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Title: An Examination of
UGS' Repeatable Digital Validation (RDV) Framework

Integrated visualization, mock-up, and simulation strategy sets the stage for real time, knowledge-based "what-if" analysis

A Cyon Research White Paper
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Executive Summary

Validating proposed changes has become more difficult as products have become more complex. Will the proposed change work? Will it do what it's supposed to do without breaking other things? The increasing complexity of products and the increased number of product variations demanded by the market, coupled with the necessity for innovation and decreased time-to-market, have outstripped the ability of engineering-process support systems to respond in a timely fashion.

Digital models were supposed to make it all easy. Business and engineering managers have long expected that the ability to completely model products, with all their variations, in the computer, would simplify and streamline the product-data management and validation processes. While that has happened to some extent, the problem in general has proven to be more than current systems can readily digest. Both graphics and general computation are still pushed beyond their current capabilities by full-size product models.

Before digital modeling, engineers would manually explore the potential impact of every proposed change. That took time, and mistakes were common. Digital modeling has made things a little easier, but much of the impact analysis—the validation—of a proposed change is still done manually. Consequently, changes are either not appropriately validated—leading to expensive recalls and re-work—or else they delay product releases, with potentially disastrous marketing results.

Eventually, computer power will increase enough to make current approaches viable in a real-time context. But until then—and that day is at least five years away, based on today's technology growth rates—judicious application of "shortcuts" in the form of more intelligent data-handling tools must bridge the gap.

Cyon Research calls this critical area "RAVDA" – rapid analysis and validation of design alternatives. UGS' Repeatable Digital Validation is a process that unites a number of tools to address the RAVDA challenge. Cyon Research's opinion is that it goes a long way toward making the promise of real-time digital validation a usable reality.

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The number of parts and assemblies in a complex product, or the number of possible configurations of a less-complex product with many variants, presents a big challenge when assessing the potential impact of a proposed change. Simply put—it's a lot of work to deal with change under such circumstances.

In fact, it is a major bottleneck for truly lean manufacturing and rapid innovation. The number of potential problems for a given change increases roughly with the square of the number of parts in a product. So the burden of validation in a product with 10,000 parts is not ten times that of one with 1,000 parts—it's a hundred times as great!

What is needed is the ability to quickly and easily explore the impact of any and all proposed changes on the product model, and to be able to validate these changes across all possible product configurations. Cyon Research calls this emerging area, "RAVDA" – rapid analysis and validation of design alternatives.

The Challenge: Managing Complexity in Product Development

Product complexity has mushroomed in recent years. Concomitantly, so have the processes through which products are designed and developed. What's more, many products are made in multiple variants—sometimes tens, or even hundreds, of different configurations—in response to customer demand for "mass customization," and the manufacturers' desire to say, "Have it your way."

With such a high degree of product variability, the sheer volume of product information can become unmanageable when dealing with complex products and processes. In this context, information is at risk of becoming so voluminous that it clouds rather than clarifies – making it absolutely critical that management has access to valid, relevant, and current information.

Further complicating this effort is the fact that digital product development is being performed more and more by virtual teams (often consisting of members that are separated by geography, time zones, and cultural or language barriers), which means that the ability to perform "what if's" and to clearly communicate proposed changes becomes even more crucial, even as it becomes tougher to do.

Couple all of this with the inherent "trial-and-error" nature of design, and a desire to support concurrent engineering efforts that take into account, for example, manufacturability requirements – and the ability to monitor and validate change becomes that much more challenging. In short, the potential for error is great, even as the potential for developing great products is enhanced.

	Challenges
Product Complexity	Manufactured products are increasing in complexity. The part count for an automobile today is far greater than it was 20, or even 10, years ago. Meanwhile, market demand for "mass customization," with each customer being able to select among many options, has imposed enormous variability in configurations. Complex products involve multiple layers of people, systems, sub-systems and components, resulting in the need to manage many iterations at many levels; often over an extended period of time (months or years). Highly variant products result in the need to quickly validate many different configurations of the same base model—often over a very short time (hours or weeks). In fact, each additional variant increases the number of possible combinations by the square of the number of parts.
Process Complexity	Product design is not a linear process; various stages of development occur at different rates, and iterate, due to the "trial-and-error" nature of design. Concurrent engineering—the attempt to design the product and its manufacturing processes at the same time--adds another layer of complexity.
Organizational Complexity	Product design involves multiple departments and disciplines, often with differing, and poorly coordinated, objectives Virtual teams, which include participants from outside the organization, introduce an additional set of opportunities and challenges. Their members may be separated in geography, in time, and even in culture.

Table 1. Managing product, process, and organizational complexity in today's product development environment presents many challenges

How has this challenge been addressed in the past?

