Product Lifecycle Management
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Speed product development with integrated Digital Mockup solutions

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Today's business challenges

Today's manufacturers have never been under more pressure. Competition is global, customers are fickle and demanding, and financial markets are unforgiving.

The answer? Repeatedly delivering the right product at the right time and at the right price. However, achieving this is far from easy. Successfully balancing increasing product and process complexity with rising performance and quality requirements is a challenge.

These pressures are forcing fundamental changes in the way companies are structured and in the way they conduct business. The result is a new global business model based on collaborative communities working within, and beyond, company boundaries.

The product development differentiator

It is estimated that 80 percent of product costs are determined early in the product lifecycle, leading many companies to look for ways to front-load product development decisions to help meet time-to-market, quality and cost issues.

Maintenance costs are also escalating as product complexity increases. The amplified effect of decisions made during the product development process on downstream business metrics means that 'building in' quality during the early stages has never been more important. Realtime collaboration, appropriate simulation tools and a significant reduction in the number of physical prototypes through virtual prototyping are key initiatives in this regard.

In addition, a major effort has been taking place within the manufacturing industries to shift from a product-centric to a customer-centric strategy as customers become more demanding. Product differentiation can only be achieved by continuous innovation – a strategy many companies have embraced to address an ever increasing number of target markets. The ability to deliver high levels of customisation starts with the design process. Manufacturers need to know early on that the many variants of a final product will all perform adequately during service and designers need to know the impact of a change to a product component on the variants in which it is used.

Finally, inefficiencies during product development can have a tremendous impact on the overall time-to-market of a product. The effect of Computer Aided Design (CAD) products on increasing designer efficiency is well known. However, what may not be as well known or understood are the many other bottlenecks that slow down product development. For example, consider the time required for multiple stakeholders from multiple development partners to understand, and all agree to, a design at each relevant stage of the product development process.

PLM and Digital Mockup: Improving product development

Over recent years, Product Lifecycle Management (PLM) has been embraced by leading manufacturers as a means of leveraging leading business strategies and supporting technologies to substantially impact the product development process. Supporting decision-making throughout the product development process, Digital Mockup (DMU) is a key component of PLM. It substantially decreases product development time and costs, while helping improve product quality.

DMU is the process of building and using a computer-based digital 3D representation of a product – a mockup – to conduct tests that will predict product function and performance in the real world. One of the most obvious advantages of DMU is the ability to reduce, or even eliminate, the need for physical prototypes – one of the most expensive aspects of product development. For example, the complete design of a car can require up to 40 physical prototypes, each costing more than one million dollars.

However, the benefits of DMU extend beyond merely reducing the number of physical prototypes. By providing a mechanism for sharing product information and allowing design reviews to be quickly and easily conducted among multiple team members and across multiple companies and geographies, DMU also encourages more design alternatives, leading to increased product innovation.

The importance of efficiency and integration

The concept of DMU originated in the late 1980s shortly after the adoption of 3D CAD systems. It was typically provided as an 'add-on' application to CAD systems and was provided by companies such as EAI (Engineering Animation Inc) and Division Inc. Unfortunately, almost two decades have now passed, and apart from the company names, little has changed. Most DMU applications are still provided as standalone applications that are not integrated with CAD authoring tools or with the overall PLM solution, CAD, Product Data Management (PDM) or Computer Aided Manufacturing (CAM) applications.

While this may have been acceptable in the past, today's competitive pressures to shorten the product development cycle and improve product quality are exposing problems with this approach. For example, designers, project leaders and process engineers can find it challenging to use a DMU application that is decoupled from the CAD environment.

As an analogy of this approach, imagine writing a document on a word processor and using a standalone spell checker, rather than one that is fully integrated within the word processor. Consider the problems of having to export the document from the word processor and then import it into a standalone spell checker. And then, because the word processor has no ability to import the format output by the spell checker, having to go back to the original document to implement the corrections. Once this was done, you would then need to repeat the entire process to verify that all the spelling corrections had been completed correctly.

