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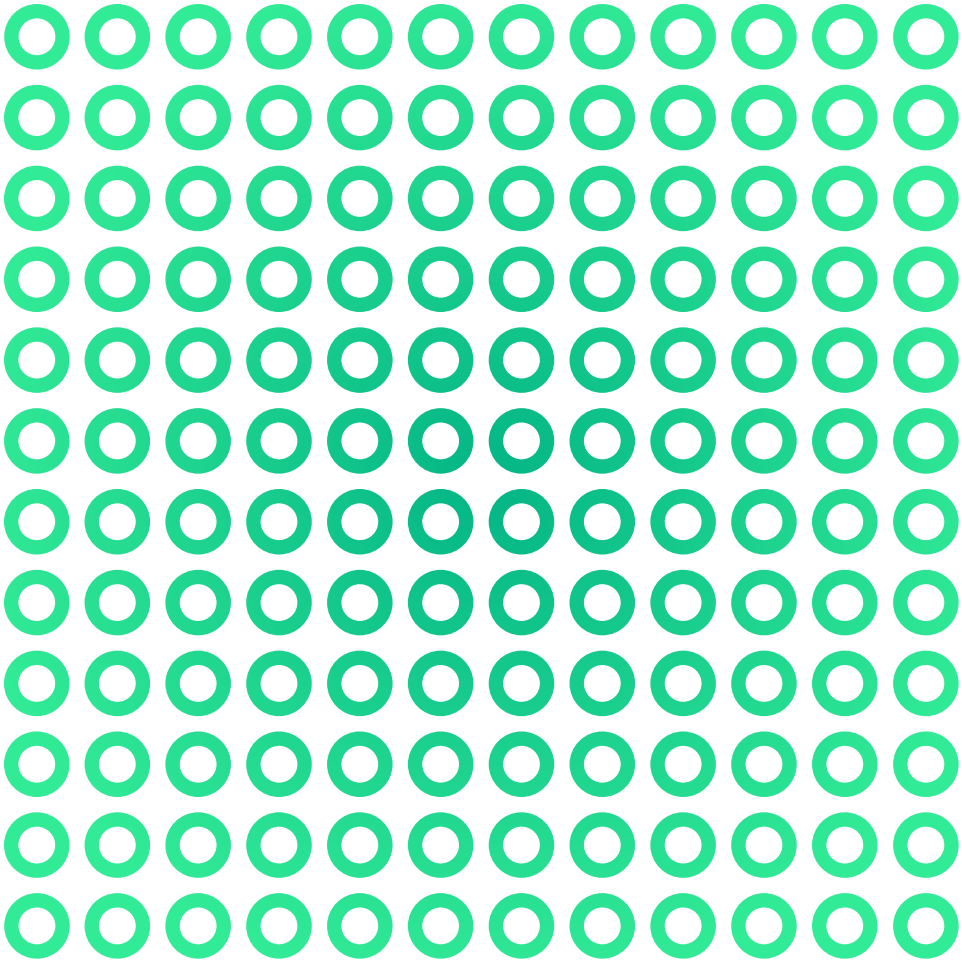
WHITE PAPER

Product Testing and Validation: How Simulation Makes the Difference



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Introduction

Engineers in the test and measurement industry are increasingly embracing new technologies as they strive to meet the challenges of efficient and effective product testing and validation. In addition, companies must be flexible to respond rapidly to the competition and market changes.

According to a McKinsey study, products that are six months late to market earn 33 percent less profit over five years. Products released on time but 50 percent over budget, on the other hand, only cut into profits by 3.5 percent. These numbers explain how a faster time to market is the most important metric for engineers, as it holds the key to delivering future value to their respective companies.

Another consideration is that time to revenue is much longer than time to market, and products that take months to release may not deliver significant revenue for 18 months. The market demands businesses to be adaptive and responsive to change while delivering an exceptional customer experience to remain competitive. Releasing a substandard product is not the right solution.

To change this trend, it's important to use technology to catch defects before production, test more corner cases than production testing can reasonably assess, and reduce costs through software-based testing rather than field testing.

Digital simulation is the key across the entire design process because it:

- Increases test coverage, creating faster design iterations
- Improves speed by minimizing the number of redundant tests
- Accelerates product quality testing for corner cases and all possible scenarios

This white paper explains how to implement digital simulation using innovative best practices.

How to Manage and Master Product Complexity

Additional features and capabilities in modern devices require an increased level of embedded system complexity. This intricacy comes with risks—especially when delivering hardware-focused products requiring synchronization with software and other tools.

A rough estimate for the number of defects found in embedded software is on the order of 10 to 20 for every 1,000 lines of code. This may not seem like a lot, but when you look at how many lines of code are now in everyday systems, the estimated number of defects can be incredibly high. For example, a smart washing machine can have around 100,000 lines of code, which means that you could expect 2,000 defects in this system alone. A failure here interrupts your laundry, which is frustrating but not life-threatening. However, when you consider medical devices, like pacemakers, which have 80,000 lines of software code, or an MRI scanner with 7,000,000, the impact of the expansiveness in system complexity becomes apparent—and far more serious.

