Siemens PLM Software

Virtual product development in high tech and electronics

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white paper



Shortening time-to-market, controlling product development costs, safeguarding quality and relentlessly innovating are keys to success in the high tech and electronics (HTE) industry. To compete and win, manufacturers have to identify product features that customers want, then implement those features in products that align with customer expectations and deliver them to market faster than the competition.

This report documents how industry leaders are creating virtual product development (VPD) environments that make it possible for teams to define, simulate, refine and validate products digitally by better integrating the various phases of product development and the disparate engineering disciplines involved, all while reducing or eliminating physical prototypes and freeing project stakeholders from the need for physical co-location.

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Answers for industry.

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Executive summary

Minimizing time-to-market and controlling costs are critical to success in the high tech and electronics (HTE) marketplace. To compete and win, manufacturers must identify product features that customers want, develop products that implement these features and deliver them to market faster than the competition – all while controlling development costs and safeguarding product quality. HTE manufacturers historically have struggled with several key barriers to achieving these goals:

- *Difficulties in sharing data among the various phases of the product development process*
- *Poor integration between disparate engineering disciplines*
- *Reliance on costly and time-consuming physical prototyping and testing*
- *Obstacles to collaboration among globally dispersed project stakeholders*

Today, however, all this is changing. Best-in-class HTE manufacturers are re-engineering their product development processes to ensure that demand drivers identified during requirements definition are translated into product features that customers want, more rapidly and at lower cost than before. Many companies are moving to implement virtual product development (VPD) environments that make it possible for teams to design, simulate, refine and validate products digitally.

By providing a single source of product and process information, these new environments enable cross-functional design teams to validate new products digitally, and connect all stakeholders to the design process so that their product design and evaluation activities can proceed concurrently. The benefits also include reduced need for physical prototypes, enabling more design iterations, often in less time, which in turn promotes product quality as well as fostering higher levels of innovation.

Introduction

Virtual product development work processes and the technology environments enabling them are making it possible for teams creating high tech and electronics (HTE) products to define, simulate, refine and validate products digitally by better integrating both the various phases of product development and the disparate engineering disciplines involved, while also reducing or eliminating physical prototypes as well as the need for physical co-location of project participants.

Historically, HTE manufacturers' efforts to achieve the business goals of accelerating time-to-market, controlling product development costs, validating and improving product quality and fostering innovation have been constrained by shortcomings of their product development processes:

- Difficulties in sharing data among the various phases of the product development lifecycle – industrial design and styling, design engineering, design validation (computer-aided engineering and physical prototyping), manufacturing engineering, production release and ramp-up
- Poor integration between the disparate engineering disciplines involved – mechanical design, electrical and electronics design, software engineering/CASE
- Reliance on costly and time-consuming physical prototyping and testing in the design validation stage
- Obstacles to collaboration among distributed design teams, contractors and other globally dispersed project stakeholders

Today, all this is changing. Best-in-class HTE manufacturers are re-engineering their product development processes to ensure that demand drivers identified during requirements definition are translated into product features that customers want, more rapidly and at lower cost than before. Many companies are moving to optimize this part of the product development lifecycle by creating virtual product development environments that make it feasible for teams to design, simulate, refine and validate products digitally.

By providing a single source of product and process information, these new digital collaboration environments enable cross-functional design teams to validate new products digitally, and connect all stakeholders to the design process so that their product design and evaluation activities can proceed concurrently. The benefits also include reduced need for physical prototypes, enabling more design iterations, often in less time, which in turn promotes product quality as well as fostering higher levels of innovation.

This report examines how these improvements are being realized in each of these process areas:

Integrated product development How can VPD enable HTE manufacturers to create a single integrated product definition across all the phases of the product development lifecycle – industrial design and styling, design engineering, design validation (computer-aided engineering and physical prototyping), manufacturing engineering, production release and ramp-up?

Whole product management How can VPD help coordinate activities across disparate engineering disciplines – mechanical design, electrical and electronics design and software engineering/CASE?

Digital validation What's needed in VPD to connect requirements to design verification, and to liberate design validation processes from the time and cost constraints of physical prototyping and testing?

Global collaboration How can VPD deployments establish a virtual co-location environment in which globally dispersed project stakeholders can collaborate to evaluate designs and resolve product development issues?

Integrated product development

How can VPD enable HTE manufacturers to create a single integrated product definition across all phases of the product development lifecycle – industrial design and styling, design engineering, design validation (computer-aided engineering and physical prototyping), manufacturing engineering, release to production and volume ramp-up?

