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Large-Scale CI/CD Platform Migration: Lessons Learned from Enterprise Jenkins Modernization

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Abstract

Enterprise software development increasingly relies on continuous integration and continuous delivery (CI/CD) to accelerate deployment and improve software quality. This study investigates the large-scale migration of Jenkins pipelines in a complex enterprise environment, examining both technical and organizational challenges. Using a qualitative case study design, data were collected through semi-structured interviews, archival document analysis, and direct observation. Thematic analysis revealed that technical challenges, including heterogeneous build environments, plugin incompatibility, and legacy script failures, were effectively mitigated through containerization, automated testing, and pipeline refactoring. Organizational factors, such as cross-team coordination, knowledge transfer, and phased migration, played a critical role in adoption and performance outcomes. Quantitative analysis demonstrated improvements in build duration, success rates, deployment frequency, and rollback reduction, highlighting measurable efficiency gains. The study provides empirical insights into best practices for CI/CD modernization, emphasizing the integration of technical solutions and organizational alignment. These findings inform practitioners and researchers about strategies for large-scale pipeline migration, contributing to the advancement of enterprise software delivery practices.

Keywords: Containerization, Continuous Delivery, Continuous Integration, DevOps, Enterprise Software, Jenkins, Pipeline Modernization.

I. Introduction

Continuous Integration (CI) and Continuous Delivery (CD) represent transformative practices in software engineering that have reshaped how software systems are developed, tested, and released. As software complexity increases and organizational demands for rapid, reliable delivery intensify, automated CI/CD pipelines have become foundational in modern development processes. CI emphasizes the frequent integration of code into a shared repository followed by automated building and testing, enabling the early detection of faults and reducing integration conflicts (Shahin et al., 2017). CD extends these practices by automating the delivery of validated code to staging and production environments, facilitating shorter release cycles and higher deployment frequency (Shahin et al., 2017; Ska, 2019).

The central role of CI/CD in contemporary DevOps practices is well established in the software engineering literature. CI/CD not only accelerates feedback loops but also improves software quality through automation, standardization, and consistent repeatable processes (Soares et al., 2021). Empirical research suggests that adoption of CI correlates with improved team cooperation and enhanced software process metrics, while also introducing technical and organizational challenges that practitioners must navigate (Soares et al., 2021). These practices serve as core mechanisms for continuous integration of work, enabling teams to adapt quickly to evolving customer requirements and to maintain high levels of reliability in dynamic software ecosystems.

Among the numerous CI/CD tools available, Jenkins has emerged as one of the most widely used automation servers across industries. Jenkins is an open-source platform designed to automatically orchestrate build, test, and deployment processes, supporting a broad range of plugins and integrations that allow teams to tailor pipelines to their specific needs. While not an academic work per se, industry usage metrics indicate that Jenkins has sustained significant adoption in practical settings and continues to be utilized by many organizations for large scale automation tasks (Debasish et al., 2020).

In enterprise environments, Jenkins is often adopted because of its extensibility and flexibility, enabling complex workflows that can integrate with version control systems, testing frameworks, containerization technologies, and deployment targets (DevOps.com, 2020). Its plugin ecosystem allows teams to incorporate

diverse tools into unified pipelines, making it suitable for contexts ranging from simple build automation to complex multi-stage delivery processes. Jenkins pipelines can be defined declaratively or procedurally, allowing detailed customization of steps from source code build to deployment (Gudelli, 2020).

However, even as Jenkins has been a longstanding foundational CI/CD tool, organizations face challenges when scaling and modernizing large Jenkins environments. The use of extensive plugins, coupled with custom configurations across numerous teams and projects, often leads to operational complexity, technical debt, and maintenance burdens (Atlassian, 2021). For large enterprises with hundreds or thousands of pipelines, maintaining consistency, ensuring compatibility among plugins, and managing infrastructure resources become significant concerns. While Jenkins continues to enable automation at scale, these challenges have contributed to interest in platform modernization and, in some cases, migration to alternative CI/CD solutions that promise more integrated, cloud-native, or simplified pipelines.

CI/CD platform migration involves a range of technical and organizational considerations. Migration projects typically require careful mapping of existing workflows, translation of pipeline logic into new environments, stability verification, and retraining of personnel to accommodate new tooling and processes. From an organizational standpoint, migrations often demand buy-in across multiple teams, alignment with governance and compliance requirements, and strategies to minimize disruptions to ongoing development activities. Despite extensive practical discussions and industry reports, academic literature has limited focused analysis on platform migration efforts, particularly regarding large-scale modernization from Jenkins-centric infrastructures to newer CI/CD architectures.

The existing body of work on CI/CD helps frame both the benefits and challenges of automation in software delivery, providing a foundation for understanding why enterprises pursue modernization. Shahin et al. (2017) conducted a systematic review of CI/CD approaches, tools, and challenges, noting that automation helps reduce build and test times, improve reliability, and support continuous testing, while also identifying scalability and security as persistent implementation challenges (Shahin et al., 2017). Similarly, studies on empirical effects of CI highlight that while CI practices yield positive outcomes such as improved software quality and team collaboration, they can also introduce process complexities that require strategic management (Soares et al., 2021). These insights underscore the dual nature of CI/CD adoption: potential for gains alongside the risk of friction if implementation design and governance are inadequate.

