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A FRAMEWORK FOR ENGINEERING DATA MIGRATION AND PLM INTEGRATION IN GLOBAL MERGER & ACQUISITION (M&A) ENVIRONMENTS

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ABSTRACT

Engineering data migration and Product Lifecycle Management (PLM) integration are major challenges in mergers and acquisitions (M&A), particularly when organizations consolidate heterogeneous CAD systems, metadata, product structures, and engineering practices. This paper presents a scalable, validation-centered framework developed through a qualitative case study of a global CAD-to-PLM migration program. Its six phases cover data assessment, preparation, transformation, phased migration, multi-level validation, and deployment governance. Project artifacts and implementation observations indicate that the framework supported migration control, cross-functional coordination, lifecycle traceability, and deployment readiness. By treating migration as a governed engineering transformation rather than a one-time conversion, the framework offers a repeatable foundation for future integration programs and further validation through quantitative measures, automation, analytics, and AI-assisted controls.

Keywords: Product Lifecycle Management (PLM), Engineering data migration, Mergers and acquisitions, CAD integration, Validation framework, Lifecycle traceability.

1 INTRODUCTION

Mergers and acquisitions (M&A) frequently require manufacturing organizations to integrate engineering data originating from multiple legacy environments. Differences in CAD systems, Product Lifecycle Management (PLM) platforms, metadata standards, product structures, release processes, and engineering practices can complicate this integration and increase the risk of data inconsistency, loss of traceability, and operational disruption. As organizations pursue digital transformation, engineering data migration has become important for maintaining product continuity and enterprise-wide lifecycle management [1–4].

Existing research has established the importance of PLM, digital-thread integration, interoperability, and engineering data governance [1–4]. However, comparatively limited attention has been given to practical frameworks for engineering data migration in global M&A environments, where technical complexity must be managed alongside organizational coordination, validation, and deployment planning.

To address this gap, this paper proposes a scalable framework for engineering data migration and PLM integration developed through a qualitative, practice-based study conducted during a global CAD-to-PLM migration program. The framework combines engineering governance, phased execution, structured validation, and deployment planning into a repeatable operating model intended to support future enterprise migration initiatives.

This study aims to develop and evaluate a scalable framework for engineering data migration and PLM integration in global M&A environments. A qualitative, practice-based case study was employed, drawing on project-generated artifacts, implementation observations, and selected literature to identify recurring migration challenges, develop the proposed framework, and evaluate its practical applicability. The findings provide qualitative operational evidence and establish a foundation for future studies incorporating quantitative performance metrics and broader validation across additional industrial migration programs.

1.1 Research Questions

This study addresses the following research questions:

- **RQ1:** What recurring technical, data-quality, and organizational challenges affect engineering data migration and PLM integration in global M&A environments?
- **RQ2:** How can these challenges be organized into a scalable, validation-centered framework for engineering data migration?
- **RQ3:** What qualitative project evidence supports the practical applicability of the proposed framework?

2 BACKGROUND AND RELATED WORK

2.1 Product Lifecycle Management and Lifecycle Integration

Product Lifecycle Management (PLM) serves as the information backbone of modern engineering enterprises by integrating product data, workflows, configurations, and lifecycle processes across geographically distributed teams. Prior studies describe PLM as an enterprise approach that connects people, processes, information, and organizational systems to maintain product consistency, enable collaboration, manage engineering changes, and support lifecycle decision-making [2]. As engineering organizations increasingly operate within interconnected digital ecosystems, PLM platforms have become foundational to lifecycle traceability, enterprise data governance, and digital transformation [1,2].

2.2 Digital Thread and Lifecycle Traceability

The digital thread extends traditional PLM concepts by establishing persistent, traceable relationships among engineering artifacts, business processes, and downstream operational systems. Research emphasizes maintaining connections among requirements, CAD models, metadata, product structures, manufacturing information, and lifecycle records to preserve engineering intent and configuration continuity [1,3–5]. Graph-based and linked-data approaches further demonstrate how heterogeneous artifacts can be connected, queried, and traced across design, manufacturing, and product-support domains [3,5].

