics: Getting Your Act Together

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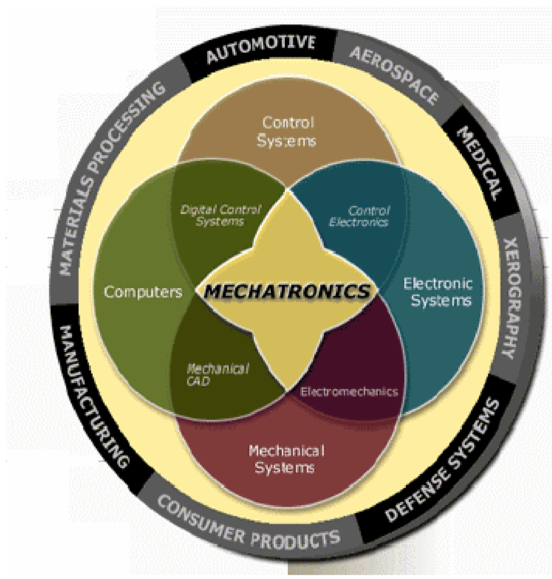
Products and systems, such as automobiles, have become increasingly complex, especially as computerized control and software systems have become ubiquitous. Coincident with this trend toward more non-human control and automation, it has become necessary that the people who design, manufacture, install, maintain, repair, and calibrate such equipment possess skills that integrate mechanical, electronic, and computerized control and software systems. In fact, it is a cliché, but persons of a certain age who fondly remember repairing their own cars under the shade of a big tree know that to do so now is almost impossible. Even many minor repairs require that one first develop a thorough knowledge of an automobile's complex computer and control systems in order to be successful.

Mechatronics is a relatively new term used to describe the multidisciplinary integration of the technical disciplines outlined above to improve the performance and functionality of products and systems such as automobiles.

There is no unique mechatronics industry sector per se; rather, it is an enabling approach to technology that is already being applied in a number of areas of economic life including biotechnology, electronics and applied computer equipment, chemical processing, transportation equipment, aerospace, homeland security and defense, and many others. To understand its pervasiveness, consider that there are a number of advantages associated with the use of mechatronics in the design of physical systems including the ability to replace many mechanical systems with electronic systems. This substitution introduces greater reliability and flexibility into systems, but also provides the ability to monitor and change the operation of a system based on information collected during its use. For example, the Toyota Prius Hybrid automobile optimizes gas mileage using various mechatronics components (i.e., computerized control systems) that optimize how power is drawn from either the internal combustion engine or electric motor based on operating conditions. Other examples of applied mechatronics principles that lie at the core of products that we rely on in our everyday lives include cochlear ear implants for the hearing impaired and antilock brakes in automobiles.

Exhibit 1
Mechatronics Applications



Source: Rensselaer Polytechnic Institute

Exhibit 2
Toyota Prius Hybrid Vehicle

Source: IGN.com

Since 2002, Technology Futures, Inc. (TFI) has conducted a series of technology forecasts for the Texas State Technical College System to identify emerging technology trends which will have a significant impact on the Texas economy and evaluate their potential implications for the state's workforce. Our most recent forecast examined the impact of mechatronics ("intelligent mechanical systems"). In developing the forecast, TFI formally interviewed and surveyed a number of representatives from academia and industry with a significant stakeholder interest in the design, manufacture, and/or utilization of mechatronics products and processes. The development of our forecast resulted in a number of critical findings that are of interest not only to the citizens of Texas, but the entire United States. Those findings, their implications, and the conclusions that we drew from them are described below.

- The trend of replacing purely mechanical mechanisms with intelligent mechanical systems is well underway. It has expanded over the past 30 years, especially as a number of technical and economic forces, including the increasing use of automation and robotics within the manufacturing environment, accelerates.

- The practice of embedding more intelligence into mechanical systems (i.e., embedded electronics) is likely to accelerate this trend as the performance of processors, memory, storage, and bandwidth continue to increase while their relative cost decreases. Additionally, standardized communication protocols and infrastructure, such as Internet protocol, Fieldbus, and Ethernet, will continue to simplify interconnections and control devices throughout industrial networks. These networks include "machine to machine" networks that enable machines to control and monitor other machines.

- Mechatronics is evolving to include the development of micro-, meso-, nano-, and bio-mechatronics systems that interface with and control physical, chemical, biological, and neurological processes. Therefore, mechatronics is important in terms of traditional manufacturing, and it is also the foundational manufacturing platform for advancements in emerging technologies and industries.

- Despite the application of mechatronics principles for over three decades, a substantial amount of legacy equipment not enabled for industrial automation is still in use. A significant amount of this equipment will not be replaced anytime soon and presents a significant challenge to organizations that are attempting to integrate mechatronics-enabled solutions into operational environments.

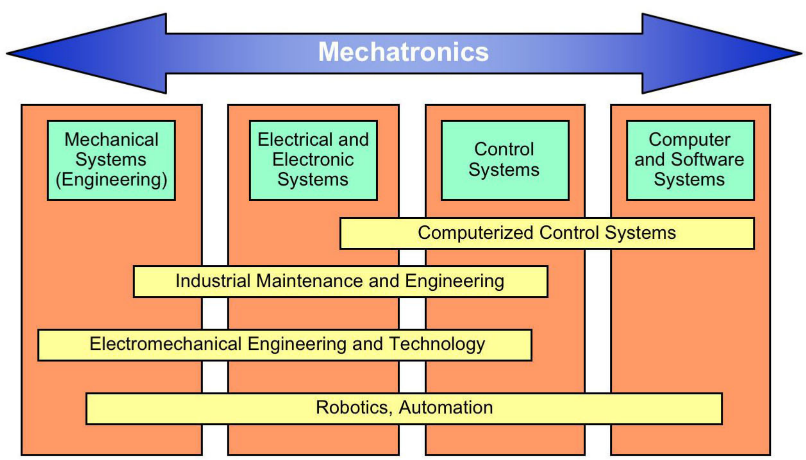
- In many industries, designers, engineers, equipment, and systems technicians, although they may not be called such, are already "mechatronics proficient." They have developed multi-disciplinary skill sets, mostly through on-the-job training, apprenticeship programs, and employer- and vendor-sponsored specialized short courses and training.