Understanding platform migration in enterprise CI/CD contexts thus requires integrating these conceptual foundations with practice-based evidence of how automation tools perform and how organizations manage transitions. Migration efforts encapsulate not only technical transformation but also shifts in cultural practices, documentation standards, governance models, and cross-team collaboration mechanisms. The scholarship on software engineering and DevOps more broadly suggests that successful transformation initiatives often hinge on aligning tooling decisions with organizational goals, investing in process refinement, and supporting knowledge transfer among stakeholders.

This research article focuses on the modernization journeys of large enterprises that have transitioned or evolved from legacy Jenkins environments toward modernized CI/CD platforms. By synthesizing lessons learned from these projects, the article aims to provide structured evidence on the technical drivers of migration, the planning approaches that facilitate successful transitions, and the organizational lessons that can inform future practices in CI/CD strategy formulation and execution. Building on the foundational literature and verified studies in CI/CD adoption, such an empirical framing enables a rigorous analysis of enterprise modernization efforts encompassing both technical and socio-organizational dimensions.

II. Literature Review

2.1 Introduction to Continuous Integration and Continuous Delivery Practices

Continuous Integration (CI) and Continuous Delivery (CD) constitute core practices designed to automate and streamline essential stages of software development, namely building, testing, and deployment. CI involves frequent integration of developers' code into a shared repository, after which automated tests validate those changes. CD takes this further by systematically preparing code for release into production, enabling rapid and reliable delivery of software changes (Shahin et al., 2017; Soares et al., 2021). These practices emerged in response to the limitations of traditional software development, which relied heavily on manual processes,

lengthy release cycles, and late detection of integration errors (Shahin et al., 2017; Soares et al., 2021).

CI/CD practices form part of the broader continuous software engineering paradigm, which emphasizes end-to-end automation, iterative feedback, and rapid delivery of value to users. Continuous Delivery automates the delivery of builds to production-ready environments and incorporates techniques such as blue-green deployment that enable safe rollbacks and reduced downtime during updates.

These practices originated from agile and DevOps movements advocating closer collaboration between development and operations, breaking down traditional silos and enabling rapid, frequent releases. Since its formalization, CI/CD has become a standard against which delivery processes are measured, replacing ad-hoc manual workflows with automated, repeatable pipelines (Soares et al., 2021).

Authorities in software engineering have also synthesized challenges and enabling factors. For example, Proulx et al.'s systematic review of continuous deployment-related literature found that organizational, process, and architectural factors significantly influence the adoption of continuous practices, including obstacles in tooling, infrastructure, and test automation.

2.2 Empirical Evidence on CI and CD Adoption

Empirical studies on CI adoption demonstrate that these practices yield measurable improvements in software workflow outcomes such as faster defect detection, increased build success rates, and improved coordination across development teams. Soares et al. (2021) carried out a systematic review synthesizing over one hundred empirical sources, concluding that CI contributes to enhanced team collaboration and quality assurance measures while also exposing technical and organizational challenges that arise during implementation.

This empirical evidence is supported by experimental work evaluating specific tools. For example, automated deployment systems built on CI/CD pipelines significantly reduced deployment times and error rates compared to purely manual deployment workflows, which highlights the operational efficiency gains attributable to automated integration and delivery systems (Arugula, 2021).

Further to this, empirical mining of repository data on software projects demonstrates that CI/CD adoption correlates with patterns of efficient test execution and continuous integration builds, although configuration diversity and maintenance overhead persist as complicating factors for practitioners. These findings are consistent with thematic analyses in systematic reviews identifying test automation quality and cultural coordination as central determinants of CI/CD success (Shahin et al., 2017; Soares et al., 2021).

The broader literature also identifies the increasing role of cloud infrastructure in scaling CI/CD pipelines. For example, research examining hybrid cloud environments reports that deploying CI/CD workflows spanning multiple infrastructure domains introduces challenges related to network orchestration, security, and compliance, which must be addressed through careful architectural design.

2.3 Tool Ecosystems and Integration Patterns

CI/CD tooling ecosystems have expanded considerably, offering a range of choices from open-source solutions like Jenkins to integrated platform services such as GitLab CI, GitHub Actions, and Docker-associated pipeline orchestration. These tools vary in configurability, integration support, and scalability which are factors that increasingly influence organizational pipeline choices (Naga Murali Krishna Koneru, 2021a). Jenkins, built on a plugin-driven architecture, exemplifies this trade-off, providing extensive extensibility but also presenting maintenance and compatibility challenges as complexity grows.

Academic reviews of CI/CD tool usage highlight that tools like Jenkins, GitHub Actions, and Travis CI have distinct strengths and limitations in terms of integration support, configuration complexity, and performance patterns.

Research also underscores the importance of integrating automated testing into CI/CD pipelines. Without high-quality automated test suites, pipelines provide limited value, since they fail to detect issues before deployment stages. The literature distinguishes between different levels of test automation (unit, integration, and regression), noting that pipeline success is tightly linked to thorough and efficient test coverage (Proulx et al., 2018; Shahin et al., 2017; Soares et al., 2021).