After requirements for a new product are captured, product development in HTE moves to the all-important step of industrial design (ID) and styling, critical to consumer appeal and shelf appeal. Then the functionality captured during requirements definition must be implemented by design engineers – mechanical designers, electrical and electronics engineers, embedded-software developers – within the packaging constraints developed in the ID phase.

During all this, aspects of the emerging design – operation of mechanisms in the product packaging; structural integrity in the event the product is dropped; functioning of the product's electrical and electronic components and how these interact with its mechanical systems – need to be validated. The goal is to ensure the design will work as intended – and to rapidly explore design alternatives, to ensure the optimal solution does not go overlooked.

Finally, engineering design specifications must be translated into an efficient manufacturing process that optimizes materials usage, production speed, robustness and repeatability.

Traditionally, each of these phases of product development has often been carried out sequentially, with little if any collaboration with participants in subsequent phases, but instead with distinct handoffs of the output of one phase to the next. The result of such rigid, linear, non-collaborative work processes has been to make it difficult to find new and innovative ways to implement new product requirements, and to slow the pace of new product introductions.

This report highlights three high tech and electronics manufacturers moving to put in place the elements of a VPD process. One of these, a leading consumer electronics company, is moving aggressively to transform its product development activities by implementing a VPD process. A manager and senior engineer at this firm describes what first motivated his company to undertake this transformation in how it develops products. "We had been using CAD technology since the late 1980s," he explains. But in 2007 the company's management decided that new product launches needed to be accelerated further. This company had already achieved tight integration of its design engineering activities with downstream manufacturing engineering. Now, management decided the time was at hand to focus on upstream product development processes as well. To this end, the executive told us, "top management asked that industrial design and styling be validated against product requirements in the early stages of product development."

As a result, last summer the company launched an aggressive initiative to achieve closer integration of its industrial design and styling activities with design engineering and design validation. To enable this, the company is focusing on "collaboration, digital validation and giving everyone access to the right information at the right time."

A particular focus of this firm's VPD initiative is ensuring the ability to leverage digital validation at every stage of product development – that is, re-engineering product development to reduce or even eliminate dependence on physical prototypes to test and verify design concepts and production processes, replacing them with digital simulation and analysis (CAE) tools and techniques. The benefits of leveraging digital validation include reducing or eliminating the time and cost penalties of building physical prototypes, becoming able to evaluate more design iterations within the time and budget available, potentially obtaining more insight into product performance from digital simulations than from physical tests, and validating designs more quickly.

This is demonstrated in one of the company's key business goals for its VPD initiative – "fewer physical mockups in less time, to get quality products to market faster." At the same time, however, the company also set a goal of doubling the number of mockups on each project – something that will be made possible by transforming the basis of its digital validation process from physical mockups to digital mockups.

Key digital tools with which the firm is pursuing this goal include Siemens PLM Software's NX™ software for engineering design, CAM solutions and Siemens' Teamcenter® software, plus some in-house-developed PDM capabilities. In addition, the company has implemented virtual reality technology for industrial design. "With that system, we can have good interaction with virtual prototypes in evaluating color, finish and other attributes," our source explains, enabling photorealistic visualization from the virtual product model.

A second HTE manufacturer that has implemented key elements of a VPD strategy is a major opto-electronics manufacturer, including digital cameras. When the company set out to redesign a popular digital camera, targeted at advanced amateurs and professionals, they set a challenging goal of combining high image resolution with fast image capture. Typically when resolution goes up, speed goes down. But the company wanted its new model to be able to capture as many as five high-resolution images per second.

Another challenge with the new model was its shape. An ergonomic design was critical, but so was a design that would stand out visually on store shelves. Further, to seize fleeting market opportunities, the manufacturer wanted to develop this camera much faster than previous models. This meant overcoming obstacles such as miscommunication between design and manufacturing that led to engineering changes and rework. It also required fast evaluation of multiple shapes to ensure that the new camera was perfectly suited to the needs of the target market.

The customer decided to model the entire new camera model in 3D using NX, beginning with the initial stages of design. As the director of the design department says, "It is difficult to think of an ergonomic design without the use of 3D CAD." NX made it possible for designers to review more iterations of the camera than in the past. Highly realistic rendered images could be viewed from all angles. The grip of the new model is about 3.5 mm thinner than the old model. To ensure a good grip with this body volume, the design team used the history function of NX numerous times to fine-tune the shape.