The example above may sound trivial, but this is exactly the kind of inefficient process that is used today by many product development organisations when reviewing 3D design data. The visualisation format used by the DMU applications is different to the formats used by CAD applications, and the CAD applications have limited (or no) ability to integrate the output from the design review application for easy resolution by the designer.

Now imagine the complexities of this approach for design reviews in the automotive industry: A typical automobile can have 8,000 parts, with many of these being used in different models and configurations of a given vehicle and with the parts themselves also having different release levels and variants.

Using a DMU application that is not tightly integrated with your other PLM applications leads to several other business issues as well:

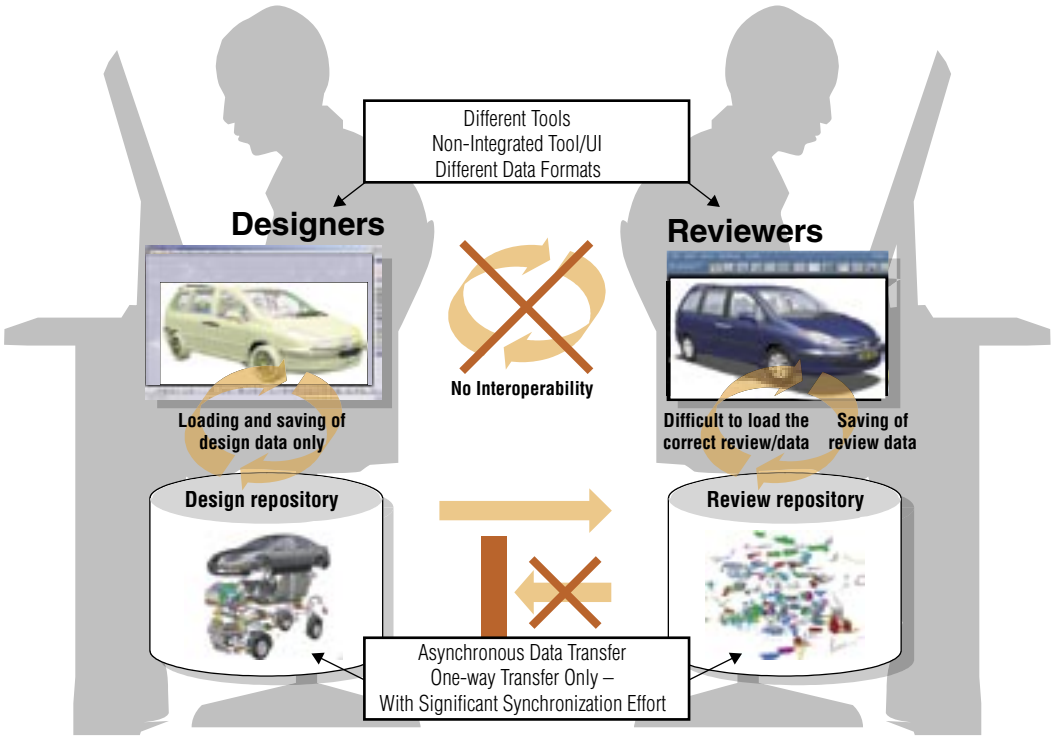
- *Increased cost, time and effort – IT infrastructure, business processes and support requirements all increase when maintaining separate design review and CAD authoring formats and repositories*
- *Poor product quality – Design errors result from an inability to simulate the performance of all product variants and configurations, leading to quality and warranty issues*
- *High warranty costs – Manufacturing and product in service quality and performance suffer due to inadequate simulation during the product design stage.*

Meeting the challenges

Integration

Maintaining a separate review repository from a design repository may seem like the most expedient way to initially implement DMU capabilities. However, it introduces several challenges:

