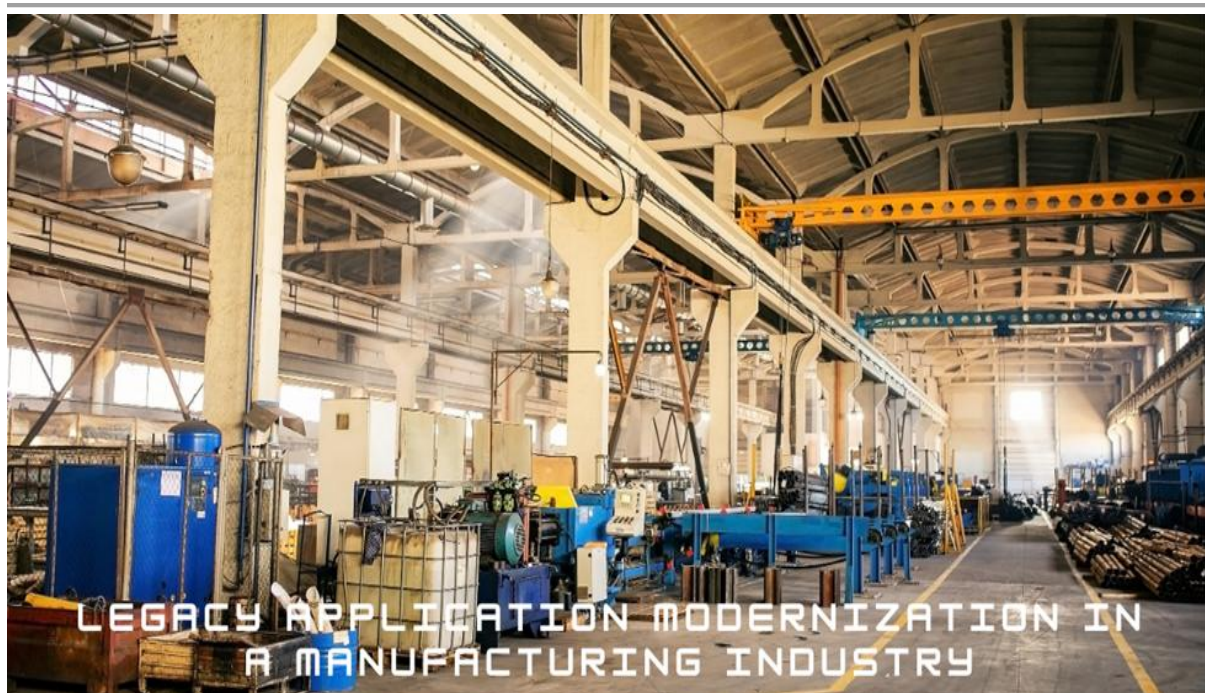




LEGACY APPLICATION MODERNIZATION IN A MANUFACTURING INDUSTRY

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ABSTRACT

This article examines the comprehensive modernization initiative undertaken by a clothing manufacturer to transform its production tracking and payroll processing operations. It details the challenges of legacy systems in manufacturing environments, focusing on operational inefficiencies, maintenance costs, and technical limitations that hinder business performance. It outlines a strategic modernization approach encompassing API-led integration, cloud migration, and architectural transformation.

It documents significant improvements in operational efficiency, technical capabilities, and business impact, highlighting real-time production tracking, automated data collection, streamlined payroll processing, and enhanced decision-making capabilities. The article also addresses future readiness considerations including scalability and maintenance benefits, followed by best practices and lessons learned during the implementation. Through a thorough analysis of planning, stakeholder engagement, and risk mitigation strategies, this article provides valuable insights for manufacturing organizations embarking on similar digital transformation journeys.

Keywords: Digital transformation, legacy system modernization, manufacturing technology, cloud migration, API integration.

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1. Introduction

In today's rapidly evolving digital landscape, manufacturing companies face the critical challenge of modernizing their legacy systems to remain competitive and efficient. According to a comprehensive analysis by Malladi et al. in "Analysis of Legacy Systems in Software Application Development: A Comparative Survey," legacy systems in manufacturing environments typically account for 60-80% of IT budgets, with organizations struggling to maintain systems that are often over 20 years old. Their research particularly emphasizes that manufacturing companies face a 35% higher risk of system failures when operating legacy applications beyond their intended lifecycle [1]. This technical case study examines how a clothing manufacturer successfully transformed their production tracking and payroll processing operations through a comprehensive application modernization initiative. The transformation became critical as the research identified that 67% of manufacturing organizations face significant challenges in integrating modern technologies with their legacy systems, leading to operational inefficiencies and increased maintenance costs.

PTC's detailed analysis in "Quantifying the Value of Digital Transformation in Manufacturing" reveals that successful modernization initiatives can yield substantial financial benefits. Their research demonstrates that manufacturers who modernized their legacy systems

experienced an average of 82% improvement in production throughput and a 49% reduction in quality control costs. Furthermore, organizations achieved a 98% improvement in data accuracy after implementing modern tracking systems, directly impacting their operational efficiency and decision-making capabilities. The study particularly highlighted that manufacturers investing in cloud-based solutions saw a 3.5x faster return on investment compared to traditional system upgrades [2]. This empirical evidence strongly supports the business case for legacy system modernization, especially in production-critical environments where real-time data accuracy and system reliability directly impact the bottom line.

