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*Original Article*

# Modernizing Hardware Validation with DevOps: Integrating GitHub, Perforce, JIRA, Automation, and Continuous Testing

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**ABSTRACT:** *Validating hardware has become more demanding with the integration of complex CPUs, GPUs, high-speed memory, firmware, drivers, operating systems, along with the rapidly changing software parts of modern systems. Traditional validation approaches that rely on diverse tools, manual testing procedures, slow defect reporting, and limited traceability make it difficult for engineering teams to spot flaws and maintain consistent product quality quickly. This document presents a hardware validation technique that combines DevOps by connecting GitHub, Perforce, JIRA, automated validation technologies, and continuous testing into a unified engineering process. This method combines source-code management, hardware and firmware updates, test automation, defect monitoring and validation results into automated pipelines with defined feedback loops. GitHub supports collaboration and automated workflows. Perforce is used for huge hardware-centric code repositories and configuration resources. JIRA is used for structured defect tracking and cooperation across engineering teams. Automated testing frameworks continually test new releases, firmware updates, configuration changes, and system-wide activities to find errors closer to the time changes are made. This methodology is applied in a pragmatic case study for hardware and system validation, including different configurations and interdisciplinary teams. The study highlights expected improvements in test consistency, defect tracking, reaction time, repeatability and collaboration. The proposed technique highlights how DevOps methodologies can improve the continuity, transparency, scalability and responsiveness of hardware validation in more complex development environments.*

**KEYWORDS:** *Hardware Validation, DevOps, Continuous Testing, GitHub, Perforce, JIRA, Test Automation, CI/CD.*

## 1. INTRODUCTION

As computing systems grow in scale, performance and architectural complexity, modern hardware validation has become increasingly stringent. Modern CPUs, GPUs, SoCs, memory architectures, and server systems combine large amounts of hardware and software that must work well under diverse workloads and operating conditions. Validation therefore is not limited to checking the effectiveness of specific hardware attributes in operation. Engineering teams check firmware, drivers, and operating systems, testing environments, configuration changes and interactions of different system components. As development cycles shorten, traditional validation approaches that rely on human execution and multiple technologies can slow feedback and make failures harder to reproduce. DevOps methods let us rethink this process by merging development, validation, automation and defect management. Integrations with GitHub, Perforce and JIRA, for example, can tie automated testing and continuous validation to a more synchronized workflow that tracks changes, runs tests reliably, instantly communicates failures and gives engineering team's practical feedback as part of the development process.

### *1.1. CHALLENGES*

Typically, hardware validation teams use a variety of tools installed at different points in the engineering process. Source code might be stored on GitHub, large hardware-related files and test items could be managed through Perforce, while issues and validation procedures are tracked separately in JIRA. Engineers can spend a lot of time manually connecting code changes, test results, hardware configurations and documented problems when these systems are run in an autonomous mode.

Another challenge is doing manual testing. Repetitive validation processes use significant engineering resources and can produce inconsistent results if you change settings, configurations, or execution methods. Hardware availability can compound testing issues, as validation often relies on these specific platforms, firmware versions, drivers, operating systems, and laboratory equipment.

When software, scripts, firmware, configuration files and test suites move at different rates, version control can get complicated. An error found during testing may not easily be traced to the exact change that caused it. Extended validation cycles make defect tracking harder and can break communication between design, software, validation and program teams. These issues can delay root-cause identification, increase redundant work and lengthen the overall validation process.

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### *1.2. PROBLEM STATEMENT*

The main problem is the lack of a consistent validation procedure that systematically brings together source-code revisions, hardware configurations, test resources, automated operations, results, and defect tracking. When GitHub, Perforce, JIRA and validation environments are siloed, engineers must manually connect changes to failures. This reduces traceability and makes it harder to reproduce issues consistently. In modern hardware validation, a coherent framework is required to trigger appropriate tests independently, maintain version links, gather validation documentation, report discrepancies and link defects to the correct code, configuration and test execution, while accounting for the realistic constraints of hardware-dependent environments.

### *1.3. MOTIVATION*

The motivation to use DevOps methods for hardware validation comes from the need to get reliable information much earlier in the development cycle. Automated, continuous testing can identify problems early after relevant code, firmware, configuration or test changes, rather than waiting for lengthy validation cycles to end. Proactive identification gives engineers better insight into a malfunction and may reduce troubleshooting and root-cause research effort.

Repetitive automation improves consistency. Assessments can run with standardized configurations and well-documented versions, which eases reproducing and comparing failures in validation procedures. Combining GitHub, Perforce and JIRA along with these automation tools can improve collaboration by giving development and validation teams a single view of changes, test results and open issues.