Rapid prototyping was used in conjunction with the 3D model data for fast evaluation of physical prototypes. Using an in-house rapid prototyping system, the chief designer said the company was able to evaluate multiple design iterations "to ensure a good grip with this body volume" with very little cost incurred.

The new model went from concept to production in half the time it formerly took Canon to develop a new camera. "Without NX, it would have been impossible to finish this design within a very short timeframe," says the chief designer. One reason for the faster development cycle was smoother communication between the design and manufacturing divisions. "When communicating with the design division previously, we had to redo the mockup a number of times," says the director of the design department. "As a result, the final cost was enormous. Since design information in the form of 3D NX data can now be shared, feedback from the design division can be incorporated easily. With the new model, we were able to exchange communications much faster than in the past. NX has demonstrated its brilliance as a communication tool." More efficient communication, combined with inexpensive rapid prototypes, resulted in lower development costs for the new model compared to other models.

Another critical aspect of integrated product development is managing the release of information at key stages of the product development process. A third HTE manufacturer, a market leader in semiconductor manufacturing equipment, has implemented key elements of a VPD approach. In addition to NX for design, the company has implemented Siemens' Teamcenter PLM product offering for process management, in particular management of the design release process. Teamcenter handles this process at two of its sites. The release process has a number of stages, and Teamcenter gives management another way of monitoring project status. More importantly, having Teamcenter manage the process ensures data quality, preventing data quality errors that require time-consuming and costly fixes.

Integrated product development enabled by VPD environments provides the following key capabilities:

- Concept validation through industrial design (ID) and styling with rendering
- Design layout and product modeling for detail design and documentation
- Product and process templates for performing repeatable design activities that enable best practice quality procedures

How can VPD help coordinate activities across disparate engineering disciplines – mechanical design, electrical and electronics design, software engineering/CASE?

Development of HTE products requires coordination and cooperation among three key engineering disciplines: mechanical engineering, electrical and electronics engineering and software engineering. Unfortunately, the digital toolsets used to automate each of these disciplines – MCAD (mechanical computer-aided design), ECAD (electrical computer-aided design) and CASE (computer-aided software engineering) – often are not integrated with one another well, if at all.

Because of this, data created by one discipline has had to be re-entered manually into the tools used by other disciplines, giving rise to errors and delays and hindering efforts to speed product development and enable more design iterations, exploration and innovation by having these activities proceed in parallel rather than sequentially.

This was, to some extent, the case at the first consumer electronics manufacturer that we studied. In implementing VPD, our source says, his firm is "moving toward more concurrent engineering. Before moving to VPD, our product development projects had been more linear – one step had to be finished before the next could get started."

To remedy this, a key objective of VPD initiatives is to put in place an environment into which mechanical, electrical/electronics and software development applications are all directly integrated – information needs to be created only once, and is then available to all project participants as needed.

Integration among these three disciplines, and among the application software tools supporting them, is especially critical in HTE product development. The core functionality of HTE products is almost always heavily dependent on the electrical and electronics components and systems inside them – integrated circuits (ICs), printed circuit boards (PCBs), busses, wiring harnesses and connectors. These components, in turn, must be engineered to fit within the physical packaging requirements – often quite restrictive – that were defined during the industrial design and styling phase of product development, and refined during mechanical design. When product development teams have difficulty sharing data between MCAD and ECAD applications, the results are suboptimal product designs, schedule delays or both.

Mechatronics design is likewise critical to HTE product development, for similar reasons. This discipline is the design of mechanical systems such as the disc tray of a DVD player or the autofocus mechanism of a camera, in coordination with design of the electrical and electronic systems that control their operation.

Because of the high embedded-software content often required to control the functioning of the mechanical, electrical/electronic and mechatronic systems that make up HTE products, software engineering is a third critical discipline. Thus, CASE (computer-aided software engineering) tools and the data they generate are also key elements to be integrated into VPD for HTE.

By capturing, storing and tracking design data from each of these domains within a single concurrent development environment, VPD can provide whole product management of HTE product lifecycle information, regardless of the toolsets used:

- Schematics, layout, parts and derived files
- Mechanical drawings and electronics design data including simulation models
- Wire harness logical, physical and component data
- Software source code and binary files

The benefits are clear:

- Eliminate information duplication and error by managing all product IP assets within a common framework of related electrical/electronics, mechanical and software design information and integrating to the respective native design tools
- Enable concurrent product development by allocating system information through embedded requirements, across all design disciplines within a unified information model
- Improve design collaboration by leveraging visualization and markup of MCAD and ECAD designs across the value chain
- Ensure that, at any time, the latest information from each discipline is being integrated to support the system- or product-level decisions

To implement such a whole product management platform, HTE industry leaders we studied are first moving to establish a single source for all product information. This environment interconnects authoring application so as to manage their companies' intellectual property in the native formats of the MCAD, ECAD and CASE tools in which it was created. The benefit is a single source of product information that eliminates the time and accuracy penalties of data re-entry and facilitates information re-use.