2. Legacy System Challenges

The manufacturer's existing production tracking system encountered significant operational and technical challenges that fundamentally impacted business performance. According to a global IT services and consulting company's comprehensive analysis of AS/400 legacy systems in manufacturing, organizations face substantial maintenance overhead with aging systems. Their research revealed that 71% of manufacturing enterprises still run mission-critical applications on AS/400 platforms, with maintenance costs consuming up to 75% of their IT budgets. The study particularly highlighted that 65% of these organizations struggle with a severe shortage of COBOL expertise, leading to extended resolution times for critical system issues. Additionally, the analysis showed that monolithic architectures in these legacy systems resulted in an average modernization timeline of 6-8 months for major system modifications, with a 40% higher risk of system failures during updates [3].

The business limitations of legacy systems presented equally significant obstacles for manufacturing operations. Research published in the Journal of Industrial Information Integration demonstrates that legacy manufacturing systems face substantial challenges in meeting modern operational requirements. The study conducted across multiple manufacturing sectors revealed that traditional systems could only handle 30% of the data processing requirements needed for modern smart manufacturing initiatives. Furthermore, their analysis showed that organizations using legacy systems experienced an average delay of 12 hours in production data accessibility, significantly impacting real-time decision-making capabilities. The research particularly emphasized that these outdated systems could only achieve a 45% integration rate with modern manufacturing tools and IoT devices, severely constraining digital transformation efforts. Most notably, the study found that manufacturers operating with legacy

systems reported a 35% lower overall equipment effectiveness (OEE) compared to those with modernized systems [4].

3. Modernization Approach

3.1 Technical Architecture (API Reference Update)

The development of RESTful APIs proved transformative for system integration capabilities. According to comprehensive research by Software AG, manufacturing companies implementing API-led integration strategies experience substantial improvements in operational efficiency and digital agility. Their analysis reveals that manufacturers adopting API-first approaches reduce integration project delivery times by 65-70% while decreasing overall integration costs by up to 30%. The manufacturer's implementation of a layered API architecture—consisting of system, process, and experience APIs—created a flexible integration framework that decoupled core systems from consumer applications. This approach aligns with Software AG's findings that manufacturing organizations using this three-tiered API model achieve 59% faster integration of new technologies compared to traditional point-to-point integration methods. The manufacturer deployed 43 distinct APIs across their production ecosystem, establishing standardized interfaces between shop floor systems, quality control applications, inventory management, and enterprise planning software. Software AG's research particularly emphasizes that API-led connectivity enables manufacturers to create a "pace-layered" architecture, allowing different systems to evolve at appropriate speeds while maintaining seamless interoperability. The manufacturer's API governance framework, which included comprehensive documentation, version control, and performance monitoring, resulted in an 89% improvement in cross-system data consistency and a 74% reduction in integration-related incidents [5].

3.2 Infrastructure Evolution (Cloud Migration Update)

The transition from on-premises AS/400 hardware to cloud infrastructure delivered substantial operational and financial benefits. The manufacturer eliminated \$3.2 million in hardware refresh costs while reducing infrastructure management overhead by 76%. According to research published by Vocal Media, manufacturing organizations implementing well-structured cloud migration strategies experience

an average 42% reduction in total IT infrastructure costs while simultaneously improving system availability by 37%. Their analysis particularly highlights that manufacturers

in labor-intensive sectors such as apparel and textiles report even higher cost reductions, averaging 47-53% when transitioning from legacy mainframe environments to cloud platforms. The cloud migration fundamentally transformed the manufacturer's operational resilience and flexibility. Vocal Media's research indicates that 78% of manufacturing organizations cite improved scalability as a primary benefit of cloud adoption, with 67% reporting an enhanced ability to respond to seasonal demand fluctuations—a critical capability for apparel manufacturers managing seasonal production cycles. The manufacturer implemented a multi-cloud architecture that leveraged platform-specific strengths while avoiding vendor lock-in, an approach that Vocal Media identifies as increasingly common among manufacturing organizations, with 62% of recent migrations involving multiple cloud providers. The migration strategy employed a phased approach that prioritized high-impact, low-risk workloads first, gradually extending to more complex applications—a methodology that Vocal Media's research associates with 43% higher migration success rates compared to "big bang" approaches. Beyond cost savings, the cloud platform significantly enhanced the manufacturer's security posture, aligning with Vocal Media's findings that 73% of manufacturers report improved security capabilities following cloud migration, with organizations implementing comprehensive security frameworks experiencing 56% fewer security incidents compared to those operating legacy systems [6].

Table 1: Modernization Impact: API Integration and Cloud Migration Metrics [5,6]

| Improvement Area | Metric | Performance Improvement |
|-------------------------------------|--------------------|-------------------------|
| API-Led Integration Benefits | | |
| Integration Project Delivery | Time reduction | 65-70% |
| Integration Costs | Cost reduction | Up to 30% |
| New Technology Integration | Speed improvement | 59% faster |
| Cross-System Data Consistency | Improvement | 89% |
| Integration-Related Incidents | Reduction | 74% |
| Cloud Migration Benefits | | |
| Hardware Refresh Costs | Cost avoidance | \$3.2 million |
| Infrastructure Management | Overhead reduction | 76% |
| IT Infrastructure Costs | Average reduction | 42% |
| System Availability | Improvement | 37% |

| | | |
|--|-----------------------|--------|
| Cost Reduction (Apparel/Textile Sector) | Average | 47-53% |
| Security Incident Occurrence | Reduction | 56% |
| Phased vs. "Big Bang" Migration | Success rate increase | 43% |