The complexity of these systems is overwhelming to the point that it becomes impossible to exhaustively test them in the traditional way. Physically testing all scenarios is impossible; it would take an unreasonable amount of time. Moreover, it's important to be confident that the test cases cover all possible real-world conditions. Big failures, disasters, and device recalls are very expensive, but the negative impact on brand imagery and company reputation is priceless.

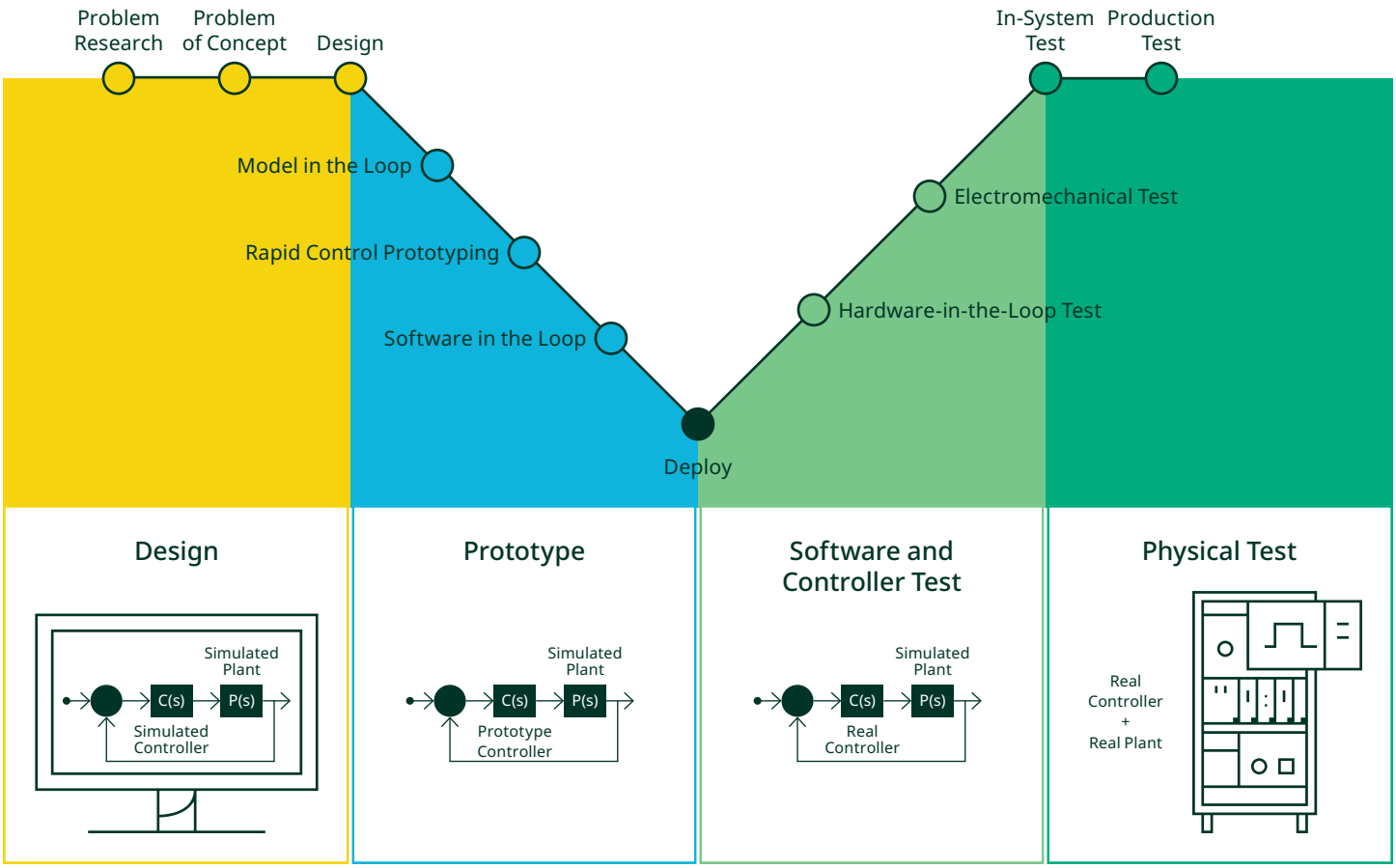
The only solution is through modeling and simulation. Virtually, we can test products in all possible scenarios and be confident that the final physical test is only the last check and not an expensive catastrophic event. The more complete your testing strategy is, the more confidence you can have in avoiding a disastrous failure.

Using Simulation to Accelerate Product Testing and Validation

Adopting a set of best practices to improve testing and validation processes is a key differentiator that yields significant benefits—testing sooner, faster, and more efficiently.