2.3 Engineering Data Migration and System Consolidation

Engineering data migration has become increasingly important as organizations modernize engineering environments, consolidate enterprise platforms, and integrate acquired businesses. Migration initiatives commonly transfer CAD files, metadata, drawings, product structures, lifecycle states, configuration relationships, and enterprise identifiers between heterogeneous source and target systems. Success therefore depends not only on transfer accuracy but also on source-data cleansing, mapping discipline, validation controls, relationship preservation, and phased deployment. Industry migration practice identifies incremental strategies, delta synchronization, integrated quality checks, and validation gateways as mechanisms for reducing operational risk and maintaining data integrity during consolidation [6].

Migration projects nevertheless encounter recurring challenges associated with inconsistent metadata, incompatible data models, customized workflows, duplicate or incomplete objects, and downstream system dependencies. Controlled execution with pilot loads, validation checkpoints, exception handling, and staged cutover provides a practical basis for containing these issues before enterprise-scale deployment [6].

2.4 M&A Integration and Research Gap

Mergers and acquisitions introduce additional complexity because engineering organizations must integrate legacy systems, engineering standards, product structures, release processes, and organizational practices developed under different governance models. While previous literature provides guidance on PLM implementation, digital-thread architecture, data interoperability, lifecycle management, and migration tooling [1–6], limited consolidated treatment exists regarding assessment, migration execution, validation governance, deployment readiness, and post-integration stabilization within a single framework targeted specifically at global M&A engineering environments. This gap motivates the scalable, validation-centered framework proposed in this study.

3 RESEARCH METHODOLOGY

3.1 Research Design and Scope

This study used a qualitative, practice-based single-case design to examine an end-to-end engineering data migration and PLM integration program in a global M&A setting. The scope extended from source-data assessment and preparation through migration, validation, go-live readiness, and post-deployment stabilization.

3.2 Evidence and Analysis

Evidence comprised source-data assessments, mapping specifications, migration-batch records, validation outputs, issue logs, readiness reviews, training materials, support records, and direct implementation observations. Structured review and thematic categorization grouped recurring issues and controls into source-data quality, lifecycle integrity, mapping, execution, validation, deployment readiness, and post-go-live support. These categories were consolidated into the six framework phases. Without a pre-migration benchmark or control project, the analysis assessed practical applicability and completed outputs rather than statistical improvement.

3.3 Trustworthiness and Ethics

Because the author participated directly in the program, observations were cross-checked against multiple artifact types and factual outputs were separated from interpretation to reduce practitioner bias. The study involved no experiments, surveys, or interviews. Operational artifacts were created during normal project execution, and organizational names, personal information, and commercially sensitive details were excluded or generalized. Findings are reported in aggregated and anonymized form.