First, continuous validation lets teams understand product quality across the entire development process, not just at release milestones. Faster feedback, higher traceability and consistent testing can lead to better engineering decisions and greater confidence that the hardware and its associated software are ready for use.

## 2. LITERATURE REVIEW

DevOps has changed how software teams build, test, and release products by merging development, testing, and operations into a single, collaborative approach. Continuous Integration and Continuous Delivery (CI/CD) practices encourage developers to integrate their changes, automate builds and testing and spot errors early in the development process. While these strategies are well known in software engineering, their use in hardware validation is still in its infancy because of physical devices, firmware, specialized testing techniques, long execution times, and complex hardware-software interactions.

More attention is being paid to testing and test automation in the embedded systems and hardware world. Automated validation pipelines can execute unit tests, integration tests, simulations, regression suites and system-level assessments for any other design or software change introduced. Recent work shows growing interest in integrating Hardware-in-the-Loop (HIL) testing with CI/CD pipelines to enable automated programming, testing, monitoring and validation of physical hardware during development. This process helps detect faults that may not show up during simulation or software-only testing.

Configuration management is a vital component of modern validation environments. Git-centric platforms like GitHub have features such as branching, pull requests, code reviews, workflow automation and change tracking. But systems like Perforce remain very useful in engineering scenarios that include large repositories, binary assets, hardware design documents and complex development baselines. Efficient version control enables the exact identification of the source code, firmware, test scripts, configuration files and hardware revisions used during a validation run. FPGA and RTL development is increasingly adopting continuous integration approaches based on Git, including automated synthesis, simulation, bitstream generation and hardware evaluation.

Defect tracking solutions (e.g., JIRA) promote traceability by integrating engineering issues with development tasks. Modern integrations can link work items to these branches, commits, pull requests, processes, and deployments, providing a more visible history from a known problem to the engineering change that fixes it.

But a large practical gap remains. Most existing methods target individual areas such as CI/CD, automated testing, source control, defect management or HIL testing and do not provide a holistic validation approach. As a result, hardware teams may still manage GitHub, Perforce, and JIRA, automation scripts, lab systems and test results as separate environments. The proposed framework addresses this shortcoming by combining these tools. It approaches this as a single, traceable continuous-validation process in which engineering changes can independently initiate tests, capture results, associate failures with defects, and retain explicit links between source versions, hardware configurations, test evidence, and validation results.

## 3. PROPOSED METHODOLOGY

The proposed methodology couples a hardware validation framework with DevOps, combining development, configuration management, and test execution, defect tracking, and reporting into a fluid workflow. Instead of viewing hardware validation as a discrete activity at the end of development, the framework treats validation as an ongoing process that begins with each

major change to code, firmware, driver or configuration. GitHub is the collaborative development environment where developers manage automation scripts, testing tools, workflow standards, and support code. Pull requests and version history help with controlled communication. CI workflows can automatically trigger validation steps once approved changes are merged.

Perforce improves GitHub by handling large verification assets that are not feasible to maintain in a traditional Git repository. Examples include firmware packages, test environments, platform snapshots, large log references, executable files, and validation documentation for specific environments. This versioning makes all validation runs reproducible, since engineers can revert to the precise code, configuration, firmware and test package used.

JIRA provides a traceability architecture that links requirements, test failures, defects, resolutions and validation documents. When an automated test finds a genuine failure, the framework can create or update a JIRA issue with the target platform, test name, software or firmware version, failure signature, logs, and execution details. This reduces the need to document defects manually and gives engineers enough context to start investigating quickly.

The cycle starts when you submit a code or configuration change through GitHub or Perforce. Once approved and reviewed, a CI trigger launches the more relevant validation process. The orchestration layer prepares the appropriate testing environment, installs the chosen firmware, drivers, settings or binaries and schedules tests to run on the available hardware. Automated suites can include functional validation, CPU/GPU activities, storage activities, performance indicators, stability assessments, compatibility assessments and regression testing. Throughout execution, the system collects events, console output, performance metrics, test logs and failure signatures.

The results are aggregated into summary reports and dashboards of pass rates, failed tests, recurring failures, execution time and platform status. Failures are logged in JIRA for review and responsibility. Once a change is committed, the relevant tests run automatically via the CI pipeline, followed by extensive regression testing. This closed feedback loop provides constant contact between the development and validation teams, allowing problems to be identified earlier and improving the repeatability, traceability and assurance of hardware releases.

## 4. CASE STUDY

Imagine a server platform undergoing validation ahead of a major firmware and driver release. The ecosystem includes multi-core CPUs, GPU accelerators, NVMe storage, network interfaces, system firmware, device drivers and Linux-based testing platforms. For validation engineers, the normal process is to get the latest build, manually install the required firmware and drivers, set up test machines, run selected test suites, review logs and create JIRA defects for failures. This works, but it is hard to keep up with regular builds. Engineers might spend a lot of time setting up environments and running tests, but problems can be detected days after the change that caused them.