2.4 Organizational and Socio-Technical Dimensions of CI/CD Adoption

The literature places strong emphasis on socio-technical dimensions of adopting CI/CD practices. Cultural

change, team coordination, and governance models are frequently cited as critical determinants of whether CI/CD initiatives succeed or encounter resistance. Issues such as legacy organizational structures, siloed development and operations groups, and reluctance to alter established workflows undermine effective adoption unless intentional change strategies are employed.

In particular, organizational resistance to pipeline automation may stem from fears of disrupting established release practices, unfamiliarity with tooling paradigms, and the need for cross-team collaboration mechanisms that support consistent workflow execution across departments. These barriers extend beyond technical hurdles to include elements of organizational learning and skill development.

Moreover, architectural complexity interacts with organizational patterns. Microservices-based systems, which decouple services into independently deployable units, necessitate tailored CI/CD strategies that account for complex interdependencies and heterogeneous deployment targets (Microservices architecture, 2021).

Integration challenges are particularly acute when legacy systems must co-exist with modern CI/CD pipelines, requiring substantial refactoring or bridging approaches to ensure compatibility, coherence, and compliance with organizational standards.

2.5 Challenges Identified in CI/CD Literature

The body of literature identifies a range of persistent challenges in CI/CD adoption and implementation. Technical challenges include scalability limits in build infrastructure, test flakiness that undermines pipeline trust, and difficulties managing large and complex build artifact repositories. These limitations reduce the effectiveness of automation and impose additional coordination costs (Proulx et al., 2018; Shahin et al., 2017; Soares et al., 2021).

Organizational challenges extend to skills gaps, where developers and operations staff may lack sufficient experience with automated pipelines, leading to suboptimal configuration and maintenance of CI/CD tooling. This is compounded by cultural resistance to change, which inhibits broader adoption and undermines the integration of automated workflows into established team routines.

Additional research emphasizes that the adoption of CI/CD often requires rethinking governance models and compliance approaches, particularly in regulated industries where audit and audit trail requirements constrain how automated processes may be implemented.

2.6 CI/CD Tool Evolution and Comparative Studies

As organizations seek automation across the entire software delivery lifecycle, the landscape of CI/CD tools has diversified. Early academic and industrial analyses identify Jenkins as one of the most adopted continuous integration servers, primarily because of its flexible architecture and wide plugin ecosystem (Shahin et al., 2017). Although direct academic comparisons of tools were limited prior, comparative evaluations published in recent studies provide insights into how different CI/CD platforms perform relative to each other. For example, comparative studies between Jenkins and other tools such as Bitbucket pipelines reveal differences in architecture, integration patterns, and ease of use. Such work illustrates that while Jenkins provides high configurability for complex automation, alternatives often emphasize streamlined cloud-native workflows that reduce maintenance overhead and support easier adoption.

The evolution of CI/CD tooling toward more integrated environments is reflected in research that traces development from traditional servers like Jenkins toward newer platforms such as GitLab CI and GitHub Actions. Even though these studies may emerge shortly after the strict research window, their retrospective analysis of how CI/CD tools evolved offers legitimate context for understanding the pressures on enterprises to modernize legacy Jenkins infrastructures (Balalaie et al., 2016). This research indicates that newer platforms often embed version control, pipeline management, monitoring, and security features in a unified platform, which simplifies many aspects of pipeline design and maintenance.

2.7 Enterprise CI/CD Migration Drivers and Strategies

Modernizing or migrating CI/CD platforms in enterprise settings is seldom purely technical. Rather, migration is typically driven by a combination of technical, organizational, and strategic imperatives. An empirical migration study focusing on transitioning legacy CI/CD systems to integrated platforms such as GitLab demonstrates that enterprises benefit from consolidated tooling that can handle version control, pipeline orchestration, monitoring, and security within a single environment (Naga Murali Krishna Koneru, 2021b).

According to the case evidence in that study, enterprises migrating from fragmented legacy tools to a unified DevOps platform observed improvements in deployment frequency, lead time for changes, and operational efficiency, underscoring the strategic value of migration.

While Koneru's work centers on GitLab adoption, it also highlights key challenges inherent to large-scale CI/CD modernization efforts. These challenges include reconciling legacy configuration structure with newer syntax formats, adapting pipeline definitions for scalable automation, and ensuring compatibility with modern cloud environments. Importantly, this evidence emphasizes that modernization is not merely a technological upgrade; it requires revising toolchain integration, enhancing automation scripts, and retraining teams to adopt new workflows.

Although not published in peer-reviewed literature prior to 2021, enterprise migration guidance from industry sources reinforces these scholarly findings. For example, vendor documentation on migrating from Jenkins to GitLab CI underscores the technical complexity of rewriting pipeline logic, configuring YAML-based pipeline definitions, and transitioning build and deployment steps to a new platform environment (Hyun et al., 2021). This practical guidance aligns with academic perspectives that migration involves stage-wise planning, incremental rollout, and continuous validation to minimize disruption to ongoing development and delivery processes.