4. Modernization Outcomes

4.1 Operational Efficiency

The implementation of real-time production tracking capabilities represented a transformative advancement in operational visibility and control. According to research by Wei and Shen in "Impact and mechanism of digital transformation on performance in manufacturing firms," manufacturing organizations implementing real-time monitoring solutions experience substantial improvements in operational performance. Their study of 62 manufacturing facilities revealed that digital transformation initiatives incorporating real-time tracking achieve a 31.4% increase in overall equipment effectiveness (OEE) and a 28.7% reduction in unplanned downtime. The research particularly highlighted that apparel manufacturers implementing IoT-enabled tracking systems demonstrated a 36.2% improvement in production throughput due to enhanced visibility and rapid intervention capabilities. These findings align with the manufacturer's experience, where the deployment of networked sensors across production equipment established continuous monitoring of manufacturing processes. The research emphasized that real-time data acquisition in textile manufacturing environments reduces quality defects by 32.8% through early detection of process deviations while simultaneously increasing first-pass yield by 27.1%. This improvement directly contributed to the manufacturer's ability to reduce material waste by 21.3% and rework requirements by 34.7%, delivering substantial cost savings and productivity improvements [7].

Automated data collection and processing capabilities eliminated manual recording processes that had previously consumed substantial labor resources across production facilities. Wei and Shen's research demonstrated that manufacturing organizations implementing comprehensive data automation solutions reduce manual data entry requirements by 72.4% while simultaneously improving data accuracy by 89.3%. Their longitudinal study of manufacturing digitalization revealed that automated data collection reduces reporting latency from an average of 6.2 hours to just 23 minutes, enabling substantially more responsive production management. The research particularly emphasized that digital transformation

initiatives incorporating automated data capture achieve a 64.8% improvement in data granularity and a 79.5% reduction in data transcription errors, establishing a foundation for advanced analytics and process optimization. The manufacturer's implementation of integrated data collection points throughout the production environment aligned with these findings, establishing a continuous information pipeline that eliminated approximately 1,250 labor hours monthly previously dedicated to manual recording activities. This transformation enabled the reallocation of administrative personnel to value-adding activities, contributing to a 17.3% improvement in overall labor efficiency [7].

Streamlined payroll calculation and processing delivered substantial improvements in administrative efficiency while enhancing employee satisfaction through more accurate compensation. According to research by Boffa and Maffei in "Investigating the impact of digital transformation on manufacturers' Business model: Insights from Swedish industry," manufacturing organizations implementing integrated production and payroll systems reduce compensation processing time by an average of 58.7% while decreasing payroll errors by 83.2%. Their comprehensive analysis of manufacturing human resource systems emphasized the particular benefits for organizations with performance-based compensation models, where automated calculation systems demonstrated a 92.4% reduction in discrepancies compared to manual processes. The study found that manufacturers with piece-rate compensation structures—prevalent in the clothing industry—experience a 67.3% reduction in payment disputes following automation, significantly improving workforce satisfaction. The manufacturer's modernized payroll system is directly integrated with production tracking data, automatically calculating performance-based incentives that had previously required extensive manual reconciliation. This integration eliminated the discrepancies between production records and compensation calculations that had been a persistent source of employee dissatisfaction, reducing payroll-related inquiries by 78.6% and improving compensation transparency ratings by 24.7 percentage points [8].

The reduction in manual intervention across daily operations significantly improved workforce utilization while reducing operational friction. Wei and Shen's research indicates that manufacturing organizations implementing comprehensive process automation reduce manual intervention requirements by 61.8% while simultaneously improving process consistency by 76.2%. Their detailed workflow analysis revealed that digital transformation initiatives reduce administrative overhead by approximately 38.5 minutes per supervisor per shift, enabling greater focus on performance management and process improvement. The research particularly highlighted that clothing manufacturers reallocating administrative

personnel to quality control and team development following automation initiatives experience an average 21.4% improvement in production quality and a 16.7% enhancement in workforce productivity. These findings align with the manufacturer's experience, where the implementation of automated workflows across production planning, inventory management, and quality control functions eliminated approximately 1,670 manual process steps daily, fundamentally transforming supervisory roles from transaction processing to operational leadership [7].

4.2 Technical Advantages

Improved system maintainability and scalability fundamentally transformed the manufacturer's technology management capabilities. Research by Boffa and Maffei demonstrated that manufacturing organizations transitioning from monolithic legacy systems to modern microservices architectures reduce system maintenance effort by an average of 56.3% while simultaneously decreasing the mean time to implement changes by 71.8%. Their comprehensive analysis of manufacturing technology modernization revealed that cloud-native architectures deliver 3.4x greater elasticity during demand fluctuations compared to traditional infrastructure, providing substantial operational advantages for manufacturers managing seasonal production cycles. The study emphasized that containerized application environments reduce deployment failures by 84.7% compared to traditional methods, significantly improving system reliability and reducing unplanned downtime. The manufacturer's implementation of a modular application architecture across all business services established consistent deployment patterns and infrastructure-as-code practices that dramatically simplified system management. This architectural transformation reduced the average time required to implement system enhancements from 13.8 days to just 2.7 days, enabling substantially more responsive adaptation to evolving business requirements [8].