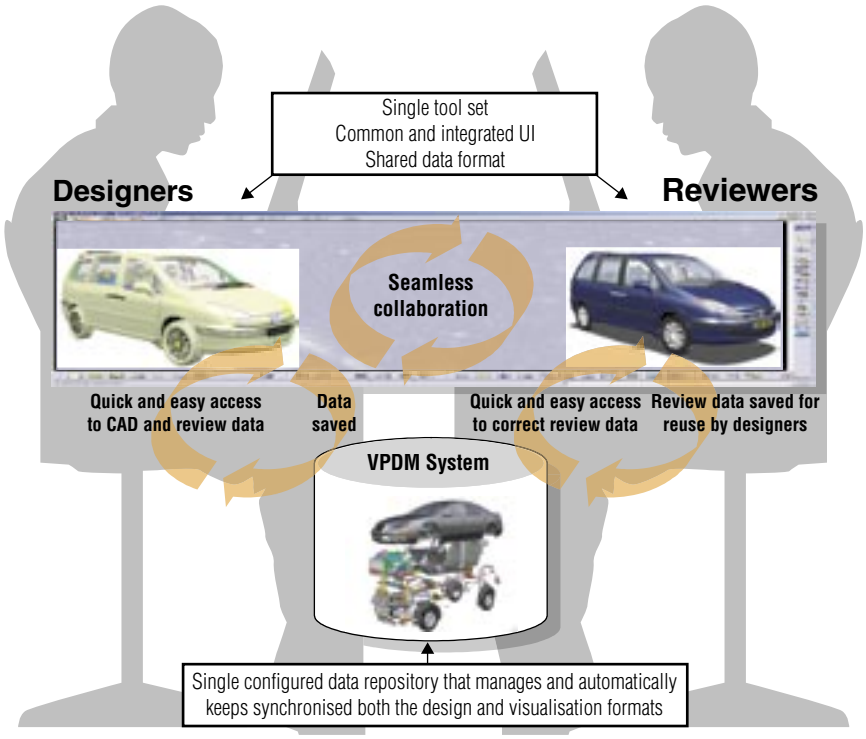
- *How to synchronise the design data repository and the visualisation data repository*
- *How to ensure that data being used for a design review is up-to-date. For example, has the design evolved since the visualisation 'snapshot' was taken?*
- *How to select the appropriate data for analysis within the DMU environment*
- *How to 'close the loop' to get feedback from the design review application back into the design applications.*



Concurrent engineering – a vision originally conceived in the early 1990s – relies on simultaneous efforts from multiple designers. However, when two separate repositories are used, engineering must stop until the design review is completed. Otherwise, reviewers cannot be certain that they are looking at the most up-to-date design.

Ideally, the design data and visualisation data are integrally linked within the PLM environment and synchronisation is inherent within the architecture. Engineers can then work rapidly, and if data used in the visualisation is changed, all affected reviewers are notified, ensuring that everyone involved in both design and review is up-to-date. This tight coupling of design data and visualisation data, as well as integrated data management, optimises the overall DMU review process, leading to significant productivity improvements.

In addition to productivity improvements, significant business benefits can be gained by integrating CAD design applications and DMU review tools within a single application framework. In an integrated environment, a design engineer simply selects a menu pick within the CAD application to immediately change to a design review session. The designer then uses the power of the design review tools to simulate the product being designed. If a problem with a design (for example, a kinematic mechanism clashing with other components) is found, the user can immediately switch back to the design environment to rectify the problem – without any data translation or migration. The integration of these two environments into a single logical application leads to immense productivity improvements in the overall design process.



"Thanks to the digital mockup configured with ENOVIA, we have eliminated the need for a physical prototype of the Falcon 7X."
Jean-Claude Hironde, Deputy Senior Vice President, Research, Design and Engineering, Dassault Aviation

"One of the most expensive things in the design of complex products is a physical prototype. With the ENOVIA DMU Navigator, we can work with different CAD data in the same environment and we can exchange design data quickly and easily between Canada and Austria. Normally, we need up to three different physical prototypes (for different design phases). Now we can build up digital prototypes in the first part of the design phase. So we save one to two physical prototypes and this saves around $360,000 per year."
Harald Okruch, CAD/CAM Management, Bombardier Rotax

