CIMdata, Inc. • 3909 Research Park Drive • Ann Arbor, MI 48108 USA
tel: +1 (734) 668-9922 • fax: +1 (734) 668-1957 • http://www.CIMdata.com

Meeting the Challenges of Mechatronics Development

PLM can help companies more effectively design complex products with mechanical, electronics, and software components

By Ed Miller
President, CIMdata Inc.

Increasing product complexity is a trend in many industries. One reason for this trend is the growing importance of software-driven electronics in many products that traditionally have been comprised mostly of mechanical components. In some cases, software is being used to enable innovative and sophisticated capabilities not previously available or economically feasible. In other cases, software-driven electronics allows common mechanical product configurations to deliver different operating characteristics for different markets; a huge cost benefit for manufacturers.

Creating software is cheaper than building hardware. That is, to a manufacturing-intensive company, duplicating software is much less expensive than providing the same feature in mechanical parts. Thus, if an assembly can be replaced with a software component, everything else being equal, opting for the software component usually makes sense from an economic perspective. These opportunities are driving the trend toward mechatronics: designs that blend mechanical, electronics, and embedded software.

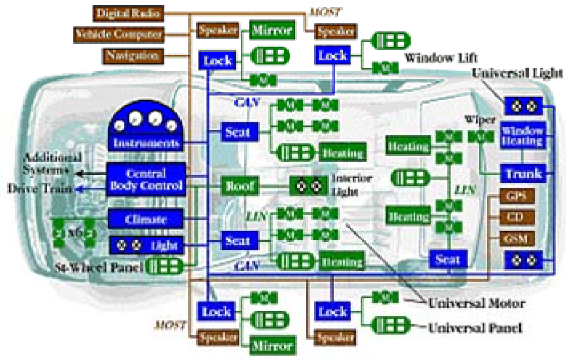
The term “mechatronics” is becoming widely recognized in many industries but not commonly used in some others, where a variety of names such as “total systems engineering” or “electro-mechanical systems engineering” are often used. Regardless the terminology, the issue is of growing importance across to an expanding range of companies. Since the name mechatronics is so widely recognized by many of these companies, that is the term we will use in this article.

Wide Range of Products

Today, a wide range of products incorporate software-driven electronics as a major component, including automobiles, aircraft, defense systems, machine tools, home appliances, and many others. Automobiles, for example, are increasingly utilizing software-driven electronics to provide a wide range of capabilities such as advanced safety features, diagnostics, engine control, and other functionality that was not even feasible until recently.

To provide the most efficient power, for instance, one General Motors (GM) concept engine has a control module that automatically opens and closes intake and exhaust valves on selected cylinders based on load and speed conditions. On another front, mechatronics is used in hybrid vehicles for managing the crossover from mechanical to electrical power, displaying vehicle status information and managing electric regeneration processes. GM and Chrysler have announced efforts in working collaboratively on an electronically-controlled electric variable hybrid transmission for full-size SUVs.

Most automakers are replacing complex wiring harnesses with local area networks in which one signal line contains instructions for the controller and for all components being controlled. One line goes to all taillights rather than individual lines to each light, for example. This provides the opportunity to reduce manufacturing costs by removing complexity from the factory floor and placing it in discrete electronic devices and software. The following figure illustrates this concept.

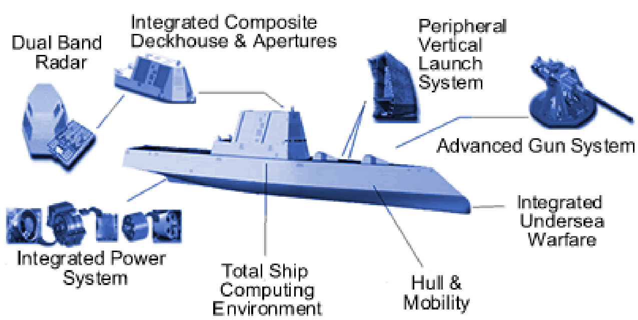


Area networks designed specifically for the auto industry replace complex wiring harnesses with one signal line from an electronic control unit.