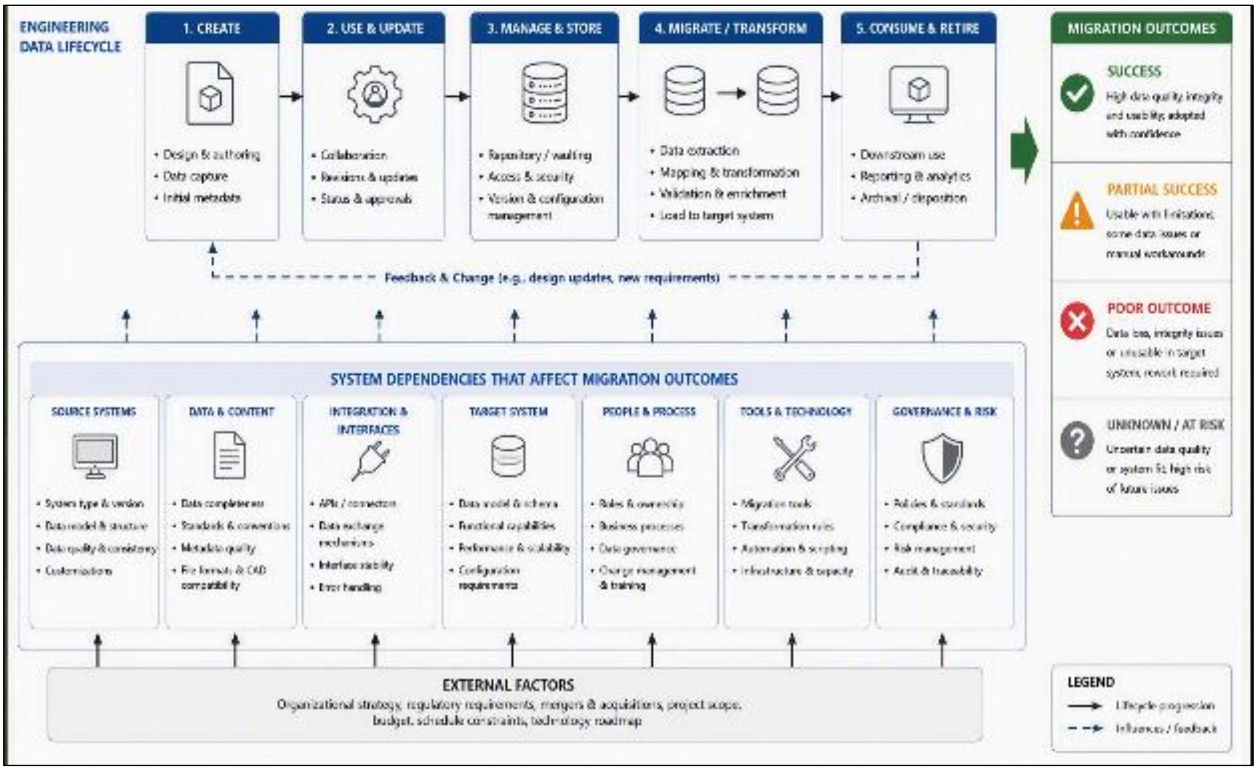

Figure 1: Typical lifecycle and system dependencies affecting engineering data migration outcomes.

3.4 Problem Definition

In M&A environments, acquired engineering data often comes from legacy CAD/PLM landscapes with incompatible structures, naming conventions, metadata, and release logic. In the observed target environment, part numbers, CAD models, drawings, BOMs, release states, visualization, and enterprise synchronization were lifecycle-controlled and interconnected. Migration failure could therefore appear not only as file corruption but also as broken traceability, missing attributes, invalid release conditions, or downstream misalignment. A scalable solution must preserve this engineering meaning while coordinating validation, data quality, BOM consistency, and distributed team execution.

3.5 Proposed Scalable Framework for Engineering Data Migration and PLM Integration

The proposed framework consists of six interdependent phases

3.6 Framework Overview

The framework is designed as an end-to-end migration operating model rather than a data-load sequence. It addresses design data, enterprise attributes, product structure, validation, and deployment governance. Its purpose is to provide repeatability across current and future M&A integration programs.

Figure 2: Validation-centered scalable framework for engineering data migration and PLM integration in M&A environments.

3.7 Foundational Design Principles

The framework is built on four principles: lifecycle integrity, validation-first execution, process standardization, and phased scalability. These principles align with prior work emphasizing lifecycle connectivity, interoperability, traceability, completeness, and controlled change [1,3,4], while addressing the data-quality, BOM-consistency, governance, and integration risks identified in the case evidence.

3.7.1 Phase 1: Data Assessment and Discovery

This phase inventories source systems, CAD objects, drawings, metadata, revisions, BOM structures, and downstream relationships. It produces a migration-readiness view of the source landscape and identifies anomalies requiring remediation.

3.7.2 Phase 2: Data Preparation and Cleansing

This phase removes duplicates, standardizes naming and attributes, resolves lifecycle inconsistencies, and prepares data for transformation.

3.7.3 Phase 3: Data Mapping and Transformation

This phase maps source geometry, metadata, structure, and enterprise identifiers to the target PLM model. The process preserves traceability across design objects, part numbers, and product structures, consistent with the integrated system.

3.7.4 Phase 4: Migration Execution

Migration is executed in controlled waves. Pilot loads, rule refinement, and checkpoints support issue containment and scalable deployment across business units or acquired entities.

3.7.5 Phase 5: Multi-Level Validation Framework

Validation covers geometry, metadata, BOM/product structure, and deployment readiness. Structured records support traceable issue identification and resolution without implying unmeasured performance gains.

3.7.6 Phase 6: Deployment and Post-Migration Integration

The final phase covers release readiness, system adoption, downstream synchronization, support handling, and transition into steady-state governance. Deployment is treated as a controlled operational milestone rather than the endpoint of technical conversion.

3.8 Case Study: Application of the Framework in a Global Engineering Migration Program

The framework was applied in a post-acquisition, multi-regional CAD-to-PLM migration program. Project evidence included source assessments, mapping and batch records, validation outputs, issue logs, readiness reviews, training materials, and support records. The program coordinated data quality, product structures, BOM consistency, release controls, drawing-image flows, deployment readiness, and user support across distributed engineering teams.