"The $300,000 investment we made in CATIA and in ENOVIA virtual product design and product data management applications has helped this company repeatedly compete for, and win, big design contracts. ENOVIA helps us nail the design with few mistakes and reduce supplier costs by 30 percent. The potential to correct mistakes early in the process can definitely save us and our clients money and time."
Tom Porterfield, Vice President of Operations, Farnham & Pfile

An integrated environment is also essential to build an efficient digital prototype. First of all, the user has much more latitude in selecting relevant data for DMU analysis: Selecting data may seem easy for a simple product, but it can be much more complex for automobiles, aeroplanes and ships containing part counts ranging from thousands to more than one million parts. An integrated environment enables the user to limit the mockup study to a specific area by selecting only the parts that are necessary to create the 'correct' mockup environment – one that contains data at the correct version and release level, and for the right configuration of the product being analysed. The user can also choose to only use data modified by the CAD system after a particular date and time. The ability to select DMU data directly from the PLM system in this way ensures that data selection is fast, easy, accurate and efficient.

An environment that uses common data for both design and DMU facilitates rapid throughput of engineering changes resulting from the design review and enables feedback from reviewers to be easily transmitted to design. Integration allows formal validation, authorisation and tracking of changes as well as providing the right people with the right information for immediate corrective actions. For example, within this environment, it is possible to capture a request for change and route it to an appropriate department and/or designer for resolution. The necessary corrective action is communicated in the context of the configured 3D product – along with all of the necessary DMU information such as identified clashes and impacted geometry, cross sections, measurements and annotations.

Supporting mass customisation

It is easy to imagine performing a clash analysis on a DMU of a single configuration. But how do you perform the same analysis for an automobile, truck or aeroplane that can have literally thousands of configurations? How do you manage interferences detected during the design review when the impacted parts are used in multiple configurations of a product?

Fortunately, capabilities exist in today's PLM solutions to manage multiple product configurations. These capabilities originated with PDM systems, which were used to model product structures and engineering bills of materials. However, modern PLM systems leverage configuration management that is much more closely aligned to the design environment than can be provided by PDM systems. This technology is Virtual Product Development Management (VPDM).

VPDM capabilities provide an understanding within the design environment of all product variants and configurations. Whereas most PDM systems are document-centric, VPDM allows users to manage design data at a much more granular level than that understood by most PDM systems. VPDM not only understands design configurations stored in the CAD system, but also understands and manages the visualisation representation, preventing loss of data synchronisation and increasing accuracy of design.

As well as supporting DMU studies across all configurations, VPDM also provides a very efficient process for managing the results of clash analysis. This process ensures that all interferences are captured and addressed, and limits risks by providing decision support capabilities specifically designed to support complex environments.

For example, consider a situation in which two parts interfere in 47 out of 61 possible configurations. Now, imagine making an adjustment on a part dimension to try to eliminate the interference. Running clash detection indicates that making this change eliminates the interference in 35 of the configurations, but creates interference in 12 other configurations. Without VPDM providing understanding and management of design information at a granular level, the complexity of this environment could be overwhelming and require significantly more human intervention.

Leveraging advanced DMU capabilities

Using a common architecture and data management platform is critical to being able to leverage advanced DMU capabilities, such as product synthesis. Using a single solution for DMU frees users from painful data translations and the difficulties associated with non-compatible data.

Advanced DMU capabilities also allow engineers to find answers to questions about the overall product design, such as:

Do the parts of the assembly fit well together?

As explained earlier, VPDM is a key technology for managing clash detection. However, the capabilities of VPDM go further than simply managing the detections – VPDM helps manage the entire DMU process from clash detection to resolution.

VPDM manages the interferences as discrete change actions, ensuring that all designers involved with the product are notified and aware of what needs to be changed, and why. This is much more efficient than simply identifying clashes in a report which then require human intervention for resolution. This effective management of the clash resolution process can have a significantly positive impact on the overall product development process.

VPDM enables users to define the clashes' specifications, launch, or even schedule, the clash computation, store the results and then detect non-relevant clashes or delete solved clashes. Finally, as the clash process can be scheduled at any time, reviewers are able to focus their time and expertise to find solutions.