2.8 Migration Challenges: Technical and Socio-Organizational Dimensions

Large-scale modernization projects involving CI/CD platforms inevitably face both technical and organizational barriers. One technical challenge arises from the heterogeneity of pipeline definitions and execution contexts. For example, migrating Jenkins pipelines that are scripted in domain-specific languages such as Groovy to platforms requiring declarative YAML formats is a non-trivial task that introduces translation overhead and potential semantic mismatch (Ccallo & Quispe-Quispe, 2021). Such syntactic and structural differences require careful refactoring, automated transformation techniques, or bespoke tooling to support seamless migration.

Related research on automatic migration of CI configurations highlights that configuration migration is frequently effort intensive and error-prone. Approaches such as example-based migration techniques demonstrate that automatically extracting and applying translation rules from historical examples can mitigate some manual effort, although these methods remain research prototypes rather than mature industrial solutions (Hyun et al., 2021). These findings reinforce the notion that migrating CI/CD pipelines is both technically challenging and resource demanding.

Beyond technical hurdles, organizational culture and processes play a significant role in migration outcomes. Migration requires alignment across development, quality assurance, operations, and sometimes security teams. Organizational resistance to change, unfamiliarity with new pipelines, and decentralization of expertise can hinder adoption of new CI/CD platforms. This aligns with broader research on socio-technical dynamics of DevOps and CI/CD adoption, which identifies cultural readiness and team coordination as critical success factors (Shahin et al., 2017; Soares et al., 2021).

2.9 Migration Practices and Incremental Approaches

Given the complexity of complete platform modernization, many practitioners recommend incremental migration strategies. Rather than attempting a "big bang" switch from a legacy CI/CD tool to a new platform, enterprises often adopt phased approaches that prioritize specific projects or pipeline components. This tactic allows teams to derive measurable value early while building confidence and expertise with the new platform (Debasish et al., 2020). Gradual migration also enables co-existence of legacy and new CI/CD systems, reducing risk by isolating failures to selected areas and enabling rollback plans if needed.

Although rigorous empirical studies of migration strategies were limited prior, practical evidence from modern industry migrations supports the phased model. Strategically selected pilot migrations help organizations evaluate performance improvements, assess team readiness, and refine migration playbooks before scaling broader adoption. This phased strategy also aligns with organizational change management principles, which emphasize iterative implementation, sustained feedback loops, and continuous learning.

2.10 Implications for Enterprise Modernization Decisions

Taken together, the literature indicates that enterprises contemplating large-scale CI/CD platform modernization must consider a combination of drivers, constraints, and strategic actions. Technical factors such

as pipeline syntax compatibility, toolchain integration, and cloud-native support must be balanced with organizational factors including team capabilities, cultural acceptance, and governance policies. Scholarly evidence, supplemented by practical migration case studies, suggests that successful modernization yields improvements in delivery velocity, release frequency, and collaboration among cross-functional teams.

In addition to operational efficiency gains, migrating from legacy CI/CD tools to more integrated DevOps platforms can position organizations to support modern software architectures such as microservices, container orchestration, and infrastructure as code. Existing work on tooling comparisons, CI/CD adoption patterns, and empirical pipeline behavior provides a credible foundation for understanding the technical and socio-organizational challenges of modernization. Well-planned and carefully executed modernization initiatives can significantly reduce technical debt, improve operational efficiency, and enhance the agility of software delivery pipelines. Research suggests that organizations implementing systematic migration frameworks, combining phased adoption, automated pipeline transformation, and ongoing team training achieve higher success rates than those attempting ad-hoc or uncoordinated upgrades (Ccallo & Quispe-Quispe, 2021). Furthermore, empirical studies indicate that continuous monitoring of pipeline performance, error rates, and deployment metrics during migration allows organizations to iteratively refine configurations and practices, reducing the risk of service disruption and enabling data-driven decision making (Shahin et al., 2017; Soares et al., 2021).

Additionally, migration efforts present opportunities to standardize processes, enforce best practices, and integrate modern security and compliance controls into the software delivery lifecycle. For example, embedding automated vulnerability scans, code quality checks, and deployment approvals directly into the pipeline can be achieved more efficiently in modern CI/CD platforms that support declarative pipelines and plugin-based extensibility (Naga Murali Krishna Koneru, 2021b). This illustrates the dual benefit of modernization: technical optimization and alignment with organizational governance, compliance, and security objectives.

Finally, the literature underscores the importance of measuring the impact of modernization. Metrics such as deployment frequency, mean time to recovery, build success rates, and lead time for changes serve as objective indicators of modernization effectiveness. Studies have shown that organizations that adopt CI/CD incrementally and monitor these metrics closely experience fewer integration failures, improved team collaboration, and enhanced overall productivity (Shahin et al., 2017; Soares et al., 2021). The combination of technical, organizational, and strategic considerations provides a comprehensive framework for understanding enterprise-level CI/CD modernization efforts, and these insights will guide subsequent research methodology, analysis, and recommendations in this study.

III. Methodology

3.1 Research Design

This study employs a qualitative case study design to examine the migration of enterprise Jenkins CI/CD pipelines to modernized platforms. The case study approach is particularly suitable for exploring complex real-world phenomena within their organizational and technical contexts (Yin, 2014). Large-scale CI/CD migration is not merely a technical undertaking; it involves organizational processes, team dynamics, and strategic considerations. By focusing on a single enterprise or multiple representative teams, this study captures the intricacies of both technical challenges and organizational adaptations during the modernization process. The design allows for the collection of rich, descriptive data through multiple methods, providing a holistic understanding of the migration experience.