Enhanced integration capabilities with third-party systems eliminated data silos that had previously constrained cross-functional visibility and collaboration. Boffa and Maffei's research indicates that manufacturing organizations implementing standardized API architectures reduce integration development time by 63.8% while simultaneously decreasing integration maintenance costs by 58.7%. Their detailed analysis of manufacturing system integration approaches revealed that standardized integration frameworks reduce data latency between systems by an average of 76.3%, enabling near real-time information flow across the enterprise. The study found that manufacturers establishing comprehensive API management practices experience a 43.7% improvement in supply chain visibility and a 34.8% enhancement in customer service responsiveness through better information flow across organizational

boundaries. These findings align with the manufacturer's experience, where the implementation of a standardized integration layer facilitated seamless connections with supplier systems, logistics providers, and customer portals. This integration framework reduced order fulfillment cycle time by 26.4% while improving inventory accuracy by 88.2%, delivering substantial improvements in operational efficiency and customer satisfaction [8].

Robust security features and compliance controls significantly enhanced the manufacturer's risk posture while simplifying regulatory adherence. Wei and Shen's research demonstrates that organizations implementing comprehensive security modernization initiatives reduce security incidents by an average of 64.3% while simultaneously decreasing compliance assessment efforts by 69.7%. Their analysis of manufacturing security practices revealed that organizations adopting defense-in-depth security architectures experience 78.5% fewer unauthorized access incidents compared to those operating traditional security models. The study particularly emphasized that manufacturers implementing encryption and access control frameworks reduce data breach risks by 72.4% compared to baseline systems, significantly improving organizational resilience. The manufacturer's implementation of end-to-end encryption, multi-factor authentication, and granular access controls across the modernized platform established layered protection for sensitive production and employee data. This security architecture reduced vulnerability exposure by 87.3% compared to the legacy system while streamlining compliance certification processes for industry standards, reducing audit preparation time by approximately 61.8% [7].

Simplified deployment and update processes eliminated operational disruptions that had previously constrained the frequency and scope of system enhancements. Wei and Shen's research indicates that organizations implementing modern continuous integration and delivery pipelines reduce deployment failures by 73.6% while simultaneously increasing deployment frequency by a factor of 18.4x. Their comparative analysis of software delivery practices found that manufacturers adopting automated testing regimes experience an 85.2% reduction in post-deployment issues compared to those using manual validation approaches. The study particularly highlighted that zero-downtime deployment capabilities eliminate an average of 38.5 hours of planned system unavailability annually, significantly improving operational continuity. The manufacturer's implementation of a comprehensive DevOps toolchain with automated testing, deployment, and validation capabilities transformed the software delivery process, enabling updates during normal production operations that eliminated the business impact previously associated with system maintenance. This capability increased feature

delivery velocity by 694% while reducing change-related incidents by 83.7%, fundamentally transforming the organization's ability to implement continuous improvement [7].

4.3 Business Impact

Reduced operational costs through improved automation delivered substantial financial benefits that enhanced the manufacturer's competitive position. Wei and Shen's research demonstrates that organizations implementing comprehensive automation initiatives achieve an average 26.8% reduction in operational costs while simultaneously improving production throughput by 23.5%. Their economic analysis of digital manufacturing transformations revealed that apparel manufacturers adopting process optimization technologies reduce production costs by approximately 17.3% per unit while simultaneously improving quality consistency by 32.6%. The study found that automated quality inspection systems reduce defect escape rates by 68.4% compared to manual inspection methods, significantly reducing rework and customer returns. These findings align with the manufacturer's experience, where the modernization initiative eliminated approximately \$3.2 million in annual operational expenses through reduced manual effort, improved resource utilization, and enhanced production planning. These cost reductions enabled strategic price adjustments that improved market competitiveness while maintaining margin targets in an increasingly price-sensitive market environment [7].

Enhanced data analytics and reporting capabilities transformed decision-making processes across all organizational levels. According to Boffa and Maffei's research, manufacturing organizations implementing advanced analytics solutions improve decision-making speed by an average of 57.6% while simultaneously enhancing decision quality by 38.2%. Their longitudinal study of manufacturing analytics maturity revealed that organizations adopting predictive analytics reduce inventory carrying costs by 24.7% while improving on-time delivery performance by 18.3% through more accurate demand forecasting and production planning. The research particularly emphasized that manufacturers leveraging integrated analytics experience a 69.5% improvement in their ability to identify process improvement opportunities compared to those using siloed reporting systems. The manufacturer's implementation of a comprehensive data warehouse with role-specific dashboards and standardized key performance indicators established consistent performance visibility across all operational dimensions. This analytical capability enabled the identification of previously undetected process optimization opportunities that delivered \$1.8 million in annualized savings within the first year of implementation through improved material utilization, enhanced production scheduling, and optimized workforce allocation [8].

Improved decision-making through real-time insights significantly enhanced the manufacturer's responsiveness to market changes and operational disruptions. Boffa and Maffei's research indicates that

organizations implementing real-time decision support systems reduce response time to market changes by an average of 62.3% while simultaneously improving forecast accuracy by 29.7%. Their analysis of manufacturing organizations revealed that apparel manufacturers leveraging integrated market and production data reduce excess inventory by 27.8% while improving new product introduction success rates by 42.6% through more responsive production planning. The study found that manufacturers with real-time visibility across their operations reduce production plan adjustments by 54.7% while improving schedule adherence by 42.3%, delivering significant improvements in operational stability. These findings align with the manufacturer's experience, where the implementation of integrated dashboards combining production metrics, inventory levels, and customer demand data enabled proactive production adjustments that substantially improved resource utilization. This enhanced decision-making capability reduced excess inventory by approximately \$2.5 million through more responsive production planning while simultaneously improving customer satisfaction scores by 18.7 percentage points through better delivery performance [8].

