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Thought Leadership White Paper

Continuous validation and verification

Reducing product rework, accelerating design and development, and improving quality in product engineering

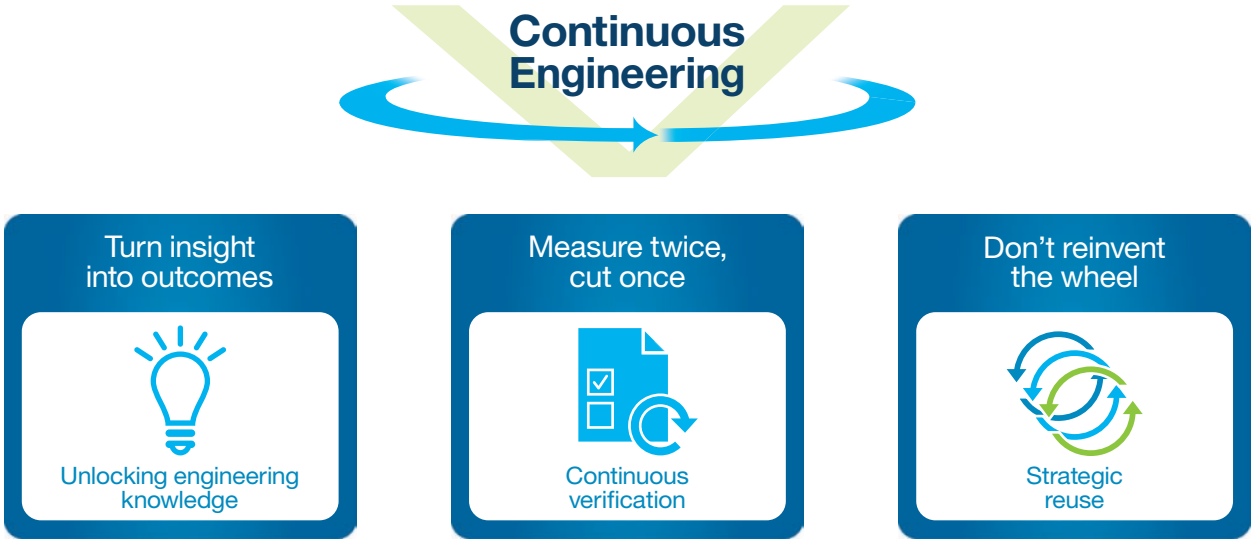
IBM

Introduction

Engineering a product is a risky and complicated process—and one that is rapidly evolving. Whether it's mobile phone units that sell by the tens of millions, or multi-million-dollar investments in spacecraft-related development, the value of building a product right—and the cost of building it wrong—has never been higher. The number of new features users and customers expect with each new release continues to increase at a frantic pace, along with expectations for improved ease of use, higher reliability and greater safety features.

Product manufacturers are struggling to stand out in this new world. Companies are betting big on new technologies, especially those that inject products with greater intelligence and sophistication. But with big bets come big risks. With much more embedded software in these products, design errors can go undetected until after the products have been shipped and sold. These problems are largely a result of the complexity associated with product design. In fact, the level of complexity can be so high that anticipating and testing all possible system interactions is physically impossible.

To address today's manufacturing challenges, companies are adopting the practice of *continuous engineering*. Continuous engineering is an enterprise capability that speeds the delivery of increasingly sophisticated and connected products by helping businesses better meet the accelerated pace of change. Continuous engineering can help manufacturers take advantage of new opportunities to offer smarter products, while enabling their engineers to better address the challenges of developing them.



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At the core of continuous engineering are three practices. The first is unlocking access to and understanding of engineering knowledge and information, regardless of the source, to enable the right decisions at the right times. The second is the continuous verification of requirements and design at all stages of the product lifecycle to prevent rework and achieve faster time to quality. And the third is strategic reuse across the engineering lifecycle to increase design efficiency and tame complexity. With these principles, you can start infusing continuous engineering into your product development. As they spread throughout your teams, you can use them for larger continuous engineering transformations down the road.

This paper describes how you can apply continuous verification practices—including the sub-practices of continuous validation and verification—to develop today's smarter products and create the opportunities that can put you on the path to competitive advantage.

Continuous validation and verification: Measure twice, cut once

There are a handful of key questions and problems engineering teams commonly struggle with:

- I need better ways to explore my requirements and designs with my customers.
- My hardware won't be ready for months. How can I verify the behavior of the software and hardware together and reduce my technical risk earlier?
- How can I optimize my design choices before we sign the contract and start ordering parts?
- I have to build the product to run some of my tests. I need ways of ensuring proper test execution—and need to make it easy to capture the results.