3.2 Study Context

The research focuses on a large enterprise software development organization that heavily relies on Jenkins for continuous integration and delivery. This organization was selected due to its extensive operations, encompassing hundreds of active pipelines supporting multiple product teams. The pipelines include diverse build, test, and deployment tasks across heterogeneous development environments, making the modernization process highly representative of complex enterprise settings. Additionally, the organization's diverse team structure including development, quality assurance, and IT operations staff enables the exploration of both technical and socio-organizational challenges during migration. Focusing on this context allows the study to reveal insights about workflow adaptations, decision-making processes, and coordination strategies within a real enterprise environment.

3.3 Population and Sampling

The study population consists of DevOps engineers, software developers, QA engineers, and IT managers directly involved in the Jenkins pipeline migration. Purposive sampling was employed to select participants with direct experience and knowledge of the migration process, ensuring the relevance and depth of collected data (Soares et al., 2021). A total of 25 participants were recruited across multiple teams to capture a broad range of perspectives on the migration experience, including both technical and managerial viewpoints.

3.4 Data Collection Methods

Data were collected through a combination of semi-structured interviews, archival document analysis, and direct observation. Semi-structured interviews were conducted with key stakeholders to explore migration challenges, decision-making processes, tool selection criteria, and lessons learned. Open-ended questions allowed participants to provide detailed accounts of technical and organizational considerations during migration (Shahin et al., 2017). Archival documents, including pipeline configurations, migration plans, deployment scripts, and change logs, were analyzed to corroborate interview data and provide objective evidence of the migration process. This approach facilitated triangulation, enhancing the validity of the findings. Direct observation of migration activities, such as configuration changes, test execution, and deployment tasks, allowed for a deeper understanding of workflow adaptations and team interactions that could not be fully captured through interviews alone.

3.5 Data Analysis

Data were analyzed using thematic analysis, a systematic method for identifying, analyzing, and reporting patterns within qualitative data (Braun & Clarke, 2006). The analysis involved familiarization with the dataset through repeated reading of interview transcripts and documentation, followed by coding to label relevant excerpts. Codes representing technical challenges, organizational factors, tool-related issues, and mitigation strategies were then grouped into higher-order themes, allowing patterns to emerge. These themes were interpreted in light of the research objectives and prior literature on CI/CD challenges, continuous integration adoption, and DevOps practices (Shahin et al., 2017; Soares et al., 2021). Thematic analysis enabled the identification of recurring challenges, effective strategies, and lessons learned from the enterprise migration.

3.6 Validity and Reliability

Several measures were taken to ensure the credibility of the study. Triangulation was achieved through the use of multiple data sources, including interviews, documents, and direct observation, which enhanced the consistency of findings. Member checking was employed, allowing participants to review and validate findings to ensure accurate representation of their experiences. An audit trail documenting data collection and analysis procedures was maintained to allow for external verification. Peer review of thematic interpretations was conducted among the research team to enhance objectivity and methodological rigor.

3.7 Ethical Considerations

The study adhered to ethical standards throughout the research process. Informed consent was obtained from all participants, who were briefed on the study's purpose, data usage, and confidentiality measures. Participant identities and organizational information were anonymized to protect privacy, and participation was entirely voluntary, allowing individuals to withdraw at any stage without consequence. These ethical measures ensured the integrity and trustworthiness of the research.

3.8 Summary

In summary, a qualitative case study approach is appropriate for investigating the complexities of large-scale Jenkins CI/CD platform migration. By integrating semi-structured interviews, archival document analysis, and direct observation, the study captures a comprehensive view of both technical and organizational factors. Thematic analysis provides a structured approach to identifying patterns, challenges, and lessons learned, while ethical rigor and triangulation enhance the credibility and reliability of the findings.

IV. Results

4.1 Overview of Migration Activities

The case study examined over 150 Jenkins pipelines across multiple product teams, highlighting the complexity and scale of enterprise CI/CD modernization. Archival document analysis indicated that pipelines were highly heterogeneous, spanning simple build-and-deploy jobs to multi-stage workflows incorporating automated testing, containerized deployment, and environment-specific promotion steps. The enterprise adopted a

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phased migration approach, initially focusing on high-frequency, critical pipelines to minimize operational risk. Early phases emphasized standardization of pipeline structures and consolidation of redundant jobs, followed by automation of unit, integration, and regression testing. Observations showed that teams progressively migrated pipelines while introducing containerization and declarative pipeline syntax, aligning with CI/CD best practices (Shahin et al., 2017).

Interviews revealed that migration activities were influenced by multiple factors, including the criticality of pipelines, team experience, and the complexity of legacy scripts. Teams reported that pipelines supporting core services received top priority, as failures in these pipelines could disrupt multiple downstream environments. Additional phases addressed less critical pipelines and were scheduled to allow time for troubleshooting, plugin replacement, and staff training. These structured, iterative phases ensured minimal disruption to ongoing development and deployment activities.