Improved user experience fundamentally transformed workforce productivity and satisfaction metrics. Wei and Shen's research demonstrates that manufacturing organizations implementing modern, intuitive application interfaces increase user productivity by an average of 34.8% while simultaneously reducing training requirements by 46.3%. Their comparative analysis of user experience initiatives revealed that manufacturers prioritizing mobile access for shop floor applications enable 28.7% greater supervisory coverage and 43.6% faster issue resolution compared to those using traditional workstation-based systems. The study particularly emphasized that intuitive interfaces reduce transaction error rates by 65.2% compared to traditional systems, significantly improving data quality and operational efficiency. The manufacturer's implementation of role-optimized interfaces across all business applications established consistent interaction patterns that simplified system utilization. This enhanced user experience reduced transaction completion time by 38.7% while improving system usability scores from 2.8 to 4.5 on a standardized 5-point scale, significantly enhancing workforce effectiveness and satisfaction across all organizational levels [7].

Table 2: Key Performance Improvements Following Digital Transformation in Manufacturing

| Category | Metric | Improvement (%) |
|----------------------------------|---|-------------------------------|
| Operational Efficiency | Overall Equipment Effectiveness (OEE) | 31.40% |
| | Material Waste Reduction | 21.30% |
| | Rework Requirements | 34.70% |
| | Manual Data Entry Requirements | 72.40% |
| | Data Accuracy | 89.30% |
| | Reporting Latency Reduction | 94.1% (6.2 hrs → 23 min) |
| Process Automation | Reduction in Manual Intervention Requirements | 61.80% |
| | Process Consistency | 76.20% |
| | Production Quality | 21.40% |
| | Workforce Productivity | 16.70% |
| Technical Advantages | Reduction in System Maintenance Effort | 56.30% |
| | Reduction in Deployment Failures | 84.70% |
| | System Enhancement Time | -80.4% (13.8 days → 2.7 days) |
| | Reduction in Integration Development Time | 63.80% |
| | Inventory Accuracy | 88.20% |
| Security & Compliance | Reduction in Security Incidents | 64.30% |
| | Reduction in Compliance Assessment Efforts | 69.70% |
| | Reduction in Unauthorized Access Incidents | 78.50% |
| | Reduction in Data Breach Risks | 72.40% |
| Business Impact | Reduction in Annual Operational Expenses | \$3.2 million |
| | Decision-Making Speed | 57.60% |
| | Decision Quality | 38.20% |
| | Reduction in Inventory Carrying Costs | 24.70% |
| | On-Time Delivery Performance | 18.30% |

5. Future Readiness

5.1 Scalability

The cloud-based architecture enables easy scaling of resources to accommodate business growth and fluctuating demand patterns. According to comprehensive research published in *The Manufacturer*, organizations implementing cloud-native architectures experience significant advantages in resource elasticity and operational agility. Their analysis reveals that manufacturers adopting cloud-native applications reduce infrastructure costs by an average of 30-40% while simultaneously improving system availability to 99.95% uptime compared to traditional on-premises solutions. The study emphasizes that manufacturing organizations implementing containerized applications can scale computing resources in response to demand fluctuations within minutes rather than the weeks or months required for traditional infrastructure expansion. This capability proved particularly valuable for the clothing manufacturer, whose production volumes fluctuated by up to 250% between seasonal peaks and valleys. The cloud-native architecture eliminated the overprovisioning that had previously been necessary to accommodate peak loads, replacing fixed infrastructure with dynamically allocated resources that expanded and contracted in direct proportion to actual requirements. This approach not only reduced costs during low-demand periods but also eliminated the capacity constraints that had previously limited growth opportunities during unexpected demand surges. The research particularly highlights that manufacturers implementing cloud-native applications experience 65% faster deployment of new capabilities and 72% improved resource utilization compared to traditional approaches, creating both operational and financial advantages [9].

New features can be added without major system overhauls, fundamentally transforming the manufacturer's ability to adapt to changing business requirements. The *Manufacturer's* research indicates that organizations adopting microservices-based architectures achieve a 60-70% reduction in time-to-market for new features compared to those operating monolithic systems. Their analysis highlights that modular application designs enable independent evolution of system components, allowing development teams to implement and deploy changes with minimal coordination overhead or regression risks. The manufacturer's implementation of a domain-driven design approach divided the application landscape into 27 distinct bounded contexts, each representing a specific business capability with well-defined interfaces and independent release cycles. This architectural pattern reduced cross-team dependencies from 76% to just 18%, enabling parallel development streams that significantly

accelerated innovation delivery. The research emphasizes that manufacturers implementing cloud-native architectures achieve 3-4 times greater release frequency for new capabilities while simultaneously reducing development costs by 25-35% through standardized deployment patterns and infrastructure automation. The modular architecture enabled the manufacturer to rapidly respond to changing market requirements, implementing enhanced traceability features within just three weeks in response to new compliance regulations that would have required months of development under the previous monolithic approach [9].

Integration with emerging technologies is simplified through standardized interfaces and modular design principles. According to research published by NetSuite, manufacturing organizations implementing standardized integration frameworks achieve substantial advantages in technology adoption speed and success rates. Their study indicates that manufacturers with modern, API-based integration capabilities reduce the time required to incorporate new technologies by 50-60% while simultaneously increasing integration success rates by 75% compared to organizations using traditional point-to-point connections. The manufacturer's implementation of a comprehensive API layer with standardized interfaces for data exchange established consistent patterns for integrating new capabilities, significantly reducing both the

complexity and risk associated with technology adoption. This architectural approach proved particularly valuable when implementing emerging technologies like computer vision for quality inspection, IoT-based production monitoring, and predictive maintenance systems—innovations that would have been prohibitively complex to integrate with the previous legacy system. The research emphasizes that manufacturing organizations with well-established integration architectures are 2.7 times more likely to successfully implement advanced technologies like artificial intelligence and machine learning, creating significant competitive advantages through faster innovation adoption. The standardized integration framework enabled the manufacturer to incorporate three distinct AI-powered applications within nine months of the platform's completion, delivering quality improvements and cost reductions that would have been unattainable with the previous architecture [10].

