

Enabling Mechatronics Product Development with Digital Prototyping

By Keith Perrin

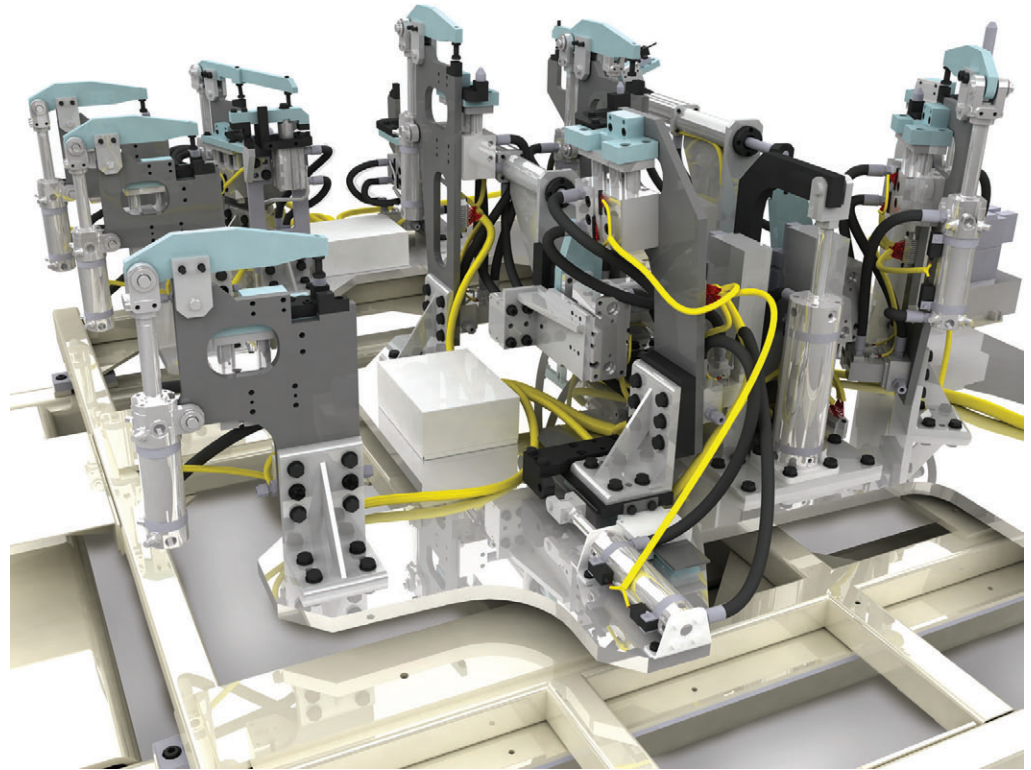


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Summary

Today's manufacturers are using a mechatronics-based approach to integrate the electronic, mechanical, and software components of their increasingly complex products. Digital Prototyping allows disparate engineering teams to work from a single digital model, saving time and reducing errors throughout the design process. The Autodesk solution for Digital Prototyping enables manufacturers to achieve the full benefits of mechatronics product development.

Overview

The Need for a New Approach

Today's manufacturers face unrelenting pressure to continuously develop innovative new products. According to a recent survey of CEOs, two-thirds of executives believe that innovation is vital to the future of their companies.¹ Their concern is understandable; according to one estimate, the products that generate nearly 70 percent of revenues today will be obsolete by 2010.²

In response to this call for innovation, manufacturers have accelerated their adoption of electronics. Research shows that 92 percent of manufacturers now incorporate electronic elements into their products.³

The automotive industry provides a prime example. While the proportion of a car's cost that can be attributed to electronic systems has increased by an average of 8.3% per year over the past eight years, the proportion attributed to mechanical systems has decreased by an average of 3.2%.⁴ These trends are broadly consistent across all industries.

1 Accenture, "Good Ideas Are Not Enough: Adding Execution Muscle to Innovation Engines," 2005.

2 Deloitte, "Mastering Innovation: Exploiting Ideas for Profitable Growth," 2005.

3 Aberdeen Group, "The Mechatronics System Design Benchmark Report," August 2006.

4 Accenture, "Tuning into Tomorrow's Frequencies: How Product Development in Automotive Electronics Drives High Performance," 2006.