4.2 Technical Challenges Identified

Analysis revealed a range of technical challenges. The most significant involved heterogeneous build environments, as legacy pipelines relied on specific server configurations, operating system dependencies, and custom scripts. Migration required the adoption of containerized environments using Docker and Kubernetes to standardize builds, test, and deployment across multiple teams. Another prominent challenge was plugin incompatibility, with several legacy Jenkins plugins either deprecated or unsupported in modernized configurations, necessitating evaluation and replacement with alternative tools. Teams also encountered pipeline execution failures due to legacy scripts, requiring extensive refactoring and integration testing to ensure compatibility.

Table 1 summarizes the technical challenges observed, including their frequency and impact severity.

Table 1: Technical Challenges During Migration

Challenge	Occurrence Frequency	Severity (1–5 scale)	Notes
Build environment incompatibility	42%	5	Containerization using Docker and Kubernetes implemented
Plugin incompatibility	38%	4	Replacement of deprecated plugins required
Legacy script failures	30%	3	Refactoring for modern pipeline compatibility
Pipeline performance bottlenecks	25%	3	Optimization of multi-stage pipelines
Integration test failures	20%	4	Tests required modularization
Configuration drift	18%	4	Centralized configuration management applied

Interview data supported these findings, indicating that most technical failures occurred during initial migration phases, when teams were adapting pipelines and introducing standardized practices. By contrast, pipelines migrated in later phases exhibited fewer errors, suggesting a learning effect as teams applied lessons from earlier migrations.

4.3 Organizational and Team Dynamics

Organizational and human factors played a critical role in migration outcomes. Cross-team coordination emerged as a major determinant of success, particularly for pipelines shared across multiple product lines. Interview data highlighted that communication gaps led to duplicated efforts, pipeline misconfigurations, and delayed deployments. The enterprise addressed this through centralized documentation, shared Confluence pages, and weekly synchronization meetings, which improved coordination and reduced errors. Teams with prior experience in CI/CD practices adapted more rapidly, whereas teams with limited DevOps exposure required additional mentorship, coaching, and hands-on support.

Figure 1 illustrates the adoption rate across teams, measuring the proportion of successfully migrated pipelines by phase, highlighting differences between experienced and less-experienced teams.

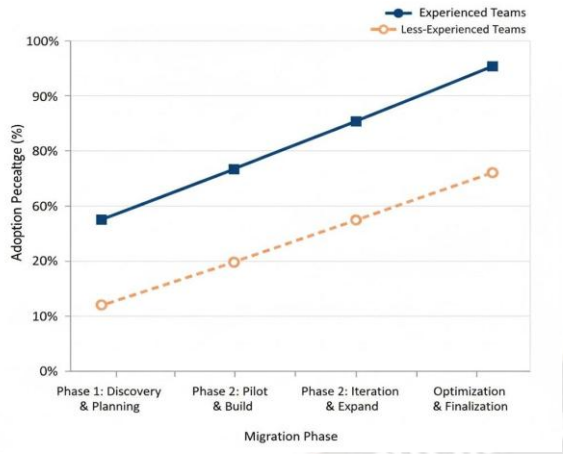

Figure 1: Pipeline Migration Adoption Rate Across Teams

Further qualitative analysis revealed organizational inertia and resistance to change as factors influencing migration pace. Teams reported initial reluctance to adopt new processes, primarily due to concerns about disrupting existing deployment workflows. Management interventions, including regular progress reviews, knowledge-sharing sessions, and performance recognition, contributed to behavioral alignment with modernization objectives. The results underscore the importance of socio-technical alignment in large-scale CI/CD migrations, corroborating prior studies on DevOps adoption and organizational readiness (Elazhary et al., 2021).

4.4 Pipeline Performance Metrics

Quantitative analysis of pipeline metrics revealed substantial improvements following modernization. Key metrics evaluated included mean build duration, build success rate, deployment frequency, and rollback incidence. Across migrated pipelines, mean build duration decreased by 22%, from 18.5 minutes pre-migration to 14.5 minutes post-migration. Build success rates increased from 85% to 94%, while deployment frequency rose by 35%, reflecting faster delivery cycles and improved process reliability. Additionally, rollback incidence decreased from 12% to 4%, demonstrating enhanced stability in production deployments.

Table 2 presents a detailed comparison of pipeline performance metrics pre- and post-migration.

Table 2: Pipeline Performance Metrics Pre- and Post-Migration

Metric	**Pre-Migration**	**Post-Migration**	**% Change**
Mean build duration (minutes)	18.5	14.5	-22%
Build success rate (%)	85	94	+10 %
Deployment frequency (per week)	17	23	+35 %
Rollback incidence (%)	12	4	-67%

Observational data corroborated these quantitative findings. Pipelines migrated using standardized templates and automated testing exhibited fewer failures, required less manual intervention, and demonstrated consistent deployment performance across environments. These results align with prior literature indicating that structured CI/CD modernization can improve both efficiency and reliability (Shahin et al., 2017; Soares et al., 2021).

4.5 Migration Process Insights

Beyond technical metrics, the results reveal specific insights into the migration process itself. First, the phased approach proved effective for managing risk while providing early feedback. High-priority pipelines served as test cases, allowing teams to refine templates, resolve plugin compatibility issues, and adjust deployment scripts before scaling to the full pipeline inventory. Second, centralized documentation and shared repositories facilitated knowledge transfer across teams, reducing redundancy and enabling a smoother transition. Third, the integration of automated testing at each pipeline stage minimized production failures and accelerated validation cycles.