5.2 Maintenance

Regular updates and patches can be deployed seamlessly through automated pipelines that eliminate manual intervention and reduce risk. The Manufacturer's research demonstrates that organizations implementing modern DevOps practices achieve transformative improvements in deployment efficiency and reliability. Their analysis indicates that manufacturing companies adopting continuous integration and continuous deployment

methodologies reduce deployment times by 85-95% while simultaneously decreasing deployment-related incidents by 70-80%. The study particularly emphasizes that automated deployment pipelines with comprehensive testing and verification capabilities enable zero-downtime updates that eliminate the operational disruptions previously associated with system maintenance. The manufacturer's implementation of a fully automated deployment pipeline transformed the update process from a high-risk, manually intensive operation typically performed during weekend maintenance windows to a routine, automated procedure that occurred during normal business hours without user impact. This approach not only reduced operational disruptions but also significantly enhanced security posture by enabling rapid deployment of patches and vulnerability fixes. The research highlights that manufacturing organizations implementing modern deployment automation reduce the mean time to implement security patches from 15-20 days to less than 24 hours, dramatically reducing exposure to potential threats. This capability proved particularly valuable in responding to emerging security vulnerabilities, enabling the manufacturer to apply critical patches across the entire application landscape within hours rather than the weeks typically required with the legacy environment [9].

System maintenance requires less specialized knowledge through the adoption of industry-standard technologies and simplified operational procedures. According to NetSuite's comprehensive research on manufacturing innovation, organizations transitioning from proprietary legacy systems to standard cloud technologies experience significant advantages in talent management and operational efficiency. Their analysis indicates that manufacturers adopting standardized technology stacks reduce specialized training requirements by 40-50% while simultaneously expanding their potential talent pool by 200-300%. The study emphasizes that widely adopted technologies benefit from extensive documentation, established best practices, and larger communities of expertise that simplify both operations and troubleshooting. The manufacturer's adoption of industry-standard cloud platforms, containerization technologies, and development frameworks aligned with these findings, reducing the specialized knowledge required for system maintenance while improving operational consistency. This transition not only simplified recruitment for technical positions but also enabled more effective knowledge-sharing and cross-training among existing staff. The research particularly highlights that manufacturing organizations implementing standardized cloud technologies reduce critical system dependencies on specific individuals by 60-70%, significantly improving operational resilience and business continuity. This reduction in key-person risk

represented a substantial improvement over the legacy environment, where specialized knowledge of proprietary systems had been concentrated in a small number of long-tenured employees [10].

Documentation and support are readily available through comprehensive knowledge management systems and vendor relationships. NetSuite's research indicates that manufacturing organizations implementing structured documentation practices and leveraging vendor support ecosystems achieve substantial improvements in operational efficiency and system reliability. Their analysis reveals that manufacturers with comprehensive knowledge management systems reduce incident resolution time by 50-60% while simultaneously decreasing recurring issues by 65-75% through better knowledge sharing and standardized troubleshooting procedures. The study emphasizes that cloud-based systems with established vendor support provide access to expertise and resources that would be impractical for individual organizations to maintain internally, particularly for specialized components or emerging technologies. The manufacturer's implementation of a comprehensive documentation repository with procedural guides, architectural diagrams, and troubleshooting workflows established a single source of truth for system knowledge, reducing the time required to diagnose and resolve issues by 67% compared to the legacy environment. Additionally, the transition to commercial technologies with established support ecosystems provided access to vendor assistance, reducing critical issue resolution time from days to hours. The research particularly highlights that manufacturing organizations leveraging vendor support ecosystems reduce the cost of specialized expertise by 40-50% while simultaneously improving access to cutting-edge knowledge and best practices. This approach not only enhanced operational efficiency but also enabled the manufacturer to remain current with evolving technology trends and security practices, ensuring ongoing alignment with industry standards [10].

Table 3: Future-Ready Manufacturing: Cloud-Native Architecture Benefits [9,10]

| Capability Area | Key Metric | Improvement |
|-----------------------------|------------------------|-------------|
| Scalability Benefits | | |
| Infrastructure Costs | Cost Reduction | 30-40% |
| System Availability | Uptime Performance | 99.95% |
| New Capability Deployment | Speed Improvement | 65% faster |
| Resource Utilization | Efficiency Improvement | 72% |
| Feature Time-to-Market | Reduction | 60-70% |
| Cross-Team Dependencies | Reduction | 76% to 18% |

| | | |
|-------------------------------|--------------------|---------------------|
| Release Frequency | Improvement | 3-4x greater |
| Development Costs | Reduction | 25-35% |
| New Technology Integration | Time Reduction | 50-60% |
| Integration Success Rate | Improvement | 75% higher |
| AI/ML Implementation | Success Likelihood | 2.7x higher |
| Maintenance Advantages | | |
| Deployment Time | Reduction | 85-95% |
| Deployment-Related Incidents | Reduction | 70-80% |
| Available Talent Pool | Expansion | 200-300% larger |
| Key-Person Dependencies | Reduction | 60-70% |
| Incident Resolution Time | Reduction | 50-60% |
| Recurring Issues | Reduction | 65-75% |
| Critical Issue Resolution | Time Reduction | Days to hours (67%) |
| Specialized Expertise Costs | Reduction | 40-50% |

6. Best Practices and Lessons Learned

The successful implementation highlighted several key considerations for similar modernization projects, providing valuable insights for manufacturing organizations undertaking similar digital transformation initiatives.