Thus defined, whole product management provides the following key capabilities:

- Product structure and information model for use by multiple design disciplines
- Electrical/electronic data and process management that integrates needed ECAD applications
- Software development and CASE tool integrations
- Mechanical design data and process management that integrates needed MCAD applications
- ECAD/MCAD geometry exchange to enable digital validation of electromechanical product descriptions

Digital validation

What's needed in VPD to connect requirements to design verification, and to liberate design validation processes from the time and cost constraints of physical prototyping and testing?

Validation of product concepts has long been dependent on building and testing physical prototypes – a process that can exact heavy penalties in time, cost and quality. Physical prototypes can be costly to produce. Testing them can be a slow and not always revealing process. Physical test results are not always easy to integrate back into digital design flows and act on to improve the design. Moreover, HTE products present special challenges in validating the multiple, often interacting and interdependent determinants of their performance – mechanical components, electrical and electronics systems and the mechatronic systems where these two domains come together.

Because of this, digital validation processes built on digital simulation and analysis (CAE) technologies are increasingly critical in enabling HTE manufacturers to meet program objectives for schedule, budget and quality – the complexity, performance and efficiency demanded of today's products simply can't be achieved any other way. Companies we studied are working not just to use digital validation on more projects, but to make its use pervasive throughout product development. This extends from early concept design, where good decision-making has the greatest leverage on lifecycle costs, all the way through manufacturing engineering where simulation helps shorten production ramp-up, control unit costs and boost fit and finish.

What business goals are best-practice leaders seeking through more effective use of digital validation? Shortening schedules and controlling development and manufacturing costs while safeguarding product quality are key goals at companies we studied. Packing more features, capability and customer appeal into each new product is a baseline requirement for success in HTE. But fierce price competition is pushing manufacturers to reduce development and production costs even as they continue adding features and innovating new products. Another constraint – getting all this done within the industry's brutally short product cycles, where time-in-market is often months, not years, and development schedules may be as brief as 12 weeks.

At the first consumer electronics company we studied, a key driver of the move to VPD was the decision to make validation capabilities available earlier than ever before in product development – namely, during industrial design. Our source explains: "The ID phase is where top management asked us to implement a capability to validate the mechanical aspects of new product designs," as well as in subsequent phases of the design process.

For this firm, what's the business goal of integrating digital validation with the earliest phases of product development? "We're hoping to see lead time reductions," our source says, "as well as a reduction in post-production problems such as engineering changes." And the ultimate payoff? "To further strengthen confidence in the company" – both as an internal design goal and in reinforcing how the company is perceived in the marketplace.

The semiconductor equipment manufacturer we studied likewise uses key elements of VPD to continually shrink product development cycles. As a producer of semiconductor manufacturing equipment, being first to market with new technology is critical. A big part of their strategy for reducing cycle time is its use of NX. The company models entire machines, consisting of as many as 25,000 mechanical and electromechanical parts, digitally in its CAD environment. Using NX to detect interferences digitally prevents time-consuming rework, enabling the company to avoid interferences and improve the quality of its design data, directly enabling cycle time reductions.

What digital simulation and validation results are used for, and by whom, is also evolving at HTE best-practice leaders. More than one company we studied reported that the application of digital validation has expanded beyond analyzing product performance to include visualization and virtual-reality presentations of material qualities and appearance to project participants outside the analysis group.

In summary, digital validation – implementing simulation (CAE) to augment or replace physical validation – lets manufacturers evaluate and optimize product performance virtually. In becoming better able to link simulation to upstream functions such as requirements definition and industrial design, companies strengthen their ability to ensure that end products meet defined requirements and customer demand drivers. Digital validation can also reduce or even eliminate costly, time-consuming physical prototyping. Finally, by enabling designers and analysts to work concurrently to test and validate product behavior without building physical prototypes, it increases project teams' ability to iteratively explore and evaluate design alternatives.