As manufacturers respond to the demands of the market, they must deal with the added complexities of synchronizing mechanical, electronic, and software elements into one integrated system. In the process, they must effectively coordinate disparate engineering teams. A mechatronics-based approach can help.

Effective mechatronics product development demands a focus on three key engineering activities:

- **Multi-Disciplinary Design and Engineering.** Mechatronics refers to the integration of control systems, electrical systems, and mechanical systems. A mechatronics system is not just a marriage of electrical and mechanical systems, and is more than just a control system. It is a complete integration of all of them.⁵ Top-performing manufacturers are 3.2 times more likely to allocate design requirements to systems.⁶
- **Managing Communication and Workflow.** Integration of systems should be coupled with improvements in the coordination between the discipline-specific teams that are responsible for creating individual sub-systems. The often complex inter-relationships between individual sub-systems demand effective communication and clear ownership.⁷ Top-performing manufacturers are 2.8 times more likely to communicate change among their engineering disciplines.⁸
- **Effective Early Validation.** If manufacturers are going to develop cheaper, more reliable, and more flexible systems, they must validate across the traditional boundaries of mechanical engineering, electrical engineering, electronics, and control engineering at the earliest stages of the design process.⁹ Top-performing manufacturers are 7.3 times more likely to digitally validate system behavior.¹⁰

The Mechatronics Advantage

Manufacturers that harness the best practices of mechatronics can achieve significant benefits. Best-in-class manufacturers are more able to reach their targets for development costs, product revenue, and product quality, and to hit their product launch dates. Such manufacturers can also:

- Add more features and functions.
- Reduce the size, weight, and cost of their products.
- Improve their overall efficiency.
- Leverage adaptive control and diagnostics to improve reliability and reduce maintenance costs.
- Customize or upgrade products by reprogramming embedded firmware.

In addition, a mechatronics-based approach mitigates risk and solves common design challenges such as the slow, serial machine design process; poor communication between machine designers and customers; and risky physical machine testing.¹¹

The Challenges of Adopting a Mechatronics Approach

As manufacturers focus on improving their mechatronics product development processes, they often face significant challenges:

Challenge	Response
Difficulty finding and hiring experienced system engineers / lack of cross-functional knowledge	50%
Early identification of system level problems	45%
Ensuring all design requirements are met in the final system	40%
Difficulty predicting / modeling system product behavior until physical prototypes exist	32%
Difficulty implementing an integrated product development solution for all disciplines involved in mechatronics product development	28%
Inability to understand the impact a design change will have across disciplines ¹²	18%

Source: Aberdeen Group



5 Bolton, William, "Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering," Third Edition. Saddle River, New Jersey, Prentice Hall, 2004.
 6 Aberdeen Group, "System Design: New Product Development for Mechatronics," January 2008.
 7 Bolton.
 8 Aberdeen Group, "System Design: New Product Development for Mechatronics," January 2008.
 9 Bolton.
 10 Aberdeen Group, "System Design: New Product Development for Mechatronics," January 2008.
 11 Mathur, Nipun, "Mechatronics for machine builders – design challenges and solutions," August 21, 2007. http://www.myfen.com.au/articles/Mechatronics-for-machine-builders-design-challenges-and-solutions_271096.htm
 12 Aberdeen Group, "System Design: New Product Development for Mechatronics," January 2008.

Finding design conflicts across disciplines depends largely on the knowledge base of the staff—and yet manufacturers list a lack of cross-functional knowledge as their leading challenge. Although hiring issues are partly to blame, manufacturers seldom have design tools that can integrate design data from all the elements that make up a product. As a result, their teams fail to understand the impact of design change across disciplines.

If manufacturers are going to achieve all the benefits of mechatronics product design, they clearly need technology solutions that enable their design disciplines to collaborate and communicate seamlessly, while also helping them identify system-level problems early, verify that all design requirements are met, and predict the behavior of the final product.

Key Elements of a Mechatronics Solution

Ideally, a mechatronics solution should support the following best practices:

1. Multi-disciplinary design and engineering
2. Managing communication and workflow
3. Effective early validation

Multi-Disciplinary Design and Engineering

As the saying goes, “If you don’t know where you’re going, you’ll end up somewhere else.” In product development, knowing what you need is the first step to getting the final product right. Outlining product-level requirements is usually the first step in outlining product performance. The ability to drive these key parameters into system and sub-system operational performance goals is often what sets leading manufacturers apart from their peers.