(Leen, G., ISERC, March 2005)

As with automotive companies, organizations in the aerospace and defense industry have been addressing mechatronics and related issues for years. In fact, specific initiatives from the Department of Defense (DOD) and other Ministries of Defense (MOD) around the world force organizations that design and develop defense products/systems to manage the mechatronics environment more effectively. The U.S. DOD's Force Transformation initiative is one such example.

As part of this initiative, network-centric communications and control, modular design and electromechanical-enabled automation are key elements of the Army's Future Combat Systems (FCS), the new class DD(X) ships being designed by the Navy, and the Defense Advanced Research Projects Agency's (DARPA) J-UCAS project for an autonomous fleet of unmanned aerial vehicles (UAVs) and a Common Operating System (COS).



A new class of Navy ships designated DD(X) will be network-centric, built in modularity and use electro-mechanical product development. Platforms are hybrid powered, using electric motors located separately from the diesel, turbine or future power plant system.

(Courtesy of the US Navy)

Formidable Challenges

Although mechatronics is clearly an issue that more and more companies want to address, it isn't a problem that has been easily solved. Effectively incorporating mechatronics systems into products isn't done without overcoming some formidable challenges. Traditionally, the environments used to support development of mechanical, electronic, and software components and products are completely separate, utilizing different protocols. These include Mechanical Computer-Aided Design (MCAD), Electronic Design Automation (EDA), and Computer-Aided Software Engineering (CASE) tools. These different categories of systems often do not support reasonable exchange of data between each other. Additionally, simulation technologies generally cannot account for mechanical, electronic, and software behavior to fully evaluate overall product performance in a single virtual model that integrates all these disciplines.

While technical challenges are substantial, some of the biggest impediments to success with mechatronics are organizational in nature. At most companies, structures generally are organized for the different disciplines to work independently, for the most part functioning in isolation from one another and passing project information from one group to another in serial fashion. In many cases, mechanical engineering completes work and then forwards tasks to electronic/electrical design engineering, which then forwards tasks to software engineering. Disciplines work in silos with their own individual design processes and non-integrated information system tools. As a result, engineers downstream in development have little opportunity to provide valuable input early in the cycle, and design deficiencies often are not uncovered until late in the process when changes are costly and time-consuming.

By necessity, mechatronics is changing this perspective with a more holistic approach in which managers are focused on the product in its totality and design teams are becoming more integrated. Members work in parallel and more collaboratively under one virtual roof. In this way, work is completed more efficiently, problems are circumvented up front in development, product design is optimized, development time is shortened, and innovation is encouraged. One of the biggest challenges to this approach is developing appropriate work processes that accommodate the nuances and intricacies of the different design fields in a single coherent program.

PLM as an Enabler

By creating a virtual "big room" where multidisciplinary teams can collaborate, PLM is a key enabler to ensure that mechatronics is effectively supported within a company's design organization. CIMdata defines PLM as a strategic business approach that applies a consistent set of business solutions to support the collaborative creation, management, dissemination, and use of product definition information across the extended enterprise from concept to end-of-life, integrating people, processes, business systems, and information.

The resulting cross-functional visibility allows for the management of a total design program in which PLM processes and tools allow people to work as an integrated design team. Specific processes provided by PLM that enable full mechatronic design organizations include the following:

Product/Process Design Tool Integration. PLM integrates the process and product design tools into the mechatronic process. Mechanical design (MCAD), Electronic/Electrical design (EDA or ECAD), and Computer-Aided Software Engineering (CASE) software are increasingly being integrated into a common PLM design environment. Since mechatronics is the integration of these three engineering disciplines, PLM functions become a key enabler of mechatronics design processes. The user interfaces of the design tools now allow the designer to easily check-out and check-in appropriate design components from the enterprise PLM application.