- Although the term mechatronics is still relatively underutilized in the United States, it is commonly used in European and Asian countries, where degree programs in mechatronics are quite common.

- The concept of a mechatronics engineer or technician is not new, but the idea of formalizing this type of training into degree programs is fairly recent, at least in the United States. A small, but growing number, of technical and four-year colleges and universities in the United States, including North Carolina State University at Asheville, are beginning to grant degrees in mechatronics.

- Secondary institutions that already have strong existing programs in electrical systems, electronics technology, robotics and automation, computerized control systems (instrumentation), industrial maintenance and engineering, electromechanical engineering, and mechanical engineering are well positioned to develop mechatronics programs. However, even colleges with faculty in these disciplines will have to devote resources to restructuring the teaching of mechatronics as an integrated whole within specific industry applications.

Exhibit 3
Relationship of Mechatronics to Existing Technical Disciplines



Source: Technology Futures, Inc.

- Although there is a lack of formal mechatronics training, employers foresee significant value in employee technicians with formal mechtronics training. A significant majority of employers (over 80%) that completed our formal survey for the TSTC project indicated that formal mechatronics training can decrease the cost and time needed to train technicians in the required skills and minimizes the risk of hiring employees who do not have the ability or desire for multidisciplinary training.

- Thus, increasing the number of formally trained mechatronics technicians is of importance for many reasons.

    - Many traditional manufacturing jobs have or may become dated and obsolete as a result of developments in mechatronics. The result has been an acceleration of the displacement of unskilled labor by skilled labor in all facets of the U.S. economy. Formal mechatronics training can provide incumbent and dislocated workers with skills to broaden job and career opportunities. Graduates with prior industry experience are especially attractive to employers because they already possess industry experience that many traditional students lack.

    - As increasing numbers of experienced technicians of the "baby boomer" generation reach retirement age, employers must find technicians capable of replacing multi-craft mechatronics technicians who have acquired their knowledge and skills while on the job.

    - The retirement of baby boomers from technical trades affiliated with mechatronics has implications beyond the aggregate numbers. Specifically, many industries face a discontinuity in the transfer of knowledge between older and younger generations of workers. This discontinuity in knowledge transfer has profound and possible deleterious implications for the economic competitiveness and labor productivity of U.S. companies.

These findings were useful in the formulation of a number of conclusions and recommendations that academic, government, and industry leaders should consider to ensure that the United States fully understands and utilizes this technology to maintain the country's economic competitiveness.

- Academic, government, and industry leaders should identify critical industry-identified competency gaps in mechatronics training and facilities and construct programs to fill them. Leaders should work to develop systemic initiatives that connect mechatronics in use today with micro-, nano-, and bio-mechatronics to achieve a fully integrated system for innovation and the production of human capital. This is necessary to lead the world in the application of 21st century science to the resolution of global challenges and economic opportunities.

- Mechatronics training should target the entire educational and workforce system including primary education, secondary education, post secondary education, and training for incumbent and dislocated workers. Starting early is important because the general systems nature of mechatronics provides a foundation to connect previously separate areas of academic study into a unified whole with the possibility of creating young learners able to think and act systemically.

In many ways, the technological convergence evident in mechatronics is the distinguishing characteristic of 21st century innovation. Companies of every size in multiple sectors will increasingly require operators, technicians, engineers, designers, and scientists fluent in mechatronics. Intelligent mechanical and electronic systems, from large automated industrial machines to microscopic actuators, are already having an impact on numerous industries and hold great promise for future applications. The integration of academic disciplines for students (knowledge mergers), the integration of applied skills for workers (skill mergers), and the integration of distinct occupations (job mergers) present an opportunity for the United States to lead the world in anticipating and acting on the knowledge that 21st century innovation is characterized by systemically restructuring education and work. We have no choice if we are going to continue to compete with the emerging industrial economies of the world, which are building out new infrastructure that can utilize the latest mechatronics techniques.

Technology Futures' report, *Mechatronics: A Technology Forecast*, is available at no charge at http://www.tfi.com/pubs/white.html#mechatronics.

Authors

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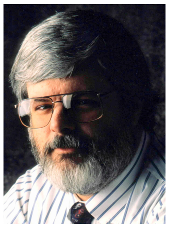
John H. Vanston, Ph.D., Chairman, Technology Futures, Inc., is an internationally-renowned consultant, educator, and author in the fields of technology forecasting, technology/market integration, and technology management in uncertain environments. He is the leader in the development of TFI's Five Views of the Future™ Analysis Framework and the Technology Advantage Management concept.



James A. Irwin is an Austin-based consultant with extensive experience in automated process control, material handling systems, process application engineering, development of equipment reliability and productivity standards, and a number of other mechatronics related areas. He has been employed in senior research and management positions in a wide range of semiconductor and engineering companies, including AMD, Veeco Instruments, Utratech Stepper, GCA, IBM, Watkins-Johnson, Fairchild, and Texas Instruments.

TFI excels at *projecting future developments in an organized, responsible, and timely manner. If your organization would benefit from TFI's expertise at identifying and evaluating new technological opportunities and developing strategies for bringing these technologies to the marketplace, please contact us at (800) TEK-FUTR, (512) 258-8898, or info@tfi.com.*