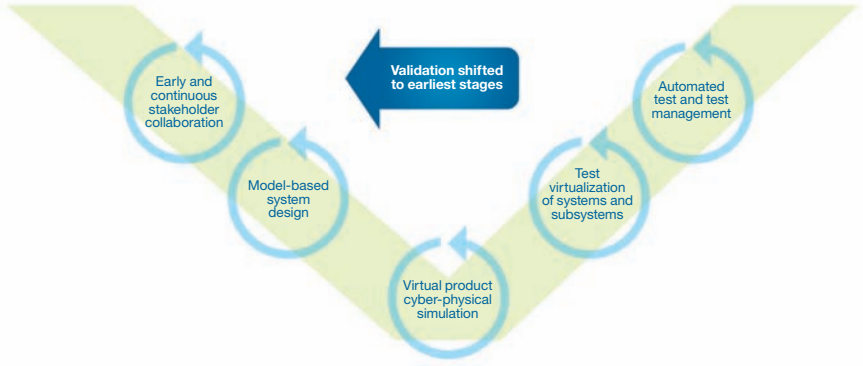
Continuous validation and verification practices can help address these issues. *Continuous validation* helps engineering teams make sure they have captured the correct requirements so they can *design the right product. Continuous verification* helps teams make sure they are adhering to those requirements so they can *build the product right*.

Continuous validation and verification allow companies to reduce overall design and development time while improving quality, reliability and ease of use by continuously validating and verifying requirements throughout the design and development phases. By creating and using computer models and other virtual prototypes, it is possible to share design ideas with customers and other stakeholders early and continuously throughout the process to ensure that everyone is on the same page.

This approach also allows for early definition of test cases that can be traced to the customer's requirements, helping to ensure that all of the requirements have a test case associated with them. These test cases can then be run continuously as the design evolves to help ensure it does not deviate from the customer's initial intent, and to ensure that engineers are automatically notified if it does. Additionally, when a requirement is changed, it is easier for the team to understand the impact of the change on the rest of the system.

Continuous validation and verification that span the entire value chain can help:

- Drive down costs by providing a clear roadmap that reduces rework and accelerates the design and development process
- Reduce risk by facilitating iterative development with quality checks that begin earlier in the cycle, helping development teams identify and resolve defects sooner
- Improve cycle time by replacing slow, manual quality processes with faster and more accurate automated processes



Shifting customer validation activities to the earliest phases of development can allow organizations to accommodate changes with less cost and effort.

Continuous validation

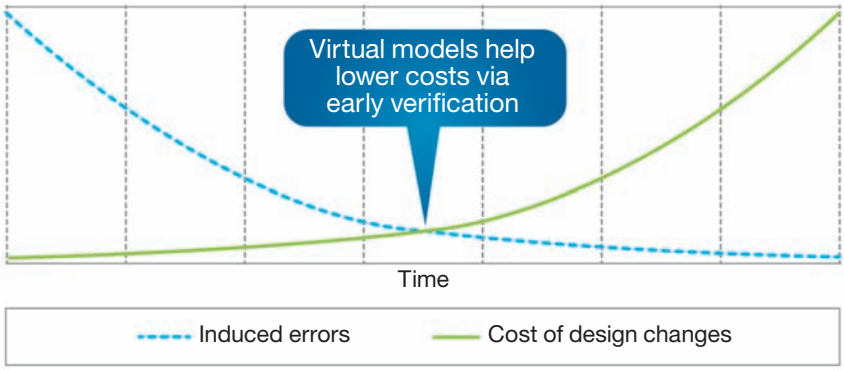
Continuous validation allows engineers to check their designs against requirements to help ensure that they have understood them correctly and are building the right product. It is often an outbound discovery process—one that provides assurance that the product, service or system meets the needs of the customer, the end user and other identified stakeholders. Shifting those quality activities to the earliest phases of development can allow organizations to accommodate any necessary changes with less cost and effort.

Continuous validation activities often include the use of virtual modeling and simulation iteratively and incrementally throughout the development process. Doing so before the stage of building physical prototypes can help you maximize knowledge—and leverage insights—at early design stages, resulting in more accurate designs. Engineers using these strategies have realized numerous benefits, including:

- Reduction in development cycle time
- Faster delivery to the market
- Improved quality and accuracy
- Lower development costs
- Reduction in the number of change requests over time

Continuous verification

Continuous verification allows engineering teams to evaluate whether a product, service or system complies with a regulation, requirement, specification or imposed condition. It is often an internal or inbound process that involves testing throughout the development lifecycle.



Engineering teams can increase design stability—and lower development costs—by verifying requirements using virtual models early in the process.

Continuous verification can help you balance quality and speed so you can deliver products faster without sacrificing features, form or functionality. Automation and integration are critical components that can help eliminate major bottlenecks. These capabilities can help reduce the cost of development and shorten test cycle times by enabling quality measurement, traceability and visibility early in and throughout the development lifecycle.