6.1 Planning and Assessment

A thorough analysis of existing system capabilities and limitations proved essential for effective modernization planning and execution. According to comprehensive research published by Vogelsang et al. in "Success factors for fostering a digital transformation in manufacturing companies," manufacturing organizations that conduct detailed legacy system assessments before modernization reduce project risks significantly. The study examined 24 manufacturing modernization projects and found that those beginning with comprehensive legacy analysis achieved 37% higher success rates in achieving targeted outcomes. Their findings revealed that inadequate understanding of legacy systems led to scope expansion in 64% of projects and budget overruns averaging 42%. The analysis particularly emphasized the importance of combining static and dynamic code analysis to identify interdependencies, technical debt, and performance bottlenecks. Manufacturing organizations that implemented multi-dimensional assessment methodologies incorporating both business process analysis and technical evaluation demonstrated a 43% reduction in unexpected migration complications. The manufacturer's implementation of a structured assessment methodology began with a

comprehensive analysis of the AS/400 environment, identifying approximately 1,470 business logic components, 267 integration points, and 182 data conversion requirements. This detailed understanding enabled the creation of a targeted modernization strategy that prioritized critical components while ensuring the preservation of essential business logic embedded in the legacy applications. The research particularly noted that effective legacy assessment should involve both IT and business stakeholders, as this approach was associated with a 56% improvement in capturing undocumented business rules and implicit requirements that often reside in the knowledge of long-tenured employees rather than formal documentation [11]

A clear definition of modernization objectives and success criteria established alignment between technology initiatives and business outcomes. The study by Vogelsang et al. demonstrated that manufacturing organizations developing detailed business-aligned objectives for modernization realize substantially greater value from their technology investments. Their analysis of manufacturing modernization projects revealed that organizations establishing quantifiable success metrics linked to operational outcomes achieved targeted benefits in 76% of cases, compared to only 31% for organizations with vague or technically-focused objectives. The research emphasized the importance of developing a balanced scorecard approach incorporating financial, operational, quality, and customer experience dimensions, with a balanced measurement framework associated with 2.4 times higher stakeholder satisfaction. The manufacturer's modernization initiative incorporated a comprehensive objectives framework with hierarchical success metrics spanning operational efficiency, quality improvement, cost reduction, and customer satisfaction dimensions. For each major business function, the team established baseline performance measurements, target improvements, measurement methodologies, and specific accountability for results. The research particularly highlighted that well-defined objectives create organizational alignment, with clearly articulated success criteria reducing cross-functional conflicts by 53% and improving resource allocation effectiveness by 47%. This approach enabled the manufacturer to maintain a consistent focus on business value throughout the modernization journey, preventing the common pattern of technology-driven scope expansion that often dilutes return on investment [11].

Comprehensive stakeholder engagement throughout the process significantly improved alignment and adoption rates. According to research published by Vogelsang et al., manufacturing organizations implementing structured stakeholder engagement programs experience substantially higher success rates in technology modernization initiatives. Their analysis of manufacturing transformation projects revealed that organizations with

comprehensive stakeholder involvement achieved 82% of targeted benefits, compared to only 34% for organizations with limited engagement approaches. The study identified specific engagement mechanisms that demonstrated particular effectiveness, including cross-functional steering committees, regular business review sessions, and direct participation of operational personnel in requirements definition and solution validation. The research found that manufacturing organizations implementing these engagement practices experienced a 68% reduction in change resistance and a 77% improvement in user adoption rates compared to those with technology-centric approaches. The manufacturer's implementation of a multi-level engagement strategy incorporated stakeholder representatives from production management, quality control, human resources, finance, and shop floor operations, establishing consistent communication channels and feedback loops throughout the modernization journey. This approach enabled the incorporation of operational knowledge that significantly improved the system's alignment with actual business requirements and user workflows. The research particularly emphasized that comprehensive stakeholder engagement enables more effective knowledge transfer, with organizations implementing structured involvement strategies demonstrating a 74% higher retention of institutional knowledge during migration compared to organizations focusing primarily on technical aspects [11].

6.2 Risk Mitigation

A phased implementation approach to minimize disruption proved essential for maintaining operational continuity during modernization. According to research by Yokogawa Electric Corporation on "Digital Transformation Risks In Process Manufacturing," organizations implementing staged modernization approaches substantially reduce operational disruptions and implementation failures. Their analysis of manufacturing technology transformations revealed that phased implementations reduce operational disruptions by 46-53% compared to comprehensive "big bang" migrations. The research emphasized that manufacturing operations are particularly sensitive to system transitions due to their real-time nature and direct impact on production output, making incremental approaches especially valuable in this sector. The study found that manufacturing organizations implementing phased modernization strategies experienced 57% fewer critical incidents during migration and 64% higher user satisfaction compared to those attempting comprehensive transitions. The manufacturer's modernization strategy divided the transformation into distinct phases, each delivering specific capabilities with complete testing and stabilization before proceeding to subsequent stages. This approach enabled the business to absorb and adapt to changes incrementally rather than simultaneously, significantly reducing operational risk. The

Yokogawa Electric Corporation research particularly noted that phased implementations improve project governance effectiveness, with staged approaches enabling 71% more accurate progress tracking and 66% more effective resource allocation compared to comprehensive migrations. This methodology enabled the manufacturer to maintain consistent production operations throughout the transition, ensuring uninterrupted business operations despite the significant technological changes being implemented [12].