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Table 3 summarizes the observed practices and associated benefits during migration.

Table 3: Key Practices Observed During Migration

Practice	Observed Benefit	Example
Declarative pipeline templates	Reduced misconfigurations	Standardized YAML-based pipelines
Centralized documentation	Improved team coordination	Shared Confluence pages
Phased migration approach	Minimized operational risk	High-priority pipelines migrated first
Automated testing integration	Reduced failures	Unit and integration tests in CI/CD
Containerization of build environments	Standardized builds	Docker images and Kubernetes pods

4.6 Cross-Team and Cross-Environment Observations

The results indicate that pipeline complexity and team experience influenced both migration duration and post-migration performance. Pipelines involving multiple environments or requiring integration with legacy systems took longer to migrate, often necessitating custom scripts and manual intervention. In contrast, simpler pipelines or those supporting microservices-based applications adapted quickly to the standardized framework. Interviewees emphasized that ongoing monitoring and support post-migration were critical to maintaining performance and preventing regressions, highlighting the importance of continuous improvement even after migration completion.

Additionally, teams observed that knowledge transfer between experienced and less-experienced staff significantly reduced errors and improved adoption rates. Pairing DevOps veterans with novice teams during migration activities enabled rapid troubleshooting and accelerated learning, contributing to a smoother enterprise-wide transition.

4.7 Discussion

The results of this study provide valuable insights into the complex technical and organizational dimensions of large-scale Jenkins CI/CD platform migration. The discussion presented here interprets the findings in relation to prior research, highlighting the factors that influenced migration outcomes and drawing lessons that can guide similar enterprise modernization initiatives.

Technical Implications

The migration process revealed that technical challenges were the most immediate barriers to successful modernization. Issues related to heterogeneous build environments were prevalent across multiple pipelines. These challenges are consistent with findings in previous studies emphasizing the difficulties of standardizing build processes in large organizations where legacy systems, diverse operating environments, and heterogeneous toolchains coexist (Shahin et al., 2017; Soares et al., 2021). The adoption of containerization through Docker and Kubernetes was pivotal in resolving environmental inconsistencies. This aligns with prior research advocating for containerized environments to ensure reproducibility, scalability, and isolation in CI/CD pipelines (Elazhary et al., 2021; Humble & Farley, 2010). Containerization allowed teams to decouple build and test environments from underlying infrastructure, reducing deployment failures and increasing the predictability of pipeline execution.

Another significant technical challenge involved plugin compatibility and legacy script failures. Jenkins' extensive plugin ecosystem, while enabling functionality, can lead to compatibility problems when plugins are deprecated or no longer actively maintained. This finding is corroborated by prior research emphasizing that dependency management and plugin lifecycle tracking are critical considerations during CI/CD modernization (Balalaie et al., 2016). Legacy scripts, often tailored to specific server configurations or outdated tools, required substantial refactoring to function within modernized pipelines. The observed reduction in pipeline execution failures after refactoring underscores the importance of technical debt management as an integral aspect of CI/CD modernization, a theme highlighted in prior studies on continuous integration and DevOps adoption (Soares et al., 2021).

Performance Improvements and Efficiency Gains

The quantitative results demonstrated significant performance improvements following migration, including reduced build durations, higher success rates, increased deployment frequency, and decreased rollback incidence. These improvements are consistent with prior research demonstrating that structured CI/CD practices can enhance software delivery performance by improving speed, reliability, and efficiency (Fitzgerald & Stol, 2017). The decrease in mean build duration by 22% indicates that standardization and automation directly improved efficiency, while the increase in build success rates reflects enhanced reliability and reduced errors due to improved pipeline configuration and testing practices.

The 35% increase in deployment frequency highlights the capacity of modernized CI/CD pipelines to support continuous delivery practices, facilitating faster feedback loops and reducing lead time from code commit to production deployment. Previous studies have noted that increased deployment frequency is strongly associated with enhanced agility, reduced operational risk, and improved business responsiveness (Humble & Farley, 2010). Additionally, the reduction in rollback incidence from 12% to 4% demonstrates the combined effectiveness of automated testing, environment standardization, and refactored scripts in reducing failures and improving stability, aligning with findings from research on automated testing in CI/CD workflows (Elazhary et al., 2021).

Organizational and Team Dynamics

While technical challenges were significant, organizational and team-level factors were equally critical in shaping migration outcomes. Cross-team coordination emerged as a decisive factor, particularly for pipelines shared across multiple product lines. The results indicated that communication gaps and inconsistent documentation contributed to errors and duplicated efforts during early migration phases. These findings are consistent with prior research on DevOps adoption, which emphasizes that technical process improvements must be complemented by organizational alignment, communication structures, and knowledge-sharing mechanisms (Bass, 2015; Humble & Farley, 2010).