With continuous verification, you build in quality from concept to launch. Real-time analysis enables you to make informed decisions and proactive changes based on quantitative information. Defect tracking and change management are used to rigorously address and prioritize problems and issues. The automated reuse of information and quality management artifacts smooth the information and workflow between testers and developers and can help reduce errors.

Why use continuous validation and verification?

Let's take a look at how this approach differs from more traditional, document-driven approaches. Typically, an informally specified requirements document is developed and handed off to the next phase of systems analysis and design. In this phase, a high-level architecture is designed to capture the hardware, component software, mechanical, and other relevant pieces of the system. Again, this is informally defined with textual specifications. Software engineers take the design specifications and begin modeling the software architecture of the system. As before, this typically takes the form of textual specifications. At this point, the design should be fully specified so that it can be implemented and unit tested, so that integration testing and then validation testing can be done in order to gain system acceptance from the customer.

Unfortunately, it generally doesn't work this way. Between each of the development phases stands a barrier and an opportunity for communication breakdown, as textual specifications are often developed and thrown over the wall to the next team for further elaboration. The input into each phase is expected to be correct; however, the document-driven approach provides no proof or guarantees.

The problem with this approach is that the groups working in each phase don't know if the information they are getting is correct until system integration and testing—the most costly phase of the development process. Defects found at this stage have to be corrected at great expense and as part of a cycle that may have to be repeated if the issue isn't completely resolved. Many times, the errors are induced early on in the development process. However, when they are not found until integration or system test, it often results in products with less functionality and/or extended release dates.

Continuous validation and verification practices break these communication barriers by enabling concurrent engineering through model-driven development. The model-driven approach allows formal specifications in the requirements capture and analysis phase, which in turn provides, through model-based specification, a set of validation tests that can be used in system test. Models of the system architecture produced in systems analysis and design give engineers a visualization of the component structure up-front, so that development teams can plan the partition of their work early on and can begin creating integration test plans.

Not only does virtual prototyping and testing help engineers understand the dynamic behavior of a system as a whole (including all subsystems), it saves time because there is no longer a need to create numerous prototypes. Instead of repeatedly taking measurements, model-based simulations make it more convenient to capture status and can help engineers quickly pin down the optimal design.

In the end, it all comes down to saving time and money in the development process. New products are supposed to be more compact, more efficient, more reliable and delivered in a flexible and timely manner. This is true for most industries, especially for manufacturers of technical systems from the automotive, energy, oil and gas, aerospace and defense, medical engineering, mining, or ship building industries, or for producers of rolling stock or machinery, to name a few. Continuous validation and verification provide the clear advantage of detecting defects early in the development cycle, greatly reducing the cost of finding them later. This ultimately produces a higher quality product that meets customers' deadlines and expectations.

How IBM can help

IBM has a full suite of integrated products that support continuous validation and verification processes for engineering teams across all industries. For example:

- IBM® Rational® Rhapsody® serves as the core of continuous verification by allowing design and simulation of systems and software behavior while providing an architectural framework. It also provides integrations with tools for designing and simulating the physical components.
- IBM Rational Rhapsody with Design Manager facilitates strategic reuse and product-line engineering (PLE) by allowing Rhapsody and third-party design elements to be reused.
- Rational Rhapsody with Design Manager also helps development teams unlock engineering design data for Rhapsody, Simulink, SA, RSA, and IDA, and the Design Manager SDK enables other third-party integrations.

In addition, IBM Rational Quality Manager enables the planning and execution of different aspects of quality, including continuous verification. This solution, which is based on the Rational solution for systems and software engineering, is designed to provide automated end-to-end traceability, from requirements to systems testing. Testing and feedback loops enable you to test smart products more efficiently and provide greater visibility across development teams. As a result, you can significantly reduce the cost of identifying and fixing defects and accelerate product delivery times.

Conclusion

Design complexity is just one of the challenges facing today's engineers. The workflow can be daunting in itself, since many organizations use a parallel or distributed development approach that often features multiple teams and/or company relationships working in different time zones, speaking several languages, and using different tools and methods. In addition, software has become the dominant product differentiator for many of today's engineered products, making the software simultaneously intricate and important.

On top of this, the ability to test your application and the architecture that supports it is imperative, and it is best to do this testing early in the design process, when rectifying problems is easiest and cheapest—rather than at the end, when it is most costly and difficult. Along the way, requirements will change, and having a means to easily trace and follow the impacts the changes have had down to the implementation level is critical. By following the best practices of continuous validation and verification, engineers can help ensure they are building the right product with high quality.

For more information

For more information on IBM solutions for continuous engineering, please visit: **ibm.com**/continuousengineering

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