Identifying clashes is an extremely important activity throughout the design cycle. Resolving clashes on the manufacturing floor can cost hundreds of times what it costs to resolve them during the design phase. However, the potential of DMU extends well beyond clash analysis. Other activities supported by DMU include:

Can my product be serviced?

One of the most important questions to ask during the design phase is how easy it will be to service the product once it is in the field as problems can be incredibly expensive to address. Fortunately, advanced DMU capabilities allow a user to simulate and analyse assembly and disassembly operations to validate the feasibility of maintenance operations.

For example, consider the process of changing an oil filter. The filter needs to be easily accessible and removable without affecting any surrounding equipment or causing undue oil spillage. DMU can simulate the removal of the filter and automatically generate an extraction path, verifying no collisions between the filter and surrounding equipment. Moreover, it can generate swept volumes for the extraction path – and even take into account a tool being used to remove the filter – and create space reservation to ensure that no other parts or equipment are mounted in the way.

How will my product appear with real materials, textures and lighting?

Realistic product visualisation is especially important in the automotive and consumer packaged goods industries, where styling can make the difference between success and failure. Using advanced rendering, marketing can view realistic images of early designs and participate in the conceptual design process, saving hundreds of thousands of dollars on physical prototypes.

Using these capabilities, a designer can also create realistic and dynamic renderings and animations in realtime, leading to efficient design evaluation and validation at any time during the product development process.

Does my product's mechanism work?

While clash analysis is an important part of product design, many products have moving parts. For these products, it is important to understand how parts move relative to each other to ensure no interferences in actual usage. Advanced DMU capabilities allow a user to define mockup kinematics using a wide variety of joint types, or to generate them automatically from mechanical assembly constraints. The user can also simulate and analyse mechanism motion by checking interferences and computing minimal distances, and generate the trace or swept volume of a moving part to drive further design.

Will the space allocated to the fan mechanism be sufficient?

Closely related to the question of the interference of moving parts is the question of how much space a part will require once it is in service. This question is particularly important for industries in which parts of the product are designed by different partners. For instance, in the automotive industry, one company may design the bonnet, another the engine compartment, and yet another the engine. To work concurrently, designers must understand space constraints early in the design process before all the component designs are complete. Advanced DMU capabilities allow a user to generate the swept volume of a moving part using a simulation and then compute space reservation early in the assembly design process.

Do my product's ergonomics meet human comfort and safety standards?

With an increasing focus on customer safety and comfort, today's manufacturers are placing even greater focus on ergonomics. DMU allows designers to simulate the usage of a product by a human by creating and manipulating standard and user-defined human mannequins. The range of human motion required to operate the product, lifting, lowering, carrying, pushing and pulling activities as well as human vision considerations can then be assessed. This understanding early in the design process can help manufacturers avoid situations where a product cannot be used effectively once placed into service.

"The cockpit is the nucleus of a race car. It is a very confined space that protects the vital elements of the car – most importantly the driver. An improved cockpit, with a comfortably and safely installed driver brings us closer to success at every race. The integration of the V5 Human Modeling ergonomics tools within our PLM product development platform allows us to manage ergonomics data in an efficient and intuitive manner within the overall development process of the entire car."
Waldemar Klemm, IT Manager,
Toyota Motorsport GmbH

Ensuring future success

In an increasingly competitive business environment, DMU, integrated within a PLM environment and utilised throughout product development, can provide significant business and competitive advantages. Moreover, DMU enables more than visualisation, analysis and simulation, promoting 3D usage beyond the product development stage by supporting downstream processes in the manufacturing and technical publication areas.

Significant benefits include a reduction in time-to-market and product development costs by minimising the need for physical prototypes, higher product quality due to tighter integration between design and manufacturing, and increased product innovation through the ability to simulate multiple product alternatives and understand real world behaviour early in the design process.

For companies looking to not only survive but succeed, an integrated DMU environment provides a means of successfully beating the competition, creating customer loyalty and delivering strong business results well into the future.

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