Implementation followed phased migration, formal validation, and readiness checkpoints. Automated log checks and controlled release practices supported completeness checks, while designated local contacts, engineering leads, training, and enterprise application support addressed organizational readiness and post-go-live stabilization.

Table 1: Illustrative phased implementation path used in the global engineering migration program.

1. Source Assessment Inventory source CAD/PLM data, metadata, drawing images, BOM structures, dependencies, and lifecycle status.	**2. Pilot Migration** Run a controlled pilot to test mapping rules, migration scripts, validation criteria, and issue-resolution workflow.	**3. Batch Migration** Execute migration in planned waves, beginning with Batch 1 completion and lessons learned before scale-up.
4. Validation Checkpoints Validate geometry, metadata, BOM consistency, release state, visualization behavior, and downstream synchronization.	**5. Go-Live Readiness** Confirm business sign-off, support readiness, training/communication, cutover controls, and operational acceptance.	**6. Support Stabilization** Monitor post-go-live issues, provide hypercare support, resolve defects, and transition to steady-state governance.

4 RESULTS AND OBSERVATIONS

Results were evaluated through completed project outputs rather than subjective ratings. As summarized in Table 2, the evidence covers phased CAD migration, drawing-repository transition, engineering-environment alignment, validation controls, automation, and user readiness.

Table 2: Evidence-based results from application of the migration framework

Result area	Project evidence	Relevance to the framework
Phased CAD migration	Tens of thousands of unique part numbers and their associated CAD datasets were migrated through an initial phase followed by controlled delta migrations.	Demonstrates scalable wave execution, controlled incremental loading, and traceable migration closure.
Drawing-repository transition	Hundreds of thousands of drawing images and their associated metadata were transferred from the legacy repository to the target visualization environment.	Shows that the framework covered linked downstream content, not only native CAD objects.
Engineering-environment transition	The acquired engineering team moved from a legacy CAD/PDM environment to an upgraded CAD release and unified enterprise PLM platform, supported by migrated	Confirms lifecycle integration across applications, configurations, standards, and user practices.

	libraries, drawing formats, naming rules, and configuration controls.	
Validation and rule control	Migration rules were refined to address naming limits, duplicate components, missing references, model failures, release behavior, and unintended object relationships.	Demonstrates validation-centered governance and controlled remediation of source-data and transformation issues.
Automation-enabled continuity	CAD automation solutions were implemented to support drawing classification, drawing-image and metadata generation, and obsolete-state processing.	Shows how repeatable automation extended the framework into post-migration engineering operations.
User and operational readiness	User-access preparation and localized training were completed, supported by dedicated training material and a structured post-go-live support model.	Validates that deployment governance included adoption, knowledge transfer, and operational stabilization.

These qualitative results show how the framework supported traceability, phased control, issue remediation, user readiness, and operational continuity. They do not establish comparative performance improvement because no baseline or control project was available. Future applications should measure first-pass validation, defect density, rework effort, migration throughput, and post-go-live incident-resolution time.

5 DISCUSSION

The case study indicates that M&A engineering migration is a lifecycle-integration challenge rather than a simple data-load activity. This interpretation is consistent with research emphasizing connected lifecycle information, cross-domain interoperability, and traceability [1,3,4]. In the case examined, interdependencies among part identity, CAD models, drawings, BOMs, release states, visualization, and downstream systems required technical controls to be combined with governance, validation, training, support, and cross-team standardization.

Future Work

Future work should validate the framework across additional organizations and technology environments, introduce formal performance metrics, and assess the value of automation, analytics, AI-assisted anomaly detection, and broader digital-thread connectivity.

6 CONCLUSION

This paper presented a scalable six-phase framework for engineering data migration and PLM integration in global M&A environments. The case study illustrates how lifecycle continuity, validation discipline, phased execution, and deployment readiness were applied across part identity, CAD data, product structures, release controls, drawing-image flows, and downstream systems.

The study's main contribution is to frame migration as a governed engineering transformation rather than an isolated technical conversion. Project artifacts and implementation observations provide qualitative evidence of the framework's practical applicability, while the single-case design and absence of baseline metrics limit broader generalization.

Subject to further quantitative and cross-case validation, the framework offers a practical, repeatable foundation for integrating heterogeneous engineering environments into a unified PLM ecosystem after M&A activity.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

The author declares no conflict of interest.

Author Contribution Statement

The author was solely responsible for the conceptualization, methodology, investigation, analysis, framework development, manuscript preparation, review, and editing.

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