Many manufacturers assume that building a single, integrated design process across all disciplines is the best way to coordinate multi-disciplinary design and engineering so that all product requirements are met. But statistics show that the extra effort spent on process engineering ultimately goes to waste. Instead, best-in-class manufacturers use separate design processes across disciplines in order to leverage the domain expertise of their designers. However, this requires that they be diligent in coordinating and synchronizing their engineering groups. It is this synchronization that is key.

This approach is a best practice that should be adopted by other manufacturers seeking to improve their mechatronics design processes. From a practical perspective, this will require manufacturers to deploy focused engineering tools that allow individual disciplines to excel at their work, while providing the ability to share information easily. But it is not enough to be able to model these systems. System-level performance is usually a function of the disparate engineering and design needs of various sub-systems. Breaking down a system into its core constituents, therefore, demands some formality. As a result, it is essential to establish clear processes for effectively communicating changes, and to align collaboration and system engineering tools that can help make sure teams communicate changes effectively.

Managing Communication and Workflow

As manufacturers seek to coordinate and synchronize their separate engineering groups, there are many ways to bring information together. The average company often prefers to generate the bill of materials (BOM) from a customer database application. However, this method requires not only dedicated maintenance and support, but also manual synchronization of design information—making it complex and error-prone for a structure that contains thousands of parts.

Best-in-class manufacturers take advantage of discipline-specific structures for designing products. Rather than maintaining one large database across all groups, companies can use individual, discipline-specific databases that allow groups to manage their workgroup-level data and workflow at a local level.

But even the discipline-specific approach can create problems if manufacturers do not manage it correctly. Ultimately, manufacturers must strike a balance between providing the focus that engineering disciplines require and making certain that the data they create can be brought together easily.

Digital Prototyping Success Story

Bosch Rexroth Canada

“Autodesk Inventor allowed Rexroth to move directly from the design stage to production, without the need for expensive prototypes.”

—Jim Lambert, C.E.T., design engineering manager, Hydraulic Business Unit, Bosch Rexroth Canada

Benefits

With the Autodesk solution for Digital Prototyping, Bosch Rexroth Canada:

- Transitioned from 2D to 3D design
- Landed a five-year project to modernize locks on the St. Lawrence Seaway
- Reduced average monthly non-conformances by 46 percent
- Cut drawing errors by 25 percent
- Increased drawing accuracy by 7 percent
- Decreased design times by over 50 percent
- Made changes 50 percent faster than in 2D
- Cut material and labor costs by 15 to 20 percent
- Produced twice as many drawings with the same staff

Effective Early Validation

No one disputes that it is a good idea to resolve integration issues before committing money to tooling and manufacturing ramp-up. Leading manufacturers focus on resolving integration issues early in product development, and maintain this focus right up until verification and testing.

By focusing on validation, simulation, and verification earlier in the development process, manufacturers can avoid the costs and delays associated with resolving integrations later on. But to achieve these benefits, manufacturers must bring together a wide variety of design and engineering information for review. The goal is to synchronize the efforts of larger teams into single design reviews where all pertinent information is available at once. This is just one of the benefits of digital prototyping.

Driving Mechatronics Product Development with Digital Prototyping

Rather than trying to integrate information from disconnected engineering systems, manufacturers can save time and money by enabling all their teams to work from the same digital model. Today, many best-in-class manufacturers are augmenting traditional physical prototyping by building digital prototypes. By tracking and comparing physical and digital prototype test results, these companies are gaining a deeper understanding of their products and the environments in which they operate—leading to greater overall product quality.

How Digital Prototyping Enables Best-in-Class Manufacturing

According to recent research, best-in-class manufacturers that use digital prototyping outpace average manufacturers by:

- Building 50 percent fewer physical prototypes.
- Getting products to market 58 days faster.
- Reducing prototyping costs by 48 percent.
- Freeing up time and resources for greater innovation.¹³

An Action Plan for Mechatronics Excellence

Although manufacturers have been talking about the benefits of digital prototyping for many years, the ability to build and test a true digital prototype has, until recently, been beyond the budgets of most manufacturing companies. In recent years, however, vendors have introduced increasingly practical solutions that are more attainable, scalable, and cost-effective than their predecessors.