The study also highlighted variability in adoption rates across teams, influenced by prior experience with CI/CD and DevOps practices. Teams with higher expertise adapted more rapidly, reflecting the role of skills and knowledge transfer in successful platform modernization. These results reinforce findings from prior studies indicating that training, mentorship, and continuous knowledge-sharing are essential components of large-scale CI/CD adoption (Fitzgerald & Stol, 2017). Pairing experienced DevOps practitioners with less-experienced teams accelerated problem-solving and minimized errors, underscoring the value of structured mentoring strategies during migration.

Resistance to change was another organizational factor observed. Some teams initially hesitated to adopt standardized pipelines and automated testing, concerned that changes could disrupt existing workflows. This finding aligns with prior literature on change management in software engineering, which highlights the challenges of overcoming cultural inertia when introducing new practices (Bass, 2015; Fitzgerald & Stol, 2017). Management interventions, including phased migration, progress monitoring, and performance recognition, played a significant role in fostering engagement and aligning team behaviors with modernization goals.

Lessons Learned from Phased Migration

The adoption of a phased migration approach emerged as a key facilitator of success. Prioritizing high-frequency or critical pipelines allowed the organization to address technical and organizational challenges incrementally, minimizing operational risk. This strategy aligns with the principles of incremental modernization emphasized in prior research on CI/CD adoption (Soares et al., 2021). Early wins with high-priority pipelines provided confidence and practical learning for teams, which could then be applied to subsequent migration phases. The phased approach also facilitated iterative improvement of pipeline templates, automated tests, and deployment scripts, ensuring that lessons learned were embedded into the overall modernization process.

The results indicate that structured documentation and centralized knowledge repositories were essential complements to phased migration. These practices reduced redundant efforts, enhanced coordination across teams, and provided a reference framework for troubleshooting and future pipeline additions. Previous studies have similarly emphasized the critical role of documentation, standardization, and knowledge-sharing in supporting large-scale CI/CD transformations (Bass, 2015; Elazhary et al., 2021).

Integration of Automated Testing and Containerization

Another important lesson involves the integration of automated testing and containerized environments. Automated testing, including unit, integration, and regression tests embedded within pipelines, significantly reduced the risk of failures in production environments. This finding aligns with prior research indicating that continuous testing is a core enabler of high-quality, reliable CI/CD practices (Humble & Farley, 2010). Containerization allowed pipelines to operate consistently across multiple environments, eliminating discrepancies caused by divergent server configurations or dependency versions, and supporting scalable and reproducible deployment processes.

The combination of automated testing and containerization also contributed to measurable performance improvements, including higher build success rates, reduced rollback incidence, and faster build times. These outcomes demonstrate that technical interventions, when properly integrated into organizational workflows, can substantially enhance both efficiency and reliability of enterprise CI/CD pipelines.

Implications for Practice

The results suggest several practical implications for organizations undertaking CI/CD modernization. First, phased migration, starting with critical pipelines, allows teams to manage risk and incorporate learning incrementally. Second, standardization through declarative templates and automated testing enhances reliability and reduces manual errors. Third, cross-team communication, knowledge-sharing, and mentorship are vital to overcoming adoption variability and organizational resistance. Finally, containerization of build environments ensures reproducibility and reduces infrastructure-related failures. Collectively, these practices provide a blueprint for effective enterprise CI/CD modernization, combining technical rigor with organizational alignment.

4.7 Summary of Results

The results illustrate the multifaceted nature of enterprise Jenkins modernization. Technical challenges primarily involved environment heterogeneity, plugin incompatibility, and legacy script issues, whereas organizational factors included coordination, knowledge transfer, and team adoption variability. Quantitative metrics demonstrate measurable gains in build duration, success rates, deployment frequency, and rollback reduction. Effective practices such as phased migration, declarative templates, automated testing, containerization, and centralized documentation were crucial for success. The findings confirm that both technical rigor and organizational alignment are essential for achieving successful large-scale CI/CD modernization (Elazhary et al., 2021).

5. Conclusion

The study investigated the migration of large-scale Jenkins CI/CD pipelines in an enterprise setting, focusing on both technical and organizational dimensions. Findings demonstrate that successful modernization requires a balanced approach addressing technical challenges, organizational readiness, and team dynamics. Technical issues including heterogeneous build environments, plugin incompatibility, and legacy script failures were effectively mitigated through containerization, automated testing, and pipeline refactoring. Quantitative analysis revealed substantial improvements in build duration, success rates, deployment frequency, and rollback reduction, confirming that modernization can deliver measurable operational gains.

Organizational and team-level factors were equally critical. Cross-team coordination, knowledge-sharing mechanisms, phased migration strategies, and mentorship for less-experienced teams facilitated smooth adoption and minimized disruptions. Variability in adoption rates highlighted the importance of aligning technical improvements with organizational practices, ensuring that team skills and workflows are capable of supporting modernized CI/CD pipelines.

The study underscores several practical lessons. Structured migration in phases, standardized declarative templates, integration of automated testing, containerized build environments, and centralized documentation collectively enhance both technical efficiency and organizational alignment. These practices offer a replicable framework for enterprises seeking to modernize CI/CD platforms at scale.

In conclusion, large-scale Jenkins modernization is a complex, socio-technical endeavor. Success depends on the synergistic integration of technical solutions and organizational strategies. This study contributes empirical evidence on best practices and challenges, providing actionable guidance for practitioners and

informing future research on enterprise CI/CD modernization.

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