It is only recently that the design-to-production process in manufacturing firms has begun to be viewed by even leading-edge users as an integrated whole. Software vendors have offered approaches for such integration for years; but in practice, design, document management, production, and so on generally still operate as independent entities, each with its own ways of keeping track of things.

Despite the widespread use of CAD, and the growing use of PDM, approaches to creating and managing engineering information still vary widely. The issues addressed by RDV have been—and often still are—dealt with by coordinating these independent processes in different ways.

In the past, managing design change in complex scenarios was accomplished using a variety of product-data-management tools and methodologies, from standardized engineering-change-management procedures to the use of advanced 3D visualization tools to aid in evaluating design alternatives. Configuration management programs have also played a role, but have typically fallen short in terms of providing the kinds of “in-context” design-validation capabilities needed.

Engineering-change-management programs have also provided some benefit, but in general have offered little guidance as to which changes need to be made, or what the impact of these changes might be.

To a large extent, managing the design of complex products or highly variable products has often relied on trusted, but time-consuming, manual methods—from approval processes that involve routinely manually entering or re-entering design data as needed, to the creation of representative digital mockups or physical prototypes constructed specifically for design reviews or to validate some key aspect of the design. Virtual analysis and testing programs have gained some ground in terms of providing the kind of feedback that designers require – but there is still a certain degree of reluctance to accept the results of such virtual – rather than physical – evaluations. It’s not that such results have been found to be invalid; it is simply an abiding mistrust of the digital by senior engineers.

Therefore, in their efforts to explore the impact of a potential design change, manufacturers have learned to take a conservative approach. Design professionals often spend an inordinate amount of time and effort on design-checking activities. Even those who use 3D design models must frequently “start from scratch” each time they perform a validation procedure. The tools have not, to date, supported repetitive or iterative processes very well.

What types of solutions are being proposed in the market today?

Recognizing that manufacturers must address such challenges in order to remain competitive, PLM providers have taken steps to help manufacturers better manage design change throughout the design cycle; they have begun staking their respective claims in the RAVDA domain. PTC’s initiative in this area, for example, includes the change-management, configuration-management, and collaboration capabilities of its Windchill PLM solution. And Dassault Systemes’ ENOVIA PLM offering supports a capability called *relational design*, which makes it possible to link parts of a design such that the relationship is maintained even if changes are made.

But it is still typical to see designers using manual methods to validate changes.

Change management, configuration management, and collaboration capabilities all represent point solutions to the challenge of managing change across organizations involved in complex-product design and development. These capabilities are generally part of a comprehensive PLM, or product-lifecycle management solution; but most, to date, lack the level of integration necessary to support intelligent, automatic, change-impact analysis.

There is progress being made, however. All the leading PLM vendors are aggressively working towards addressing the need for functional integration at the system level.

We conclude from reviewing the offerings of companies like PTC and Dassault Systemes that the desire to deliver on the promise of real-time impact analysis and validation is not unique to any single PLM provider. Moreover, we hasten to point out that while we have not performed an in-depth comparative analysis of the offerings of Dassault Systemes, PTC, and others; we have examined their solutions to a point where we can say we believe they comprehend the complex issues, and are making progress toward RAVDA solutions that address them.

What is perhaps most notable is the direction that such efforts promise to take digital product development. Ultimately, design systems will be intelligent enough to run required analyses, as needed.

At this stage, it is our belief that there are no solutions available that are powerful enough to accomplish this, but initiatives like UGS' Repeatable Digital Validation strategy represent an important and compelling step in this direction—a migration away from a reliance on manual validation methods towards more intelligent, knowledge-based PLM: RAVDA.

What is UGS's solution?

RDV: Repeatable Digital Validation

The source of the graph shown in Figure 1 is from a UGS presentation. However, with the exception of the "Repeatable Digital Validation" point on the x-axis, it could be used by any leading PLM vendor. The phenomenon that it portrays is one that is well-understood by both users and vendors—productivity increases as we move along the continuum from a physical and static product-development environment to one that is more digital and dynamic.

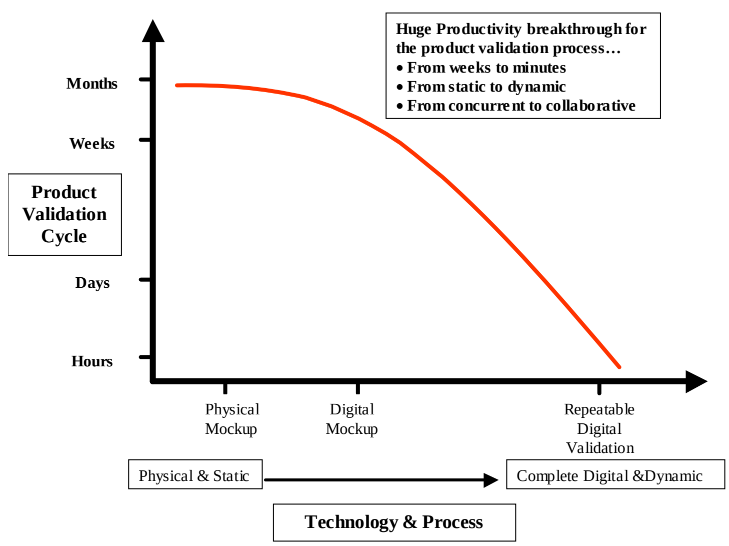

Figure 1. RDV - what is it?