Aberdeen Group has identified four key capabilities needed for best-in-class mechatronics product development:

- Implement processes to overcome the lack of cross-functional knowledge and promote better communication.
- Use simulation to identify system-level problems early in the design process.
- Manage design requirements throughout the entire design lifecycle.
- Accelerate the design of system controls with automated software tools and simulations.¹⁴

For all of these reasons, manufacturers should look for an integrated engineering suite that enables a digital prototyping workflow.

Digital Prototyping Success Story HTC Sweden

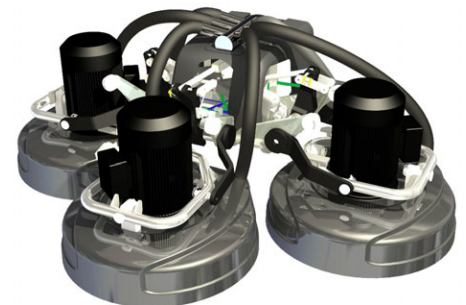
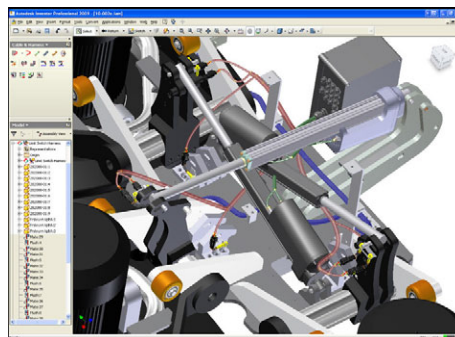
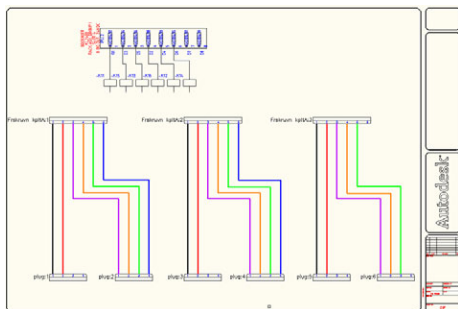
“Our choice of Autodesk solutions is largely a result of our vision of a complete, digital world within the company’s walls.”

— Karl Thysell, Head of Product Development, HTC Sweden

Benefits

With the Autodesk solution for Digital Prototyping, HTC has:

- Achieved up to 200% annual growth, growing from a \$7.5 million to \$56 million company in six years
- Slashed the number of physical prototypes from five to one
- Integrated Vault Manufacturing with enterprise resource planning (ERP) system to connect suppliers in a streamlined, online supply chain



Images courtesy of HTC, Sweden

¹³ Aberdeen Group, “The Transition from 2D Drafting to 3D Modeling Benchmark Report,” September 2006.

¹⁴ Aberdeen Group, “System Design: New Product Development for Mechatronics,” January 2008.

The Autodesk Solution for Digital Prototyping

The Autodesk solution for Digital Prototyping helps mainstream manufacturers realize the full benefits of mechatronics by allowing them to quickly create and easily maintain a single, digital model. This model connects mechanical and electrical teams by bringing together design data from all phases of development for use across all disciplines. Because the digital model simulates the complete product, engineers can better visualize, optimize, and manage their design before producing a physical prototype.

As engineering teams work on the digital prototype, Autodesk's data management tools integrate electrical and mechanical components into a single bill of materials (BOM). Using tightly integrated mechanical and electrical information, teams create more accurate 2D and 3D mechatronics designs in less time, enabling manufacturers to get to market faster.

The Autodesk solution for Digital Prototyping directly addresses the major obstacles to successful mechatronics design by facilitating multi-disciplinary design and engineering, managing project communications and workflows, and validating designs early in the process.

Facilitating Multi-Disciplinary Design and Engineering

Autodesk is unique in its ability to provide focused design solutions for both electrical and mechanical engineering workgroups. The Autodesk solution for Digital Prototyping includes leading tools such as AutoCAD® Electrical and AutoCAD® Mechanical, which work in parallel with Autodesk® Inventor® software to support integrated 2D and 3D mechanical and electrical design processes.

Autodesk Inventor software is the foundation for Digital Prototyping, providing a comprehensive, integrated set of design tools for producing and documenting complete digital prototypes that allow designers to simulate how a design will work under real-world conditions before a product is ever built. AutoCAD® Electrical is AutoCAD® software for controls designers, purpose-built to create and modify electrical control systems quickly and accurately with significant cost savings.