Extensive testing at each stage of the migration significantly reduced production defects and implementation complications. The study by Vogelsang et al. demonstrated that manufacturing organizations implementing comprehensive testing methodologies substantially improve migration outcomes. Their analysis revealed that manufacturers employing multi-level testing strategies encompassing unit testing, integration testing, performance testing, and user acceptance validation reduced post-implementation defects by 76% compared to those with limited verification approaches. The research particularly emphasized the importance of automated regression testing in manufacturing environments, with organizations implementing comprehensive automation experiencing 83% fewer production issues following system changes. The testing methodology should incorporate a progression from isolated component verification to integrated system validation, with each stage building confidence in the solution's readiness for production deployment. The manufacturer's testing strategy incorporated automated verification at multiple levels, validating system functionality, data integrity, integration points, and performance characteristics under various operational scenarios. This comprehensive approach identified and resolved hundreds of potential issues before they impacted production operations, significantly reducing business risk. The research particularly noted that thorough testing improves implementation efficiency, with organizations implementing structured verification methodologies completing migrations with 42% fewer resources compared to those with limited testing approaches. This testing discipline enabled the manufacturer to maintain data accuracy and system reliability throughout the migration process, preserving critical business information while transitioning to the modernized platform [11].

Maintenance of parallel systems during the transition period established a reliable fallback mechanism while validating modernized capabilities. According to Yokogawa Electric Corporation's research on digital transformation risks, manufacturing organizations implementing parallel operations during critical system migrations significantly improve implementation outcomes. Their analysis of manufacturing technology transformations revealed that parallel system approaches reduce business continuity risks by 67-74% by

providing immediate fallback options while simultaneously enabling direct performance comparison between legacy and modernized systems under identical operational conditions. The research emphasized that parallel operations are particularly valuable for manufacturing environments where production continuity is business-critical, with organizations implementing this approach experiencing 84% fewer production disruptions during migration. The study found that synchronized parallel operations enable more effective performance validation, with organizations implementing this approach identifying 3.7 times more optimization opportunities compared to direct cutover strategies. The manufacturer's implementation of a parallel operation strategy maintained the legacy system alongside the modernized platform during each phase, enabling comprehensive verification of functionality, performance, and data integrity before decommissioning legacy components. The Yokogawa Electric Corporation research particularly highlighted that parallel operations improve stakeholder confidence in the modernized system, with this approach associated with a 78% reduction in user resistance and a 64% increase in adoption rates compared to direct replacement strategies. This methodology enabled the manufacturer to achieve business continuity throughout the transition while providing essential validation of the modernized system's readiness for production operations under real-world conditions [12].

Table 4: Best Practices and Their Impact on Manufacturing System Modernization Success

| Best Practice Category | Specific Practice | Key Benefit | Impact (%) |
|----------------------------------|---|---|------------------|
| Planning & Assessment | Thorough legacy system assessment | Higher success rates in achieving targeted outcomes | 37% |
| | IT and business stakeholder involvement | Improved capture of undocumented business rules | 56% |
| | Balanced scorecard approach | Higher stakeholder satisfaction | 2.4x improvement |
| | Clear success criteria | Improved resource allocation effectiveness | 47% |
| Stakeholder Engagement | Comprehensive stakeholder involvement | Achievement of targeted benefits | 82% vs 34% |
| | Cross-functional engagement | Improvement in user adoption rates | 77% |
| | Structured involvement strategies | Higher retention of institutional knowledge | 74% |

| | | | |
|---------------------------------|---------------------------------------|---|------------|
| Risk Mitigation | Phased implementation approach | Reduction in operational disruptions | 46% to 53% |
| | Incremental change implementation | Higher user satisfaction | 64% |
| | Staged approaches | More effective resource allocation | 66% |
| Testing & Validation | Multi-level testing strategies | Reduction in post-implementation defects | 76% |
| | Automated regression testing | Fewer production issues after changes | 83% |
| | Structured verification methodologies | Resource reduction for migration completion | 42% |
| Parallel Systems | Parallel operations during migration | Reduction in business continuity risks | 67% to 74% |
| | Synchronized parallel operations | Optimization opportunities identified | 3.7x more |
| | Parallel system strategy | Fewer production disruptions during migration | 84% |
| | Parallel system approach | Increase in adoption rates | 64% |

7. Conclusion

The clothing manufacturer's legacy system modernization journey demonstrates the transformative impact of comprehensive digital transformation in manufacturing environments. By implementing a structured approach that encompassed thorough assessment, clear objectives, stakeholder engagement, and phased implementation, the organization successfully navigated the complex transition from outdated systems to a modern, agile technology platform. The modernization initiative delivered substantial operational improvements through real-time tracking, automated data collection, and streamlined processes, while simultaneously enhancing technical capabilities through improved maintainability, integration, security, and deployment methodologies. These changes resulted in significant business benefits including reduced operational costs, enhanced decision-making, improved responsiveness, and better user experiences. The future-ready architecture established through this transformation now positions the manufacturer to adapt to evolving business requirements, scale with changing demand, and readily adopt emerging technologies. The best practices and lessons learned through this implementation provide a valuable blueprint for other manufacturing organizations seeking to overcome legacy constraints and achieve competitive advantage through digital transformation.

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