In short, with the right combination of technology and real-time access to product data, a validation cycle that can take months using physical prototypes can be reduced to hours with repeatable processes and the ability to perform on-demand “what-if” analyses, with confidence. Getting this part of the equation right is one of the key areas that the leading PLM vendors are intent on addressing.

UGS, however, has united several powerful technologies out of its toolbox in a big step toward an integrated solution.

The key to RDV is a complete digital model of the entire project that can be updated in real time. Since the magnitude and complexity of automobiles, airplanes, and other complex and highly variable products is such that their representation—especially visually—pushes the limits of current workstation technology, special provisions must be made to allow it all to happen. UGS has acquired, developed, and integrated an impressive array of tools that empower it to do just that.

RDV takes it all a giant step closer to the ideal. How? The crux is the maintaining of a digital model of the entire project that is updated in real time. As soon as any component or assembly is changed, that change is reflected in the model.

Thus, any new change is validated against the current state of the design-not some prior, no-longer-totally-accurate state.

With an always-current model, all the existing automated processes, like configuration management, engineering change control, PDM, and others, acquire real power. They reflect current thinking, instead of last week’s—or last month’s. Those “driving” the project no longer have only a “rear-view-mirror” view; they can now see the road in front of them.

Having a model is not enough; you must have tools to take advantage of what it offers. Spatial search is one such tool. Currently available in two forms – zone-based and proximity-based—UGS’ spatial search capability enables engineers to quickly and easily find exactly what they’re looking for, whether that means finding all of the components of a particular type located in a specified zone, or identifying a part or collection of parts that may be “at risk” based on their proximity to another part.

Validation of changes to parts and assemblies can be complex, involving multiple steps. RDV is designed to deal with the combinatorial issues and the timing issues. It employs a variety of tools to allow timely validation of very large numbers of changes, due to product complexity and variability.

RDV introduces the concepts of "search recipes" and "validation agents" that can automate tasks such as, "Make sure the fuel line's distance from areas where the operating temperature exceeds X is always greater than Y." Even with a complete and up-to-date digital model, that is a non-trivial task. It involves determining the three-dimensional path of the fuel line; having a three-dimensional map of maximum operating temperatures; and so on. But the major parts of this validation task can be scripted, so that changes to the relevant areas simply trigger a re-run-rather than a start-from-scratch project.

RDV, developed specifically to address the challenges facing those involved in the design of complex products, offers a means to perform design validation dynamically and continuously in the context of all design changes.

Ultimately, the goal of repeatable digital validation is to build a system that is intelligent enough to know that when the shape or the size or the material associated with a design, changes -- that the system needs to perform, automatically, the kinds of validations that are appropriate for that change.

Beyond Proof-of-Concept

RDV was developed initially in response to management's request for a lightweight but information-rich, up-to-date representation of the digital product model at GM. While GM may have been the proving ground for Repeatable Digital Validation, RDV earned its wings at Eclipse Aviation. In the development of its Eclipse 500 twin turbo-fan jet aircraft, scheduled for availability in early 2006, Eclipse Aviation turned to UGS and RDV to help them accomplish their design goals. (see sidebar, "Eclipse Aviation.")

Eclipse Aviation

"Eclipse Aviation uses digital models for its frequent design reviews (3x/week during the intensive design phase). At those sessions, everyone connected with a certain section of the aircraft gets together to discuss what has recently been updated in that area. This type of visual design review takes place with suppliers as well. Because certain systems encompass a great deal of the aircraft, it is important to be able to view large assemblies and often even the entire digital aircraft, which represents tens of thousands of parts.

Normally, a model of an entire aircraft would be too large to use in a design review. It would require enormous amounts of computing power just to display the model. Zeroing in on a particular area of interest would waste everyone's time while the computer churned through the necessary calculations. This is where Teamcenter's Repeatable Digital Validation (RDV) has been invaluable to Eclipse. This solution allows reviewers to perform detailed searches of the model, such as "Show me everything connected to the cooling system" and quickly retrieve just the information they want.