Digital validation provides the following key capabilities:

- Analysis and simulation for digitally validating thermal, cooling, humidity, environmental and stress factors, enabling rapid development and improved product performance
- Requirements-driven design verification for validating designs against requirements and best practices
- Motion simulation analysis with collision detection capabilities that validate packaging and use case conditions
- Fully scalable simulation environment with ease-of-use templates and wizards for facilitating repeatable digital collaboration between designers and analysts

Global collaboration

How can VPD deployments establish a virtual environment in which all project stakeholders can collaborate to evaluate designs and resolve product development issues?

In today's globally dispersed product development processes, a key requirement is sharing the right information among the right people at the right time. One of the reasons that the semiconductor equipment manufacturer we studied originally chose NX was collateral availability of a product lifecycle management solution – namely, the Teamcenter product from Siemens PLM Software. The company needed a CAD system that was tightly integrated with PLM, because as many as 250 designers might be working on a single machine. Thus the company needed a way to keep track of changes and make sure information was up to date. In addition to its in-house design team, the company contracts with outside engineers who contribute to the design effort. It was important to give them access to up-to-date product information as well.

Since first being installed in 1997, this company's Teamcenter implementation has subsequently expanded, allowing the creation of a seamless global product development environment. Previously all design work was done in the company's European facility by in-house personnel and local contractors. When the company purchased a North American company in 2001, it gained another design team located in the U.S. It then equipped the 80 engineers at that site with NX and Teamcenter, with the goal of complete integration with the company's European operations.

Rather than dividing the work and having each site work on separate projects, the company wanted a single, virtual design team that worked concurrently – something that Teamcenter made possible. If it were just a matter of integrating a few engineers, it might be possible to share information via FTP sites and email, but with up to 80 engineers working on the same design, it's much more efficient with Teamcenter, the company found – and this is the only way to be sure that everyone works with up-to-date information, the company reports.

Similarly, for the first consumer electronics manufacturer we studied, "the first functional requirement of a VPD process is collaboration," our source reports. What's necessary to enable collaboration? "Technically, first this requires the necessary communication channels; second, some means for coordination; and third, tools to help global cooperation."

After collaboration, our source continues, the second most important enabler of VPD is "timely digital validation techniques," as discussed above. What's third? "Having the right information at the right time." The company is making this possible by further enhancing and extending its implementation of PLM technologies, such as PDM. These kinds of information support systems are what's necessary to provide the right information at the right time. In tandem with this, our source notes, "work processes have to change" in order to make the most of all that VPD environments enable. To this end, "we are doing some work process re-engineering."

CAD technology is as diverse as the companies who use it, and with the increase in collaboration with design partners, a VPD environment must consume model information from external and legacy designs without dependency on specific CAD tools or formats. A multi-CAD enabled systems can reliably combine design data from all sources to provide a common virtual model.

Today's HTE product development processes call for globally distributed design teams to collaborate, review and approve designs. Best-in-class organizations such as those described in this report are implementing collaborative virtual environments that reduce travel and improve stakeholder involvement in design review and validation. By connecting geographically and organizationally distributed teams of internal practitioners, partners and contractors, the collaboration tools being implemented in VPD environments let teams conduct design reviews, capture issues, collaborate on resolution and manage the change process.

Global collaboration provides the following key capabilities:

- Web-based collaboration portals enabling real-time access to product information for review and analysis
- Issue management and collaboration features that help teams resolve product issues prior to launch
- Integrated and intelligent view/markup and visualization tools that enable a global review process
- Access and configuration control to ensure the right people have access to the right information at the right time
- Multi-CAD design environment enables integrated supply chain development where designers work with model elements from various CAD applications

Summary

Being first to market with innovative products that customers want, while controlling product development costs, are keys to success in high tech and electronics. Best-in-class HTE manufacturers are re-engineering their product development processes from a sequence of serial, loosely coupled, physical prototype-bound activity chains to an approach marked by a parallelized, tightly integrated, fully digital product development lifecycle – virtual product development.

As firms leading the charge are proving, enabling teams to design, simulate, refine and validate products digitally helps ensure that demand drivers identified during requirements definition are translated into product features that customers want, more rapidly and at lower cost than before. Then, by providing a single source of product and process information, VPD environments let cross-functional design teams validate new products digitally, and connect all stakeholders to the design process so that product design and evaluation activities can proceed concurrently. VPD also reduces or eliminates physical prototyping, enabling more design iterations to be explored, often in less time, thus promoting quality and fostering innovation.

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