The proposed structure kept this process running. Automation scripts and test process specifications were stored on GitHub, while large firmware images, platform settings, binaries and validation packages were managed using Perforce. The test environment consisted of multiple server systems with various combinations of CPU, GPU, RAM, storage and firmware to cover a wide range of platforms.

When an engineer made a legitimate driver change on GitHub, the CI pipeline automatically captured the required validation parameters. The system pulled the latest sanctioned firmware and configuration package from Perforce, and the appropriate servers were set up automatically. We ran smoke tests to check boot performance, device detection, driver initialization, CPU and GPU functionality, storage availability and overall system stability. If these evaluations were successful, the framework proceeded with extensive functional, stress, performance and regression test suites.

In a single regression cycle, a new GPU driver resulted in intermittent problems during lengthy GPU jobs and substantial NVMe operations. The automation framework logged the test results, kernel logs, driver data, firmware versions, hardware configuration and failure signatures. Rather than requiring an engineer to collect this information manually, the system automatically added the evidence to a JIRA defect and correlated it with the correct GitHub change.

The developers reproduced the problem on the documented setup and suggested a fix. The CI process then automatically reran the failed scenario. After the required test completed successfully, the update entered continuous regression testing across several server configurations. GitHub tracked code and automation changes, Perforce protected validation resources, and JIRA tracked the defect from detection to resolution. This instance emphasizes the need for continuous validation to evolve a traditional manual and disconnected hardware testing process toward a more efficient, traceable and reproducible engineering flow.

## 5. RESULTS AND DISCUSSION

The proposed DevOps-enhanced hardware validation framework shows considerable improvements over traditional validation methodologies in terms of speed, automation, traceability and consistency. In a traditional hardware validation environment, engineers spend a good amount of time manually setting up test environments, running test suites, gathering logs, reproducing failures, as well as updating defect reports. Integrate GitHub, Perforce, JIRA, automated test orchestration and continuous testing to automate the management of many other repetitive processes.

The validation cycle is much shorter. Automated CI triggers allow relevant tests to start right away after a change to code, firmware, configuration or test script is committed. This reduces the time between development and validation. Regression suites can run more frequently across different CPU, GPU, firmware, driver, storage and OS configurations, enabling better automated test coverage. As a result, the test completion rate becomes more stable, especially in normal development cycles.

Defects are detected during continuous validation without waiting for the full manual testing phase, reducing the time to find them. JIRA defects can be linked to logs, test results, configuration information and failure documentation, which improves engineers' ability to track down issues. This also reduces fault resolution time because developers get more detailed diagnostic information earlier. The efficacy of regression will increase through the use of both automated re-execution and systematic testing, as the manual work shifts from repeating executions to diagnosing problems, researching root causes, and improving tests. These competences together could improve release assurance by keeping teams continuously informed about platform stability.

Unlike traditional validation, DevOps techniques offer greater scalability because they can incorporate automated testing and continuous feedback. Integrating GitHub, Perforce, JIRA, continuous integration platforms, hardware labs, and reporting tools requires careful setup and reliable connections. Specialized hardware, storage, execution environments, and monitoring systems can increase infrastructure costs. Test scripts, pipelines, drivers, firmware dependencies and laboratory settings are evolving, and maintenance costs remain significant.

DevOps does not eliminate the difficulties of hardware validation. Hardware concerns, occasional issues, unavailable test environments and platform-specific behaviors may still need the knowledge of experienced engineers. The major advantage is a faster, more consistent and more verifiable validation process, where automation supplements engineering judgment rather than replaces it.

## 6. CONCLUSION AND FUTURE SCOPE

This work proposes a DevOps-based architecture to improve hardware validation by adopting GitHub, Perforce, JIRA, automated test orchestration, CI processes and continuous regression testing. The system links developmental changes to validation activities, test documentation, failure reports and defect tracking. This approach could reduce human effort, speed up validation, improve traceability, and give engineering teams more timely insight into hardware and platform quality.

With more effort, the framework's intelligence could improve substantially. AI-aided failure analysis could automatically analyze logs and infer potential root causes. Prediction models could help us determine which test configurations are likely to fail. We can then use smart test selection, so we execute only the tests that apply, rather than running all of them. Also, self-healing pipelines will allow us to find out about infrastructure problems and automatically resolve any issues related to test configuration failures. Digital twins allow for preliminary virtual validation before the physical hardware is available. Together with advanced observability and automated decision-making, these capabilities could gradually bring hardware engineering closer to more agile and self-reliant validation environments.

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