More than any other solution on the market, the Autodesk solution for Digital Prototyping gives the smoothest bi-directional interoperability between 2D and 3D mechanical and electrical design applications. AutoCAD Electrical software passes electrical design intent information for cables and conductors directly to Autodesk Inventor software to automatically create a 3D harness design. Autodesk Inventor users can pass wire-connectivity information to AutoCAD Electrical and automatically create the corresponding 2D schematics. The smooth integration between AutoCAD Electrical and Autodesk Inventor software helps users create accurate mechatronics designs in less time.

Managing Communications and Workflows

As mechatronics product designs evolve and become more complicated, Autodesk® Vault Manufacturing product data management (PDM) software protects designers and engineers from unintentional overwriting of good designs. In addition, users can save hours of valuable design time with powerful tools to rapidly copy and reuse design data, reducing the time required to start a new design.

Autodesk data management tools allow design workgroups to manage and track all the design components for a digital prototype, helping them to better reuse design data, manage bills of material, and promote early collaboration with manufacturing teams and clients. As mechanical and electrical teams work in parallel, Autodesk Vault Manufacturing data management software securely stores and manages the engineering design data and related documents that make up the complete digital prototype.

In addition, Autodesk Vault Manufacturing can automate change and release processes. Manual processes for release and change can lead to design project delays and shop-floor errors. Autodesk's PDM applications give design teams the choice of standard or configurable processes for release and engineering change order management, helping them avoid costly mistakes and remove process bottlenecks.

Digital Prototyping Success Story

Industrial Microwave

Autodesk data management software "allows us to easily manage product revisions and simply compile bills of materials, bridging the two CAD tools we use here at Industrial Microwave Systems—Inventor and AutoCAD Electrical."

— Michael Trull, design engineer, Industrial Microwave Systems, LLC

Benefits

With the Autodesk solution for Digital Prototyping, Industrial Microwave:

- Developed a complete mechatronics strategy
- Integrated AutoCAD® Electrical designs with 3D Inventor® models
- Shared complete design data with the manufacturing shop floor
- Simplified release management
- Bridged communication gaps between disciplines

Validating Designs Early and Often

Autodesk delivers the best integrated simulation tools in the industry. Tightly integrated calculations, stress analysis, and motion simulation make it possible for any engineer to optimize and validate a digital prototype before the product is built.

The dynamic simulation tools in Autodesk Inventor enable engineers to evaluate different potential solutions to a motion problem, enabling the best design decisions and preventing costly mistakes. This is a key element to developing mechatronics products because dynamic analyses are based on real-world constraints with the ability to build in all factors that influence motion in a mechanical assembly.

By taking a unique functional design approach, the Autodesk solution for Digital Prototyping focuses on product function, not geometry creation. As a result, engineers can quickly and easily build digital prototypes. Rather than defining designs with a list of parametric modeling features, they can begin by capturing its functional requirements, allowing the software to automatically create geometry. Mechatronics engineers can use the time they would have spent creating geometry to improve product performance and release designs early.

Request More Information

The Autodesk solution for Digital Prototyping can give manufacturers a mechatronics advantage. By using a Digital Prototyping solution to enable mechatronics development, teams can spend less time worrying about whether electrical and mechanical components will work together and more time innovating. To learn more about what makes Autodesk a leader in mechatronics, visit www.autodesk.com/mechatronics today.

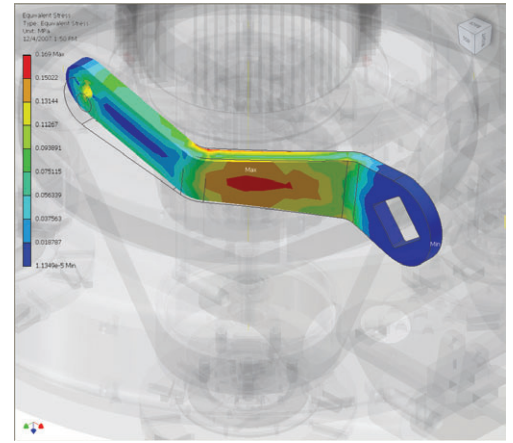


Image courtesy of HTC, Sweden