Common Repository. In mechatronics development at many companies, engineers may hide their intermediate designs rather than allow the other disciplines to share the current iterations. As a result, functional workgroups often proceed with their tasks based on out-of-date information, resulting in significant mistakes and delays. PLM overcomes this problem by providing cross-functional teams with a common repository that serves as a “single source of the truth,” one place to store all of the design data and to maintain integrated configuration control. This promotes a timely deployment of the integrated design and guarantees that the version and configuration of the mechatronic components and end product are universally understood. Most importantly, cross functional teams can readily iterate mechatronic designs.

Collaboration Support. PLM provides a product information backbone where all of the mechatronic design stakeholders may use reliable information for simulating the design of the products or processes. Simulation vendors are beginning to provide tools that integrate mechanical, electrical and control processes. The only way these applications can work reliably is if *all* of the data (with the correct revisions) are maintained. This allows for real-time access of the design worldwide and provides a way for all of the mechatronic stakeholders to participate: supply chain partners, service providers and contractors inside and outside the firewall. Most importantly, unique domain expertise is available to the total integrated development team.

Requirements and Program Management. Presently, new-product features and specifications from customers are often parsed out to individual engineering disciplines, thus hampering mechatronic projects because customer needs and problems to be corrected are dispersed. PLM overcomes this difficulty by maintaining individual views for mechanical, electrical, and software engineers while managing a global, integrated view of customer requirements and issues. In this way, portfolio tracking, project and program management become integrated across all disciplines when they are managed in a PLM application.

Workflow Support. In industries where stringent design protocols must be followed, PLM workflow engines support the execution of the required product life cycle steps across all design disciplines. Furthermore, it provides an audit that all steps have been completed. In this way, PLM guarantees that reliable and timely new product builds will be executed. Such capabilities are especially valuable to supply chain managers who need to ensure that all intellectual property of the product is available in time for planning, engineering, and procurement processes.

Gaining the Competitive Advantage

In this way, PLM provides the cross-functional visibility for managing the total design program together with tools and processes that allow people in the different disciplines to work as an integrated team. By acting as an information backbone, PLM enables cross-functional mechatronics teams to iterate more effectively and work more collaboratively on the design.

Enabled by PLM, companies can more effectively organize and manage the integrated, collaborative teams needed to develop the mechatronics designs that are becoming critical to the success of a growing number of manufacturers. The most successful companies will be those that address this increasingly critical aspect of product development now, as a differentiator against slower-moving competitors that may not yet fully understand the shifting dynamics of product design.

About PLM

CIMdata defines PLM as a strategic business approach that applies a consistent set of business solutions in support of the collaborative creation, management, dissemination, and use of product definition information across the extended enterprise from concept to end of life—integrating people, processes, business systems, and information. PLM forms the product information backbone for a company and its extended enterprise.

About CIMdata

CIMdata, an independent worldwide firm, provides strategic consulting to maximize an enterprise's ability to design and deliver innovative products and services through the application of Product Lifecycle Management (PLM) solutions. Since its founding more than 25 years ago, CIMdata has delivered world-class knowledge, expertise, and best-practice methods on PLM solutions. These solutions incorporate both business processes and a wide-ranging set of PLM enabling technologies.

CIMdata works with both industrial organizations and suppliers of technologies and services seeking competitive advantage in the global economy. In addition to consulting, CIMdata conducts research, provides PLM-focused subscription services, and produces several commercial publications. The company also provides industry education through international conferences. CIMdata serves clients worldwide from locations in North America, Europe, and Asia Pacific.

To learn more about CIMdata's services, visit our website at www.CIMdata.com or contact CIMdata at: 3909 Research Park Drive, Ann Arbor, MI 48108, USA. Tel: +1 (734) 668-9922. Fax: +1 (734) 668-1957, or Siriusdreef 17-27, 2132 WT Hoofddorp, The Netherlands. Tel: +31 (0)23 568-9385. Fax: +31 (0)23 568-9111.

Ed Miller president of CIMdata, is an internationally recognized authority on PLM and a frequent keynote speaker at conferences and seminars around the world on trends, directions, strategies, methods, and technology issues. He welcomes reader comments and can be reached at e.miller@CIMdata.com.