"RDV lets us quickly navigate through the entire plane," explains Dr. Oliver Masefield, senior vice president of engineering. "We can create the precise digital mockups we need at any given moment. This has transformed the design process by allowing our designers to conduct iterations to optimize the design and keep up-to-date with current product configurations. We also use Teamcenter RDV capabilities company-wide to permit true concurrent engineering across all disciplines." This has allowed Eclipse to detect design errors early, especially cross-disciplinary errors that usually don't show up until a metal prototype is built."

What is Cyon Research's opinion of the UGS Solution?

RDV represents a major step forward in addressing complex product design, offering the kind of advanced change-impact analysis that stand-alone change-management, virtual prototyping, and PDM offerings can't.

UGS is clearly making important strides in tackling the job of digital validation with its RDV solution. By helping users to become more proficient in applying RDV, we expect to see the benefits of being able to to work with a complete model of a complex product that can be updated in real time to be realized more widely.

Ultimately, the challenge isn't about just automating the change-management process – it's about building an intelligent system. One that will enable manufacturers to explore the impact of change across a wide range of alternatives—in real time, during design.

In a few years, the inexorable progress of Moore's Law will make it easier for everyone to create, explore, and manipulate very large models. But to achieve this goal within current computational limitations requires a new way of thinking. Methodologies are needed that make it possible to manage more information, more effectively, and in less time.

By harnessing a variety of powerful technologies, UGS has brought forward an important part of everyone's ultimate vision for the design process: An overall model that is updated at every step, and universally available to design teams.

RDV offers a systems-based framework for managing the complexity of product design.

RDV takes a systems-based approach to managing the complexity in product design. As defined by INCOSE, the International Council on Systems Engineering, (www.incose.com) "Systems Engineering is an interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis and system validation while considering the complete problem: Operations, Performance, Test, Manufacturing, Cost and Schedule, Training and Support, and Disposal. Systems Engineering integrates all the disciplines and specialty groups into a team effort forming a structured development process that proceeds from concept to production to operation. Systems Engineering considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs."

In other words, implicit in a systems approach is the understanding that every aspect of the operation of a manufacturing organization is, in some way, interconnected with every other aspect. To be faithful to reality, a model must reflect this interconnectedness. RDV does just that, and in a way that avoids the "aliasing" impact of an update cycle that is longer than key model events.

More than just a visualization tool, RDV sets the stage for validating the complete product for packaging, analysis, process simulation, manufacturability, test, and more.

The intent of RDV is to allow designers to make design changes, validate the complete product for packaging, analysis, process simulation, manufacturability, test, serviceability, cost and function, and to compare the validation result to alternative designs. Eventually it will enable designers to rapidly and easily configure, visualize, analyze and compare a new part design in all its usages, in all products, and to fully understand the impact of any changes made to the model in real-time. It also promises to enable designers to readily determine which parts of the model can be reused successfully in the creation of new products.

But perhaps the most powerful capabilities of RDV as yet remain hidden from view. Right now, it is possible to answer such fundamental questions as “how will this change affect the cost of the overall product? Or “will this change violate weight restrictions, and if so, how?” In the future, however, it will be possible to generate a set of valid design alternatives and to choose the one that best addresses a manufacturer’s requirements based on the knowledge and insight gained from previous analyses. Therein lies the real power behind RDV and similar simulation and validation strategies. Such strategies are as important for what they enable manufacturers to accomplish in the long run as in the short term.

Complete simulation is the end of CAD – its ultimate purpose. RDV is an important milestone on the road to that end.

UGS is careful to point out that RDV is a process, not a product. But it represents a comprehensive RAVDA framework for design validation, a major bottleneck in today’s complex-product design and production processes. It is clear that UGS will continue to enhance RDV.

About Cyon Research…

Cyon Research is a consulting firm that provides design, engineering, construction, and manufacturing firms with a strategic outlook on the software tools and processes they rely on to create the world around us. Cyon Research also supports the vendor community with its unbiased insight, vision, and expertise to help them understand the complex nature of their markets and grow, by serving the needs of their customer base.

Cyon Research brings to its clients a unique combination of experience, perspective, and insight, supported by an extensive network of well-established industry relationships. Our close contacts throughout the user, analyst, vendor, and developer communities provide surprising benefits for our clients and add significant value to our services.

Those relationships are enhanced by our publications and events. While consulting is the heart of our activities, our publications and websites—including *CADCAMNet*, *Engineering Automation Report*, *AECNews*, and *CADwire.net*—are our voice. Through them, we connect daily and monthly with the user and vendor communities. And COFES: The Congress on the Future of Engineering Software, our annual, invitation-only event, is our face—the place where we can make the types of connections that just aren't possible through any other means than face-to-face.

The focus of our research within the realm of design, engineering, construction, and manufacturing is technologies and markets that are likely to become real within the next two to six years.

The domain of our research is the tools, processes, and procedures used in the design, engineering, management, and production of the built environment and manufactured goods.

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