The first pivotal step is decoupling dependence on other teams. Taking this step enables rapid reconfiguration and execution of tests. In many organizations, a rigid barrier exists between design and testing. In a traditional development cycle, the software engineer writes a feature and merges the code. Then, the test engineer creates and sets up the test case. If a bug is found, it's reported back to the software engineer, and the cycle repeats. Depending on the test complexity and system readiness, this process can take days to weeks. To eliminate this delay, it's necessary to adopt a software testing process that allows a software engineer to write a feature without merging the code into the master codebase, repeating the process remotely, if necessary, and obtaining timely feedback.

Testing Early and Often Before Production Test



Embedded software testing serves as a methodology for problem detection, connecting design and test teams with a compatible workflow. The first stage, model in the loop, simulates everything, including the control unit and the entire product or "plant."

During the second, software-in-the-loop stage, the software engineer generates code only from the control model, replacing the block and creating the prototype while the plant is still simulated. This enables test execution using simulation and models instead of physical tests.

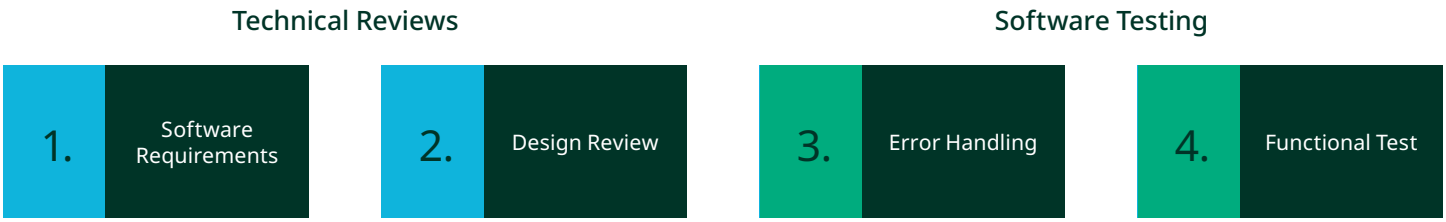
The third stage, hardware in the loop, is pivotal in this methodology. The code is deployed on a physical control unit, allowing testing of all possible real-world scenarios using the simulated plant before the last production and physical test.

With over 40 years of validation test expertise, NI is an expert in this methodology, serving as a trusted advisor to maximize your testing investment. Consider this in action: A software quality assurance manager in a multinational energy company used NI systems to implement a validation solution simulating the behavior of embedded software, offering flexibility across product lines and analytics for product development. They emphasized, "Physical tests can be very expensive and impractical for regular use. With NI systems, we have the flexibility to design tests according to our needs, offering value in the long run."

The benefits of this approach are clear, but it does require the necessary model-based design and simulation capabilities.

Solving Problems Using Modeling and Simulation

The modeling and simulation process begins with careful problem formulation and model construction, progressing through simulation experiments, interpretation of results, model validation, documentation, and final implementation. Each step demands a systematic approach, with critical issues identified and addressed at every stage. Imitating an existing or proposed system using a model simpler than the system itself raises concerns about the accuracy of the emulation. Verifying the correctness of the computerized model and its implementation involves two main components: technical reviews and software testing.



Technical reviews include structured walkthroughs of software requirements and design assessments. The walkthroughs involve translating requirements into code, while the design assessment evaluates the correctness of the algorithm. Software testing ensures that all coded statements have been exercised and that all possible model states have been assessed. Finally, it explores the functionality of software components through the design of scenarios between inputs and outputs.

NI has a long history of working with companies to drive efficiency gains through change and innovation:

- Subaru reduced test time by 95 percent using NI hardware and software platforms, achieving the simulation speed and model fidelity required for the verification of an electric motor ECU. The automaker reduced test time to 1/20 of the estimated time for equivalent testing on a dynamometer.
- Siemens Mobility Rail Solutions used NI hardware and software to build a fully functional digital twin of an entire train.
- A global technology company in the energy market used NI systems, reducing embedded software testing by 33 percent and costs compared to physical testing repeated over the lifetime of a technology.

Test complexity and system costs increase when incorporating model-based control and simulation into a system, but the payoff for successful implementation is well worth it.

Taking Steps toward Reengineering Your Product Testing

Modeling and simulation constitute a powerful method for designing and evaluating complex systems, and it's crucial to accelerate product testing and validation.

NI surveyed 200 test managers, directors, and VPs across the test and measurement industry in the US, China, and Germany. According to the survey results, integrated testing and simulation techniques (for example, model-based test practices, hardware in the loop, embedded software tests, and digital twins) are among the top technologies these leaders will likely embrace in the next five years.

A flexible, software-centric approach to embedded software testing can help detect design issues in the first round of tests while improving the ability to modify the system for changes found after release to manufacturing.

As you consider this journey, NI, along with its partner ecosystem, can work with you to define the right strategy, as long development cycles with missed production dates are too expensive to resolve in later stages. NI is here to help you mitigate these challenges and propel your organization to success for years to come through strategic test solutions and incomparable customer support.

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